Technical Appendices

To

Comprehensive Exercise and Marine Species Monitoring Report For the U.S. Navy's Southern California Range Complex 2009–2012

Submitted By
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FINAL

This document contains amplifying technical data and information for the United States Department of the Navy's Southern California Range Complex Comprehensive Monitoring Report. It is organized into three separate appendices:

APPENDIX A – INDIVIDUAL SOCAL RANGE COMPLEX MITIGATION EVENTS FROM MAJOR TRAINING EVENTS BETWEEN JANUARY 2009 AND AUGUST 2012

APPENDIX B – TECHNICAL APPENDICES FOR: COMPREHENSIVE REPORT OF AERIAL MONITORING IN THE SOUTHERN CALIFORNIA RANGE COMPLEX 2008–2012

APPENDIX C – LIST OF PUBLICATIONS/PRESENTATIONS FROM NAVY (FLEET AND RESEARCH) FUNDED SOCAL MONITORING

APPENDIX A – INDIVIDUAL SOCAL RANGE COMPLEX MITIGATION EVENTS FROM MAJOR TRAINING EVENTS BETWEEN JANUARY 2009 AND AUGUST 2012

There were 298 total mitigation events (mid-frequency active sonar powered down or shut down) due to the sighting of marine mammals or sea turtles during major training events from 22 January 2009 to 1 August 2012. These mitigation events are summarized in Table A-1.

Table A-1. Southern California Range Complex mitigation events from 22 January 2009 to 1 August 2012.

Marine Animal Species	Range of Detection (Yards, < 200, 200–500, 500–1,000, 1,000–2,000, > 2,000)	Mitigation Measure Implemented	Excessive Mitigation (Yes/No)
22 January 2009–1 August 2009			
Whale	< 200	Sonar shut down	No
Whale	< 200	Sonar shut down	No
Whale	< 200	Sonar shut down	No
Whale	< 200	Sonar shut down	No
Whale	200–500	Sonar powered down	No
Whale	200–500	Sonar powered down	No
Whale	200–500	Sonar powered down	No
Whale	200–500	Sonar powered down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	500–1,000	Sonar shut down	Yes
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No

Marine Animal Species	Range of Detection (Yards, < 200, 200–500, 500–1,000, 1,000–2,000, > 2,000)	Mitigation Measure Implemented	Excessive Mitigation (Yes/No)
Whale	500–1,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	Yes
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	> 2,000	Sonar powered down	No
Whale	Not reported	Sonar shut down	Yes
Whale	Not reported	Sonar powered down	No
Whale	Not reported	Sonar powered down	No
Pinniped	< 200	Sonar shut down	No
Pinniped	< 200	Sonar shut down	No
Pinniped	500–1,000	Sonar shut down	Yes
Pinniped	200–500	Sonar shut down	No
Pinniped	200–500	Sonar powered down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	200–500	Sonar shut down	No
Dolphin	200–500	Sonar powered down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	1,000–2,000	Sonar shut down	Yes
Dolphin	1,000–2,000	Sonar shut down	Yes

Marine Animal Species	**Range of Detection** (Yards, < 200, 200–500, 500–1,000, 1,000–2,000, > 2,000)	**Mitigation Measure Implemented**	**Excessive Mitigation** (Yes/No)
Dolphin	1,000–2,000	Sonar powered down	No
Dolphin	1,000–2,000	Sonar powered down	No
Dolphin	> 2,000	Sonar shut down	Yes
Dolphin	> 2,000	Sonar shut down	Yes
2 August 2009–1 August 2010			
Generic	Not reported	Sonar shut down	Yes
Generic	500–1,000	Sonar powered down	No
Whale	< 200	Sonar powered down	No
Whale	< 200	Sonar shut down	No
Whale	< 200	Sonar shut down	No
Whale	< 200	Sonar shut down	No
Whale	< 200	Sonar shut down	No
Whale	< 200	Sonar shut down	No
Whale	< 200	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	500–1,000	Sonar shut down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	1,000–2,000	Sonar shut down	Yes
Whale	1,000–2,000	Sonar shut down	Yes
Whale	1,000–2,000	Sonar shut down	Yes
Whale	1,000–2,000	Sonar shut down	Yes
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	Yes
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	Yes
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No

Marine Animal Species	**Range of Detection** (Yards, < 200, 200–500, 500–1,000, 1,000–2,000, > 2,000)	**Mitigation Measure Implemented**	**Excessive Mitigation** (Yes/No)
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	> 2,000	Sonar powered down	No
Whale	> 2,000	Sonar shut down	Yes
Whale	> 2,000	Sonar shut down	Yes
Pinniped	< 200	Sonar shut down	No
Pinniped	200–500	Sonar shut down	No
Pinniped	500–1,000	Sonar powered down	No
Pinniped	500–1,000	Sonar powered down	No
Pinniped	500–1,000	Sonar powered down	No
Pinniped	Not reported	Sonar shut down	Yes
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	200–500	Sonar shut down	No
Dolphin	200–500	Sonar shut down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	500–1,000	Sonar shut down	No
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	1,000–2,000	Sonar powered down	No
Dolphin	1,000–2,000	Sonar powered down	No
Dolphin	1,000–2,000	Sonar powered down	No
Dolphin	1,000–2,000	Sonar shut down	Yes
Dolphin	1,000–2,000	Sonar shut down	Yes
Dolphin	Not reported	Sonar shut down	Yes

Marine Animal Species	**Range of Detection** (Yards, < 200, 200–500, 500–1,000, 1,000–2,000, > 2,000)	**Mitigation Measure Implemented**	**Excessive Mitigation** (Yes/No)
2 August 2009–1 August 2010			
Turtle	500–1,000	Sonar shut down	Yes
Generic	1,000–2,000	Sonar powered down	Yes
Generic	Acoustic detection	Sonar powered down	Yes
Generic	200–500	Sonar shut down	No
Generic	200–500	Sonar shut down	No
Generic	500–1,000	Sonar powered down	No
Generic	Not reported	Sonar powered down	Yes
Generic	Not reported	Sonar powered down	No
Generic	Not reported	Sonar shut down	Yes
Whale	< 200	Sonar shut down	No
Whale	< 200	Sonar shut down	No
Whale	< 200	Sonar shut down	No
Whale	< 200	Sonar shut down	No
Whale	< 200	Sonar shut down	No
Whale	< 200	Sonar shut down	No
Whale	200–500	Sonar powered down	No
Whale	200–500	Sonar powered down	No
Whale	200–500	Sonar powered down	No
Whale	200–500	Sonar shut down	Yes
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	200–500	Sonar shut down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar shut down	Yes
Whale	500–1,000	Sonar shut down	No

Marine Animal Species	Range of Detection (Yards, < 200, 200–500, 500–1,000, 1,000–2,000, > 2,000)	Mitigation Measure Implemented	Excessive Mitigation (Yes/No)
Whale	500–1,000	Sonar shut down	Yes
Whale	500–1,000	Sonar shut down	No
Whale	500–1,000	Sonar shut down	Yes
Whale	500–1,000	Sonar shut down	Yes
Whale	500–1,000	Sonar shut down	Yes
Whale	1,000–2,000	Sonar shut down	No
Whale	1,000–2,000	Sonar shut down	Yes
Whale	1,000–2,000	Sonar powered down	Yes
Whale	1,000–2,000	Sonar powered down	Yes
Whale	1,000–2,000	Sonar powered down	Yes
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	Yes
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	Yes
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	1,000–2,000	Sonar powered down	No
Whale	> 2,000	Sonar powered down	Yes
Whale	> 2,000	Sonar shut down	Yes
Whale	Not reported	Sonar shut down	Yes
Whale	Not reported	Sonar shut down	Yes
Whale	Acoustic detection	Sonar powered down	Yes
Whale	Not reported	Sonar powered down	Yes
Pinniped	< 200	Sonar shut down	No
Pinniped	< 200	Sonar shut down	No
Pinniped	< 200	Sonar shut down	No
Pinniped	< 200	Sonar powered down	No
Pinniped	200–500	Sonar powered down	No
Pinniped	200–500	Sonar shut down	No
Pinniped	500–1,000	Sonar powered down	No
Pinniped	500–1,000	Sonar powered down	No
Pinniped	500–1,000	Sonar powered down	No
Pinniped	1,000–2,000	Sonar powered down	Yes
Pinniped	> 2,000	Sonar powered down	Yes
Pinniped	1,000–2,000	Sonar powered down	Yes

Marine Animal Species	Range of Detection (Yards, < 200, 200–500, 500–1,000, 1,000–2,000, > 2,000)	Mitigation Measure Implemented	Excessive Mitigation (Yes/No)
Dolphin	< 200	Sonar powered down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	200–500	Sonar powered down	No
Dolphin	200–500	Sonar powered down	No
Dolphin	200–500	Sonar shut down	No
Dolphin	200–500	Sonar shut down	No
Dolphin	200–500	Sonar shut down	Yes
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	500–1,000	Sonar shut down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	1,000–2,000	Sonar shut down	Yes
Dolphin	1,000–2,000	Sonar shut down	Yes
Dolphin	1,000–2,000	Sonar shut down	Yes
Dolphin	> 2,000	Sonar shut down	No
Dolphin	Not reported	Sonar shut down	Yes
Dolphin	Not reported	Sonar powered down	Yes
2 August 2009–1 August 2010			
Generic	Acoustic detection	Sonar powered down	Yes
Whale	200–500	Sonar shut down	No
Whale	500–1,000	Sonar powered down	No

Marine Animal Species	**Range of Detection** (Yards, < 200, 200–500, 500–1,000, 1,000–2,000, > 2,000)	**Mitigation Measure Implemented**	**Excessive Mitigation** (Yes/No)
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar powered down	No
Whale	500–1,000	Sonar shut down	No
Whale	500–1,000	Sonar shut down	No
Whale	1,000–2,000	Sonar powered down	Yes
Whale	Not reported	Sonar shut down	Yes
Pinniped	200–500	Sonar shut down	No
Pinniped	500–1,000	Sonar shut down	No
Pinniped	500–1,000	Sonar powered down	No
Pinniped	1,000–2,000	Sonar shut down	Yes
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	< 200	Sonar shut down	No
Dolphin	200–500	Sonar powered down	No
Dolphin	200–500	Sonar shut down	No
Dolphin	200–500	Sonar shut down	No
Dolphin	200–500	Sonar shut down	No
Dolphin	200–500	Sonar shut down	No
Dolphin	200–500	Sonar shut down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar powered down	No
Dolphin	500–1,000	Sonar shut down	No
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	500–1,000	Sonar shut down	Yes
Dolphin	1,000–2,000	Sonar powered down	No
Dolphin	1,000–2,000	Sonar shut down	No
Dolphin	1,000–2,000	Sonar shut down	Yes
Dolphin	1,000–2,000	Sonar shut down	Yes
Dolphin	1,000–2,000	Sonar shut down	Yes
Dolphin	Not reported	Sonar shut down	No

APPENDIX B – TECHNICAL APPENDICES FOR: COMPREHENSIVE REPORT OF AERIAL MONITORING IN THE SOUTHERN CALIFORNIA RANGE COMPLEX 2008–2012

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Final Report

A COMPREHENSIVE REPORT OF AERIAL MARINE MAMMAL MONITORING

IN THE

SOUTHERN CALIFORNIA RANGE COMPLEX: 2008-2012

October 17, 2012

Citation for this report is as follows:

Smultea, M.A., and C.E. Bacon. 2012. A comprehensive report of aerial marine mammal monitoring in the Southern California Range Complex: 2008-2012. Prepared for Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. Submitted to Naval Facilities Engineering Command Southwest (NAVFAC SW), EV5 Environmental, San Diego, 92132 under Contract No. N62470-10-D-3011 issued to HDR, Inc., San Diego, California.

With Contributions from:

(Alphabetized by organization) BioWaves, Inc (Talia Dominello and Thomas F. Norris); Clymene Enterprises (Thomas A. Jefferson); Entiat River Technologies (Dave Steckler); Marine Mammal Research Program, Texas A&M University at Galveston (Bernd Würsig); Smultea Environmental Sciences (Anna Fowler); and WEST, Inc. (Shay Howlin, Trent McDonald, Chris Nations, and Saif Nomani).

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF ACRONYMS

AIC	Akaike's Information Criterion
Bf	Beaufort sea state
BL	body length(s)
BRS	Behavioral Response Study
CDS	Conventional Distance Sampling
CO	Calibrated omni-directional
DoN	Department of the Navy
DF	Direction-finding
ESA	Endangered Species Act
ft	foot/feet
hr	hour(s)
ICMP	Integrated Comprehensive Monitoring Program
km	kilometer(s)
kt	knot(s)
m	meter(s)
MFAS	mid-frequency active sonar
MMPA	Marine Mammal Protection Act
min	minute(s)
MTE	military training events
NM	nautical mile(s)
NAVFAC	Naval Facilities Engineering Command
NMFS	National Marine Fisheries Service
NW	northwest
PAM	passive acoustic monitoring
RSF	Resource Selection Function
SAG	Scientific Advisory Group
SCB	Southern California Bight
SCBa	Santa Catalina Basin
SCI	San Clemente Island
SD	standard deviation
SE	southeast
sec	second(s)
SNB	San Nicolas Basin
SOCAL	Southern California
SPUE	Sightings Per Unit Effort
U.S.	United States
WNW	west-northwest

1.0 INTRODUCTION

BACKGROUND AND REPORT OBJECTIVE

This report provides a comprehensive summary and analysis of aerial surveys conducted on the United States (U.S.) Navy's Southern California (SOCAL) Range Complex to monitor marine mammals and sea turtles between October 2008 and April 2012, as required by the National Marine Fisheries Service (NMFS). The U.S. Navy developed range complex-specific monitoring plans to provide marine mammal and sea turtle monitoring as required under the Marine Mammal Protection Act (MMPA) of 1972 and the Endangered Species Act (ESA) of 1973. The primary purpose of these surveys was to meet goals identified in the U.S. Navy's SOCAL Marine Species Monitoring Plan (Department of the Navy [DoN] 2009b, 2010a, 2011c) and Integrated Comprehensive Management Program (ICMP) (DoN 2010b). This involved collecting baseline data on occurrence, distribution, numbers and behavior of marine mammals and sea turtles. In particular, the integrative and comprehensive analyses reported herein are directly relevant to addressing "Overarching (Specific Study) Questions," components of the Conceptual Framework, and ICMP and Science Advisory Group (SAG) goals associated with the SOCAL Range Complex. Of particular relevance is addressing the U.S. Navy's "Overarching Question No. 6: *Are there existing unanalyzed U.S. Navy-funded or other agency data that can be used to further our understanding of the proposed questions?"* and the related sub-question No. 6a directive: "*Conduct further analysis of monitoring data collected on the SOCAL Range Complex from previous years focusing on 2008-2011 first.*" This report directly addresses these questions as well as others identified in the U.S. Navy's ICMP and the SAG Recommendations (DoN 2011b).

Baseline data on marine mammals are needed to compare and identify potential changes (or lack thereof) in occurrence, numbers, distribution, and behavior in response to naval activities particularly involving mid-frequency active sonar (MFAS) and underwater detonations (explosive events). Very little is known about the behavior of most marine mammal species while they inhabit the SOCAL Range Complex. Note that no sea turtles were seen. Although sea turtles are commonly seen during similar aerial surveys in the U.S. Navy's Hawaii Range Complex (e.g., Smultea and Mobley 2009, DoN 2011a), none have been observed on the SOCAL Range Complex during any of the aerial surveys from 2008 to 2012. Thus, they are not further addressed herein.

Numerous aerial surveys have been conducted to address various questions and were funded by different agencies over the last four decades in the Southern California Bight (SCB) (e.g., Dohl et al. 1986, Forney et al. 1995, Forney and Barlow 1998, Carretta et al. 1998, Carretta et al. 2000, Barlow et al. 2009, DoN 2010c, 2011c, 2012, Eguchi and Seminoff 2012). These surveys have focused on the occurrence, distribution, abundance, and density of marine mammals, primarily from spring through fall, with minimal effort conducted during winter. None of these surveys focused on behavior. Vessel-based and tagging studies in the SOCAL Range Complex have provided detailed information on the behavior of individual cetaceans, particularly in recent years (e.g., Falcone et al. 2009, Schorr et al. 2010, Falcone and Schorr 2011), including behavioral responses to playback of MFAS (e.g., Southall et al. 2012). Passive acoustic monitoring (PAM) studies have provided detailed data based on large sample sizes characterizing acoustic behavior, and have documented changes in calling and other behavior in the presence of MFAS in the SOCAL Range Complex (Hildebrand et al. 2011) and other areas (Norway, Florida, Hawaii) (e.g., Moretti et al. 2006, 2010, Au and Oswald 2011, Au 2012). Studies from different platforms (e.g., vessel, aerial, attached tags) complement one another, as each has its own benefits and limitations (e.g., Dawson et al. 2008). Advantages and unique perspectives from the aerial platform include (1) coverage of a large area in a short period; (2) a "bird's eye" view of behavior and inter-individual spacing and interactions, including up to several large whale lengths below the water surface; (3) when flown outside the hearing range of observed animals, an aircraft can be used as a non-intrusive observation platform (unlike vessels, whose sounds pervade for many miles below the water surface [summarized in Richardson et al. 1995]); and (4) the ability to collect line-transect density and abundance data without concerns about platform attraction or avoidance, as is an issue with vessel-based surveys.

Fifteen aerial surveys were conducted on behalf of the U.S. Navy in selected subregions of the SOCAL Range Complex (i.e., the study area) to monitor and provide baseline data on the occurrence, distribution, numbers, and behavior of marine mammals between October 2008 and April 2012; these are summarized herein and in **Appendices A-H**. Results of each survey were summarized in the U.S. Navy's annual reports submitted to NMFS (DoN 2009a, 2010c, 2011c, 2012) as well as in contractor reports submitted to the U.S. Navy (e.g., Smultea et al. 2009, 2010a, 2011a, 2012). Additional funding has been provided by the U.S. Navy to conduct specific analyses for some of these results and surveys. This additional effort has included density and abundance estimates (Jefferson et al. 2011, 2012), analyses of first-observed behaviors (Smultea et al. 2011b), and an inventory of video taken during focal follows (Smultea and Bacon 2011). In addition, a peer-reviewed journal article was published from these data (Smultea et al. 2012b), with two more articles close to submission (Jefferson et al. in prep., Smultea et al. in prep.). Eighteen conference presentations have been given since 2009 and are summarized in DoN 2011a, 2012. However, the full October 2008 through April 2012 database for the study area aerial surveys had not been previously integrated or summarized until now. Furthermore, analyses of focal follows have not been conducted until this document where focal follows of Risso's dolphins are presented (focal follows of other species remain to be analyzed). Such analyses and integration are important to assess the effectiveness of meeting monitoring goals and to identify future monitoring goals relative to NMFS requirements and U.S. Navy management policies.

REPORT ORGANIZATION

This report is organized into the following stand-alone sections, each with its own introduction, methods, and results specific to the focus of that section:

1. *General Overview and Results Summary* presents the approach, methods, and results in terms of effort and sightings of the 2008-2012 SOCAL Range Complex aerial surveys;

2. *Integration of Winter Density and Abundance Estimates* presents integrated estimates of density and abundance of marine mammals applying line-transect DISTANCE analyses for the 15 aerial survey conducted in the study area from October 2008 through April 2012;

3. *First Observed Behavior Analysis* summarizes first-observed behaviors of marine mammals including behavior state, heading, and inter-individual dispersal distance using multi-variate statistics relative to habitat and social parameters; Focal Behavior / Video Analysis: Risso's Dolphin: describes results of sequential and other analyses of group behavior of Risso's dolphins during focal follows; and

4. *Marine Mammal Distribution, Occurrence, and Relative Abundance Analysis* summarizes numbers and habitat use patterns of marine mammals based on (1) selected habitat parameters using a Resource Selection Function (RSF) analysis (Manly et al. 1993, 2002), and (2) a summary review and comparison of the 2008-2012 study area aerial survey data relative to historical data on the frequency of occurrence of marine mammals in the SCB.

In addition to the above sections, nine appendices are provided at the end of this report as follows:

- *Appendix A: Tables* provides summary tables of results including effort, sightings, types of statistical analyses conducted.
- *Appendix B: Figures* presents figures related to results including sighting and effort maps, and selected summary behavioral graphs.
- *Appendix C: Photos* contains selected photos of high priority and unusual cetacean species or events taken during the survey period.
- *Appendix D: Survey Methodology* provides a detailed summary of the survey protocol, including figures and tables defining and describing behavioral definitions (i.e., an ethogram), survey personnel roles, etc.
- *Appendix E: Report–Density and Abundance of Marine Mammals* provides detailed descriptions, figures and tables of results summarized in Item 2 above.
- *Appendix F*: *First-Observed Behaviors of Marine Mammals* contains detailed statistical methods and results.
- *Appendix G*: *Focal Follows of Risso's Dolphins* provides detailed statistical methods and results.
- *Appendix H*: *A Case Study* contains the behavior of a focal group of Risso's dolphins based on video data.
- *Appendix I: Marine Mammal Resource Selection Function Analyses* provides detailed statistical methods and results.

A map of the SOCAL Range Complex study area is shown below (**Figure 1**). To simplify report narrative, short summaries of some of the appendix reports are provided in the main body of the report, and tables and figures are presented in appendices rather than within the text due to their large quantity. Scientific names are provided in **Appendix A.**

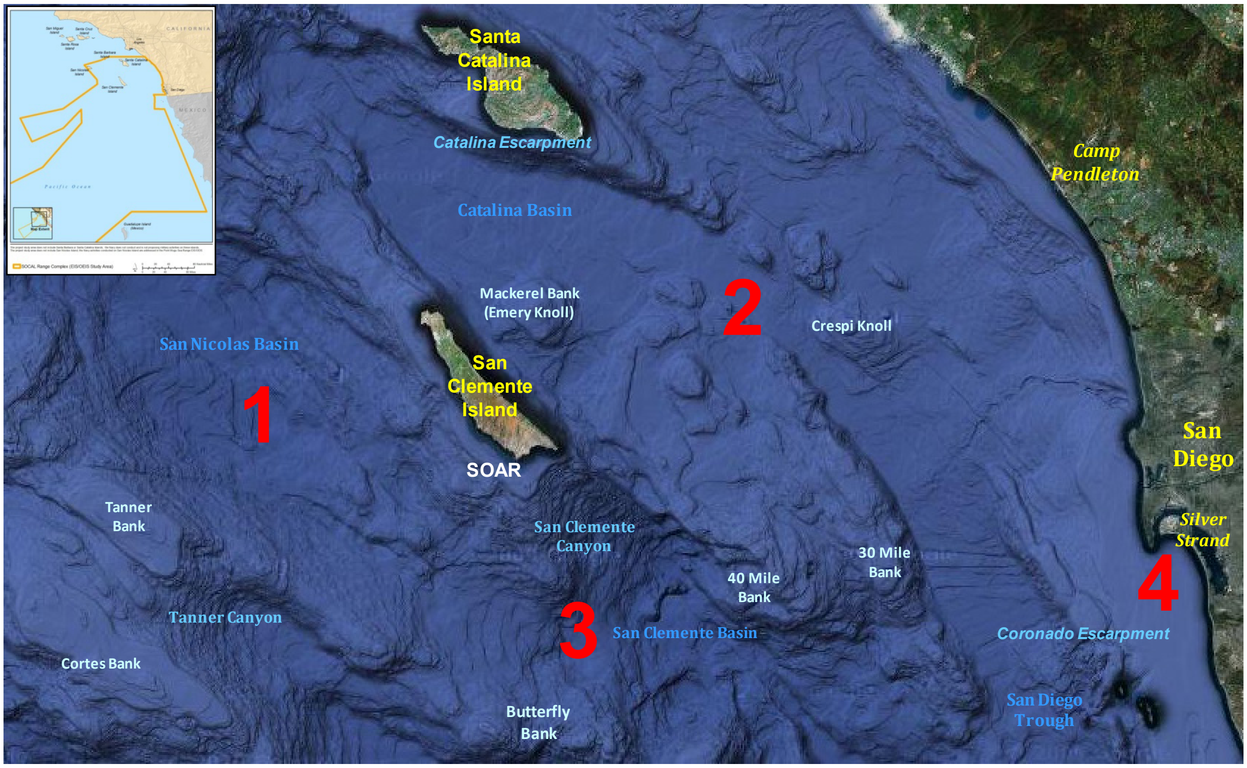

Figure 1. Priority areas selected by the U.S. Navy for marine mammal and sea turtle monitoring within the U.S. Navy's Southern California Range Complex: (1) San Nicolas Basin, (2) Santa Catalina Basin, (3) south of San Clemente Island/San Clemente Basin, and (4) Silver Strand.

2.0 GENERAL OVERVIEW AND RESULTS SUMMARY

APPROACH

The primary focus of the 2008 through 2012 aerial surveys was to collect recent baseline data on marine mammals inhabiting the SOCAL Range Complex study area. This effort represents the most extensive, focused survey effort on the SOCAL Range Complex. It also represents some of the first systematically quantified assessments of the behavior of a number of poorly-described species, including species listed under the ESA (e.g., blue, fin, and sperm whales). Other little-known species addressed herein include the short-beaked common dolphin, long-beaked common dolphin, and Risso's dolphin. An additional focus of these surveys was to identify any observable unusual behaviors potentially indicative of effects of U.S. Navy training activities involving MFAS. Given these overarching goals, in 2008, the U.S. Navy and its contractors identified a suite of measurable parameters that could be assessed from aerial surveys. These parameters consisted of variables that could be used to identify potential effects of U.S. Navy activities based on results of other studies assessing impacts of anthropogenic activities and sounds on marine mammals. For example, field studies have shown that spacing between individuals may decrease or increase in response to various stimuli (e.g., Morretti et al. 2006, Smultea and Würsig 1995, Bacon et al. in press, Bredvik et al. 2011). The parameters are summarized in **Appendix A**. Because few data were available to quantify typical or "normal" behavior for most of the species occurring off southern California, let alone within the SOCAL Range Complex, data from 2008 through 2012 were meant to provide a relative baseline for future determination of potential effects.

METHODS

Methods for aerial surveys have been described in detail in past reports; authors recommend referring to Smultea et al. (2009) for detailed description. A summary of these methods integrated across the 14 aerial surveys are provided in **Appendix D** as a single comprehensive reference source, including any changes made across surveys (e.g., equipment, personnel roles, etc.). Fourteen surveys have been conducted primarily from a Partenavia P68-C or a Partenavia Observer, with one remaining survey from an Aero-Commander (**Appendix A,** Table A-1). In addition, 2 days during one survey were flown from a Bell 206 helicopter to assess the utility of this platform for conducting focal-follow observations (see Smultea et al. 2010 for the results of this assessment). All 15 surveys involved systematic searching along pre-determined east-west transect lines located primarily east (Santa Catalina Basin) or west (San Nicolas Basin) of SCI (**Appendix B,** Figure B-1. One survey (November 2008) occurred in a grid south of SCI, and three surveys in Silver Strand just south of San Diego (winter 2011). Winter density and abundance estimates of marine mammals were applied using line-transect DISTANCE analyses (Buckland et al. 2001, 2004). In 2009 and 2010, the team aerial circumnavigated the shoreline of SCI on one day during three surveys to search for injured or stranded marine mammals or sea turtles, in addition to conducting line-transect and focal follow effort.

All 15 aerial surveys also involved some level of focal follow observation effort, depending on the specific survey goals. The general approach was to depart San Diego as soon as conditions permitted (i.e., 1 hour [hr] after sunrise, fog layer lifted, no rain, Beaufort sea state [Bf] <5), following standard line-transect survey protocol along systematic transect lines until a priority focal individual/group was located (priority included ESA-listed species, beaked whales, and Risso's dolphins - see **Appendix D**). The focal group was then circled at 365 to 457 meters (m) (1,200 to 1,500 feet [ft]) at radial distances of 0.5 to 1.0 kilometers (km) to avoid potential disturbance of the focal group. The latter protocol was developed during studies of bowhead whales in the Arctic relative to offshore oil and gas exploration activities (e.g., Richardson et al. 1985a,b, 1986, 1990, 1995, Würsig et al. 1985, 1989). These studies indicated that at these distances and altitudes, no significant changes in whale behavior were detected relative to the observation aircraft operating well outside the theoretical 26-degree incident angle of sound transmission emitted from an aircraft through the air-to-water interface (i.e., Snell's cone; see diagram in **Appendix D,** Figure 1) (Urick 1972; Richardson et al. 1995). In winter 2012, sonobuoys were deployed from the aircraft to simultaneously monitor vocal and visually observed behavior of cetaceans (see Acoustic-Visual Behavior Study subsection). Descriptions of the four primary survey modes (search, verify, focal follow, shoreline survey) and types of effort are provided in **Appendix D**.

During eight surveys from 2008 to 2010, aircraft personnel consisted of one pilot, a recorder/photographer/videographer in the co-pilot seat, and two observers in the center seats looking out bubble windows (**Appendix D,** Table D-3). Beginning in 2011, the U.S. Navy required two pilots; this requirement necessitated that the recorder/photographer/videographer was seated in the rear left seat.

STATISTICAL ANALYSES

Most statistical analyses were conducted by biostatisticians at WEST, Inc., using the Matlab and R software programs. The exception was density and abundance analyses that were conducted by Clymene Enterprises, who used DISTANCE 6.0 software. Statistical analysis approaches were chosen by the field biologists (who had designed the field protocols and collected and summarized the data) in consultation with the biostatisticians and other biologists experienced in assessing impacts of anthropogenic activities on marine mammals. Table 1 in **Appendix D** lists all the original hypotheses identified when the monitoring studies first began in 2008. These hypotheses were developed by the team of experienced biologists in the context of the U.S. Navy's SOCAL Marine Species Monitoring Plan goals (DoN 2009b), and were reviewed by U.S. Navy personnel from the Naval Facilities Engineering Command (NAVFAC) Southwest and Pacific, and Pacific Fleet.

Table 12 in **Appendix A** lists the statistical analyses applied to each of the core analysis tasks (i.e., density and abundance estimates, focal follows of Risso's dolphins, first-observed behaviors, and RSF analyses). A comprehensive list of all the selected "response" (i.e., dependent) variables and "explanatory" (i.e., independent) variables is provided in Table 1 in **Appendix F**. Specific response and explanatory variables used for each of the core analyses are identified separately in each associated appendix (i.e., **Appendices F-H**). As indicated in the *Approach* section above, response variables were chosen that included quantifiable indices used in other studies to describe baseline distribution and behavior and/or to identify effects of underwater anthropogenic sounds on marine mammals (e.g., reviewed in Richardson et al. 1995, Southall et al. 2007.

For the 2008 through 2012 baseline results discussed herein, the statistical analysis goals were to:

1. Identify if and how the selected marine mammal response variables may be influenced by explanatory variables (e.g., time of day, season, water depth, slope, etc.) under baseline "naturally occurring" conditions.
2. Identify response variables that could be used in the future to assess and differentiate potential changes in response to U.S. Navy training activities.

Species selected for statistical analyses were those determined to have adequate sample sizes by the biostatisticians in consultation with the biologists, depending on the analyses. These included up to 10 species per core analysis task as follows (listed in alphabetical order by common name): blue whale, bottlenose dolphin, California sea lion, fin whale, gray whale, humpback whale, long-beaked common dolphin, Pacific-white sided dolphin, Risso's dolphin, and short-beaked common dolphin. Minimum sample size was considered to be 8 samples per species for density and abundance analyses, 21 samples for first-observed behavior, and 25 samples for RSF statistical analyses. A sample size of 51 Risso's dolphin groups was used for focal group behavioral analyses as this was the largest focal sample size of all the species during the study.

Specific statistical analysis methods are discussed separately for each core analysis task under later corresponding section headings and in the more detailed associated **Appendices F** through **H**.

See **Appendix D** for further details on general methodology, software, and equipment.

RESULTS AND DISCUSSION

The 15 aerial surveys conducted in the study area from October 2008 through April 2012 spanned all months of the year except December. This effort covered all four solar seasons (winter, spring, summer, autumn). Survey dates, total effort and sightings, and other summary details for each of the 15 surveys are presented in **Appendices A** and **B**. In 2008-2010, surveys occurred only in late spring, summer, and fall. To facilitate comparisons with past aerial surveys focused near SCI in 1998-1999 by Carretta et al. (2000), we followed their definition of the cold- (November-April) and warm-water seasons (May-October) characterizing SCB waters. We conducted eight surveys during the cold-water season and seven surveys in the warm-water season.

Effort and Number of Sightings

A total of 72,647 km (39,129 nautical miles [nm]) of survey effort occurred during the 15 surveys on 86 days in 2008-2012 (**Appendix A,** Table A-1 and **Appendix B,** Figure B-3). The majority (34 percent or 21,503 km) of this effort consisted of systematic line-transect effort, followed by transit, circling, and connector effort. Nineteen species of marine mammals were confirmed, including 6 mysticetes, 10 odontocetes, and 3 pinnipeds. A total of 2,151 marine mammal sightings (i.e., groups) were made comprising an estimated 190,310 individuals (**Appendix A,** Table A-3). The most frequently seen species group in terms of number of sightings (*n*= 461, 21 percent) and individuals (n= 108,606, 57 percent) was the common dolphin (*Delphinus* spp.) followed by the California sea lion and Risso's dolphin (**Appendix A,** Table A-3). The most commonly seen mysticete whale was the fin whale followed by the gray whale and blue whale.

Most species (*n*=14, 74 percent) were seen year-round though some species were seasonal. Gray whales, killer whales, and Dall's porpoises were seen only during the cold-water season while harbor seals, Bryde's whales, and sperm whales were seen only during the warm-water season (**Appendix A,** Table A-5). Common dolphins had the largest mean group size of 236 (**Appendix A,** Table A-5). Sightings per unit effort (SPUE) were highest for common dolphins (0.008 sightings/km flown) followed by California sea lions and Risso's dolphins (these are approximate, as they include all effort types [e.g., transit, circling, systematic) and all Bf) (**Appendix A,** Table A-5). The predominant Bf was 3 (39 percent) followed by Bf 2 (35 percent) (**Appendix A,** Tables A-2 and A-13**)** based on the total 65,238 km of all observation effort during all leg types (**Appendix A**, Table A-13). This was followed by Bf 1 (13 percent), Bf 4 (12 percent) and Bf 5 (1 percent). **(**More detailed estimates of density and abundance of marine mammals are discussed in the next chapter and in **Appendix E**).

Dead Sightings

Seven (0.003 percent) (**Appendix A,** Table A-1) of the total 2,151 sightings consisted of dead animals. In November 2008, a dead California sea lion was seen on 2 consecutive days near the same location just off central-west SCI. A dead, subadult male blue whale was also seen during November 2008, south of SCI, with rope line loosely draped around its lower body and the line was attached to two fishing buoys. Two blue sharks (*Prionace glauca*) were videotaped circling around the carcass and over 30 gulls (*Laridae* sp.) were recorded on top of the carcass. Two dead, floating unidentified sea lions (probable California sea lions) were seen separately in July 2009. A dead humpback whale was seen on 10 and 11 May 2011; these two sightings were presumed to be the same animal based on examination of photos of the underside of the tail flukes. A blue shark about 3 m (9.8 ft) long was seen circling the dead humpback whale on 11 May. On 10 May, the whale was seen about 7 km (4 nm) west of Soledad, San Diego, and no sharks were seen. A dead California sea lion was seen in February 2012.

Calf Sightings

Overall, 165 (8 percent) of the total 2,151 cetacean sightings contained at least one calf. A calf was considered to be an individual two-thirds or less the length of an adult, that swam beside and slightly behind an adult (Shane 1990, Fertl 1994). Fifteen (5 percent) of the total 331 mysticete sightings had a calf (**Appendix B,** Figure B-24). In comparison, 150 (12 percent) of the total odontocetes sightings had at least one calf. The only confirmed species for which a calf was never observed was the minke whale (total 11 sightings), Bryde's whale (2 sightings), Cuvier's beaked whale (4 sightings) and Dall's porpoise (5 sightings). The most frequently sighted species with a calf was the common dolphin (38 percent of 172 sightings). No pinnipeds pups were confirmed at sea. Apparent nursing was observed among cetaceans on three occasions including among gray, fin, and killer whales (Moore et al. 2012). Nursing behavior as well as "calf riding mother" behavior was documented in video for 2 sightings, both of which were gray whales (Moore et al. 2012). Future examination of the many photographs, particularly of delphinids, would likely reveal other apparent nursing events.

Mixed-Species Sightings

Thirty-six (2 percent) of 2,151 total sightings consisted of mixed-species sightings (i.e., at least two different species swimming together and/or interacting) (**Appendix A,** Table A-4). The species most frequently seen associated with another marine mammal species was the Risso's dolphin (17 or 6 percent of 283 total sightings of this species). Risso's dolphins were seen with one to two other species. The greatest number of species seen together was three on three different occasions. These mixed sightings consisted of: (1) sperm whales, Risso's dolphins, and northern right whale dolphins, (2) Risso's dolphins, California sea lions, and unidentified dolphins, and (3) Pacific white-sided dolphins, common dolphins, and California sea lions. The most unusual mixed species sighting was 24 sperm whales (including four calves) with 11 Risso's dolphins and approximately 50 northern right whale dolphins on 12 May 2011 (Smultea et al. 2011a, Bredvik et al. 2011, Bacon et al. in press). This encounter was videotaped for 67 minutes (min) and included footage of Risso's dolphins repeatedly charging the heads of adult sperm whales, which responded by dropping their lower jaw and exposing their white lower lips/jaws (see photographs in **Appendix C,** Photo 6). This was believed to be a case of kleptoparasitism, whereby the Risso's dolphins may have been charging the sperm whales to induce regurgitation of prey remains that the dolphins could consume. The latter has been suggested for a sighting of pilot whales harassing sperm whales in the Gulf of Mexico when squid remains were found nearby (Weller et al. 1996).

Other Marine Species Sightings

Opportunistic and/or unusual sightings of other marine species were recorded during survey flights as requested by the Navy Technical Representative. These included approximately 30 large gulls perched on a dead blue whale's (see *Dead Sightings* above) ventrum and two blue sharks seen swimming near the whale's head and peduncle (2008); a red crab aggregation (extending 1 kilometer [km] long and about 200 meters [m] across); numerous krill aggregations (fish schools including a school of about 30 tuna near a kelp flotsam), three other shark sightings of six individuals, and ocean sunfish (*Mola mola*). Ocean sunfish sightings were recorded systematically during the April 2011 survey (and continued through the 2012 survey period). Ocean sunfish sightings are summarized in **Appendix A,** Table A-1. During the 2011-2012 surveys, 300 ocean sunfish were observed (**Appendix C,** Figure B-25). The highest number of individuals occurred in January 2012 (n=91) and April 2011 (n=68).

Vessels

Beginning with the April 2011 survey, vessel counts were recorded during systematic transect lines (and continued through the four winter 2012 surveys). A total of 244 vessels were counted and are summarized in **Appendix A**, Table A-13. Vessel types in descending order of frequency included non-Navy boats (84 percent), U.S. Navy boats (12 percent), helicopters (1 percent), U.S. Navy aircraft (1 percent), and submarines (1 percent) (**Appendix B**, Figure B-24). Based on the 11,384 km of associated systematic effort in 2011 and 2012, the overall number of vessel/aircraft SPUE was 0.02 vessels per km flown (**Appendix A**, Table A-14). The SPUE of Navy boats was 0.03 per km flown. No boats or aircraft were seen west of SCI (**Appendix B**, Figure B-24). In particular, high concentrations of vessels occurred off Silver Strand just outside San Diego Harbor and near Avalon, Santa Catalina Island (**Appendix B**, Figure B-24).

Behavioral Observations and Video/Photography Summary

A total of 300 focal group behavior sessions were conducted in 2008 through 2012 (**Appendix A,** Table 1). Fifty-three percent (n = 160) of these were 5 to 9 minutes (min) in length, with the remainder greater than 10 min long. One-hundred forty-six of the 300 focal sessions were videotaped. An estimated total of 2,072 min of useable video (see **Appendix A**, Table A-1 and Smultea and Bacon 2011) was obtained during the 15 surveys. Focal sessions involved the following 17 species: blue, fin, minke, gray, humpback, Bryde's, Cuvier's beaked, sperm, and killer whales; and Risso's, bottlenose, short-beaked common, long-beaked common, and northern right whale dolphins; California sea lion; and Dall's porpoise. Statistical analyses of 51 focal follows of Risso's dolphins are described under *Focal Behavior* / *Video Analysis* and **Appendix G**.

Selected first-observed behavior and group parameters were obtained for up to 1,649 of the total 2,151 sightings (see Methods and **Appendix D** for the list of parameters). These parameters were collected on 7 of the total 19 species seen. This included up to 78 gray whales, 122 fin whales, 65 blue whales, 295 Risso's dolphins, 103 bottlenose dolphins, 564 common dolphins (including long- and short-beaked), and 422 California sea lions. Results of statistical analyses of first-observed data for the seven most commonly seen species are presented in First Observed and Behavior Analysis sub-section and **Appendix F**.

A total of 18,935 photographs were taken in 2008 through 2012. Photographs were used to confirm species, as needed. Photographs of common dolphins were examined by a species expert (Dr. T.

A. Jefferson) to confirm species identification as short- vs. long-beaked common dolphins when possible.

Acoustic-Visual Behavior Study

The acoustic-visual behavior study conducted in winter 2012 was a pilot study designed to simultaneously collect both visual and acoustic data from focal groups of whales and dolphins being monitored from an aircraft circling overhead. Project goals included: (1) integration of hardware and software to allow simultaneous acoustic and visual data-collection and processing, and (2) real-time mapping of acoustic and visual data for marine mammals. Our ultimate goal was to attempt to provide information about behaviors of whales that can be detected acoustically, and to attempt to correlate these with surface and sub-surface behaviors (as monitored from the airplane in real-time and recorded on video and/or audio files). Sonobuoy deployments were also intended to provide important information on the general acoustic environment in the near vicinity of focal groups (e.g., anthropogenic noise, other marine mammal sounds, and natural noise).

The methods used in this component of the study involved integrating established visually based behavioral monitoring protocols (e.g., see Smultea and Lomac-MacNair 2010 and **Appendix D**) with PAM methods using sonobuoys. The integration was mostly implemented by modifying existing software programs that were already in use for aerial surveys (e.g., Mysticetus) or were developed for passive acoustic data acquisition and processing. See Smultea et al. (2012a) for detailed methods for the Acoustic-Visual Behavior Study.

Seven partial or whole flight days with sonobuoy effort occurred, for a total of 23.7 hours (hr) of flight effort (**Appendix D,** Table D-8). A total of 23 sonobuoys were deployed: 21 in the Direction-finding (DF) mode and 2 in the Calibrated omni-directional (CO) mode (**Appendix D,** Table D-9). The total 23 sonobuoys were deployed as follows: 1 during initial testing in the Santa Barbara Channel, 12 on fin whale focal groups (1 of which failed), 6 on gray whales (1 of which failed), 2 on a solitary humpback whale (but only fin whale sounds were detected), and 2 (both CO mode) on Risso's dolphins. One of the sonobuoy failures occurred because its flotation bag did not deploy (a common source of failure in other studies). Overall, the sonobuoy failure rate was approximately 9 percent (2 of 23 sonobuoys).

Because this was a pilot study, methods and protocols were refined and modified continuously throughout the effort. For example, since the existing software was not designed specifically to be used in this way, we had to modify it significantly for the project's requirements. The limited space and cargo capacity of our Partenavia observation aircraft made this effort even more challenging. For example, acoustic hardware had to be reduced into a much smaller package than typically used on ships. Also, the additional weight of the sonobuoys and acoustic processing hardware limited both the number of observers that could be carried and flight duration. Finally, the space constraints made videography (particularly in the first 3 days of effort) very difficult. Considerable effort was required to set up, integrate, and test hardware and software as well as establish and refine new protocols. In spite of these challenges, the team was able to collect both acoustic and visual data that provided a unique insight into the behaviors of marine mammals that could not be obtained using other methods. In addition, the team demonstrated that sonobuoys could be deployed from small boats, repositioned as needed and retrieved to eliminate any marine debris resulting from this effort. The data collected from this effort are directly relevant to goals of the U.S.. Navy's SOCAL Marine Species Monitoring Plan to describe baseline behavior and occurrence of marine mammals in the SOCAL Range Complex (DoN 2011c).

3.0 ANALYSIS AND INTEGRATION OF WINTER DENSITY AND ABUNDANCE ESTIMATES

This section summarizes the analysis and integration of systematic line-transect data collected from the aircraft during 15 aerial surveys conducted in the marine waters around SCI in 2008 through 2012. Density and abundance estimates are provided for both the warm-water (May-October) and cold-water seasons (November-April). We previously estimated density and abundance for the warm-water seasons of 2008 through 2011 in Jefferson et al. (2011) and for winter 2011 in Jefferson et al. (2012). The latter analyses were based on systematic line-transect effort lines plus the shorter, perpendicular connecting "connector" lines. Herein, we provide updated and refined estimates for the 2008 through 2012 warm-water and 2011 through 2012 cold-water seasons based only on systematic line-transect effort (i.e., we exclude the connector lines, due to concerns about introducing potential bias). Estimates are provided for the survey area subregions located west and east of SCI (i.e., San Nicolas Basin and Santa Catalina Basin, respectively). **Appendix E** provides a more detailed stand-alone report along with figures and tables.

METHODS

Field methods and equipment for collecting data suitable to estimate density and abundance followed standard line-transect protocol (see Methods under Overview above and **Appendix E**). Density and abundance estimates were made using standard line-transect methods (Buckland et al. 2001) and the software DISTANCE 6.0 under a conventional distance sampling (CDS) approach. Due to limited sample sizes for some species, sightings were pooled to provide four estimates of the detection function for baleen whales, large delphinids, small delphinids, and California sea lions. Estimates of density and abundance were made for species observed a minimum of eight times on effort.

RESULTS AND DISCUSSION

Totals of 15,406 km of observation effort and 863 marine mammal sightings during 2008 through 2012 were suitable for estimating density and abundance (on-effort sightings during systematic lines flown in Bf 4 or less). These sightings represented at least 19 species of marine mammals. For the warm-water season in 2008 through 2012, the estimated average number of individuals present (in descending order) were 9,894 short-beaked common dolphins, 3,847 long-beaked common dolphins, 1,613 Risso's dolphins, 781 California sea lions, 488 bottlenose dolphins, 317 fin whales, 248 Pacific white-sided dolphins, 41 blue whales, and 18 humpback whales (see Figures and Tables in **Appendix E**). During the cold-water season, the estimated averages were 13,547 short-beaked common dolphins, 5,268 long-beaked common dolphins, 2,093 California sea lions, 1,087 Risso's dolphins, 639 gray whales, 317 bottlenose dolphins, 246 fin whales, 53 Pacific white-sided dolphins, and 50 humpback whales. Blue whales were not observed during the cold-water season, and gray whales were not seen during the warm-water season. Several other species were observed for which sightings were too few to estimate numbers present and/or were seen only off effort: minke whale (n = 6 on-effort groups), northern elephant seal (n = 5), northern right whale dolphin (n = 5), Dall's porpoise (*n* = 3), Cuvier's beaked whale (*n* = 2), killer whale (*n* = 2), harbor seal (*n* = 1), Bryde's whale (n = 1), and sperm whale (n = 1).

Density and abundance estimates obtained during the 2008 through 2012 aerial surveys provide the most up-to-date and one of the largest marine mammal data bases collected within the concentrated area of the SOCAL Range Complex. Results also provide winter density and abundance estimates, when relatively few other surveys have been conducted in this region. Carretta et al. (2000) conducted line-transect aerial surveys for marine mammals near San Clemente Island on behalf of the U.S. Navy in 1998 and 1999 in an overlapping survey area during all months of the year (Figure 1). Their study and the finds in this report provide some of the only at-sea density and abundance estimates for California sea lions on the SOCAL Range Complex. See **Appendix E** for a detailed discussion and interpretation of abundance and density results.

4.0 FIRST-OBSERVED BEHAVIOR ANALYSIS

First-observed behavior analyses used similar parameters (e.g., group size, heading, maximum dispersal distance, and behavior state) as summarized in past individual reports for SOCAL Range Complex aerial surveys in 2008 through 2011 (e.g., see Smultea et al. 2009). Summary statistics for this analysis were previously reported for the combined 2008 through 2011 data in Smultea et al. (2011a in DoN 2011a). Seven species or species groups were deemed to have adequate sample sizes (n > 20) and were analyzed statistically using this approach: Risso's dolphin, common dolphin (combining short-beaked, long-beaked and unidentified common dolphins), bottlenose dolphin, fin whale, blue whale, gray whale, and California sea lion. Results of this analysis are presented in detail in **Appendix F**.

METHODS

Field data-collection equipment and methods were described briefly above under General Overview/Methods and in detail in **Appendix D**. Analyses focused on a subset of response variables consisting of: (1) group size, (2) maximum dispersal distance between nearest neighbors within a group, (3) heading, and (4) behavior state. Ten explanatory variables were evaluated to assess whether they influenced response variables: (1) subregion (east or west of SCI), (2) calf presence or absence, (3) presence or absence of other species, (4) season (warm or cold water), (5) water depth, (6) time of day (in minutes since sunrise), (7) Julian date, (8) slope (in degrees), (9) aspect (degrees), and (10) closest distance to shore (see Table A-12 in **Appendix A** and **Appendix F**). Water depth, slope, and distance from shore were determined using geo-spatial analysis capabilities of the software Mysticetus.

Statistical analyses were conducted by WEST, Inc., using the software program R (**Appendix F**). Statistics applied to the data included Pearson Correlation, Fisher's exact test, t-test, and regression modeling (**Appendix F**). Separate regression modeling was conducted for each of the response variables, and in each case, a different type of model was used for each response as appropriate.

RESULTS AND DISCUSSION

The following subsections provide a general descriptive summary and interpretation of notable results. See **Appendix F** for further details of results including graphs and tables.

Summary Statistics

In addition to statistical analyses, descriptive summary statistics were calculated for the seven species used in first-observed behavior analyses and are presented in **Appendix A,** Tables A-7, A-10, and A-11. Summary statistics were calculated for the following response variables: group size, maximum dispersal distance, and behavior state. For the first two continuous variables (group size and dispersal distance), summary statistics included sample size, minimum and maximum values, mean, median, standard deviation, standard error, and upper and lower 90 percent confidence intervals. For the categorical variable of behavior state, summary statistics included the frequency and percent of occurrence of each behavior state based on the first-observed such data collected when a sighting was made. Notable comparisons and trends are summarized below:

1. Mean group size was much larger for the common dolphin (277.1 individuals) than any of the other six species. The next largest mean group sizes were for the bottlenose dolphin (19.2) and Risso's dolphin (18.4). Mean group sizes for the remaining California sea lion (3.1) and three baleen whales were much smaller (gray whale, 2.2; fin whale, 1.7; and blue whale, 1.6).
2. Among baleen whales, mean maximum dispersal distance between nearest neighbors was closest for gray whales (1.5 BL), over three times farther for fin whales (5.1 BL), and over eight times farther for blues whales (12.6 BL).
3. Mean maximum dispersal distances for the three delphinids and the California sea lion were similar: Risso's dolphin (6.7 BL), bottlenose dolphin (4.9 BL), common dolphin (5.1 BL), and California sea lion (4.2 BL).
4. Percent frequency of occurrence (i.e., "activity budget") differed notably across species based on the three behavior states analyzed. Risso's dolphins exhibited the highest proportion of slow travel/rest (38 percent of 290 sightings) followed by both the California sea lion and fin whale (27 percent of 273 and 115 sightings, respectively). In contrast, the gray whale (*n*=77 groups) and common dolphin (*n*=555 groups) were very infrequently observed slow traveling/resting (1 percent and 3 percent, respectively).
5. Mill behavior was most common among gray whales (47 percent of 77 groups), common dolphins (38 percent of 555 sightings) and California sea lions (39 percent of 273 sightings). Mill was observed only 7 to 15 percent of the time among fin whales (n=115 groups) and Risso's and bottlenose dolphins (*n*=290 and *n*=96 groups, respectively).
6. Overall, medium-fast travel was the most frequently observed behavior state for all seven species ranging from 66 percent of 115 fin whale groups to as low as 34 percent of 273 Risso's dolphin groups.

Results of more detailed statistical analyses summarized below by species indicated that group size, maximum dispersal distance, and behavior states were significantly associated with a number of explanatory variables.

Risso's Dolphin

1. The best predictors of behavior state for Risso's dolphin were time of year and distance from shore (**Appendix F**, Table F-3). Milling increased across the year (relative to fast-medium travel) while slow travel decreased across the year (again relative to fast-medium travel). Thus, as the seasons progressed across the calendar year, Risso's dolphins were

more likely to mill than to slow travel. In addition, milling and to a lesser extent, slow travel/rest, increased with increasing distance from shore (by a factor of 1.4 for every 10 km from shore for mill vs. a 0.8 factor increase for slow travel/rest) (**Appendix F**, Table F-4).

2. With respect to time of day, medium-fast travel significantly decreased while mill and slow travel increased across the day. For each hour (60 min) after sunrise, Risso's dolphins were 0.93 times more likely to mill and 0.89 times more likely to slow travel/rest (both relative to medium-fast travel). This behavioral pattern may be related to the apparent nocturnal foraging habits of Risso's dolphins (Soldevilla 2011). Results herein, including focal video analyses, indicate that Risso's dolphins predominantly slow travel/ rest and socialize during the daytime. Similar to spinner dolphins (Norris and Dohl 1980), Risso's may rest and socialize during the daytime and become more active while foraging at night, presumably on squid based on limited stomach-content studies (Norris and Dohl 1980, Würsig and Würsig 2010).

3. The best predictors of group size among Risso's dolphins were calf presence, the presence of other accompanying species, and time of year based on results of the AIC values in regression modeling:

    a. Group size of Risso's dolphins was significantly higher when at least one calf was present (25 dolphins) vs. no calf (15 dolphins) (**Appendix F**). For reasons similar to bottlenose dolphins (see above), larger groups likely decrease predation risk to calves.

    b. Similarly, Risso's group size was significantly higher when another species was present (25 Risso's dolphins) vs. absent (15 Risso's dolphins) (**Appendix I**).

    c. Group size increased significantly across the year from 12 dolphins in February to 23 dolphins in November (**Appendix I**). This may be related to reproduction or changes in prey distribution or habits.

4. The best predictors of maximum dispersal distance were time of year, time of day, and to a lesser extent water depth based on results of regression modeling as follows (**Appendix F**, Figure F-2).

    a. Maximum dispersal distance increased significantly (1) with increasing water depth (from 2.3 BL over depth 100 m to 5.7 BL over water depth 2000 m), and (2) across the year (from 2.4 BL in February to 6.0 BL in November).

    b. In contrast, maximum dispersal distance decreased with time of day (from 6.5 BL in early morning to 2.1 BL in late afternoon).

In summary, behavioral and social characteristics of Risso's dolphins appeared to be significantly influenced in the study area by time of year, time of day, calf presence, the presence of other marine mammal species, and water depth. In addition, RSF analyses show preferential use of certain habitats and features on the range, primarily steep underwater drop offs near SCI (see

Appendix I). Similarly, Kruse (1989) found that Risso's dolphins in Monterey Bay were strongly associated with deep, steep bathymetry. Photo-identification studies in the Azores indicated strong site fidelity and differential habitat use by mothers with calves, adult males, and adult females (Hartman et al. 2008). Further detailed analyses of focal-follow video particularly groups with juveniles and calves may reveal similar patterns.

Common Dolphin

1. Behavior state was significantly related to season and subregion (**Appendix F**, Tables F-14 and F-15). Milling was 1.9 times more likely to occur during the warm-water vs. the cold-water season (compared to medium/fast travel [fm travel]) (**Appendix F**, Table F-16). Milling among common dolphins appears to be related to foraging/feeding, and was frequently associated with "zig zag" and tight circling behavior resembling feeding behavior reported for bottlenose dolphins (Leatherwood 1975, Miller 2003, Maresh et al. 2004). Milling also included pairs or trios of common dolphins sprinting in coordinated fashion for tens of meters, then abruptly turning and slowing down, repeating this sequence intermittently (as documented with video). The latter observations occurred simultaneous with unusually high reported densities of sardines in the study area.

2. Slow travel was 4.1 times more likely to occur west vs. east of SCI (**Appendix F**, Table F-16). Similar to RSF analyses (see *Resource Selection Function Analyses* below and **Appendix I**), behavior patterns among a number of marine mammal species appear to differ significantly between the waters west and east of SCI.

3. Group size was significantly related to calf presence, slope aspect, and time of year (**Appendix F**, Table F-18).

    a. Groups with one or more calves had over twice as many individuals (485) as groups without a calf (205) (**Appendix F**, Figure F-3). Given that this same pattern was found for bottlenose and Risso's dolphins and is consistent with behavioral ecology theory on benefits of social group living (e.g., Davies et al. 2012), increased group size likely benefits calf survival. Availability of resources and predation pressure has been linked to group size pattern among both bottlenose dolphins (Wells et al. 1980, Weller 1991) and spinner dolphins (Norris and Dohl 1980).

    b. Group size decreased significantly across the calendar year from 245 individuals to 170 (**Appendix F**, Figure F-3). This could be related to decreased socializing/ orienting towards one another relative to reproduction or changes in prey abundance or characteristics. Group size has been shown in many species to be associated with prey availability, i.e., greater prey abundance supports larger group sizes, though predation often plays a role as well (Davies et al. 2012). Predicted group size was highest for north-facing slopes and lowest for south-facing slopes (**Appendix F**, Figure 3). This could be related to greater upwelling on north-facing slopes associated with the predominant southern currents in the region, potentially supporting higher prey densities in return supporting larger dolphin groups.

   c. Further analyses and background literature searches are needed to interpret the relationships between group size patterns and the above variables.

4. Maximum dispersal distance between individuals increased significantly with calf presence from 3.4 to 5.1 BL (**Appendix F,** Figure F-4). The meaning of this pattern is unclear. When we observed common dolphins with calves, there were typically multiple calves in what appeared to be segregated mother-calf subgroups. An in-depth literature search on this topic may reveal possible hypotheses for this significant correlation.
5. Maximum dispersal significantly decreased across the day from 4.8 BL in early morning to 2.8 BL near dusk. This could indicate increased socializing near dusk. Huddling behavior and close inter-individual spacing is commonly associated with socializing delphinids (e.g., Norris and Dohl 1980, Würsig and Würsig 2010).
6. As depth increases, heading of common dolphin groups was significantly more likely to be NE than NW, SE, or southwest (SW). For example, for each 100 m increase in depth, the odds of heading NW decrease by a factor of 0.90. Interpretation of this pattern is unclear without further analyses of detailed topography and other factors in the study area.

In summary, common dolphin social and behavioral characteristics were significantly associated with calf presence, subregion, time of year, slope aspect, time of day, and water depth. The effects of these explanatory variables on behavior must be considered when evaluating potential effects (or lack thereof) of U.S. Navy activities on this species, particularly differences east and west of SCI given the expected higher level of Navy MFAS training activities west of SCI.

Bottlenose Dolphin

1. Behavior state was significantly related to water depth, slope aspect, and time of year.

   a. Slow travel increased with deeper water depths (by a factor of 1.3 for every 100 m increase in depth).

   b. Milling behavior increased across the season (by a factor of 3 for every 100 Julian days in the calendar year).

   c. Milling behavior also increased progressively as slope aspect changed from approximately southeast (SE) to west-northwest (WNW). At WNW-facing aspects, common dolphins were 100 times more likely to mill than over SE-facing slopes (**Appendix F**, Figure F-5 and Table F-28). The odds of slow travel increased progressively as aspect changed from approximately south-southeast to NW by a factor of 12 at the maximum. When combined, these results indicate that common dolphins were most likely to mill and slow travel over slope aspects of WNW to NW.

2. Observed increases in milling behavior as the year progresses and towards WNW facing aspects could be associated with increased socializing and/or feeding near the surface as reported for bottlenose dolphins elsewhere (Leatherwood 1975, Miller 2003, Maresh et al. 2004).
3. Group heading was significantly related to distance from shore. In particular, dolphins were most likely to be heading SW nearshore: with each 10 km increase in distance from shore, the odds of heading SW decreased by a factor of 0.3 (**Appendix F**, Table F-37).
4. Group size was significantly associated with the presence or absence of a calf (**Appendix F**, Table F-31). Groups with one or more calves had over twice as many individuals (38.9) as groups without a calf (17.1) (**Appendix F**, Figure F-6). Larger group sizes may provide increased protection for young through increased vigilance and dilution effects among other benefits of group living (Shane et al. 1986, Fertl 1994, Mann et al. 2000, Campbell et al. 2002). Bottlenose dolphins may also form nursery groups involving social-sexual segregation as reported elsewhere for the species (e.g., Connor et al. 2000, Lusseau and Newman 2004, Gowans et al. 2007, Gibson and Mann 2008). Further examination of photographs and video from bottlenose dolphin sightings relative to geographic and other parameters may shed light on this.
5. Maximum dispersal of bottlenose dolphins:
    a. Decreased significantly across the day from 4.9 BL in the morning to 2.9 BL in the late afternoon
    b. Significantly increased across the year from 2.2 BL in February to 5.8 BL in October (**Appendix F**, Figure F-7)
    c. Significantly increased with increasing distance from shore, though this effect was small (3.3 BL near 300 m from shore vs. 3.0 BL near 8 km from shore) (**Appendix F**, Figure F-7).

In summary, bottlenose dolphin social and behavioral characteristics were related to calf presence, time of year, time of day, water depth, and aspect. Results of RSF analyses indicate that this species selectively uses certain areas within the study area (see **Appendix I**). Further integration of behavioral and RSF analyses is expected to lead to refined identification of habitat-use patterns.

Blue Whale

1. Group size was associated with time of year, increasing from 1.0 whale in spring to 3.5 whales in fall (**Appendix F**).
2. During late summer and fall, aggregations of feeding blue whales were frequently observed approximately 10 km west of San Diego near the edge of a drop off associated with the shelf edge (**Appendix B**). The increase in group size in fall is believed to be

related to increased concentrations of prey leading to concentrations of feeding blue whales.

3. Preliminary analyses of video from blue whale focal follows documented intra- and inter-specific (with fin whales) competition for krill patches. Further detailed analyses of video may elucidate the nature of these and other social interactions.

4. Mean dispersal distance for blue whales was much farther than for the other baleen species (see *Summary Statistics* above). This suggests that loose blue whale groups may form as an artifact of prey distribution rather than solely for social purposes.

5. No other strong correlations were found between blue whale behaviors and the explanatory variables examined.

In summary, blue whale behavioral patterns were seasonal and concentrated primarily close to shore in the study area. Results indicate that group size more than tripled in fall compared to spring, likely in association with feeding aggregations of blue whales.

Fin Whale

1. Behavior state was significantly related to time of year and distance from shore (**Appendix F**, Tables F-51 and F-52). Milling was most likely to occur close to shore: for each 10 km increase in distance, the odds of milling decreased by a factor of 0.2. Fin whales were 0.8 times more likely to slow travel early vs. late in the year. Among fin whales, milling and slow travel appeared to be associated with social interactions and feeding based on preliminary focal follow data and video. During both behaviors, but particularly during social interactions, individuals frequently oriented towards and away from one another. Detailed analyses of focal-follow data would allow quantification of social vs. feeding behavior relative to milling and touching, etc.

2. Calf presence and time of day were the best predictors of group size for fin whales (**Appendix F**). Group size was larger when a calf was present (3.2 vs. 1.6 whales) and decreased across the day from 2.4 whales in the morning to 1.4 in the late afternoon (**Appendix F**, Figure F-10).

3. The best predictors of maximum dispersal distance were calf presence and subregion, though calf presence was not significant. Maximum dispersal distance tended to be smaller when a calf was present (1.0 vs. 2.5 BL), and was smaller east of SCI (2.5 BL) vs. west of SCI (4.7 BL) (**Appendix F**). Results indicate that mother-calf pairs tended to be accompanied by at least one other non-calf whale and that fin whales in general tended to be social. Maximum observed group size was seven fin whales and groups of three to five fin whales were not uncommon.

4. A strong trend for decreased group size across the day suggests that socializing with other whales is more likely to occur in the mornings than the afternoons.

5. Preliminary analysis of videos and focal follow data demonstrate that fin whales in the SCB appear to interact socially. This has involved non-calf whales touching, and rolling over, onto and near one another in what appears to be courtship behavior similar to that observed among humpback whales (M. Smultea, pers. obs.). This behavior has also been accompanied by apparent intra-specific aggression, including chasing and displacement among groups of three or more fin whales that may be males competing for a female(s). Nursing by fin whales has also been video-recorded as has inter- and intra-specific competition for prey.
6. A strong trend for fin whales to be spaced farther apart within groups west vs. east of SCI and for groups with a calf to have tighter dispersal may indicate differential use of subregions. Correlation of social interactions based on further detailed video analyses may elucidate the nature of these interactions. Notably, RSF analyses indicate that waters west of SCI are selectively preferred by fin whales for certain behaviors (see **Appendix I**).

In summary, available data suggest that the SOCAL Range Complex provides courting/reproductive, foraging, and nursing habitat for fin whales and that differential use of habitat is related to region, time of day, age, and possibly reproductive class.

Gray Whale

1. Gray whale behavior state was almost exclusively travel (either slow or fm travel): only one of the total 77 behavior states was mill (**Appendix D**, Table D-4). This is not unexpected given that gray whales are migrating to and from southern Mexico breeding/calving grounds and more northern feeding grounds during the winter off southern California, with little or no foraging occurring (Rice et al. 1984, Moore et al. 2003).
2. For gray whales, the best predictor of group size was subregion (nearly significant at the 0.05 percent level based on confidence intervals), and to a lesser extent slope aspect (see **Appendix I**, *Gray* Whale and **Appendix F,** Table F-66). Group size tended to be larger west vs. east of SCI (2.7 vs. 1.7 whales, respectively) (**Appendix F,** Figure F-13). Predicted group size as a function of aspect showed that highest group size was predicted for east-northeast-facing slope aspects (**Appendix F**, Figure F-13). Correspondingly, lowest predicted group size occurred for slopes facing west-southwest. The offshore migration characteristics of gray whales are poorly understood. Larger offshore group sizes may form in response to increased predation pressure, as increased group size has been shown to decrease the risk of predation for many species (e.g., Davies et al. 2012). Predation pressure on migrating gray whales is known to be relatively high, particularly in offshore waters.
3. The best predictor of maximum dispersal distance was also subregion. Maximum dispersal tended to be greater west than east of SCI (1.4 BL vs. 0.7 BL, respectively) (**Appendix F**, Tables 69 and 70 and Figure F-14).
4. Dispersal distance tended to decrease slightly across the winter sighting season from 0.8 BL in February to 0.5 BL in April.

5. Unlike fin whales, gray whales inhabit the study area only during the winter and spring migrations. Larger group sizes and greater dispersal distances west of SCI may be indicative of differential habitat use by gray whales during migration. Predation pressure may be greater west of SCI, favoring larger group sizes for predator avoidance. These differences by region may also be related to age and sex class. Sumich and Show (2011) found that large (>11.5 m) gray whales were more likely to occur in offshore migration corridors near SCI than smaller, presumably younger gray whales.
6. Results indicate that mill behavior is uncommon among migrating gray whales (see *Summary Statistics* above). Preliminary analyses of focal follow data indicate that milling individuals orient towards one another, often swim closely together, and touch, including nursing mothers with calves.
7. The observed decrease in dispersal distance across the winter is likely related to the increasing presence of north-migrating cows with calves following the calving period off Mexico, that tend to swim close together.
8. Aspect was strongly related to behavior state. Slow travel was 5 times more likely to occur over south-facing vs. north-facing slope aspects (compared to fm travel). Thus, inversely, medium-fast travel was most likely to occur over north-facing slopes. Gray whales may use north-facing slopes as migration orientation or pathway cues in the SCB during their northward and southward seasonal migrations. Further interpretation of this relationship requires further analyses and literature review.
9. The odds of gray whales heading SE decreased significantly by a factor of 0.9 for as the winter progresses (**Appendix F**, Table F-73). This is consistent with the ration of south-migrating gray whales to diminish and northbound gray whales to increase across the winter after returning from Mexican breeding/calving grounds.

In summary, data indicate that social and behavioral parameters among gray whales are influenced by region, season, and aspect. Behavioral characteristics are significantly different east and west of SCI. Similarly, results of RSF analyses indicate that offshore areas near SCI provide relatively high-use habitat for gray whales calves (**Appendix I**). Mothers with calves were also observed west of SCI (**Appendix B**).

California Sea Lion

1. One of the strongest predictive models for California sea lions was the influence of subregion on maximum dispersal distance and also behavior state.
    a. Maximum dispersal distance was significantly larger between individuals west (3.3 BL) vs. east of SCI (1.6 BL) (**Appendix F**, Figure F-16). RSF analyses indicate that behavior patterns of this species are influenced by a number of environmental parameters that predict preferred high-probability use areas in the San Nicolas

Basin (SNB) and near SCI (**Appendix I**). Dispersal distance may be related to behavior state.

b. Milling was 2.4 times more likely to occur west of SCI in the SNB than east of SCI (**Appendix F**, Table F-76). Furthermore, frequency of slow travel decreased across the year at a rate of 0.6 with each 100 Julian days. Milling and slow travel are likely associated with social and foraging behaviors. Since this species has highest densities west of SCI, these results are not unexpected. Fm travel is likely more frequent E of SCI where individuals may be transiting along the coastline or between islands and/or haul-outs and rookeries.

2. Group size of California sea lions was significantly larger (7.2 individuals) when other marine mammal species were associated with them vs. when not (2.8 individuals) (**Appendix F**, Figure F-15). California sea lions likely associate with other species to forage on similar prey. Inter-specific associations likely improve prey detection abilities (Barlow et al. 2009).

In summary, California sea lion group behavioral characteristics were found to be significantly related to a number of explanatory variables. These effects must be considered when evaluating potential effects of U.S. Navy activities.

5.0 FOCAL BEHAVIOR / VIDEO ANALYSIS: RISSO'S DOLPHIN

From 2008 through 2012, focal behavioral observations (Altmann 1974, Mann 1999) were conducted on 17 marine mammal species (see *Behavioral Observations and Video/Photography Summary*). These data consisted of periods of at least 5 min when a selected focal group was circled by the aircraft at altitudes of approximately 365 to 457 m (1,200-1,500 ft) and radial distances of approximately 0.5 to 1.0 km. This section is limited to a summary of results and analyses of selected quantified focal behavioral data for Risso's dolphin groups from 2008 through 2012. **Appendix G** discusses methods and results in more detail. Risso's dolphins were selected as a focal species due to (1) a relatively robust sample size (n=51 groups, including accompanying video); (2) their tendency to remain at or near the surface for extended periods compared to other species, thereby allowing longer observation periods; (3) their light body coloration facilitating tracking, including below the water surface to depths of approximately 10 to over 15 m; and (4) their identification as a priority species in the U.S. Navy's SOCAL Monitoring Plan and the Southern California Behavioral Response Study (BRS) (Southall et al. 2012).

Detailed analyses of the behavior from other focal species will be considered for future analyses by the U.S. Navy if additional funding becomes available. In particular, analyses of small groups of baleen whales provides data on respiration rates, and dive and surface durations of individuals that are not possible with large groups of dolphins, including the Risso's dolphin. Note that other behavioral parameters from Risso's dolphin focal groups (and other species) can be analyzed in the future, including group dive and surface durations, frequency of surface-active (e.g., breach) behaviors, associations between individuals, etc. A case study of a videotaped group of focal Risso's dolphins is provided in **Appendix H** and illustrates the detailed behavioral information that can be obtained by other detailed analyses of focal follows. However, limited resources necessitated selecting a limited number of specific parameters to analyze in this report. These parameters are meant to provide a baseline to compare with behavior during periods of exposure to U.S. Navy noise-generating activities in the future.

METHODS

Field methods applicable to focal behavior sampling are briefly described herein, but are provided in further detail in **Appendix D**. High-definition (HD) video was taken (as feasible) of focal Risso's dolphin groups using a Canon EOS 7D (2008 through 2010) or Sony HD HDR-XR550 and HXR-NX5U NXCAM (2010 through 2012) video camera to document animal behavior. Observer commentary was simultaneously recorded on the video camera's audio channel during focal follows. In addition, observer commentary was recorded using a Sony digital voice recorder connected to the aircraft's audio input or with a mini-microphone taped into an observer's headphone or a spare headphone (thus, audio was recorded when the video was both off and on). Behavioral data were recorded with a Palm Pilot TX (dimensions approximately 7 by 12 cm) (2008), Apple iTouch (2009), iPhone (2009 through 2010) or laptop computer (2010 through 2012) in a customized datasheet using BioSpectator (2008 through 2009), Microsoft Excel (2010 through 2011), or Mysticetus (2011 through 2012) software. Software and hardware efficiency has been improved with new evolving technology over the 5-year period.

Post-field analysis involved transcribing behavioral data from video onto a custom Excel spreadsheet. These data were then merged with behavioral data systematically collected in the field. In addition, digital voice recordings were used to fill in data gaps as needed, such as periods when the video was not focused on the group, or the airplane wing or glare obscured the video's view. Thus, it was important to have observations/commentary from a focal observer with a wide perspective combined with video taken by a dedicated videographer.

Data entered onto the focal behavior spreadsheet included the following variables: date, time, group identification number, species, group size, number of calves, behavior state, orientation/heading (in degrees magnetic), minimum and maximum dispersal distance between nearest neighbors (estimated from video and/or in the field based on average adult BL), Bf, declination angle to sighting (to estimate distance to the focal group), the presence of any vessels (**Appendix A**, Table A-14) or other potential disturbance (e.g., helicopters) within approximately 1 km (within view for large U.S. Navy vessels), and comments/notes (see **Appendix D** for definitions and ethogram). Behavior state, heading, and dispersal distance were recorded approximately every minute in the field based on scan sampling methodology (Altmann 1974). During post-field video/audio transcription, the latter parameters were noted for every 30-second (sec) period that Risso's dolphins were in view, based on the most recent data collected within each 30-sec period prior, starting on the minute (e.g., for the period 13:00:00-13:00:30, then 13:00:30-13:01:00, etc.).

STATISTICAL ANALYSES

Data processing and analyses were conducted using the MATLAB software program by WEST, Inc. Analyses focused on a subset of three response variables consisting of: (1) heading (*hdg*) (in degrees magnetic), (2) maximum dispersal distance (*maxdsp*) between nearest neighbors within a group, and (3) behavior state (see ethogram in **Appendix D**, Table F-4 and **Appendix G**). Seven explanatory variables were evaluated to assess whether they influenced the aforementioned response variables. These consisted of (1) presence or absence of at least one calf (*calf*), (2) presence or absence of other marine mammal species within the Risso's dolphin group (*othergrp*), (3) presence or absence of boat(s) within 1 km (*boat*), (4) *season* (warm or cold water), (5) time of day category (morning [8:00-12:00], early afternoon [12:01-16:00], and late afternoon [16:01-dusk]) (*timecat*), (6) calendar month of the year (*month*), and (7) time (minutes) since sunrise (*tfsun*) (**Appendix G**). The first four variables were binary (1 or 0), two (*timecat and month*) were categorical, and the last one (*tfsun*) was continuous, derived from field data (**Appendix A**, Table A-12). For the binary variables *calf*, *othergrp*, and *boat*, if a calf (or another species, or a nearby boat) was observed at least once during a focal-follow session, then the variable was assigned a value of 1, indicating presence (vs. 0 for absence). Month was intended as a more detailed alternative to season. Most observations occurred in February through April, so each of these months was retained as a category. The remaining cold-water months (November - January) and warm-water months (June - October) were collapsed into separate categories. Time from sunrise, *tfsun*, used local sunrise tables and was calculated as the fraction of a day that elapsed between sunrise and the first observation of a focal-follow session.

Three separate statistical analyses were undertaken using the Risso's focal group data:

1. Reorientation rate (*rrate*) was derived from heading, and defined as change in heading (degrees) per minute, following the approach described in Bowles et al. (1994), Smultea and Würsig (1995), and Gailey et al. (2007). Observations for each focal follow were sorted by observation time. Observation times were converted to "scan times" by rounding to the next 30-sec interval (e.g., observation times of 11:15:11 and 11:15:41 were assigned scan times of 11:15:30 and 11:16:00, respectively). Standard multiple-linear-regression models were used to examine the relationship between heading and candidate explanatory variables. A stepwise procedure based on Akaike Information Criterion (AIC) was used to evaluate candidate models and automatically select the model with the lowest AIC (Burnham and Anderson 2002). To avoid problems from strong associations among explanatory variables, several alternate stepwise runs were conducted with different initial sets of variables.
2. Splitting-joining was a response variable derived from maximum dispersal distance to assess whether the splitting and joining of subgroups was influenced by selected explanatory variables. It was defined based on observed variability in maximum dispersal distances, in particular, the standard deviation in maximum dispersal (after examining the distribution of raw maximum dispersal distance data for patterns). Multiple linear regression was conducted (like for *reorientation rate*), with log-transformed standard deviation of maximum dispersal as the response. In addition, standard deviation of maximum dispersal was transformed into a binomial response variable (low and high standard deviation) and analyzed using logistic regression. Candidate explanatory variables were re-examined for evidence of association since the analysis dataset was not identical to the reorientation rate dataset. Models were selected via a stepwise AIC-based procedure as described above for reorientation rate.
3. Sequential analysis was conducted to assess the likelihood of a behavior state changing (i.e., a transition) during a focal follow. Behavior states were categorized as either 'fm' (medium-fast travel), 'mill' (milling with no consistent group heading), or 'slow' (slow travel/rest) (see ethogram **Appendix D,** Table D-4):
    a. Transitions between behavior states in each successive pair of observations were identified for each focal follow. A given observation at time *t*-1 would have behavior categorized as either 'fm', 'mill', or 'slow'. The subsequent observation at time *t* would have behavior in any one of the same three categories. Thus, there were nine possible behavior transitions: (1) fm – fm, (2) fm – mill, (3) fm – slow, (4) mill – fm, (5) mill – mill, (6) mill – slow, (7) slow – fm, (8) slow – mill, and (9) slow

– slow. If there were *n* observations for a focal follow session, then there were *n* – 1 transitions for that session.

b. Explanatory variables differed somewhat from the variables used in the other two analyses (**Appendix G**). Time category had three possible values: 'am', 'early pm', and 'late pm'. Therefore, two indicator variables (*timecat1* and *timecat2*) were used to represent time, with 'late pm' serving as the reference category.

c. Multinomial logistic regression was used to model the relationship between the response (behavioral transitions) and the covariates. The slow – slow transition served as the reference category; coefficients were estimated for the remaining eight categories. AIC corrected for small sample size was calculated for each model.

Based on results of the regression modeling and AIC values, the "importance value" for each explanatory variable was calculated for the three analyses described above. The importance value was defined as the sum of the Akaike weights for each model in which that variable appeared. Thus, if a variable appeared in all 10 models, its importance value would equal 1; otherwise, the importance value was bounded between 0 and 1.

Further details of the statistical analyses performed for the three analysis parameters are described in **Appendix G**.

RESULTS AND DISCUSSION

There were 51 Risso's dolphin groups recorded during focal-follow sessions ranging in duration from 5 to 59 min (mean duration 21.6, standard deviation [SD] = 12.9). The number of 30-sec scan periods with relevant data (e.g., reorientation rate, maximum dispersal distance, or behavior state) for all focal follows combined totaled 1,446 useable data points for reorientation rate, 1,275 data points for maximum dispersal, and 1,359 data points for behavior state. Statistical results of these three focal-follow parameters are summarized separately below, with detailed results including graphs and tables presented in **Appendix G**.

Reorientation Rate

1. The only explanatory variables that appeared to influence reorientation rate was the presence of other marine mammal species (*othergrp*) with the Risso's dolphins, although this relationship was not statistically significant. The 90 percent confidence interval for the coefficient of *othergrp* was (-0.34, 11.38). As this confidence interval includes zero, there is not adequate evidence in the data to conclude that reorientation rate was related to *othergrp*. However, a positive coefficient indicates that when other species are present, the average reorientation rate is higher than when other species are absent (**Appendix G**).

2. This trend suggests that Risso's dolphins may be changing their headings more often when other species are intermixed with them, possibly to socially interact with (i.e., orient towards) other species and/or conversely, to move away from them.
3. Inter-specific associations are often associated with prey aggregations (e.g., Shane et al. 1986, Acevedo-Gutiérrez 1991 Vaughn et al. 2007), within which species may compete for food or space. Our preliminary interpretation of videos of Risso's dolphins with bottlenose dolphins suggests that the bottlenose dolphins are following the Risso's dolphins and have been seen swimming between subgroups of Risso's dolphins; the bottlenose dolphins appeared to be "separating" the Risso's dolphins.

Splitting/Joining

1. None of the explanatory variables were found to influence splitting-joining of focal Risso's dolphin groups. This was likely related to the high variation in rates of splitting and joining relative to the explanatory variables examined. Thus, none of the explanatory variables were found to improve model fit.

Behavior State

1. Risso's focal groups spent most of their time slow traveling/resting (60 percent of 1,359 records), followed by medium-fast travel (33 percent); milling behavior was rare (7 percent) (**Appendix G**, Table G-3).
    a. The 61 percent is nearly twice as frequent as indicated for first-observed behavior analyses (32 percent of 290 Risso's sightings were slow/travel rest). (Note that only the first behavior state was recorded for each of the latter sightings vs. focal follows where behavior state was noted every 30 sec for the same group). The difference could be related to differences in subregions where focal data were collected: RSF results showed that Risso's dolphins tended to use different areas/habitat types for slow travel/rest vs. medium/fast travel (see **Appendix I**). Analyzing locations and other environmental parameters associated with Risso's focal follows would shed light on this difference. This difference also could be related to a much shorter observation period (~0.5 to 3 min) for first-observed data vs. focal data (5 to 60 min).
    b. Predominant slow travel/rest by focal Risso's dolphins (61 percent) strongly contrasted common dolphins which rarely slow traveled-rested (3 percent of 555 first-observed groups) (**Appendix A**, Table A-16 and *First Observed Behavior Analysis – Common Dolphin*). Also in contrast, common dolphins frequently milled (38 percent) while Risso's dolphins did not (14 percent). We believe this is related primarily to reported differences in predominant prey, and apparent diurnal (commons) vs. nocturnal (Risso's dolphin) foraging habits in the SCB (Pusineri et al. 2007, Soldevilla et al. 2011).

c. The Risso's dolphin behavior pattern is consistent with other nocturnal-feeding delphinids. They typically rest and socialize during daytime and actively feed at night when prey move closer to the water surface in the deep scattering layer (e.g., squid) (Norris and Dohl 1980, Würsig and Würsig 2010).

2. Risso's dolphins rarely changed behavior state during focal follows. Results clearly showed that any particular behavior observed at time t-1 was most likely to be followed by the same behavior at time t. Although all possible transitions did occur, transitions from one behavior state to another were infrequent. This again could be related to location, since RSF analyses showed that behavior differed by region and other parameters (see above and **Appendix I**).

3. When calves were present, Risso's dolphins were 4.28 times more likely to continue fm travel than were groups with no calves (based on odds ratio results from estimated regression coefficients [**Appendix G**, Table G-6]). The reason for this pattern is unknown, but may be related to predation pressure, location, or other parameters. More detailed analyses focused on calf groups may reveal reasons for this difference. Identifying specific habitat needs of calf groups is important for conservative management of this species because calf survival is integral to sustained populations.

4. Similarly, calf groups were more likely to transition from fm-mill and mill-fm than non-calf groups (relative to slow-slow transitions). This suggests that socializing and possibly foraging may occur more frequently among calf groups (milling is associated with animals orienting towards one another, touching, and/or sudden apparent foraging sprints based on our unquantified observations). Detailed video analyses focusing on this behavior would help explain this pattern.

5. During mornings, fm-fm transitions were less likely than later in the day (**Appendix G**, Table G-6). Conversely, in the early afternoon, Risso's dolphin groups were 6 times more likely to continue fm travel than compared to early morning and late afternoon. This suggests that later in the day, traveling Risso's dolphins tend to keep traveling. We hypothesize that as dusk approaches they are transiting to nocturnal foraging areas, transitioning from earlier social and rest activity. Similarly, spinner dolphins (Norris and Dohl 1980) and dusky dolphins (Würsig and Würsig 1980, 2010) rest and socialize during the day with activity level increasing near dusk after which they feed in pelagic waters.

In summary, the behavior of Risso's dolphins was significantly related to calf presence and time of day. Their predominant slow travel/rest behavior contrasts that of the other delphinid species observed. This difference is likely related to their presumed nocturnal foraging habits. A significant tendency to slow travel-rest indicates that Risso's dolphins are a good candidate focal species to study relative to potential effects of Navy MFAS. If Risso's dolphins were to react to such activity, a change in behavior state to medium-fast travel away from the disturbance would be expected. This behavior state transition has frequently been reported among other delphinids as a significant change in response to anthropogenic disturbance, including vessels (Constantine et al. 2003, 2004) and human swimmers (Orams 1997, Constantine 2001, Forest 2001). A more detailed examination of video and field data, including other response (e.g., dive and surface duration) and explanatory variables, may reveal other significant baseline patterns that may be sensitive indices of disturbance.

6.0 MARINE MAMMAL DISTRIBUTION, OCCURRENCE, AND RELATIVE ABUNDANCE ANALYSIS: RESOURCE SELECTION FUNCTION

This section addresses the distribution, occurrence, and relative abundance of marine mammals in the study area using the 2008 through 2012 aerial monitoring survey data. These topics were addressed using the following three approaches:

1. Distribution and occurrence data were analyzed by applying RSF analyses (Manly et al. 1993, 2002).
2. Relative abundance was addressed by conducting a comparative analysis of changes in the relative frequency of occurrence of marine mammal species in the SCB. Results of the 2008 through 2012 aerial marine mammal monitoring data were compared with available historical data.
3. Relative abundance was also addressed by conducting density and abundance analyses using line-transect data and DISTANCE analyses (summarized previously in Section Analysis and Integration of Winter Density and Abundance Estimates and **Appendix E**).

RSF analyses are described below. The comparative analysis mentioned in (2) above is presented in **Appendix J**.

INTRODUCTION

The goal of the RSF was to identify areas commonly used by and presumably important to marine mammal species in the SOCAL Range Complex. The basic premise of resource selection modeling (Manly et al. 2002) is that resources (which may be food items, land cover types, or any quantifiable habitat characteristic) that are important to individuals will be "used" disproportionately to the availability of those resources in the environment (i.e., certain resources or habitats/attributes will be selectively "preferred"). Habitat modeling, including predictive modeling, has been conducted based on line-transect density and abundance of marine mammals in the SCB (e.g., Forney 2000, Becker et al. 2010) and elsewhere (i.e., the eastern tropical Pacific [e.g., Ferguson 2005, Ferguson et al. 2006 Barlow et al. 2009]). RSF differs from the latter approach as it accounts for the spatial availability of all habitats within a study area, not just areas where marine mammals occur. RSF thus facilitates estimating the probability of habitat occurrence relative to actual use by species.

RSF was selected by biologists involved with the 2008 through 2012 data collection in consultation with biostatisticians at WEST, Inc., as a means to identify and quantify baseline preferential distribution patterns of marine mammals on the SOCAL Range. Using the 2008 through 2012 RSF data as a baseline will facilitate quantitative statistical comparison and identification of any potential changes in preferred habitat-use patterns (or lack thereof) of marine mammals relative to exposure to U.S. Navy MFAS, underwater explosions or other future activities. WEST, Inc., biostatisticians have been conducting RSF analyses for over 20 years on terrestrial animals and marine mammals; they have co-authored a reference book on the subject (Manly et al. 1993, 2002) and have authored multiple peer-reviewed journal articles (e.g., McDonald and Amstrup 2001, Amstrup et al. 2001, McDonald and McDonald 2002, McDonald et al. 2003), conference presentations, and workshops. The RSF approach has been successfully used to identify and predict habitat-use patterns and to identify changes in these patterns relative to anthropogenic activities (e.g., oil and gas exploration, construction and other anthropogenic activities, including disturbance). It has also recently been applied by the U.S. Fish and Wildlife Service and WEST, Inc., to identify potential effects of global warming on polar bears (Durner et al. 2009). It has proven to be a useful management tool to identify and quantify effects as well as viable mitigation and management opportunities.

For this analysis, RSF were developed for marine mammal sighting locations obtained along systematic and connector survey transects from 2008 through 2012 (see **Appendix D** for definitions of effort types). Standard logistic regression models were developed to estimate a linear function of site characteristics that reliably predicted observed use from 2008 to 2012. The model results estimated the relative probability of use at locations in the study area, as a function of the site characteristics (Manly et al. 2002).

Samples sizes of five marine mammal species were detected in adequate abundance to support the development of an RSF model: bottlenose dolphin, Risso's dolphin, California sea lion, fin whale, and gray whale. The behavior state of individuals was recorded during the surveys and provided information to conduct separate modeling for three states: mill, slow travel (including rest), and medium/fast travel (see ethogram in **Appendix D** for definitions).

METHODS

For the RSF analysis, characteristics at marine mammal locations were contrasted to characteristics at randomly selected "available" locations in the study area. The available set of points for the resource selection was obtained by placing a systematic grid at a random location within the study area (excluding all observations on land [with depth greater than 0] and outside the main survey areas). Most species were modeled within the Santa Catalina Basin (SCBa) and SNB regions using a set of 35,167 available points; however, the bottlenose dolphin was modeled only in the SCBa region with a set of 23,455 available points, as sample size was inadequate for this species in the SNB.

RSFs were estimated using the standard logistic regression model to predict the probability of the species being detected at a sampled site as a function of seven covariate variables describing habitat characteristics in the study area: latitude, longitude, depth (m), "northness" (calculated as the cosine of aspect), "eastness" (calculated as the sine of aspect), slope, and distance from shore (km) (see **Appendix I** for further details). Models were run for the 127 possible combinations of these variables and ranked using the AIC (Burnham and Anderson 2002), a statistic that evaluates model fit based on the log likelihood. The top AIC models for each species and behavior state were identified. The RSF models were used to predict the relative probability of selection for areas within the study area. These values were mapped spatially and color coded to indicate the relative value of the resource selection prediction (see map figures in **Appendix I**).

RESULTS AND DISCUSSION

Notable trends and significant correlations for the RSF modeling for the bottlenose dolphin, Risso's dolphin, California sea lion, fin whale, and gray whale are summarized below. This is followed by a short interpretation of results. Associated tables and figures, including maps of relative probability of behavior state occurrence by area, are illustrated in **Appendix I**. Underwater feature locations referenced below are identified in Figure 1 under *Introduction* above. Statistical results are summarized in further detail in **Appendix I**.

RSF models for the three behavior states (mill, slow travel/rest, and medium/fast travel) and all observations combined were fit for the five species (Table 1, **Appendix I**). Due to the low number of mill behavior states observed for the bottlenose dolphin, fin whale, and gray whale, mill was combined with slow travel/rest for these three species. In the following results discussions, probability (p) values <0.05 are considered statistically significant, while p values of 0.05-0.10 are considered a "strong correlation." Specific patterns of habitat selection are also discussed based on predicted probability values illustrated on RSF analysis maps in **Appendix I**.

Bottlenose Dolphins

A total of 31 bottlenose dolphin groups were used in RSF analyses. Most (n=19) were engaged in medium/fast travel or slow-travel/rest (n=11), with one remaining group milling (Table 1, **Appendix I**). The one milling group was thus combined with slow travel/rest for RSF analyses. An RSF was not conducted for the SNB west of SCI because no bottlenose dolphins were sighted there during systematic or connector effort.

Notable Results

1. The only significant correlations for behavior state per the RSF model was for medium/fast travel and all behavior states combined based on the variables longitude, water depth and distance from shore (Table I-2, **Appendix I**).
2. Overall, for both medium/fast travel ($p=0.0302$) and all travel behavior states ($p<0.0579$), bottlenose dolphin habitat use decreased significantly from east to west in the study area (based on longitude) (Figures I-2, I-3, and I-7, **Appendix I**).
3. Habitat use for medium/fast travel and all travel also decreased significantly with (a) deeper water depths (both with $p=0.0003$), and (b) increasing distance from shore ($p=0.0419$ and 0.0201, respectively).
4. Slow travel/mill behavior was predicted to be highest in the northern part of the study area, but this trend was not significant ($p=0.1328$) (Figures I-1 and I-7, **Appendix I**).

5. Based on observed bottlenose dolphin locations and RSF habitat value modeling, the highest habitat selection indices within the SCBa occurred along steep slopes paralleling the mainland coastline, the eastern side of SCI, and east and southeast of Santa Catalina Island (Figure I-7, **Appendix I**). In particular, predicted "hot spots" for bottlenose dolphins were associated with underwater seamounts, including Emory Knoll NE of SCI and an un-named knoll approximately 30 km to the southeast, and directly E of SCI (Figure I-7, **Appendix I**).
6. An obvious lack of predicted use was near the middle of SCBa over the relatively flat San Diego Trough (Figure I-7, **Appendix I**).

Interpretation

1. The trend for mill/slow travel to occur in the northern portion of the study area near Santa Catalina Island may be related to the "island" ecotype of bottlenose dolphins occurring there (Shane 1994). Shane (1994) reported that mill and slow travel among these dolphins was typically associated with socializing. Similarly, mill/slow travel during this 2008-2012 study often included socializing (i.e., touching, orienting towards one another). Combined results suggest that this area provides important social and potentially reproductive habitat.
2. The tendency for medium/fast travel to occur along underwater drop-offs/steep slopes may be associated with foraging or fast transit between feeding or other areas.
3. Further examination and analyses of the over 1 hr of focal behavior videos we have taken of bottlenose dolphins in the SCB would further elucidate the functional importance of these behavior states and other behaviors relative to differential habitat use.

Risso's Dolphin

A total of 135 Risso's dolphin groups were used in RSF analyses. Most (n=63) were engaged in slow-travel/rest, followed by medium/fast travel (n=56), or milling (n=14) (Table I-1, **Appendix I**).

Notable Results

1. Risso's dolphins tended to use different areas/habitat types for slow travel/rest vs. medium/fast travel. Slow travel/rest was strongly associated with deep water ($p=0.0803$) while medium/fast travel was generally associated with shallower water ($p=0.1298$).
2. In general, both types of behavior were significantly more likely to occur in the eastern portion of the study area ($p<0.03$) and closer to shore ($p<0.04$).
3. Medium/fast travel was also significantly associated with latitude ($p=0.019$), with highest probability to the south (Table I-6, **Appendix I**).

4. Examination of RSF probability maps revealed higher-resolution patterns within these general trends. Patterns appeared to be associated with underwater topographic features, pointing to differential habitat selection based on behavioral state as follows.
5. East of SCI: Slow travel was strongly associated with steep slopes off the northeast side of SCI and south of Santa Catalina Island, where medium/fast travel was unlikely to occur (Figure I-11 in **Appendix I**). In contrast, medium/fast travel was most likely to occur southeast of SCI where little or no slow travel was likely to occur (Figure I-11, **Appendix I**). The latter gap is associated with Fortymile Bank, a relatively flat area between San Clemente Canyon to the west and Coronado Canyon to the east.
6. SNB (west of SCI): Medium/fast travel was highly unlikely to occur to the west and northwest of SCI, but slow travel was likely to occur there (Figure I-11, **Appendix I**). The latter behavior in this area coincided with a steep underwater drop off running generally ESE from San Nicolas Island to SCI (Figure 1). In comparison, predicted medium/fast travel was concentrated along a relatively narrow margin just W of and paralleling SCI, again along a steep, narrow underwater ledge.
7. Mainland coastline: RSF-predicted habitat selection along the mainland coast was similar for mill, slow travel/rest and medium/fast travel. These behaviors had the highest probability closest to the shore to approximately 25 to 40 km offshore (**Appendix I**). This area roughly coincides with the relatively featureless San Diego Trough.

Interpretation

1. Based on video and field observations, slow travel among Risso's dolphins appears to involve rest and socializing characterized by overall tight, inter-individual spacing. Milling involving some individuals crisscrossing through the group or subgroup has also been observed occasionally during slow travel/rest. Shane (1995) reported that Risso's dolphins off Santa Catalina Island spent most of their time resting/slow traveling.
2. In contrast, medium/fast travel involves what appears to be directed point-to-point movement. As such, these behavior states are likely associated with different functions.
3. Habitat with high medium/fast travel use paralleled underwater features and/or the coastline. Shane (1995) observed that Risso's dolphins off Santa Catalina Island tended to travel up and down the coastline during the day, a similar pattern to the RSF pattern along SCI.
4. During daylight observations, medium/fast-directed travel is the most efficient means to move between habitats. Risso's dolphins may do this to move efficiently between areas used for socializing, resting or possibly foraging. We observed (and recorded on video) apparent foraging a few times: individuals or pairs of Risso's sprinted a short (~25-50 m) distance then dove steeply and rapidly, surfacing 1-2 min later; several northern right whale dolphins were following these Risso's in some instances.

5. Other studies have shown that Risso's dolphins are strongly associated with deep waters over steep slopes (Kruse 1989, Forney and Barlow 1998, Kruse et al. 1999, Carretta et al. 2000, Baird 2008, Jefferson et al. 2008, Carretta et al. 2011). Limited available data suggest that this species feeds predominantly at night on squid (e.g., Shane 1995, Kruse et al. 1999, Baird 2008, Jefferson et al. 2008, Soldevilla et al. 2011). Risso's dolphins may preferentially socialize and slow travel/rest during daytime in preferred habitat that may later be used for foraging at night. Night-time foraging cetaceans typically rest and socialize during daytime periods, including spinner dolphins (e.g., Norris and Dohl 1980, Norris et al. 1994, Benoit-Bird and Au 2003, Thorne et al. 2012) and dusky dolphins (Benoit-Bird et al. 2004, Vaughn et al. 2007, Würsig et al. 2007, 2010, Vaughn-Hirshorn et al. 2012).
6. We found significant and previously undocumented statistical results correlating behavior with a number of environmental variables. While we have identified many correlating factors, the fundamental behavioral triggers remain poorly understood. More detailed analyses of focal follow video from this species (n=51 groups) may illuminate and differentiate potential effects of U.S. Navy activities from naturally occurring baseline behavior.

California Sea Lion

A total of 157 California sea lion groups sighted at sea were used in RSF analyses. Most (n=41) were milling, followed by medium/fast travel (n=34), then slow-travel/rest (n=18). An additional 32 sightings were excluded from RSF analyses due to missing behavioral data when sightings were so dense and frequent that it was not possible to collect behavioral data (see **Appendix I**).

Notable Results

Habitat selection differed significantly by behavior state for some co-variates, including longitude, "eastness" (i.e., east aspect), distance from shore, and water depth as described below (Table 3, **Appendix I**).

1. As expected, occurrence of California sea lions was highest near San Clemente and San Nicolas islands where they haul-out throughout the year, and seasonally concentrate to breed, pup and molt (e.g., Carretta et al. 2000). A distinct gap in expected occurrence and distribution occurred in the central to southern portion of the SCB in the San Diego Trough (Figures I-4 and I-8, **Appendix I**).
2. Milling was significantly (p=0.0090) more likely to occur in the far western portion of the range, with decreasing probability to the east (Figures I-1 and I-8, **Appendix I**). Milling was often associated with apparent foraging involving quick turning and diving.
3. Similarly, medium/fast travel (p=0.0023) and all travel combined ($p<0.001$) were significantly more likely to occur in the western half of the study area (Figures I-3 and I-8, **Appendix I**). RSF probability maps indicated highest use along the steep slopes

surrounding the center of the SNB and near islands. However, this behavior was unlikely to occur in the centers of the SNB and SCB (i.e., the San Diego Trough).

4. Medium/fast travel was also significantly (p=0.0297) associated with deeper water depths, and strongly associated with proximity to shore (p=0.0917).
5. Slow travel/rest habitat-use patterns were less apparent. High-use areas were distributed patchily based on habitat selection probability maps. However, overall, within these patches, there was a strong correlation with east-facing slopes (p=0.0863). RSF probability maps showed highest use at east-facing slopes near the islands and also east of Santa Catalina Island just west of Irvine (Figures I-2 and I-8, **Appendix I**).

Interpretation

At-sea occurrence, relative abundance, and distribution information on California sea lions based on systematic surveys in offshore areas of the SCB are virtually non-existent. Carretta et al. (2000) estimated abundance of this species at sea near San Clemente and other nearby islands. In **Appendix E**, we report at-sea line-transect density and estimates for this species. Bearzi (2006) reported at-sea number estimates for this species in Santa Monica Bay based on small-vessel surveys (Bearzi et al. 2008). However, our RSF analyses provide the first at-sea habitat-use pattern statistics.

1. As expected, the overall highest at-sea use areas were around the islands, particularly SCI. This correlates with seasonally high haul-out numbers documented there (e.g., Carretta et al. 2000).
2. RSF analyses indicated that California sea lions show preferential use of different areas within the study area for different behaviors as discussed below:
    a. The SNB, particularly the far western edge of the range, appears to be an important foraging habitat for California sea lions based on high observed milling frequencies.
    b. Medium/fast travel was associated with steep drop-offs along the edges of basins and islands. This behavior may involve animals traveling quickly to foraging and/or haul-out areas.
    c. It is interesting that the center of the SNB is predicted to provide important milling (foraging) habitat but is highly unlikely to be used for medium/fast travel. This relationship is currently unclear and merits further interpretation and investigation.
    d. The significant correlation of high-use slow travel/rest with east-facing slopes is also unclear. This is undoubtedly related to proximity of island rookeries and haul-outs but may also be related to lees or other oceanographic conditions favoring such behavior. Focal-follow behavioral analyses may help elucidate this

relationship combined with literature searches for related studies. Such areas appear to provide important habitat for the species.

Fin Whale

Sixty fin whale groups were used in RSF analyses. Most (*n*=36) were engaged in medium/fast travel (*n*=36), followed by slow travel/rest (*n*=20), and milling (*n*=2) (Table A-1, **Appendix I**). However, the two milling groups were combined with slow travel/rest for RSF analyses due to small sample size. Similar to Risso's dolphins, fin whales appeared to exhibit differential habitat use/selection, including based on behavioral state, as follows.

Notable Results

1. Overall, based on all combined behavioral data, fin whales were the only species of the five examined for which nearly the entire SNB (west of SCI) had high probability of use (in Figures I-2 and I-8, **Appendix I**).
2. Preferred areas for slow travel/rest/mill differed from those where medium/fast travel was most likely to occur. Slow travel/rest/mill occurred predominantly along steep slopes (Figure I-8, **Appendix I**) where medium/fast travel was least likely to occur.
3. In contrast, medium/fast travel was mostly likely to occur over relatively flat basins and over underwater plateaus where slow travel/rest/mill was unlikely to occur.
4. Overall, fin whales were significantly more likely to be associated with deeper vs. shallower waters ($p=0.0017$).
5. Fin whales were also significantly more likely to be associated with closer distances to shore across all behavior states ($p=0.0359$).
6. In general, the probability of encountering fin whales increased significantly from east to west ($p=0.0276$), and from north to south ($p=0.0413$) (Figure I-8, **Appendix I**).
7. Slow travel/rest/mill was strongly associated with steep slope drop offs near the southeast coasts of San Nicolas and Santa Catalina islands and off the mainland shelf (areas where medium/fast travel were least or less likely to occur) (Figure I-8, **Appendix I**).
8. In contrast, medium/fast travel was most likely to occur over the relatively flat center of the SNB, the San Diego Trough, and Fortymile Bank (Figure I-8, **Appendix I**). The maps in Figure 9 clearly show a lack of slow travel/rest/mill in these basins.

Interpretation

1. Consistent with past results summarized from our aerial data (e.g., DoN 2011a, Smultea et al. 2009, 2010, 2011a, 2012a); fin whales were the only cetacean species highly likely to occur in the SNB west of SCI.

2. RSF results also revealed other high-probability use areas preferentially selected by fin whales in the study area.

3. Similar to Risso's dolphin patterns, RSF probability maps indicated that fin whales traveled quickly over relatively flats basins and troughs.

4. In contrast, slow travel/rest/mill behavior was strongly associated with steeply sloped bathymetry contours along islands and coastlines.

5. Preliminary observations and video analyses of focal groups of fin whales indicate that medium/fast travel is associated with directed point-to-point movement, with minimal changes in heading/orientation. In contrast, slow travel/rest/mill appears to be more frequently associated with feeding (open-mouthed lunging, defecation, krill patches), socializing (rolling and touching, orienting towards one another) and apparent rest. Thus, these two types of behavior states are believed to serve different biological functions.

6. Based on the above, fin whales are believed to feed predominantly over steep slopes in the study area where upwelling is most likely to occur, providing and concentrating prey.

7. In contrast, over flatter topographic regions where prey is less likely to concentrate, fin whales are most likely to travel at medium/fast speed, possibly in transit to other areas; this may include, perhaps, steeper areas where they tend to be seen socializing and feeding. Directed travel is also likely associated with those individuals that migrate through the area. Little to nothing is known about residency times of fin whales in the SCB where they occur year-round, unlike most other baleen whale species.

8. This study found significant and previously undocumented statistical results correlating behavior with a number of environmental variables. While many correlating factors have been identified, the fundamental behavioral triggers remain poorly understood. More detailed analyses of focal follow video from this species (n=21 groups) may illuminate and differentiate potential effects of U.S. Navy activities from naturally occurring baseline behavior.

9. These focal follows have involved following individuals for extended periods of time (up to 60+ min). They should thus reveal more detailed information on types and levels of social behavior and foraging occurring by area, habitat features, and known individuals. Virtually nothing has been published on social interactions among fin whales. We have videotaped apparent socio-sexual behavior for this species on the study area numerous times. These data indicate that the area appears to be important for courting/reproductive activities. Numerous focal follows of fin whale calves have also been conducted but have not been analyzed in detail.

10. These RSF studies statistically indicate that the SNB west of SCI and the areas surrounding SCI are high-probability use areas for fin whales, and that subareas and features there are used differentially by fin whales. Such baseline information is important to differentiate

potential effects of U.S. Navy activities from naturally occurring behavior among this species.

Gray Whale

Forty gray whale sightings were used in RSF analyses. Most were engaged in slow-travel/rest (n=18) or medium/fast travel (n=21), with only one sighting observed milling (Table A-1, **Appendix I**). Milling was therefore combined with slow-travel behavior.

Notable Results

1. The overall probability of gray whale sightings of all types significantly decreased with increasing distance from the mainland coast (Figures I-2 and I-9, **Appendix I**).
2. Gray whale habitat use extended throughout all but the far west margin of the study area.
3. Certain surface-observed behavior states were strongly associated with seafloor aspect (i.e., the compass direction of the slope of the seafloor face). In particular, gray whales were unlikely to travel slowly over north-facing slopes ($p=0.0958$).
4. Overall, gray whales were significantly more likely to be observed moving faster (medium/fast travel) when closer to shore, including near San Clemente and Santa Catalina islands (Figures I-1 and I-9, **Appendix I**).
5. RSF habitat-use probability maps suggest that central SCB between SCI and the mainland is used primarily by slow-traveling/resting gray whales, with very low use by medium/fast traveling individuals (Figure I-9, **Appendix I**). This suggests some inverse relationships in habitat selection based on behavior state/travel speed.

Interpretation

1. As expected, gray whales selectively preferred shallower, nearshore waters, particularly close to the mainland coast, regardless of behavior state. Notably, nearly all focused research on gray whales in the SCB has focused on nearshore, coastal mainland waters (e.g., Reilly et al., 1983, Poole 1984, Sumich and Show 2011).
2. Gray whales were regularly seen scattered offshore near islands in the study area, with lowest probability of occurrence on the western edge of the range.
3. In offshore areas, the highest probability of occurrence was concentrated along the shores of SCI and Santa Catalina Island. Similarly, Sumich and Show (2011) reported during winter 1988-1990 that some southbound gray whales regularly used two offshore migratory corridors within 40 to 50 km W of SCI and within 80 to 90 km W of Santa Catalina Island. They found that more grays used these two offshore corridors than the coastal mainland corridor. These three corridors appeared to converge near the California-Mexico border. Based on photogrammetry data, Sumich and Show (2011) suggested that smaller (<11.5 m) and presumably younger, gray whales preferentially use the coastal migratory corridor in the SCB.

4. While the nearshore coastal waters provide an important migratory path for gray whales, the entire study area is used by gray whales during winter and spring migration. This information is important given the prior limited systematic studies of gray whale relative abundance, distribution and occurrence in offshore coastal areas.
5. We observed gray whale calves in offshore waters (see **Appendix B**, Figure B-23). Further data analyses are needed to determine the exact locations and numbers of calves and yearlings in such waters.
6. Gray whales are predicted to use nearshore waters of SCI for fast travel based on RSF results.
7. The reason for the strong tendency for gray whales to travel faster over north-facing slope aspects is unclear. This may be related to currents or other oceanographic features (e.g., upwelling, water temperature changes) that influence behavior and migration movement patterns. It is possible that whales follow these contours or associated oceanographic indices during generally east-west movements between the mainland coast and outer islands. Predator-avoidance may also influence observed regional travel speed differences along north-facing aspects.
8. The team has found significant and previously undocumented statistical results correlating behavior with a number of environmental variables. The teams has identified many correlating factors, the fundamental behavioral triggers remain poorly understood. More detailed analyses of focal follow video from this species (n=5 groups) may illuminate and differentiate potential effects of Navy activities from naturally occurring baseline behavior.
9. Additional analyses could include a quantitative analysis of the level of use of offshore north- and south-bound migration corridors by gray whales (including calves) compared to the results of Sumich and Show (2011) from over 10 years ago in the same region.
10. We have also videotaped apparent nursing and socio-sexual behavior among gray whales on the study area numerous times (e.g., Moore et al. 2012). Thus, the area appears to be important for courting/reproductive/nursing activities. Numerous focal follows of gray whale mother-calves have also been conducted but have not been analyzed in detail.

CONCLUSIONS

1. RSF analyses revealed some significant correlations between habitat use and behavior states for all five species examined. This approach serves to identify high-use areas and contributes to attributing biological meanings and levels of importance to these features and areas (e.g., foraging, courting, resting, etc.).
2. Understanding, systematically quantifying, and describing baseline habitat-use and selection patterns is critical before attempting to interpret potential effects (or lack thereof) of U.S. Navy MFAS, underwater explosions, and other activities.

3. For many of these species, RSF results provide the most extensive, up-to-date concentrated database on the occurrence, distribution, relative abundance, and habitat-use behavioral patterns available in the study area.
4. RSF analyses described herein were designed to provide a means to systematically, quantitatively and statistically assess potential changes in habitat-use and selection patterns relative to U.S. Navy activities. The RSF approach has been successfully applied for this purpose to numerous other species relative to anthropogenic activities. The baseline provided herein is integral to successful implementation of this approach (Manly et al. 2002).

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APPENDIX A: TABLES

Table A-1. Summary of Southern California Marine Mammal Aerial Surveys: 2008 – 2012. No sea turtles were seen.

Parameter	Oct	Nov	Jun	Jul	Nov	May	Jul	Sept	Feb	Mar	Apr	May	Jan - Feb	Mar	Mar - Apr	Total
Survey Dates	17-21 Oct 2008	15-18 Nov 2008	5-11 June 2009	20-29 July 2009	18-23 Nov 2009	13-18 May 2010	27 July-3 Aug 2010	23-28 Sept 2010	14-19 Feb 2011	29 March-3 April 2011	12-20 April 2011	9-14 May 2011	30 Jan - 5 Feb 2012	13-15 March 2012	28 March - 1 April 2012	**15 Surveys 2008-2012**
No. Days Flown	5	4	6	9	6	6	7	6	4	3	9	6	7	3	5	**86**
Platform Used	Partenavia P68-C	Partenavia P68-C	Partenavia P68-C	Partenavia P68-C	Partenavia P68-OBS	Partenavia P68-C	Partenavia P68-OBS and Bell 206 Helicopter	Partenavia P68-OBS	Partenavia P68-C	Partenavia P68-C	Aero Commander 685	Partenavia P68-C	Partenavia P68-C	Partenavia P68-C	Partenavia P68-C	**Partenavia, Bell Helicopter or Aero Commander**
Study area Area‡	CSCI, Santa Catalina Island	SNB, CSCI, SSCI	SNB, SCB	SNB, SCB	SNB, SCB, CSCI	SNB, SCB	SNB, SCB	SNB, SCB	SNB, SCB, SS	SNB, SCB	SNB, SCB, SS	SNB, SCB, SS	SNB, SCB	SCB	SCB	**CSCI, SNB, SSCI, SCB, SS, Santa Catalina Island**
Survey Type#	CSCI, LT, FF	CSCI, LT, FF	LT, FF	LT, FF	CSCI, LT, FF	LT, FF	LT, FF	LT, FF	LT, FF	LT, FF	LT, FF	LT, FF	LT, PAM	LT, PAM	LT, PAM	**CSCI, LT, FF, PAM**
Major Training Exercise Before, During or After Survey	Before, During	After	After	After	During, After	During	During, After	During, After	Before, During, After	None	None	During	None	None	None	**During, Before or After**
Total Flight Hours (Wheels up/down)	28	21	30	34	28	29	18	27.7	17.2	9.5	46	27	34.5	19.1	26.9	**396**
Total Observation Effort (km and nm) *(excl. poor weather, over land)*	4,563	3,838	6,140	6,500	4,823	4,891	3,125	3,918	3,193	1,865	10,976	4,902	5,973	3,233	4,527	**72,467 km**
	2,464	2,072	3,315	3,510	2,604	2,641	1,688	2,116	1,724	1,007	5,926	2,647	3,225.30	1,746	2,445	**39,129 nm**
No. Groups Seen	114	185	161	218	94	152	91	252	83	71	136	81	228	156	129	**2,151**
Estimated No. Individuals	11,745	4,784	9,172	20,527	12,829	6,365	11,090	38,042	11, 131	2,165	14,130	3,291	28,208	11,082	5,749	**190,310**
No. Groups per km*	0.03	0.05	0.03	0.03	0.02	0.03	0.3	0.06	0.03	0.04	0.01	0.02	0.04	0.05	0.03	**0.05**

Parameter	Oct	Nov	Jun	Jul	Nov	May	Jul	Sept	Feb	Mar	Apr	May	Jan - Feb	Mar	Mar - Apr	Total
No. Marine Mammal Individuals per km*	2.8	1.5	1.5	3.2	2.7	1.1	3.6	17.4	3.5	1.2	1.3	0.7	4.7	3.7	1.3	**3.3**
No. Dead Sightings	0	3 (2 CA sea lions, 1 Blue whale)	0	2 Probable CA sea lions	0	0	0	0	0	0	0	1 Humpback whale	1 CA sea lion	0	0	**7**
No. of Marine Mammal Species	9	9	11	10	10	9	5	9	8	8	11	11	11	10	10	**19 total species seen**
No. Focal Groups Circled 5-9 min	22	20	24	37	14	10	6	6	2	4	0	1	12	0	2	**160**
No. Extended Focal Groups Circled ≥10 min	5	7	7	8	10	20	13	10	6	10	15	14	4	6	5	**140**
Longest Focal Follow Duration	29 min (Fin whale)	60 min (Fin whale)	48 min (Fin whale)	38 min (Long-beaked common dolphin)	40 min (Killer whale)	144 min (Fin whale)	59 min (Blue whale)	45 min (Bryde's whale)	30 min (Gray whale)	22 min (Common dolphin sp.)	48 min (Fin whale)	67 min (Sperm whale)	31 min (Fin whale)	15 min (Fin whale)	23 min (Fin whale)	**144 min (Fin whale) longest focal follow**
No. Photos Taken	1,050	1,280	1,099	2,301	2,203	1,350	2,900	741	473	323	424	976	1,868	1,026	921	**18,935**
Estimated Usable** Video (min)	53	41	83	50	90	334	373	143	79	95	239	299	82	54	57	**2,072 min**
Ocean Sunfish Sightings (*Mola mola*)†	0	0	0	0	0	0	0	0	0	0	68	16	91	65	60	**300**

‡ CSCI= Circumnavigate San Clemente Island; SCB= Santa Catalina Basin (representing the area between SCI and the California mainland); SNB= San Nicolas Basin (area west of SCI [San Clemente Island]); SS= Silver Strand (and in San Diego Bay, just south of Point Loma); SSCI= South of San Clemente Island (ocean area south of San Clemente Island)
# CSCI = Circunavigate Scan Clemente Island to search for stranded or injured marine mammals or sea turtlesLT= Line Transect, FF= Focal Follow, PAM= Passive Acoustic Monitoring with sonobuoys
† Ocean sunfish (*Mola mola*) sightings were recorded starting during the April 2011 survey (and continued through the 2012 survey period).
* Based on total observation effort (see above) during all effort types (e.g., systematic, connector, transit, random, circling).
● Acoustic-visual behavior studies (PAM) occurred on 7-10 Feb 7-10; 16 March 2012; and 2-3 April 2012
** Useable video= video that could be used to transcribe behavioral data (i.e., animal in view, audio from observers and longer than 5 seconds in length) (see **Appendix D** for video quality definitions)

Table A-2. Summary of flight effort during SOCAL Marine Mammal Aerial Survey Monitoring: 2008 - 2012.

Survey Date	No. of Days Flown	No. of Flights	Platform	Total Flight Time	Total Flight Distance (km)†	Total Flight Distance (nm)*	Total Obs. Time	Study Area‡	Beaufort Sea State
17-21 Oct 2008	5	7	Partenavia P68-C	28.0	4,563	2,464	24.1	CSCI, Santa Catalina Island	1-6
15-18 Nov 2008	4	4	Partenavia P68-C	21.0	3,838	2,072	9:36	SNB, CSCI, SSCI	0-3
5-11 June 2009	6	8	Partenavia P68-C	30.0	6,140	3,315	26.3	SNB, SCB	1-6
20-29 July 2009	9	9	Partenavia P68-C	34.0	6,500	3,510	31.6	SNB, SCB	1-6
18-23 Nov 2009	6	7	Partenavia P68-OBS	28.0	4,823	2,604	26.4	SNB, SCB, CSCI	1-6
13-18 May 2010	6	7	Partenavia P68-C	29.0	4,891	2,641	14:24	SNB, SCB	1-4
27 July-3 Aug 2010	7	7	Partenavia P68-OBS, Bell 206 Helicopter	18.0	3,125	1,687	17.3	SNB, SCB	2-6
23-28 Sept 2010	6	10	Partenavia P68-OBS	27.7	3,918	2,116	27.8	SNB, SCB	1-5
14-19 Feb 2011	4	7	Partenavia P68-C	17.2	3,193	1,724	16.7	SNB, SCB, SS	1-5
29 March-3 April 2011	3	3	Partenavia P68-C	9.5	1,865	1,007	9.0	SNB, SCB	0-3
12-20 April 2011	9	11	Aero Commander 685	46.0	10,976	5,927	44.3	SNB, SCB, SS	1-6
9-14 May 2011	6	10	Partenavia P68-C	27.0	4,902	2,647	25.5	SNB, SCB, SS	1-5
30 Jan - 5 Feb 2012	7	12	Partenavia P68-C	34.5	5,973	3,225	32.9	SNB, SCB	1-4
13-15 March 2012	3	6	Partenavia P68-C	19.1	3,233	1,746	17.5	SCB	1-4
28 March - 1 April 2012	5	8	Partenavia P68-C	26.9	4,527	2,444	24.2	SCB	1-4
Total	**86**	**116**		**396**	**72,467**	**39,129**	**372**		

†km = kilometers; *nm = nautical miles

‡ CSCI= Circumnavigate San Clemente Island; SCB= Santa Catalina Basin (representing the area between SCI and the California mainland); SNB= San Nicolas Basin (area west of SCI [San Clemente Island]); SS= Silver Strand (and in San Diego Bay, just south of Point Loma); SSCI= South of San Clemente Island (ocean area south of San Clemente Island)

Table A-3. Summary of numbers of sightings and best estimates of numbers of individuals for each marine mammal species during each of the 15 aerial surveys, Southern California Marine Mammal Aerial Survey Monitoring: 2008 - 2012. No sea turtles were seen.

Common Name	2008 (8,401 km)*		2009 (17,463 km)		2010 (11,934 km)		2011 (20,936 km)		2012 (13,733 km)		Total (72,467 km)	
	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv
Blue Whale	2	3	28	36	20	46	15	19	0	0	65	104
Bottlenose Dolphin	5	136	2	15	18	402	26	438	52	1,031	103	2,022
Bryde's Whale	1	1	0	0	1	1	0	0	0	0	2	2
Bryde's/Sei Whale	0	0	0	0	1	3	0	0	0	0	1	3
California Sea Lion	93	268	76	228	135	374	40	92	78	222	422	1,184
Common Dolphin spp.	45	9,837	83	21,316	181	47,496	79	12,250	73	17,707	461	108,606
Cuvier's Beaked Whale	0	0	3	10	1	2	0	0	0	0	4	12
Dall's Porpoise	0	0	0	0	0	0	2	8	3	7	5	15
Fin Whale	11	22	34	53	6	11	23	35	48	87	122	208
Fin/Bryde's/Sei Whale	0	0	0	0	0	0	1	1	1	2	2	3
Fin/Sei Whale	1	1	3	7	0	0	0	0	0	0	4	8
Gray Whale	0	0	0	0	0	0	14	27	64	144	78	171
Harbor Seal	10	16	2	2	1	2	2	4	0	0	15	24
Humpback Whale	3	7	2	2	0	0	5	6	3	4	13	19
Killer Whale	0	0	2	67	0	0	0	0	0	0	2	67
Long-beaked Common Dolphin	5	615	5	1,303	2	9	12	3,282	10	5,495	34	10,704
Minke Whale	0	0	2	2	2	4	6	8	1	1	11	15
Northern Elephant Seal	1	1	0	0	4	23	0	0	0	0	5	24
Northern Right Whale Dolphin	0	0	3	1,200	0	0	7	115	2	151	12	1,466

Common Name	2008 (8,401 km)*		2009 (17,463 km)		2010 (11,934 km)		2011 (20,936 km)		2012 (13,733 km)		Total (72,467 km)	
	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv	# Grps	# Indiv
Pacific White-Sided Dolphin	11	212	7	309	2	81	0	0	0	0	20	602
Risso's Dolphin	19	613	89	1,613	40	517	60	1,579	78	1,062	286	5,384
Short-beaked Common Dolphin	17	4,020	18	9,666	0	0	17	9,715	17	9,894	69	33,295
Sperm Whale	0	0	0	0	0	0	1	20	0	0	1	20
Unidentified Baleen Whale	4	4	13	13	2	2	7	8	9	9	35	36
Unidentified Dolphin	24	701	69	6,479	64	5,854	41	3,072	62	9,209	260	25,315
Unidentified Large Whale	6	7	1	1	1	1	1	1	0	0	9	10
Unidentified Marine Mammal	7	27	3	5	2	14	0	0	0	0	12	46
Unidentified Medium Marine Mammal	0	0	0	0	2	2	1	1	0	0	3	3
Unidentified Medium Whale	1	2	2	2	0	0	2	5	0	0	5	9
Unidentified Pinniped	25	25	17	23	2	2	0	0	0	0	44	50
Unidentified Sea Lion	3	3	0	0	0	0	0	0	0	0	3	3
Unidentified Small Dolphin	0	0	4	160	6	649	1	20	0	0	11	829
Unidentified Small Marine Mammal	4	7	4	15	2	2	3	3	2	2	15	29
Unidentified Small Whale	1	1	0	0	0	0	1	1	0	0	2	2
Unidentified Whale	0	0	1	1	0	0	4	7	10	12	15	20
Total	**299**	**16,529**	**473**	**42,528**	**495**	**55,497**	**371**	**30,717**	**513**	**45,039**	**2,151**	**190,310**

*km = kilometers

Table A-4. List of mixed-species sightings (sightings with more than one species) made during Southern California Marine Mammal Aerial Survey Monitoring: 2008 – 2012.

Date	Initial Sighting Time	Species (Number of Individuals)	Latitude (N)	Longitude (W)	Water Season*	Study Area**
10/17/08	14:09:01	Bottlenose Dolphin (75), Common Dolphin sp. (1200)	33.0905	-117.4190	warm	E of SCI
10/20/08	14:26:01	Bottlenose Dolphin (6), Risso's Dolphin (23)	33.2719	-118.2600	warm	E of SCI
11/17/08	11:00:58	Short-Beaked Common Dolphin (240), Pacific White-Sided Dolphin (300)	32.7690	-117.5201	cold	E of SCI
11/17/08	12:47:57	Short-Beaked Common Dolphin (60), California Sea Lion (7)	32.6338	-118.0311	cold	E of SCI
11/18/08	11:52:57	California Sea Lion (7), Common Dolphin sp. (50)	32.5905	-117.9241	cold	E of SCI
06/06/09	14:12:06	Fin Whale (2), Northern Right Whale Dolphin (700)	32.9104	-119.1821	warm	W of SCI
06/07/09	13:36:43	Risso's Dolphin (60), Common Dolphin sp. (52)	32.6056	-117.8228	warm	E of SCI
06/11/09	8:59:04	Fin Whale (1), Blue Whale (1)	33.1191	-117.4537	warm	E of SCI
07/25/09	15:04:44	Fin Whale (1), Fin/Sei Whale (3)	33.0234	-118.9897	warm	W of SCI
07/27/09	15:33:37	Short-beaked Common Dolphin (230), California Sea Lion (1)	32.8971	-118.1566	warm	E of SCI
05/17/10	17:06:00	Common Dolphin sp. (500), California Sea Lion (4), Pacific White-Sided Dolphin (26)	32.9492	-117.9017	warm	E of SCI
05/17/10	12:48:55	Bottlenose Dolphin (12), Risso's Dolphin (35)	33.1511	-117.4551	warm	E of SCI
05/17/10	10:24:43	Risso's Dolphin (28), California Sea Lion (1), Unidentified Dolphin	32.9385	-118.1627	warm	E of

Date	Initial Sighting Time	Species (Number of Individuals)	Latitude (N)	Longitude (W)	Water Season*	Study Area**
		(90)				SCI
05/17/10	16:40:26	Risso's Dolphin (44), California Sea Lion (1)	32.8721	-118.2795	warm	E of SCI
07/27/10	15:24:12	Blue Whale (6), Fin Whale (2)	32.8287	-117.3788	warm	E of SCI
07/28/10	15:45:49	Blue Whale (5), Fin Whale (3)	32.6433	-117.3460	warm	E of SCI
07/31/10	17:41:28	Blue Whale (1), Fin Whale (1)	33.0567	-117.3682	warm	E of SCI
08/02/10	14:52:58	Common Dolphin sp. (300), Blue Whale (3)	32.9122	-117.3052	warm	E of SCI
09/24/10	12:40:16	California Sea Lion (30), Unidentified Dolphin (4)	32.9785	-119.2063	warm	W of SCI
09/24/10	14:16:14	Risso's Dolphin (2), Long-Beaked Common Dolphin (250)	32.9922	-118.3178	warm	W of SCI
09/25/10	10:32:58	Risso's Dolphin (10), Common Dolphin sp. (700)	32.9450	-117.6785	warm	E of SCI
04/01/11	9:17:28	Risso's Dolphin (20), Northern Right Whale Dolphin (8)	32.9515	-118.6773	cold	W of SCI
04/01/11	9:58:38	Risso's Dolphin (11), Northern Right Whale Dolphin (2)	33.0015	-118.7087	cold	W of SCI
04/18/11	13:19:59	Bottlenose Dolphin (5), Risso's Dolphin (250)	33.0802	-117.6663	cold	E of SCI
05/10/11	15:46:27	Fin Whale (2), Blue Whale (2)	32.8778	-117.3047	warm	E of SCI
05/11/11	13:58:19	Risso's Dolphin (32), Bottlenose Dolphin (8)	32.6730	-117.5750	warm	E of SCI

Date	Initial Sighting Time	Species (Number of Individuals)	Latitude (N)	Longitude (W)	Water Season*	Study Area**
05/14/11	10:41:28	Risso's Dolphin (11), Sperm Whale (24), Northern right whale dolphin (50)	32.6228	-117.7247	warm	E of SCI
01/30/12	15:56:00	Gray Whale (4), Bottlenose Dolphin (2)	32.9204	-117.2956	cold	E of SCI
02/02/12	12:49:52	Risso's Dolphin (75), Bottlenose Dolphin (25)	33.4176	-118.1176	cold	E of SCI
02/04/12	14:27:51	Risso's Dolphin (48), Northern Right Whale Dolphin (1)	32.8099	-118.6381	cold	W of SCI
03/13/12	11:39:17	Risso's Dolphin (7), Bottlenose Dolphin (5)	32.6263	-118.0023	cold	E of SCI
03/14/12	13:40:36	Risso's Dolphin (15), Bottlenose Dolphin (25)	32.6669	-117.5390	cold	E of SCI
03/28/12	16:44:16	Fin Whale (2), Common Dolphin sp. (125)	33.2272	-117.5354	cold	E of SCI
03/30/12	11:38:40	Gray Whale (2), Long-Beaked Common Dolphin (50)	32.7349	-117.7448	cold	E of SCI
03/30/12	11:16:47	Risso's Dolphin (15), California Sea Lion (1)	32.6312	-118.0085	cold	E of SCI

* Warm-water season = May-October, cold-water season = November-April, after Carretta, J. V., M. S. Lowry, C. E. Stinchcomb, M. S. Lynn, and R. E. Cosgrove. 2000. Distribution and abundance of marine mammals at San Clemente Island and surrounding offshore waters: results from aerial and ground surveys in 1998 and 1999. Southwest Fisheries Science Center Administrative Report LJ-00-02. National Marine Fisheries Service, La Jolla, California.

** E of SCI = east of San Clemente Island; W of SCI = west of San Clemente Island

Table A-5. Sightings per unit effort (SPUE)(per kilometer of all flight track effort*) of marine mammal groups and individuals by species during the warm- and cold-water seasons during SOCAL Marine Mammal Aerial Survey Monitoring: 2008 – 2012. These rates are based on all observation effort leg types (circling, transit, systematic, connector, and random flight tracks). They are meant to provide a gross measure of SPUE and should not be used for density reference. (See Appendix E for density and abundance estimates based only on systematic line-transect effort).**

Common Name	Cold-Water Season		Warm-Water Season		Cold-Water Season (38,428 effort in km◊)		Warm-Water Season (34,039 effort in km)	
	# Grp	# Indiv	# Grp	# Indiv	# Grp/km	# Indiv/km	# Grp/km	# Indiv/km
Blue Whale	4	5	61	99	0.0001	0.0001	0.002	0.003
Bottlenose Dolphin	73	1,346	30	676	0.002	0.03	0.0009	0.02
Bryde's Whale	0	0	2	2	0	0	0.00006	0.00006
Bryde's/Sei Whale	0	0	1	3	0	0	0.00003	0.00009
California Sea Lion	188	542	233	642	0.005	0.01	0.007	0.02
Common Dolphin spp.***	170	32,665	291	75,941	0.004	0.9	0.008	2.2
Cuvier's Beaked Whale	2	6	2	6	0.00005	0.0002	0.00006	0.0002
Dall's Porpoise	5	15	0	0	0.0001	0.0004	0	0
Fin Whale	73	131	50	78	0.002	0.003	0.001	0.002
Fin/Bryde's/Sei Whale	2	3	0	0	0.00005	0.00008	0	0
Fin/Sei Whale	1	1	3	7	0.00003	0.00003	0.00009	0.0002
Gray Whale	78	171	0	0	0.002	0.004	0	0
Harbor Seal	9	15	6	9	0.0002	0.0004	0.0002	0.0003
Humpback Whale	9	15	4	4	0.0002	0.0004	0.0001	0.0001
Killer Whale	2	67	0	0	0.00005	0.002	0	0
Long-beaked Common Dolphin†	26	9,315	8	1,389	0.0007	0.2	0.0002	0.04
Minke Whale	7	9	4	6	0.0002	0.0002	0.0001	0.0002
Northern Elephant Seal	1	1	4	23	0.00003	0.00003	0.0001	0.0007

Common Name	Cold-Water Season		Warm-Water Season		Cold-Water Season (38,428 effort in km◊)		Warm-Water Season (34,039 effort in km)	
	# Grp	# Indiv	# Grp	# Indiv	# Grp/km	# Indiv/km	# Grp/km	# Indiv/km
Northern Right Whale Dolphin	8	216	4	1,250	0.0002	0.006	0.0001	0.04
Pacific White-sided Dolphin	17	486	3	116	0.0004	0.01	0.00009	0.003
Risso's Dolphin	135	2,768	151	2,616	0.004	0.07	0.004	0.08
Short-beaked Common Dolphin#	61	29,820	8	3,475	0.002	0.8	0.0002	0.1
Sperm Whale	0	0	1	20	0	0	0.00003	0.0006
Unidentified Dolphin‡	121	12,361	151	13,783	0.003	0.3	0.004	0.4
Unidentified Pinniped	48	71	29	60	0.001	0.002	0.0009	0.0020
Unidentified Whale	42	49	23	27	0.001	0.001	0.0007	0.0008
Total	**1,082**	**90,078**	**1,069**	**100,232**	**0.03**	**2.3**	**0.03**	**2.9**

*Effort includes all leg-type efforts as follows: systematic line transect, connector (shorter legs between systematic lines), transit (point-to-point movement, usually from San Diego to study area), random (usually opportunistic effort or effort when the U.S. Navy required the plane to depart an area), and circling (circling a sighting for photographs or focal follow effort).

** Warm-water season = May-October, cold-water season = November-April, after Carretta et al. 2000

***Excludes 6 common dolphin sightings that did not have group size information (2 during warm-water season and 4 during cold-water season).

◊ km = kilometers

†Excludes 2 long-beaked common dolphin sightings that did not have group size information during the warm-water season.

#Excludes 1 short-beaked common dolphin sighting that did not have group size information during the cold-water season.

‡Excludes 9 unidentified dolphin groups that did not have group size information (2 during cold-water season and 7 during warm-water season).

Table A-6. Sightings per unit effort (SPUE)(per kilometer of all flight track effort*) of marine mammal groups by species by year during SOCAL Marine Mammal Aerial Survey Monitoring 2008 – 2012. These rates are based on all observation effort leg types (circling, transit, systematic, connector, and random flight tracks). They are meant to provide a gross measure of SPUE and should not be used for density reference. (See Appendix E for density and abundance estimates based only on systematic line-transect effort).

Species (Common Name)	2008		2009		2010		2011		2012		Total	
	Total No. of Grp	Grp/ km◊	Total No. of Grp	Grp/ km	Total No. of Grp	Grp/ km	Total No. of Grp	Grp/ km	Total No. of Grp	Grp/ km	Total No. of Grp	Grp/ km
Whales												
Blue Whale	2	0.0002	28	0.002	20	0.002	15	0.0007	0	0	65	0.0009
Bryde's Whale	1	0.0001	0	0	1	0.00008	0	0	0	0	2	0.00003
Bryde's/Sei Whale	0	0	0	0	1	0.00008	0	0	0	0	1	0.00001
Fin Whale	11	0.001	34	0.002	6	0.0005	23	0.001	46	0.003	120	0.002
Fin/Bryde's/Sei Whale	0	0	0	0	0	0	1	0.00005	1	0.00007	2	0.00003
Fin/Sei Whale	1	0.0001	3	0.0002	0	0	0	0	0	0	4	0.00006
Gray Whale	0	0	0	0	0	0	14	0.0007	64	0.005	78	0.001
Humpback Whale	3	0.0004	2	0.0001	0	0	5	0.0002	3	0.0002	13	0.0002
Minke Whale	0	0	2	0.0001	2	0.0002	6	0.0003	1	0.00007	11	0.0002
Sperm Whale	0	0	0	0	0	0	1	0.00005	0	0	1	0.00001
Unidentified Whale#	12	0.001	17	0.001	3	0.0003	14	0.0007	20	0.001	66	0.0009
Dolphins												
Bottlenose Dolphin	5	0.0006	2	0.0001	18	0.002	26	0.001	51	0.004	102	0.001
Common Dolphin spp.	46	0.005	82	0.005	182	0.02	79	0.004	67	0.005	456	0.006
Cuvier's Beaked Whale	0	0	3	0.0002	1	0.00008	0	0	0	0	4	0.00006
Dall's Porpoise	0	0	0	0	0	0	2	0.0001	3	0.0002	5	0.00007
Killer Whale	0	0	2	0.0001	0	0	0	0	0	0	2	0.00003
Long-Beaked Common Dolphin	5	0.0006	4	0.0002	1	0.00008	12	0.0006	15	0.001	37	0.0005

Species (Common Name)	2008		2009		2010		2011		2012		Total	
	Total No. of Grp	Grp/ km◊	Total No. of Grp	Grp/ km	Total No. of Grp	Grp/ km	Total No. of Grp	Grp/ km	Total No. of Grp	Grp/ km	Total No. of Grp	Grp/ km
Northern Right Whale Dolphin	0	0	3	0.0002	0	0	7	0.0003	2	0.0001	12	0.0002
Pacific White-sided Dolphin	11	0.001	7	0.0004	2	0.0002	0	0	0	0	20	0.0003
Risso's Dolphin	19	0.002	86	0.005	40	0.003	60	0.003	78	0.006	283	0.004
Short-Beaked Common Dolphin	17	0.002	18	0.001	0	0	17	0.0008	18	0.001	70	0.001
Unidentified Dolphin†	24	0.003	63	0.004	70	0.006	42	0.002	61	0.004	260	0.004
Pinnipeds												
California Sea Lion	93	0.01	76	0.004	135	0.01	40	0.002	74	0.005	418	0.006
Harbor Seal	10	0.001	2	0.0001	1	0.00008	2	0.0001	0	0	15	0.0002
Northern Elephant Seal	1	0.0001	0	0	4	0.0003	0	0	0	0	5	0.00007
Unidentified Pinniped‡	39	0.005	24	0.001	8	0.0007	4	0.0002	2	0.0001	77	0.001
Overall Marine Mammal	300	**0.04**	458	**0.03**	495	**0.04**	370	**0.02**	506	**0.04**	2129	**0.03**

#Unidentified Whale includes Unidentified Baleen Whale, Unidentified Large Whale, Unidentified Medium Whale, and Unidentified Small Whale sightings.

†Unidentified Dolphin includes Unidentified Small Dolphin sightings.

‡Unidentified Pinniped includes Unidentified Marine Mammal, Unidentified Small Marine Mammal, Unidentified Sea Lion, Unidentified Medium Marine Mammal sightings.

◊Grp/km was used to stay consistent with previous reports (Smultea et al. 2011a, Jefferson et al. 2011, Carretta et al. 2000), km = kilometers

*Effort includes all leg-type efforts as follows: systematic line transect, connector (shorter legs between systematic lines), transit (point-to-point movement, usually from San Diego to study area), random (usually opportunistic effort or effort when the U.S. Navy required the plane to depart an area), and circling (circling a sighting for photographs or focal follow effort).

Table A-7. Frequency of occurrence and percentage of behavior states of seven species of marine mammals during Southern California Marine Mammal Aerial Surveys: 2008 – 2012.

	Frequency of Occurrence (Count)				Percent Occurrence			
Species	Slow travel/ Rest	Medium-Fast travel	Mill	Total No. Groups	Slow travel/ Rest	Medium-Fast travel	Mill	Total Percent
Blue Whale	11	36	11	**58**	19	62	19	**100**
Fin Whale	31	76	8	**115**	27	66	7	**100**
Gray Whale	36	40	1	**77**	1	52	47	**100**
Bottlenose Dolphin	22	60	14	**96**	23	62	15	**100**
Common Dolphin spp.	16	328	211	**555**	3	59	38	**100**
Risso's Dolphin	110	139	41	**290**	38	48	14	**100**
California Sea Lion	73	92	108	**273**	27	34	39	**100**

Table A-8. Summary of flight effort during Southern California acoustic-visual behavior study of cetaceans, February-April 2012.

Date	Flight of Day	Time Engines On	Time Engines Off	Total Engine Time (hh:mm)	Time Wheels Up	Time Wheels Down	Total Flight Time (hh:mm)	Study Area within /near Santa Catalina Basin
2/7/2012	1	15:29	16:13	0:44	15:37	16:11	0:34	Oil platform off Oxnard, Santa Barbara Channel
2/8/2012	1	7:45	9:05	1:20	7:55	9:00	1:05	~16 kilometers (km) West of Laguna Canyon
2/8/2012	2	11:34	13:57	2:23	11:39	13:55	2:16	~ 7 km West of La Jolla
2/9/2012	1	11:50	14:46	2:56	11:59	14:43	2:44	~15 km West of Carlsbad
2/10/2012	1	9:46	12:52	3:06	9:55	12:49	2:54	~5 km West of Oceanside
2/10/2012	2	14:23	17:11	2:48	14:28	17:06	2:38	~5 km Northwest of Oceanside
3/16/2012	1	12:00	15:02	3:02	12:08	14:57	2:49	~43 km West of Encinitas
3/16/2012	2	15:57	17:24	1:27	16:02	17:19	1:17	~42 km West of Carlsbad
4/2/2012	1	11:30	16:22	4:52	11:46	16:19	4:33	~18 km West of La Jolla Canyon
4/2/2012	2	17:32	19:18	1:46	17:42	19:13	1:31	~ 38 km West of La Jolla Canyon
4/3/2012	1	8:42	10:13	1:31	8:49	10:10	1:21	~16 km Southwest of La Jolla Canyon
Total Engine Time (hh:mm)				**25:55**	**Total Time Flown: (hh:mm)**		**23:42**	

Table A-9. Sonobuoy success/fail log for February 7-10, March 16, and April 2-3, 2012. Recording times were estimated based on field notes Secondary (non-focal) species encountered on some sonobuoy deployments are excluded from this focal-species list.

Date	Buoy Number	Success /Fail	Sonobuoy Mode	RF‡ Channel	Focal Species	Estimated Recording Time (hh:mm)
2/7/2012	1	Success	DF*	53	Test (Oil Platform)	N/A
2/8/2012	2	Success	DF	50	Gray Whale	0:41
2/8/2012	3	Success	DF	56	Gray Whale	0:24
2/8/2012	4	Success	DF	55	Gray Whale	0:25
2/9/2012	5	Success	DF	90	Fin Whale	1:32
2/9/2012	6	Success	DF	52	Fin Whale	1:09
2/9/2012	7	Success	DF	59	Fin Whale	0:41
2/10/2012	8	Fail	DF	54	Gray Whale	NA
2/10/2012	9	Success	DF	60	Gray Whale	1:25
2/10/2012	10	Success	DF	68	Gray Whale	1:10
2/10/2012	11	Success	DF	43	Fin Whale	0:37
2/10/2012	12	Fail	DF	47	Fin Whale	NA
3/16/2012	13	Success	DF	65	Fin Whale	1:45
3/16/2012	14	Success	DF	68	Fin Whale	1:04
3/16/2012	15	Success	DF	62	Fin Whale	0:18
4/2/2012	16	Success	DF	51	Fin Whale	0:54
4/2/2012	17	Success	DF	53	Fin Whale	0:49
4/2/2012	18	Success	CO†	61	Risso's Dolphin	0:21
4/2/2012	19	Success	CO	63	Risso's Dolphin	0:22
4/2/2012	20	Success	DF	55	Fin Whale	0:15
4/2/2012	21	Success	DF	59	Fin Whale	0:06
4/3/2012	22	Success	DF	51	Humpback Whale/Fin Whale	1:28
4/3/2012	23	Success	DF	54	Humpback Whale/Fin Whale	1:01
TOTAL 23		**91%**				**16:27**

†CO = Calibrated omni-directional, *DF = Direction-finding; ‡RF = Radio Frequency

Table A-10. Summary statistics for maximum dispersal distance between individuals (in estimated adult body lengths [BL]) within subgroups* for seven species of marine mammals sighted during Southern California Marine Mammal Aerial Surveys: 2008-2012. Species are limited to those for which statistical analyses were conducted for first-observed behaviors (minimum sample size ≥20).

Species	No. Groups	Minimum	Median	Maximum	Mean	Std Dev	Std Error	L90**	U90***
Blue Whale	22	1	6	40	12.6	13.15	2.80	7.77	17.41
Fin Whale	58	0.5	2	20	5.1	6.60	0.87	3.61	6.50
Gray Whale	47	0.1	1	20	1.5	2.86	0.42	0.80	2.20
Bottlenose Dolphin	81	0	3	55	4.9	7.60	0.84	3.51	6.33
Common Dolphin spp.	511	0.5	3	50	5.1	5.16	0.23	4.75	5.50
Risso's Dolphin	250	0.2	3	100	6.7	11.98	0.76	5.43	7.94
California Sea Lion	62	1	2	20	4.2	5.27	0.67	3.03	5.26

* Subgroup = A group (or subgroup) was defined as a set of individuals that interacted socially and/or showed coordinated activity in their behavior (Whitehead 2003; Visser et al. 2011). For delphinids, these individuals tended to be within 10-20 body lengths of one another ("nearest neighbor"); for baleen whales, especially blue whales, this distance was occasionally up to 50 body lengths.

**L90 = Lower 90% confidence limit.

***U90 = Upper 90% confidence limit.

Table A-11. Summary statistics for mean group size of seven species of marine mammals sighted during Southern California Marine Mammal Aerial Surveys: 2008-2012. Species are limited to those for which statistical analyses were conducted for first-observed behaviors (minimum sample size ≥20).

Species	No. Groups	Minimum	Median	Maximum	Mean	Std Dev	Std Error	L90*	U90**
Blue Whale	62	1	1	6	1.6	1.12	0.14	1.39	1.87
Fin Whale	115	1	2	7	1.7	0.94	0.09	1.58	1.87
Gray Whale	78	1	2	9	2.2	1.59	0.18	1.89	2.49
Bottlenose Dolphin	96	1	12	150	19.2	23.24	2.37	15.27	23.15
Risso's Dolphin	293	1	11	120	16.7	16.5	0.96	15.09	18.27
Common Dolphin spp.	566	1	110	2600	277.1	408.06	17.15	248.84	305.35
California Sea Lion	417	1	1	60	3.1	5.83	0.29	2.66	3.6

*L90 = Lower 90% confidence limit.

**U90 = Upper 90% confidence limit.

Table A-12. Variables used in statistical analyses.

Variable Code	Type of Data	Description / Definition	How Detemined
Response (i.e., dependent) variables			
behavior	category	behavior state: "slow" = slow travel/rest, "fm travel" = medium/fast travel, "mill" See Ethogram (Table 3 in Appendix D)	Field data, including video
behavioral transition	category	(fm-fm, fm-mill, fm-slow, fm-travel)	derived
maxdsp	scale	maximum dispersal distance between nearest neighbors within a subgroup based on estimated adult body lengths	Field data, including video
hdg	category	Cardinal heading/direction of movement/ orientation in degrees magnetic while traveling, determined using aircraft compass and WAAS-enabled GlobalPositiioning System (GPS). Not applicable to milling animals. NorthEast (0-90 degrees), SouthEast (90-180 degrees), SouthWest (180-270 degrees), NorthWest (270-360 degrees)	Field data, including video
bestcnt	count	best estimate of group size	field data, including photographs & video
reorientation rate	scale	change in heading per minute	derived
splitting-joining	category	variability in intra-group distances, in particular, the standard deviation in maximum dispersal	derived
Explanatory (i.e., independent) variables			
aspect	continuous	degrees magnetic to which the underwater slope faces; transformed via cosine and sine functions for analysis	Mysticetus*
boat	binomial category	presence (1) or absence (0) of a boat within 1 km of the sighting	
calendar month	category	month of the year (e.g., January, February, etc.)	calendar month

Variable Code	Type of Data	Description / Definition	How Detemined
calf	binomial category	at least one calf absent (0) or present (1)	Field data, including photographs & video
cos_asp, sin_asp	derived	aspect transformed into cosine and sine	WEST, Inc., biostatisticians calculated
datejul	scale	Julian day number (1 = January 1, each year)	derived from field data
depth_m	continuous	seafloor (bottom) bathymetric water depth in meters, positive-valued	Mysticetus*
distshore_km	continuous	closest distance to shore from sighting location in kilometers	Mysticetus*
minfromsun	continuous	time in minutes since sunrise	derived from field data
month	category	categorical month (1=Nov-Jan, 2=Feb, 3=Mar, 4=Apr, 5=May, 6=Jun-Oct)	derived from field data
timecat	category	categorical time of day ('am'[8:00-12:00], 'early pm'[12:01-16:00], 'late pm' [16:01-dusk])	derived from field data
season	category	cold-water (November-April) or warm-water season (May-October (cold = 0, warm = 1) (after Carretta et al. 2000, Lomac-MacNair et al. 2011)	derived from field data
slope	continuous	degrees of an underwater slope calculated as the maximum, three-dimensional rise over the run	Mysticetus*
subregion	binomial category	Study Area subregion relative to direction from San Clemente Island (SCI) (E = east = 0, W = west = 1). E consisted of the San Nicolas Basin east of SCI; W included the Santa Catalina Basin, Silver Strand, and the subregion South of San Clemente Island (the latter two subregions were combined with Santa Catalina Basin because they were rarely sampled)	derived from field data using Mysticetus*

*Mysticetus Geographic Information Systems (GIS) used the following databases to determine the values of these variables for sighting locations: Depth, Slope, Aspect, Distance from Shore- NOAA National Geophysical Data Center - Digital Elevation Models (DEM):
Locations near-shore: San Diego, CA, Tsunami Inundation project, 1/3 arc-second DEM http://www.ngdc.noaa.gov/dem/squareCellGrid/download/3543
Locations outside the 1/3 arc-second DEM: US Coastal Relief Model, Southern California (region 6), 3 arc-second DEM
http://www.ngdc.noaa.gov/mgg/coastal/grddas06/grddas06.htm

Table A-13. Number of kilometers of all flight effort by Beaufort sea state during 2008-2012 aerial monitoring for marine mammals on the U.S. Navy's Southern California Range Complex.

BF	2008	2009	2010	2011	2012	Total	% of Total
0	181	0	0	60	43	284	0.004
1	2009	675	702	2449	2331	8166	13
2	1306	3399	4398	8117	5589	22810	35
3	1225	6888	5196	7676	4221	25206	39
4	595	3562	691	1936	1093	7877	12
5	0	0	0	642	163	805	1
6	0	0	0	17	73	90	0.001
Total	**5317**	**14516**	**10977**	**21371**	**14374**	**65238**	**100**

Table A-14. Number of vessels and aircraft sighted by type along systematic line-transect lines in 2011 and 2012 flown during Southern California Marine Mammal Aerial Surveys. Systematic counts of vessels and aircraft began during the April 2011 survey and continued through three winter surveys in 2012.

Vessel & Aircraft Type*	Count	No. Vessel Sightings per Unit Effort (SPUE) (# / km flown)	Percent of Total Sightings
Helicopter	2	0.0002	1
Large Boat	52	0.005	21
Medium Boat	17	0.001	7
U.S. Navy Aircraft	4	0.0004	2
U.S. Navy Boat Large	19	0.002	8
U.S. Navy Boat Medium	10	0.001	4
Sailboat	51	0.005	21
Small Boat	86	0.008	35
U.S. Navy Submarine	3	0.0006	1
Total	**244**	**0.02**	**100**

*Boat size definition = <30 m= small, 30-100 m = medium, and >100 m = large.

Table A-15. Locations and distances from shore of baleen and sperm whale groups with calf during Southern California Marine Mammal Aerial Surveys.

Date	Species	Latitude (N)	Longitude (W)	Distance From Mainland Coastline in km◊	Distance From Mainland Coastline in nm‡	Distance To Nearest Land* in km	Distance To Nearest Land* in nm
10/21/2008 13:32:01	Fin Whale	33.050583	-117.770466	43	23	43	23
06/06/2009 14:12:06	Fin Whale	32.910380	-119.182070	180	97	59	32
06/07/2009 14:57:07	Fin Whale	32.733340	-118.677350	133	72	23	13
05/14/2010 11:26:13	Fin Whale	33.117933	-118.957217	151	81	34	18
08/02/2010 15:55:28	Blue Whale	33.188333	-117.929833	50	27	37†	20†
02/15/2011 08:45:08	Gray Whale	32.821500	-117.311333	3	2	3	2
04/01/2011 10:02:48	Gray Whale	33.031000	-118.716667	132	71	10	5
04/15/2011 09:16:24	Fin Whale	32.773167	-117.589500	30	16	72	39
04/19/2011 12:55:38	Gray Whale	33.071833	-117.475333	15	8	89	48
05/14/2011 10:36:14	Sperm Whale	32.617000	-117.726167	54	29	63	34
02/01/2012 14:39:02	Gray Whale	33.181023	-117.935125	52	28	38†	20†
02/03/2012 11:05:29	Gray Whale	32.965845	-118.869215	147	79	27	15
02/03/2012 14:44:05	Fin Whale	32.793438	-118.112289	78	42	23	12
03/13/2012 15:46:33	Fin Whale	32.967203	-117.783081	47	25	55	30

*San Clemente Island
†Santa Catalina Island
◊km = kilometers
‡nm = nautical miles

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APPENDIX B: FIGURES

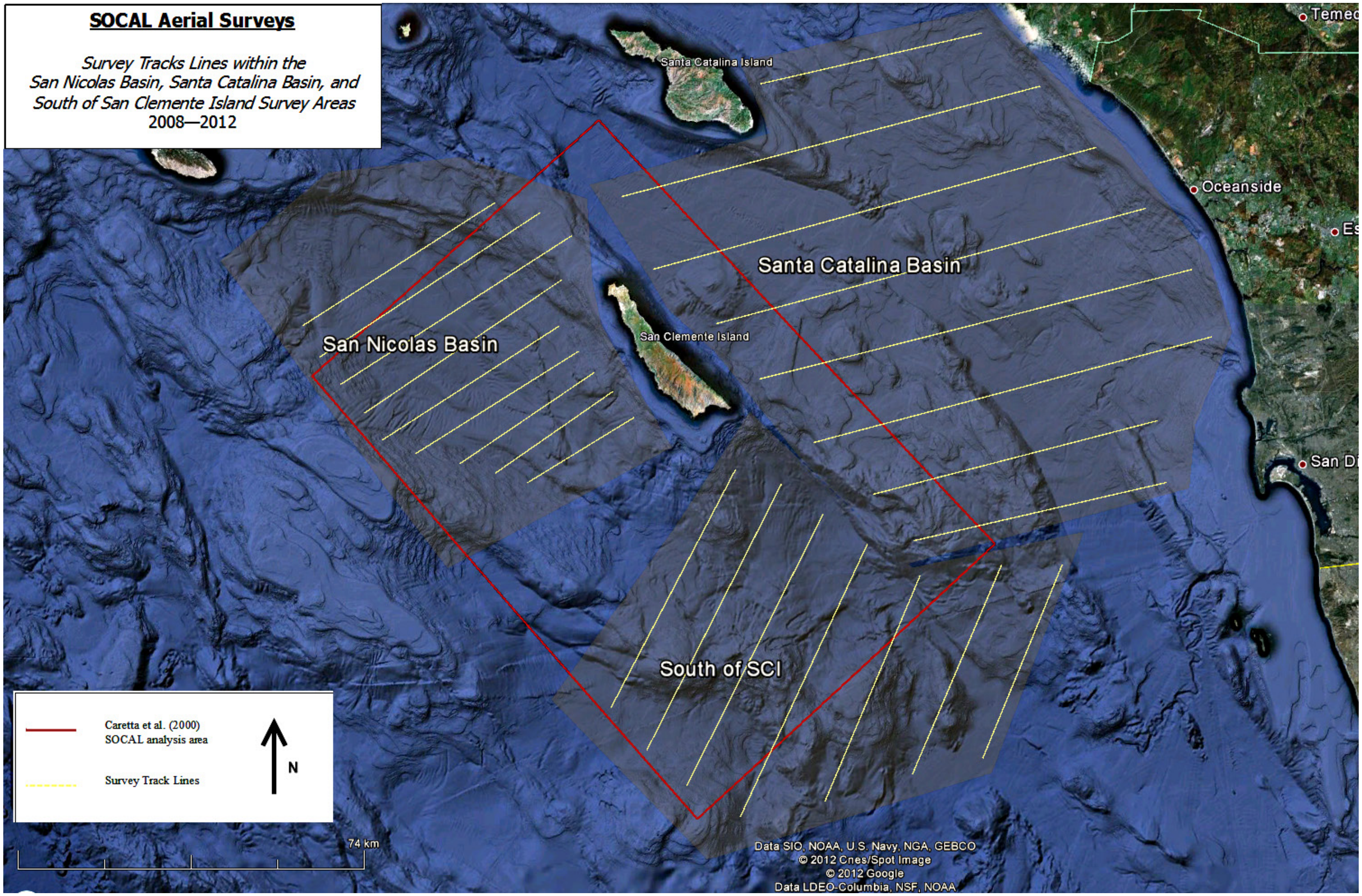

Figure B-1. Pre-determined survey tracklines (yellow lines) within the U.S. Navy's Southern California Range Complex study area 2008 – 2012. The shaded polygons delineate the primary study area within the SOCAL Range Complex (i.e., study area) subregions. The red box indicates the analysis study area used by Carretta et al. (2000) for aerial surveys of marine mammals in 1998-1999.

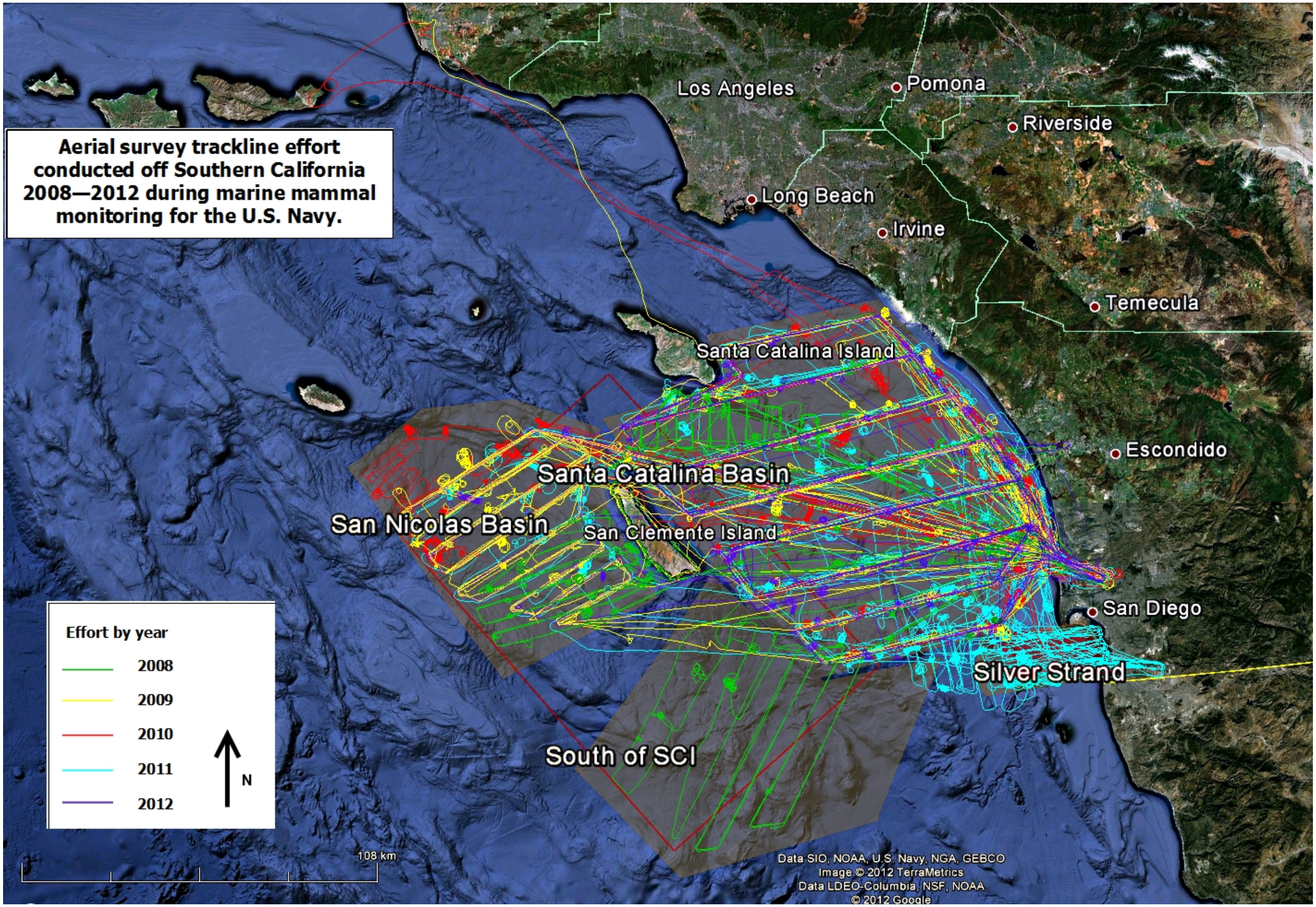

Figure B-2. All aerial survey effort within the U.S. Navy's Southern California Range Complex study area: 2008 – 2012. Different colored lines indicate different survey years.

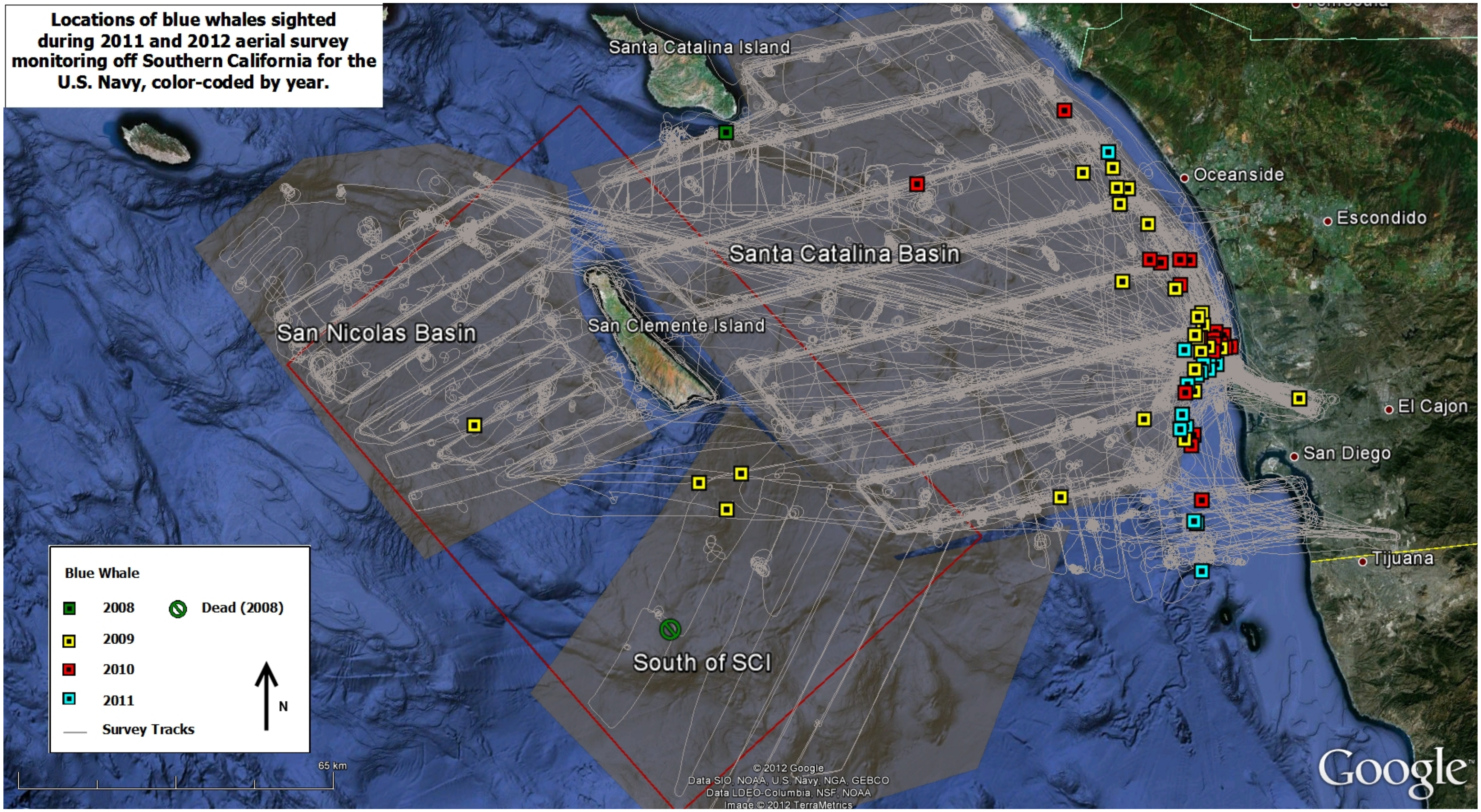

Figure B-4. Blue whale (*Balaenoptera musculus*) sightings in the SOCAL Range Complex study area: 2008 - 2012. Note: no sightings of blue whales in 2012, though all survey effort in 2012 and most in 2011 occurred during the cold-water period (November-April)(see Table 1 in Appendix A). Light-colored lines indicate all survey effort 2008-2012.

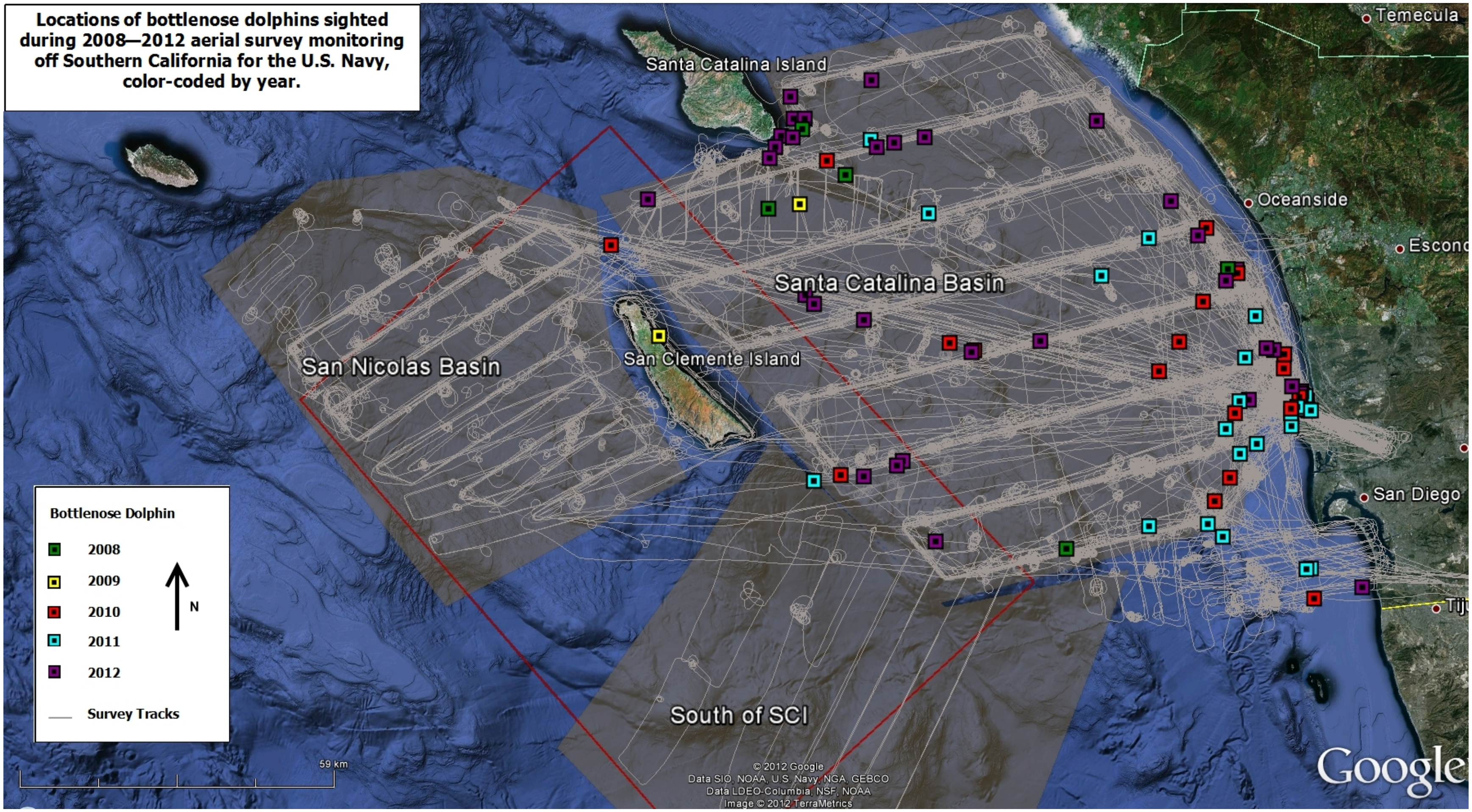

Figure B-5. Bottlenose dolphin (*Tursiops truncatus*) sightings in the SOCAL Range Complex study area 2008 – 2012. Light-colored lines indicate all survey effort 2008-2012.

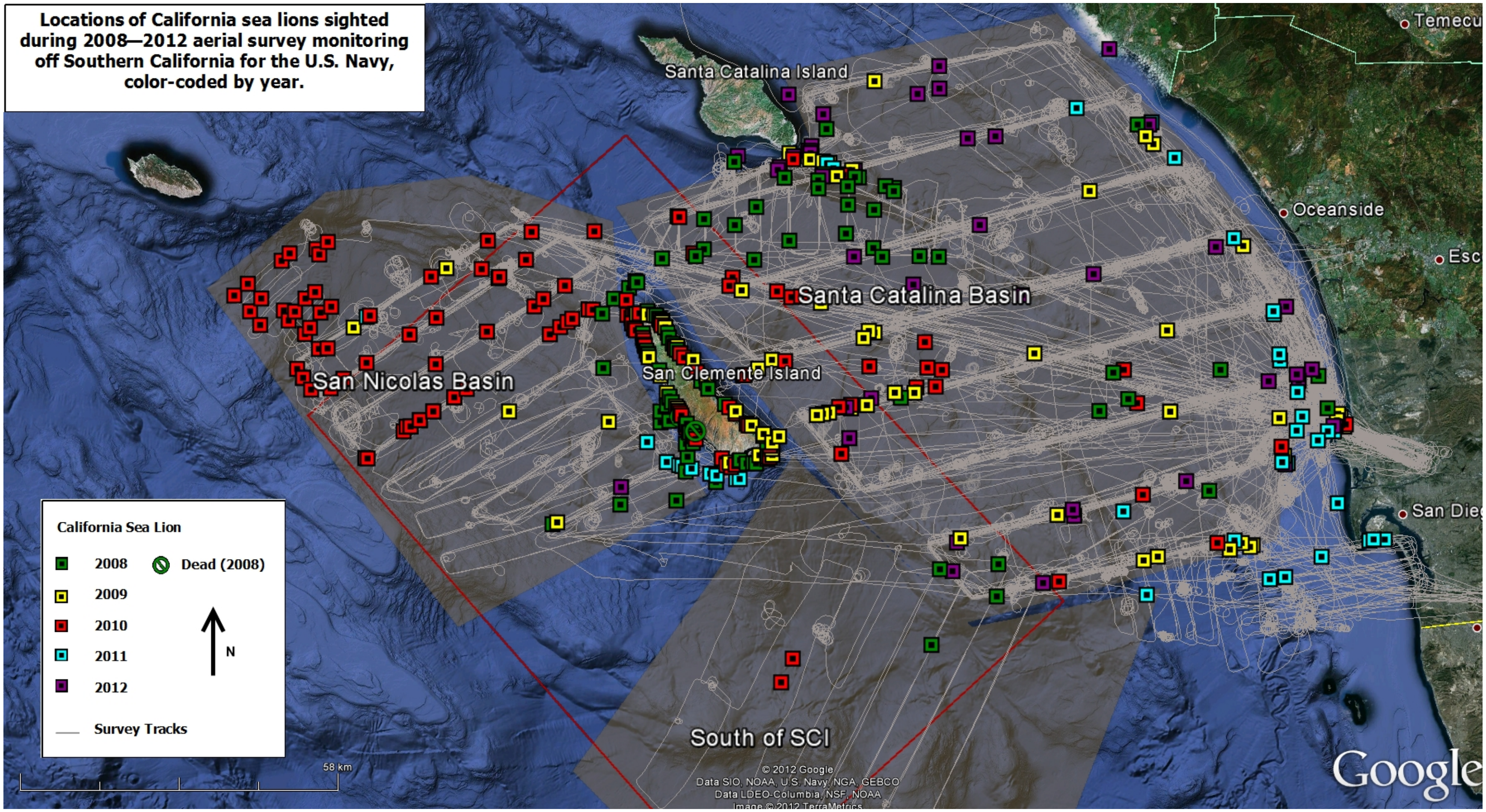

Figure B-6. California sea lion (*Zalophus californianus*) sightings in the SOCAL Range Complex study area 2008 – 2012. Light-colored lines indicate all survey effort 2008-2012. Note that the aircraft circumnavigated the shoreline of San Clemente Island only in 2008 and 2009 (see Table 1 in Appendix A).

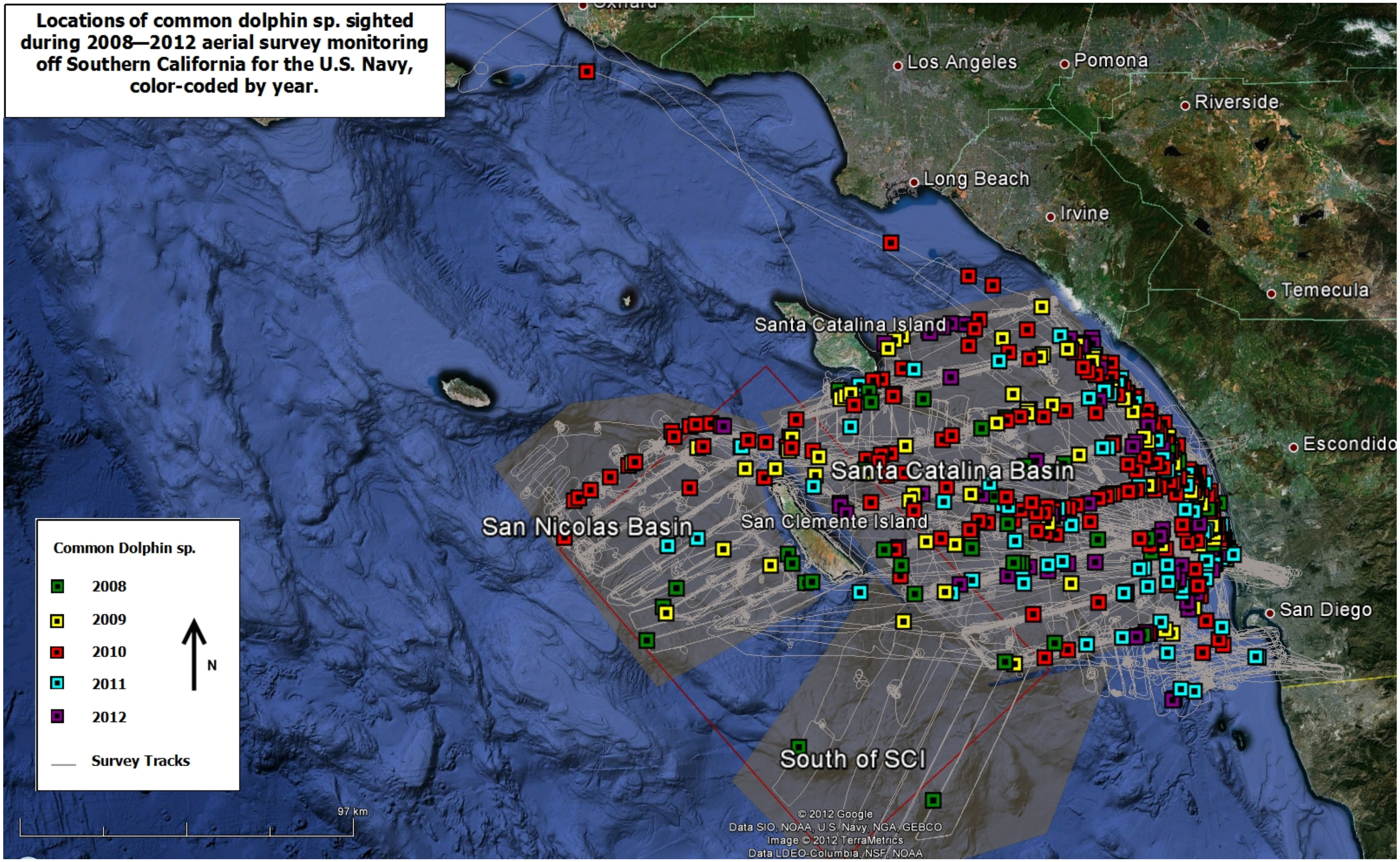

Table B-7. Common dolphin sp. (*Delphinus* sp.) sightings in the SOCAL Range Complex study area 2008 – 2012. Light-colored lines indicate all survey effort 2008-2012. These sightings could not be differentiated between short-beaked (*Delphinus delphis*) and long-beaked (*Delphinus capensis*) common dolphins (usually because they were too far away from the aircraft track line).

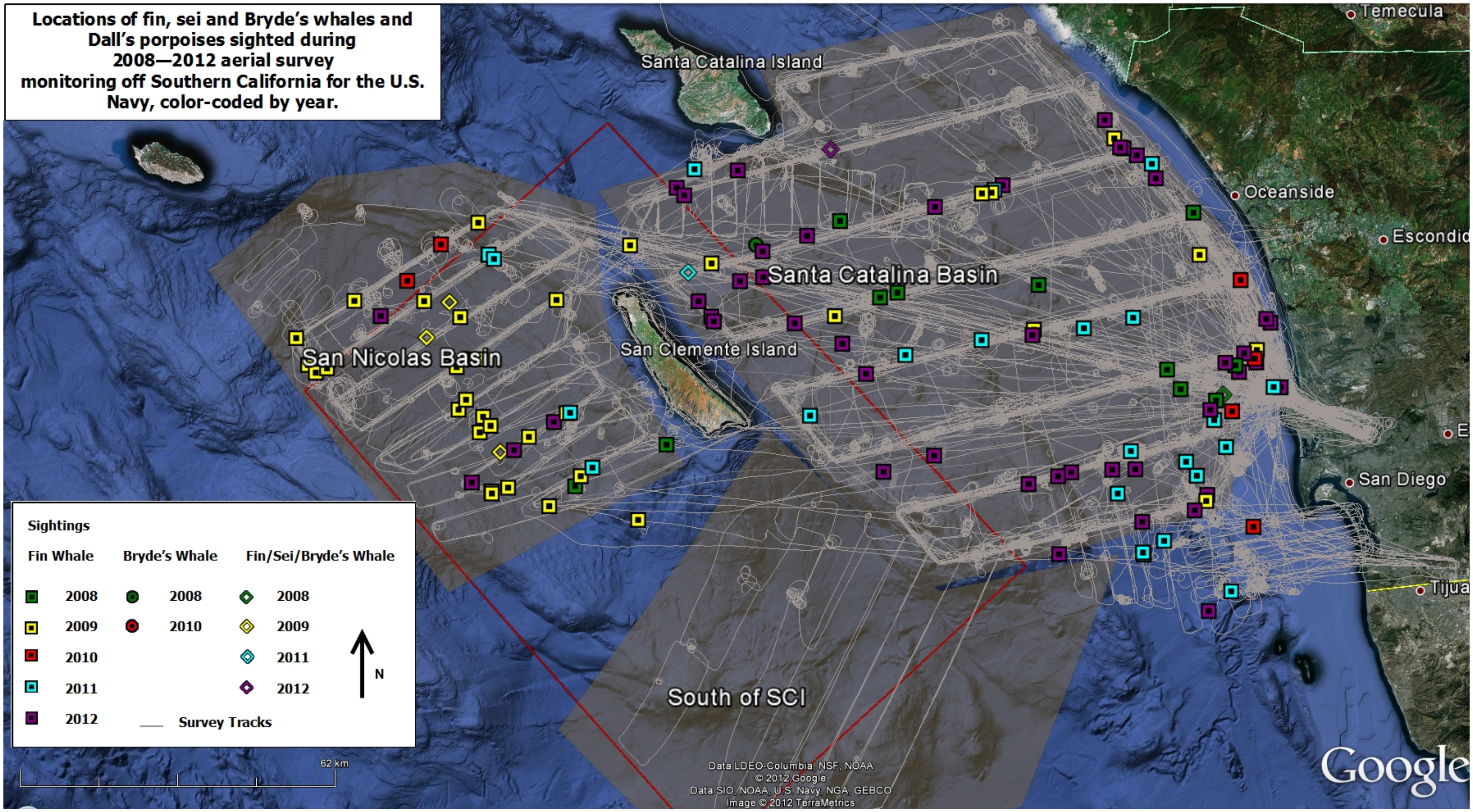

Figure B-8. Fin whale (*Balaenoptera physalus*), Bryde's whale (*Balaenoptera edeni/brydei*), and fin/sei (*Balaenoptera borealis*)/Bryde's whale sightings in the SOCAL Range Complex study area 2008 – 2012.

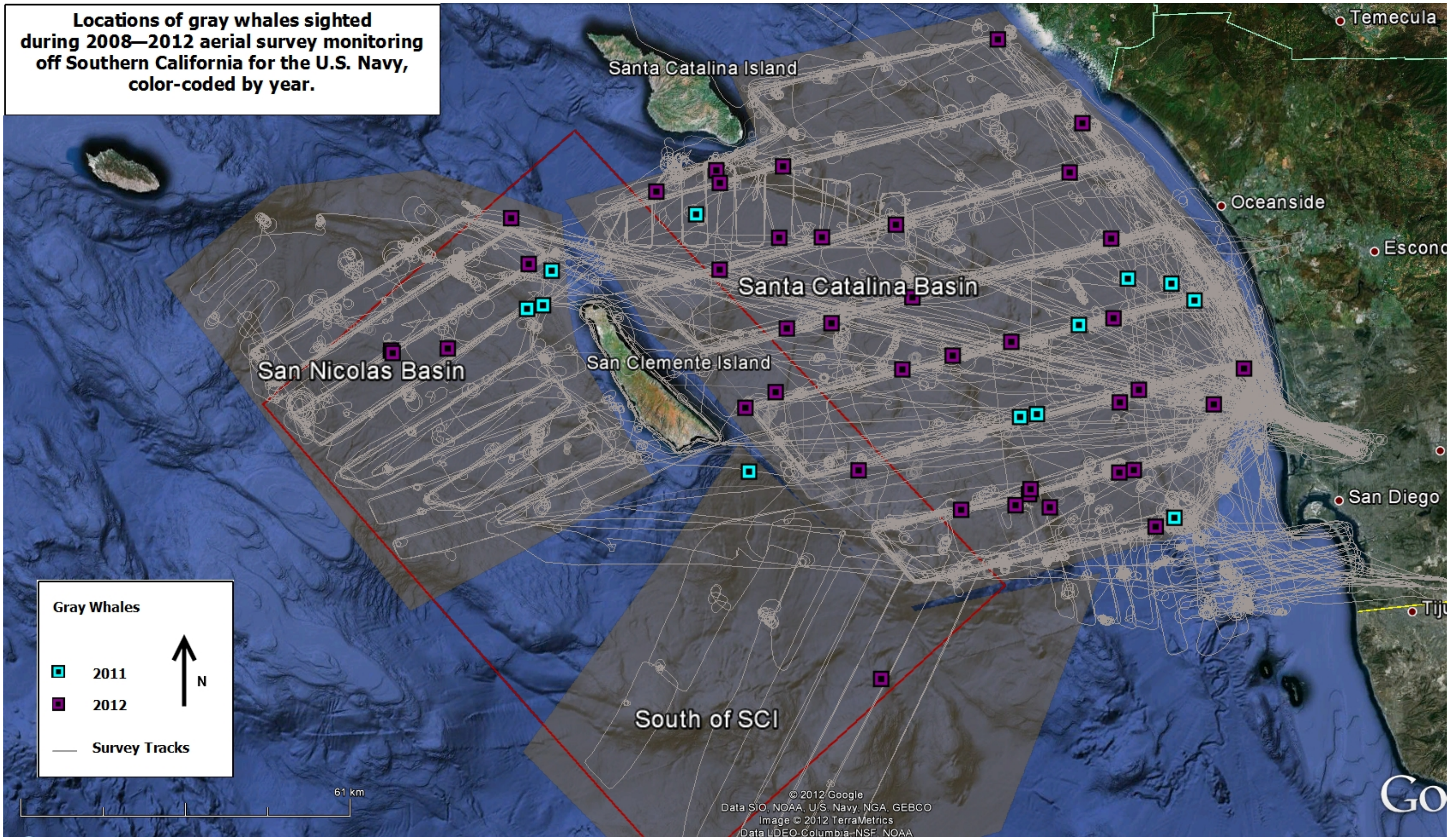

Figure B-9. Gray whale (*Eschrichtius robustus*) sightings in the SOCAL Range Complex study area 2008 – 2012. Light-colored lines indicate all survey effort 2008-2012. Note that survey effort occurred during January-April only in 2011 and 2012. Effort in 2008 occurred in October-November, in 2009 between June and November, and in 2010 between May and Septemer (see Table 1 in Appendix A).

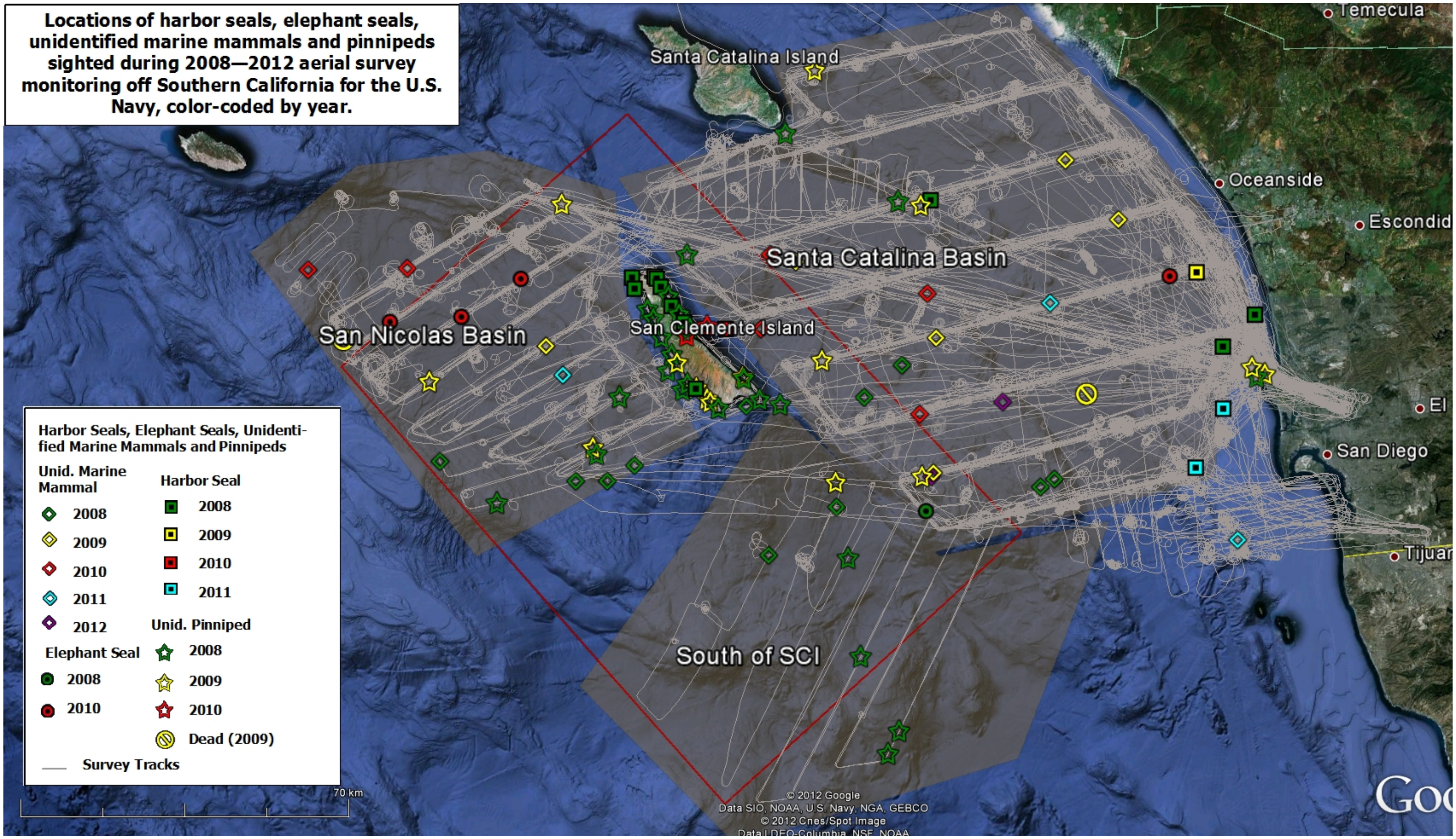

Figure B-10. Unidentified marine mammals and Phocid sightings in the SOCAL Range Complex study area 2008 – 2012. Light-colored lines indicate all survey effort 2008-2012. Note that the aircraft circumnavigated the shoreline of San Clemente Island only in 2008 and 2009 (see Table 1 in Appendix A).

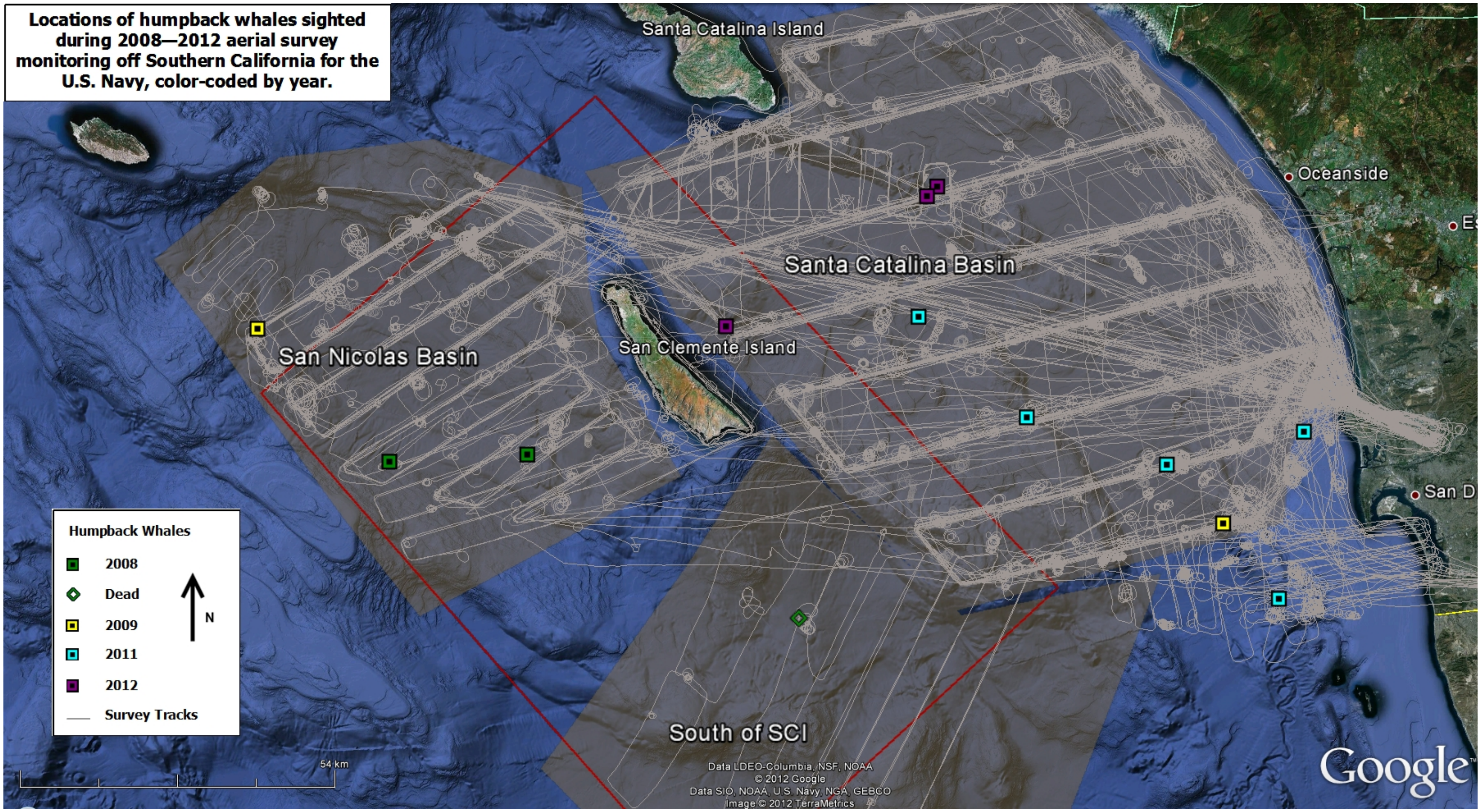

Figure B-11. Humpback whale (*Megaptera novaeangliae)* sightings in the SOCAL Range Complex study area 2008 – 2012. Light-colored lines indicate all survey effort 2008-2012.

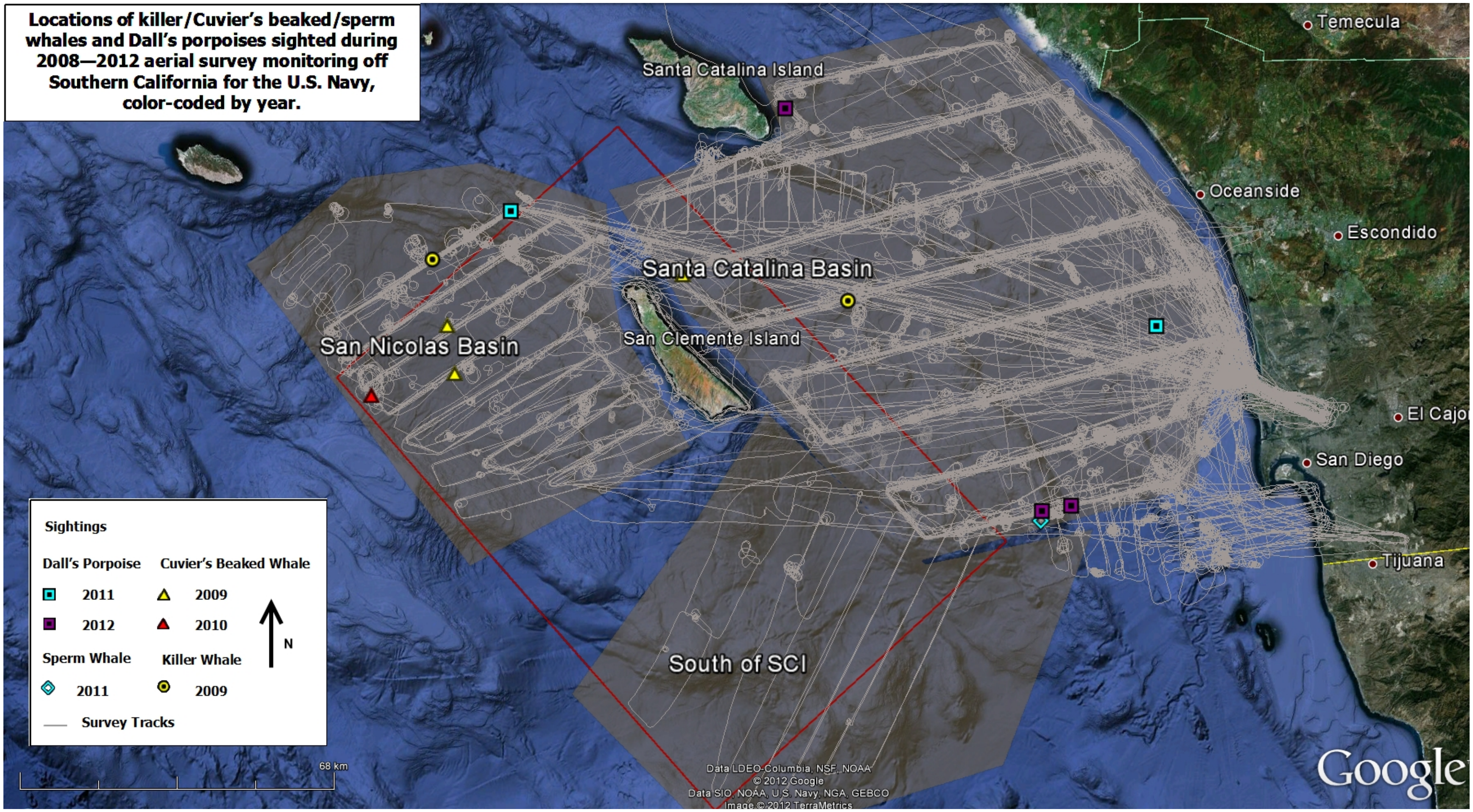

Figure B-12. Killer whale (*Orcinus orca),* Cuvier's beaked whale *(Ziphius cavirostris),* Dall's porpoise *(Phocoenoides dalli) and* sperm whale *(Physeter macrocephalus)* sightings in the SOCAL Range Complex study area 2008 – 2012. Light-colored lines indicate all survey effort 2008-2012.

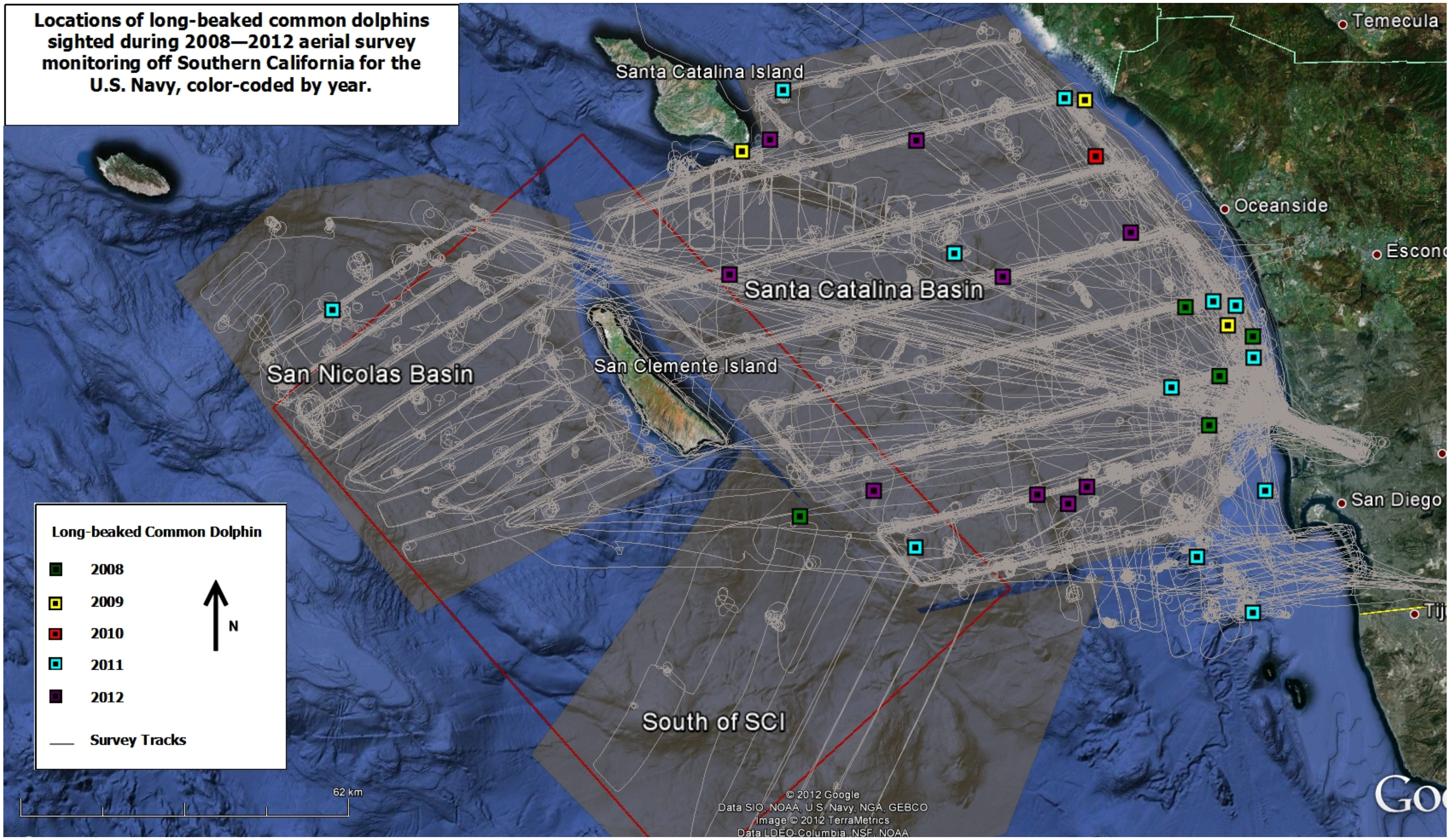

Figure B-13. Long-beaked common dolphin (*Delphinus capensis)* sightings in the SOCAL Range Complextudy area 2008 – 2012. Light-colored lines indicate all survey effort 2008-2012. These sightings are limited to confirmed species sightings. See Common Dolphin spp. figure in this appendix for unidentified common dolphin sightings that presumably include both short-beaked and long-beaked common dolphins.

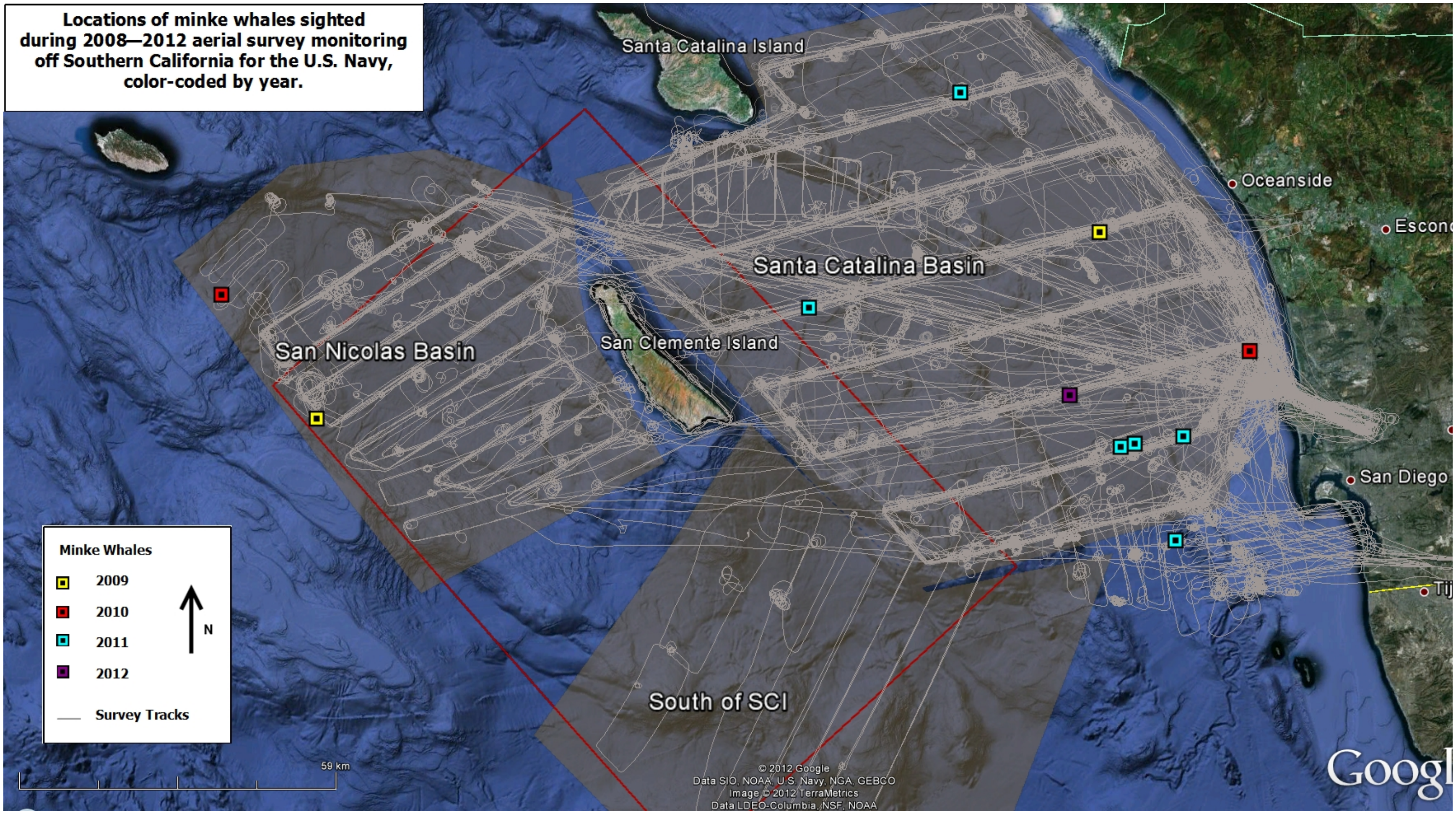

Figure B-14. Minke whale (*Balaenoptera acutorostrata)* sightings in the SOCAL Range Complex study area 2008 – 2012. Light-colored lines indicate all survey effort 2008-2012.

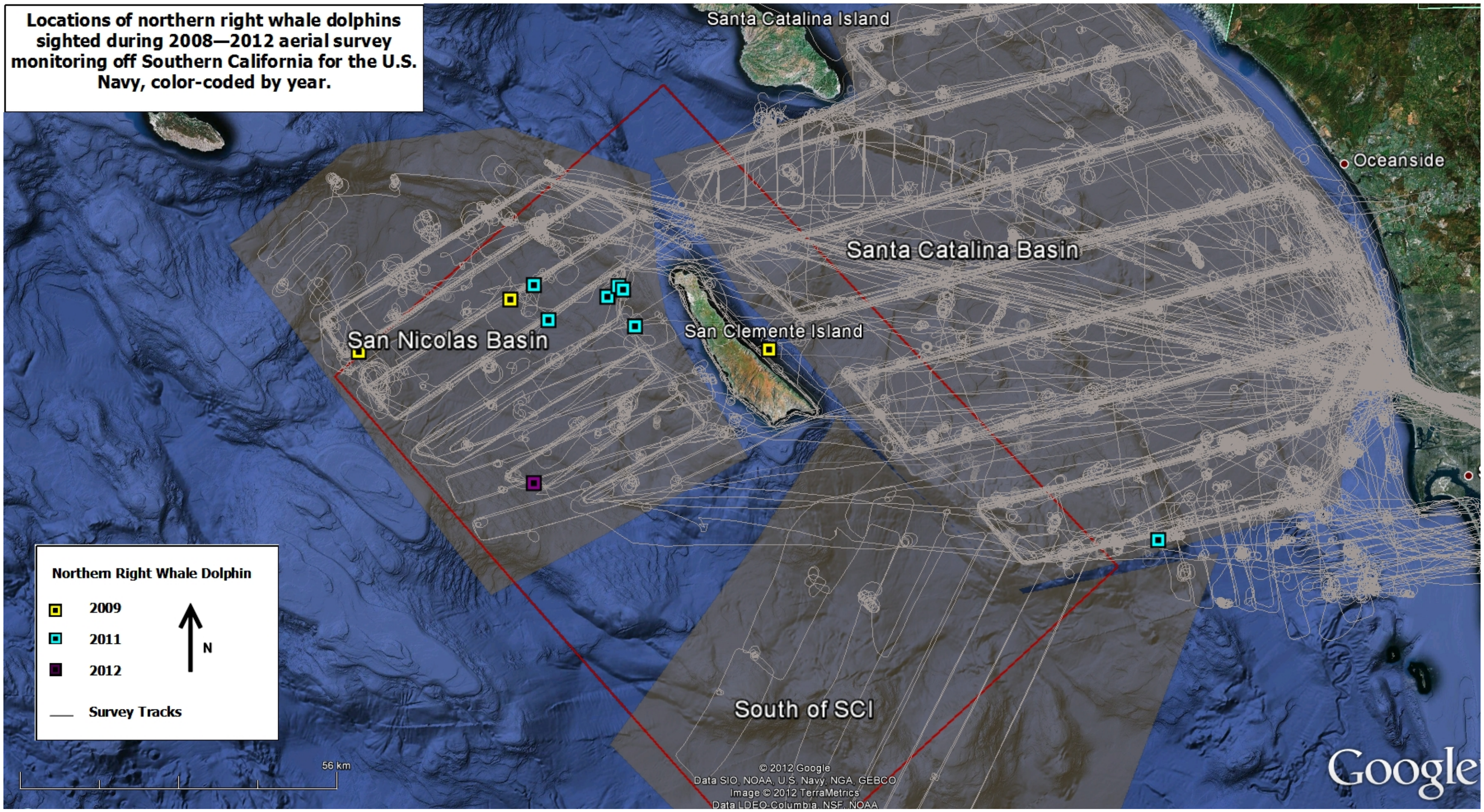

Figure B-15. Northern right whale dolphin (*Lissodelphis borealis)* sightings in the SOCAL Range Complex study area 2008-2012. Light-colored lines indicate all survey effort 2008-2012. Note that survey effort in 2011 and 2012 occurred primarily during the cold-water season (November-April) while effort in 2009 and 2010 occurred primarily during the warm-water season (May-October); effort in 2008 occurred in October-November (see Table 1 in Appendix A).

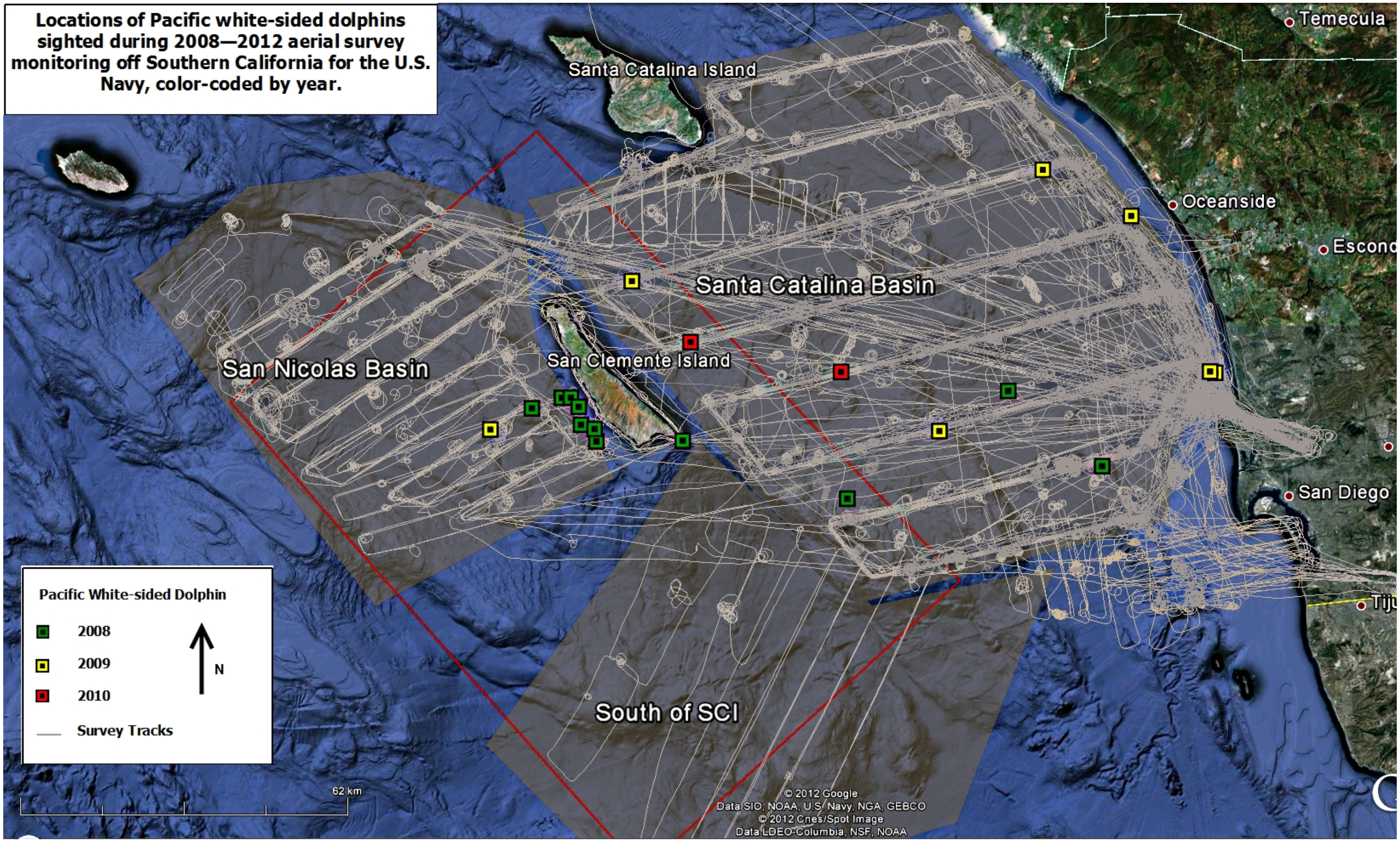

Figure B-16. Pacific white-sided dolphin (*Lagenorhynchus obliquidens)* sightings in the SOCAL Range Complex study area 2008-2012. Light-colored lines indicate all survey effort 2008-2012. Note that survey effort in 2011 and 2012 occurred primarily during the cold-water season (November-April) while effort in 2009 and 2010 occurred primarily during the warm-water season (May-October); effort in 2008 occurred in October-November (see Table 1 in Appendix A).

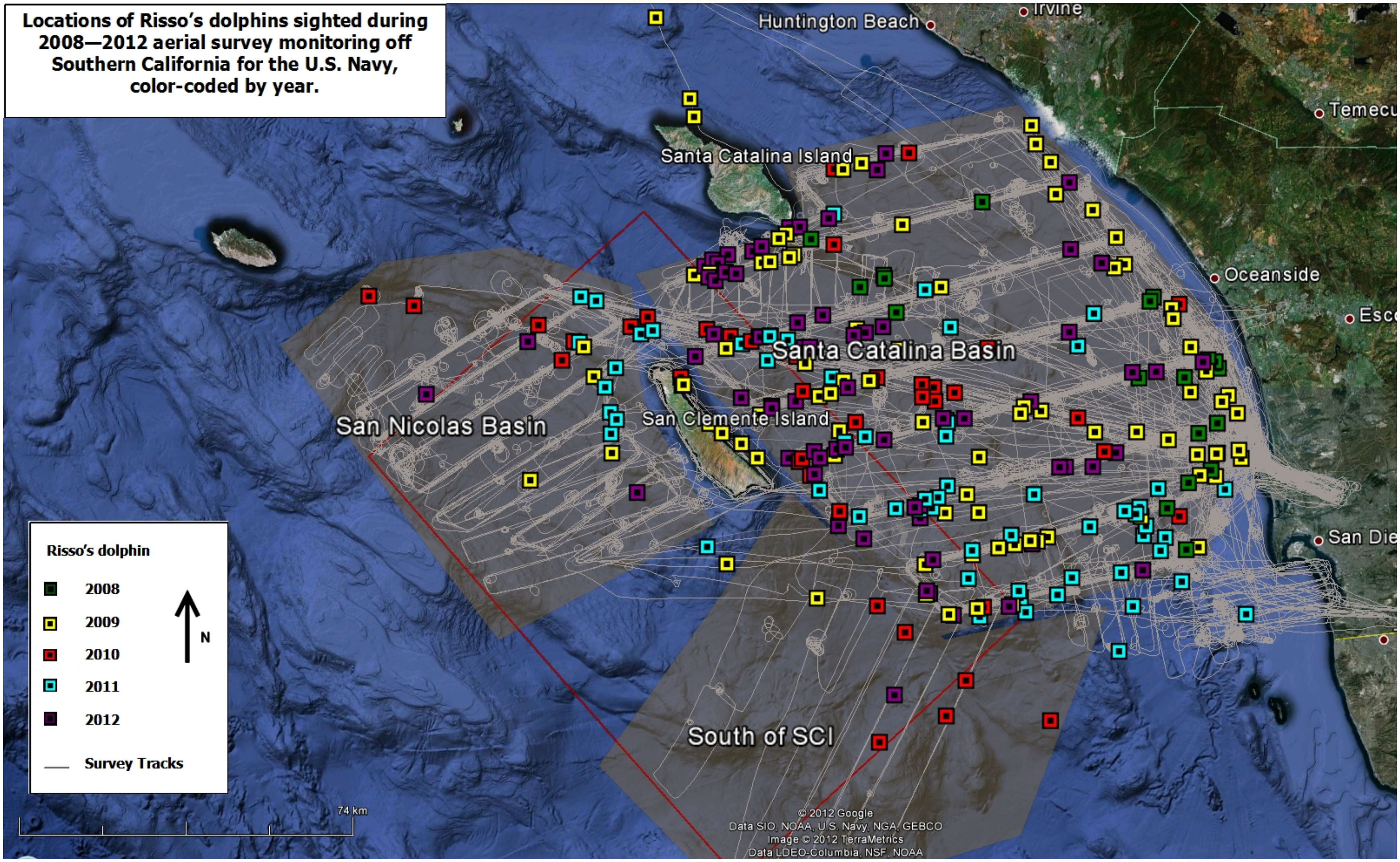

Figure B-17. Risso's dolphin (*Grampus griseus)* sightings in the SOCAL Range Complex study area 2008-2012. Light-colored lines indicate all survey effort 2008-2012. Note that survey effort in 2011 and 2012 occurred primarily during the cold-water season (November-April) while effort in 2009 and 2010 occurred primarily during the warm-water season (May-October); effort in 2008 occurred in October-November (see Table 1 in Appendix A).

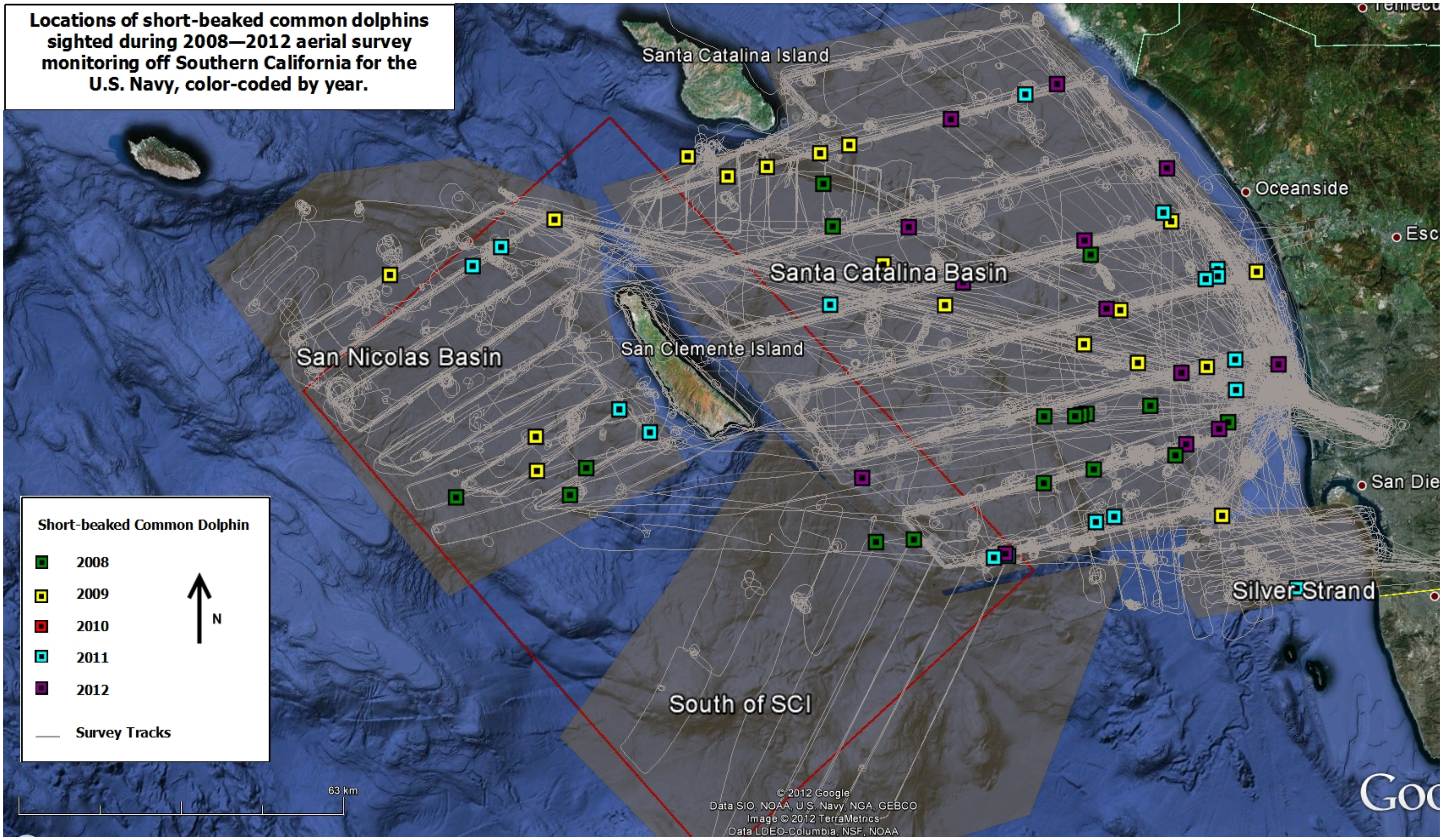

Figure B-18. Short-beaked common dolphin (*Delphinus delphis*) sightings in the SOCAL Range Complex study area 2008-2012. Light-colored lines indicate all survey effort 2008-2012. These sightings are limited to confirmed species sightings. See Common Dolphin spp. figure in this appendix for unidentified common dolphin sightings that presumably include both short-beaked and long-beaked common dolphins.

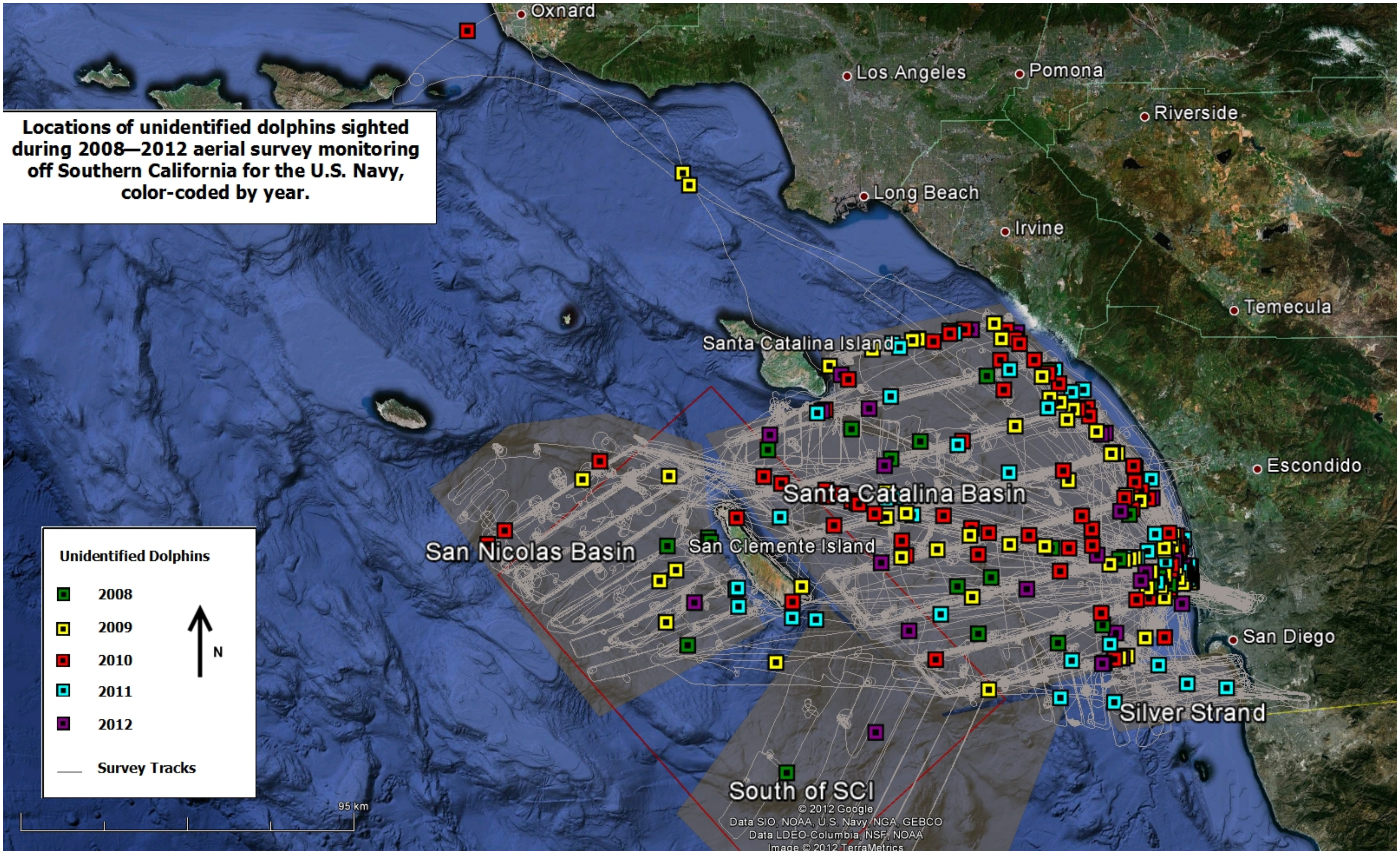

Figure B-19. Unidentified dolphin sightings in the SOCAL Range Complex study area 2008-2012. Light-colored lines indicate all survey effort 2008-2012.

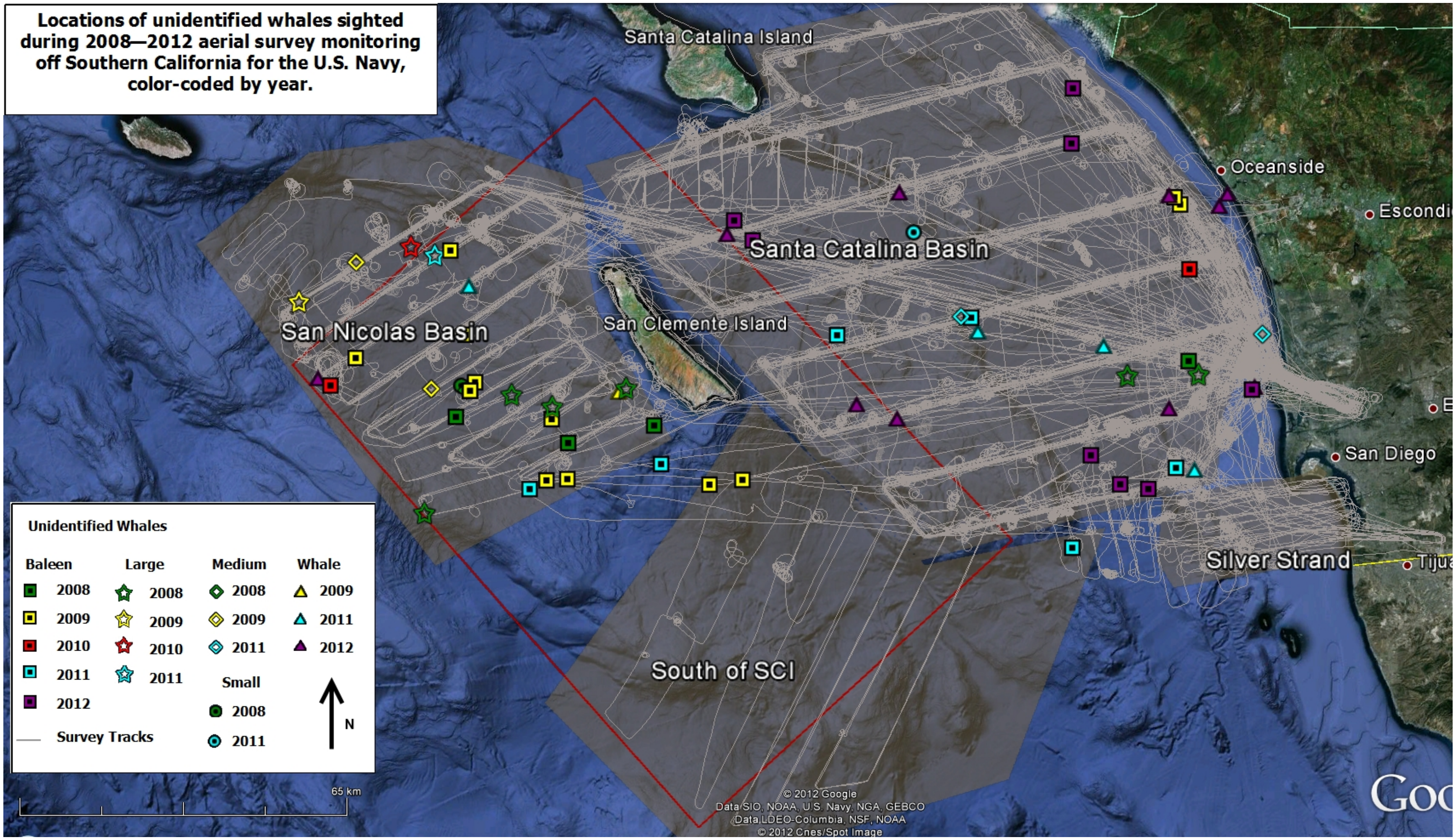

Figure B-20. Unidentified whale sightings in the SOCAL Range Complex study area 2008-2012. Light-colored lines indicate all survey effort 2008-2012.

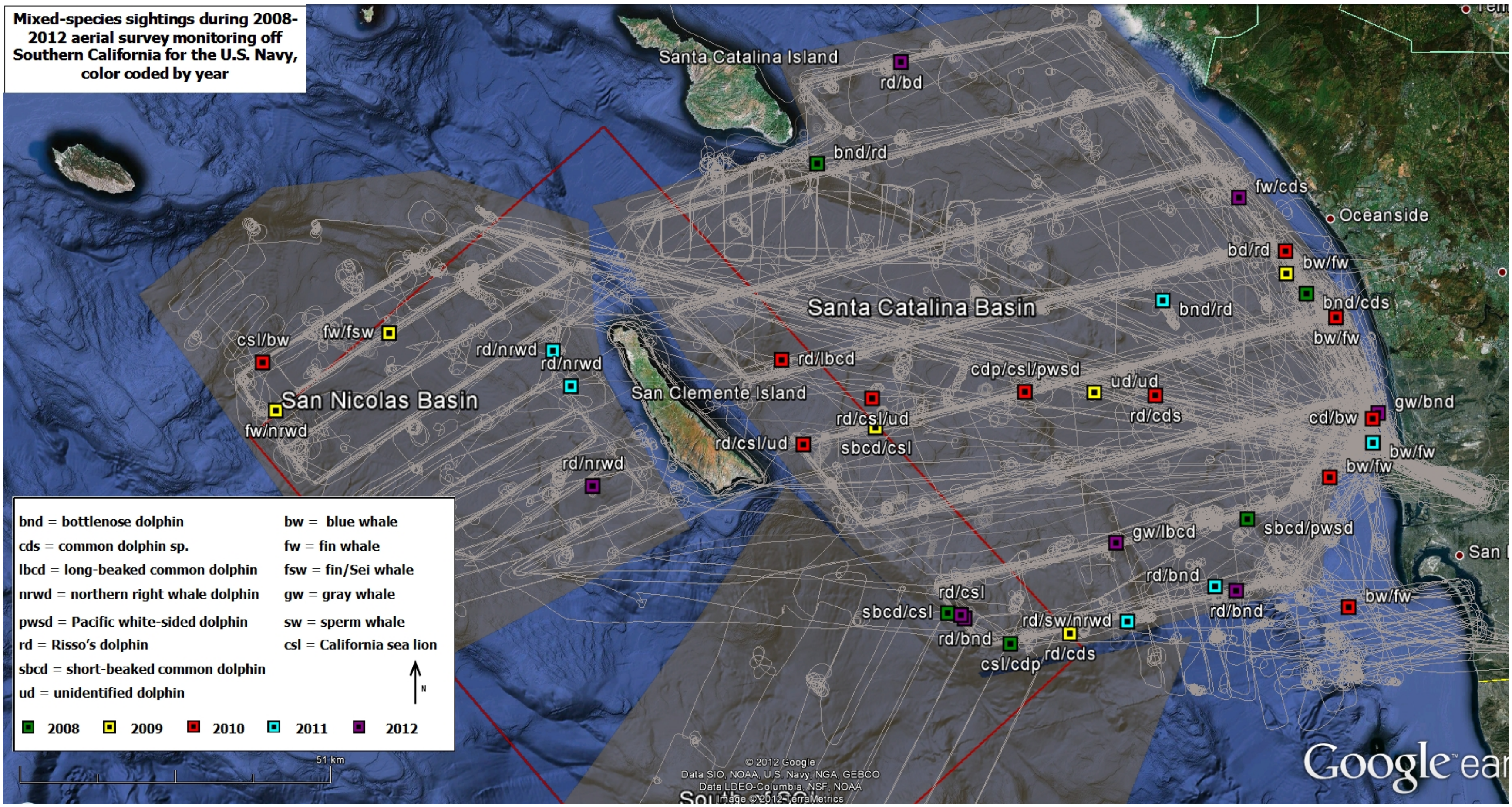

Figure B-21. Mixed-species sightings in the SOCAL Range Complex study area 2008-2012. Light-colored lines indicate all survey effort 2008-2012. See key for species codes corresponding to sighting locations on the map.

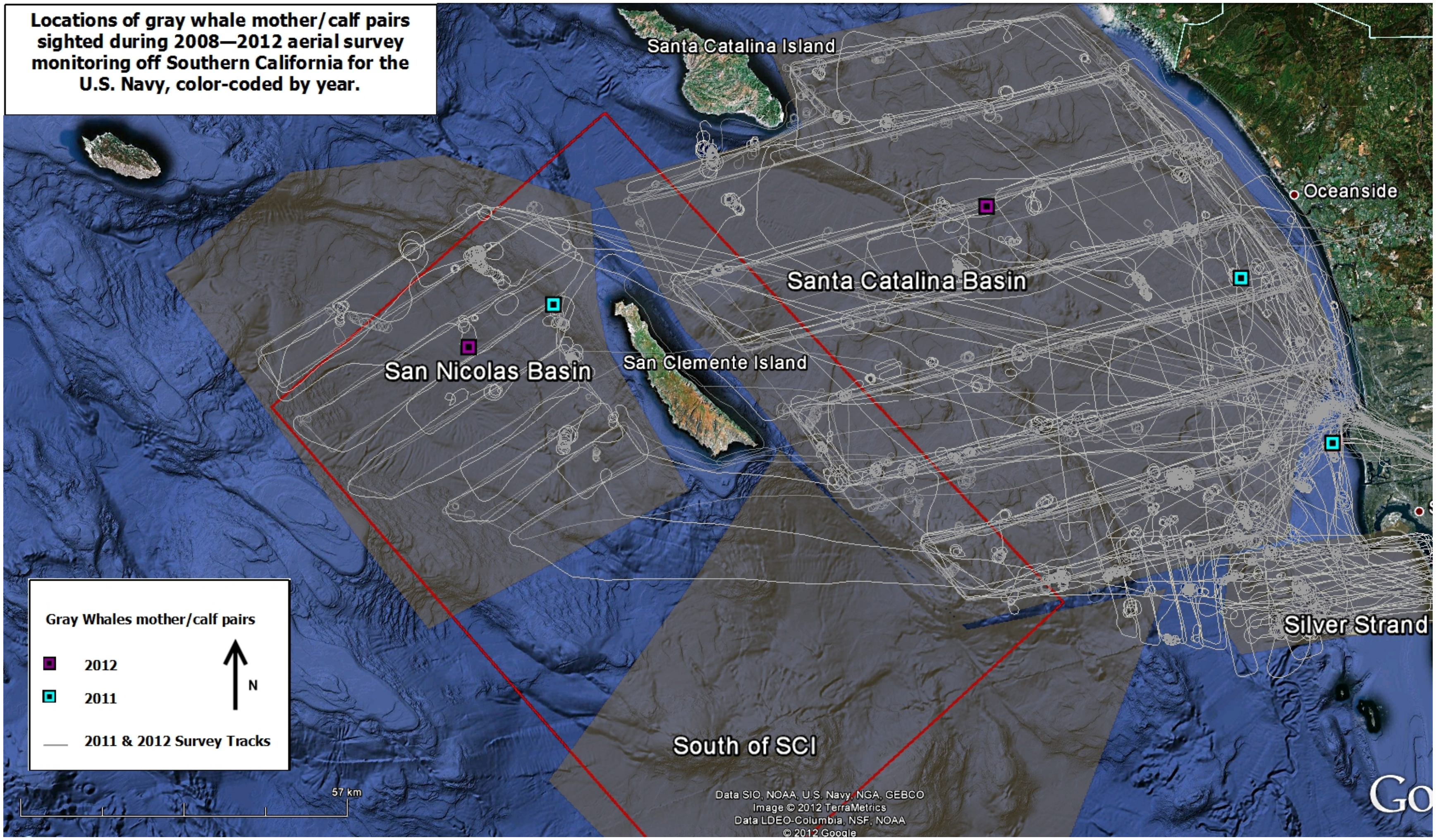

Figure B-22. Gray whale (*Eschrichtius robustus*) mother/calf pair sightings in the SOCAL Range Complex study area 2008-2012. Light-colored lines indicate all survey effort 2011-2012. See key for species codes corresponding to sighting locations on the map. Note: Gray whales were only seen in 2011-2012 during the cold-water surveys.

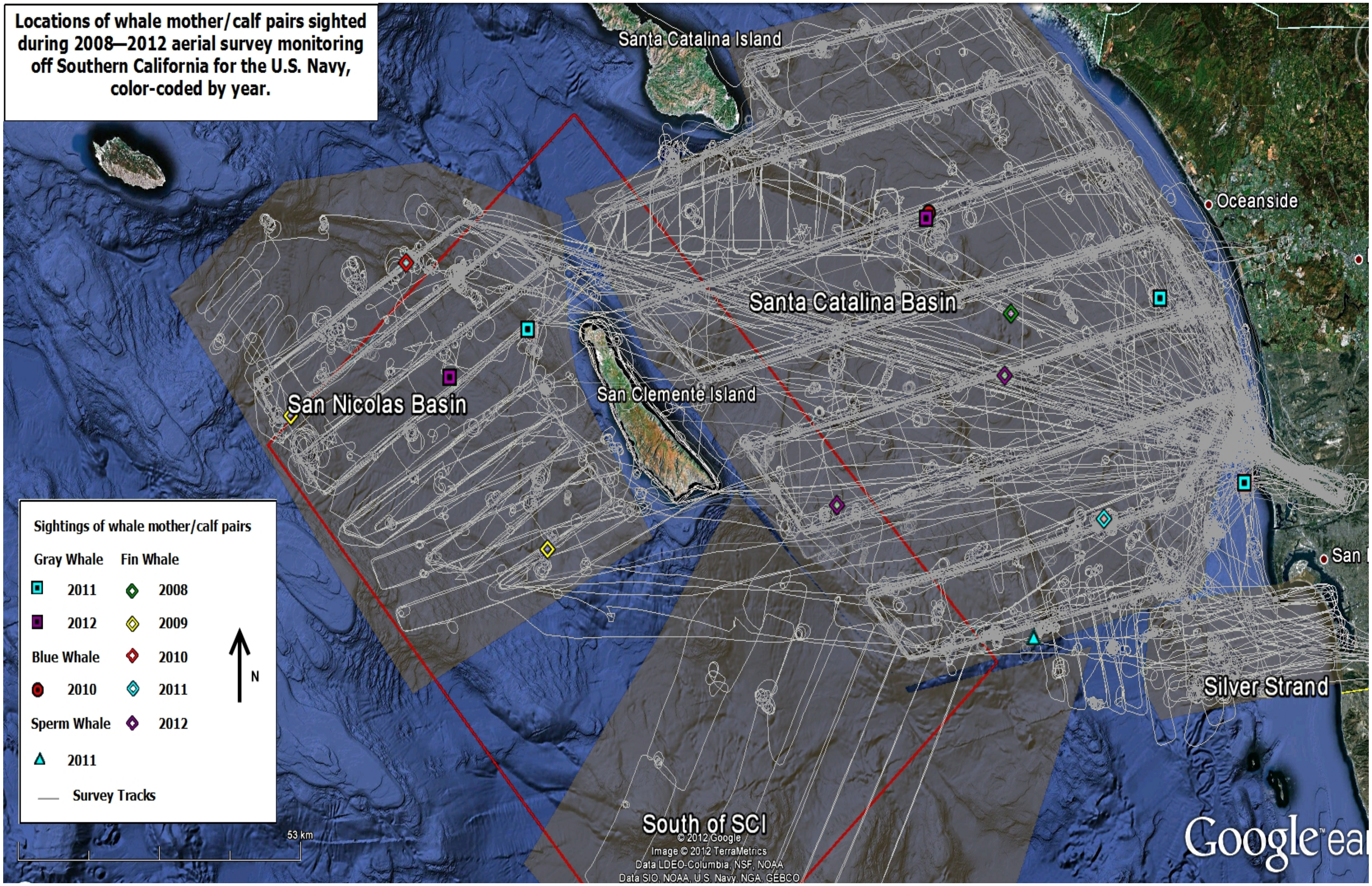

Figure B-23. Blue (*Balaenoptera musculus*), gray (*Eschrichtius robustus*), fin (*Balaenoptera physalus*) and sperm whale mother/calf pair sightings in the SOCAL Range Complex study area 2008-2012. Light-colored lines indicate all survey effort 2008-2012. See key for species codes corresponding to sighting locations on the map.

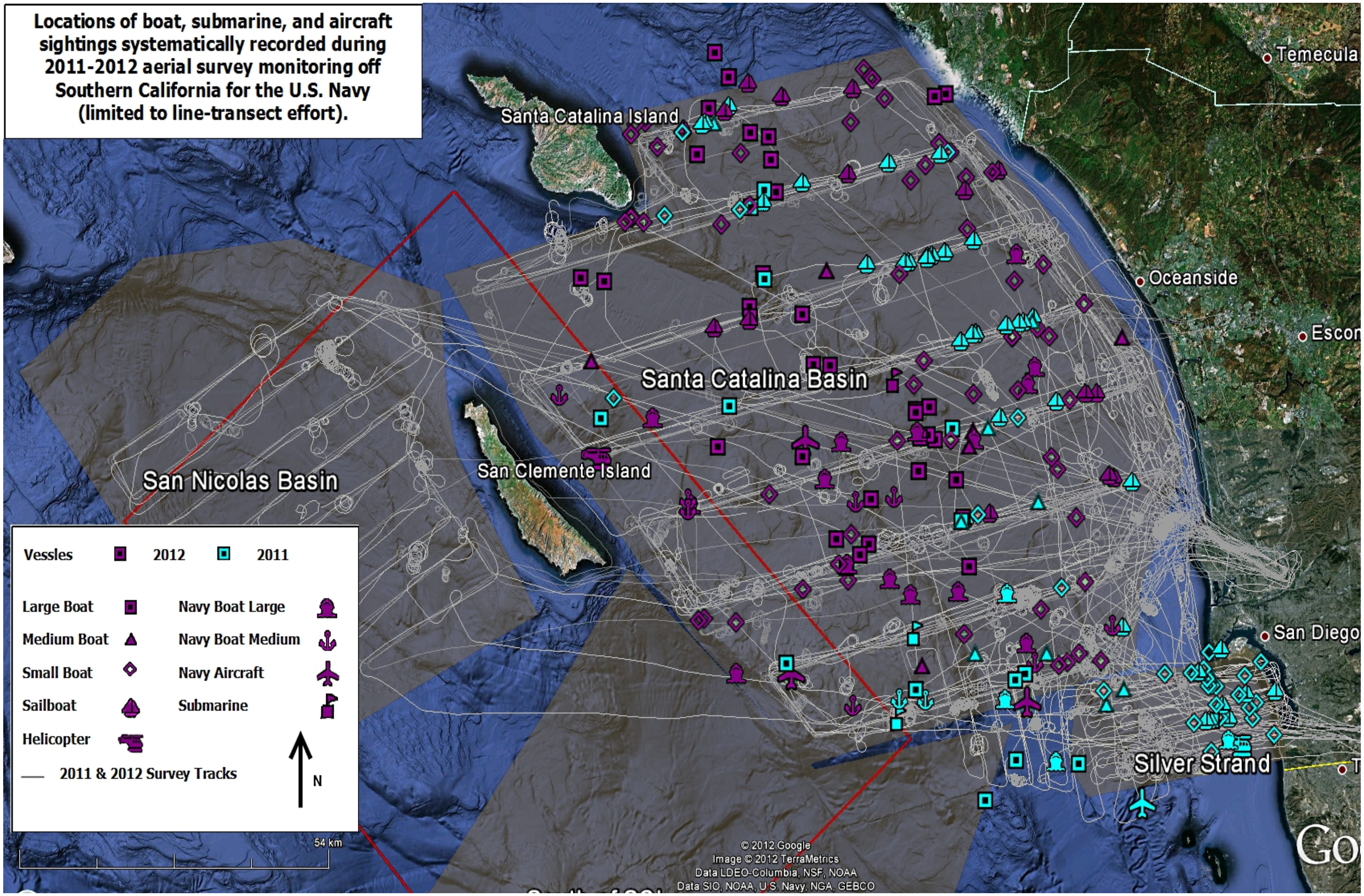

Figure B-24. Sightings of vessels and aircraft made from the observation aircraft during systematic line transect effort in the SOCAL Range Complex study area 2008-2012. Light-colored lines indicate all survey effort 2011-2012. See key for species codes corresponding to sighting locations on the map.

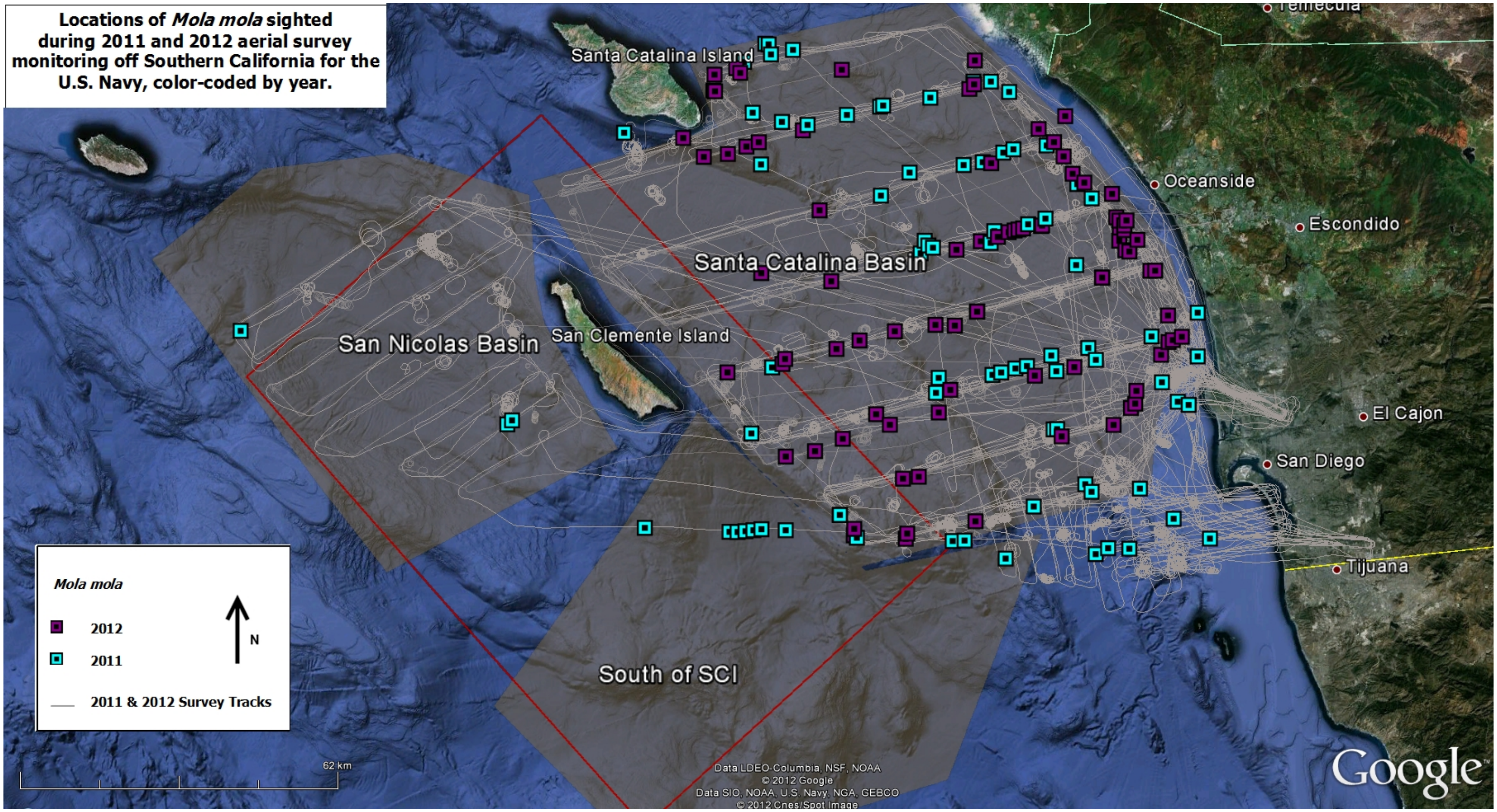

Figure B-25. Ocean sunfish (*Mola mola)* sightings in the SOCAL Range Complex study area 2011- 2012. Light-colored lines indicate all survey effort 2008-2012. Note that locations of mola mola sightings were recorded systematically only beginning in 2012.

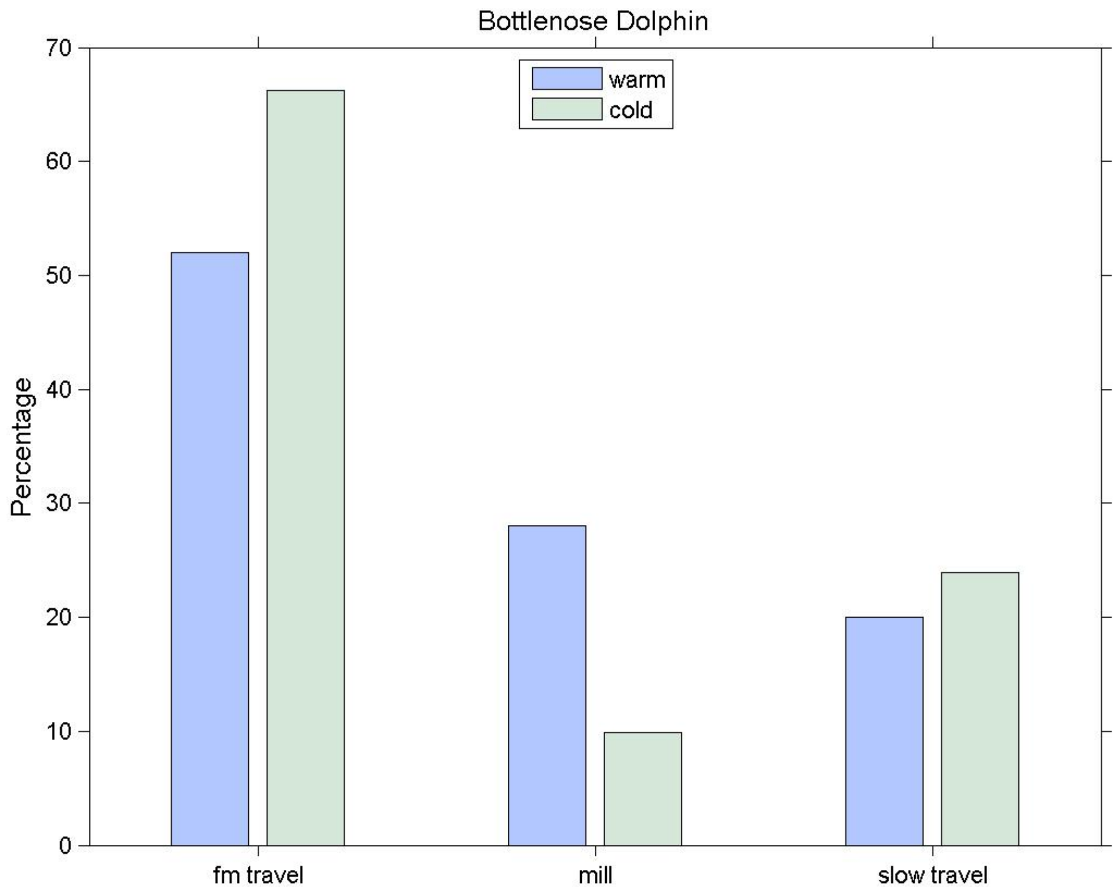

Figure B-26 Frequency of occurrence (percent of the total 96 groups observed) during the warm-water (May-October) and cold-water seasons (November-April) of first-observed behavior states of bottlenose dolphin (*Tursiops truncatus*) groups sighted during Southern California Marine Mammal Aerial Surveys: 2008-2012. Fm travel = medium-fast travel, mill = milling, slow travel = slow travel/rest. See ethogram in Appendix D for detailed definitions of behavior states. Percentages represented by blue and green bars sum to 100%.

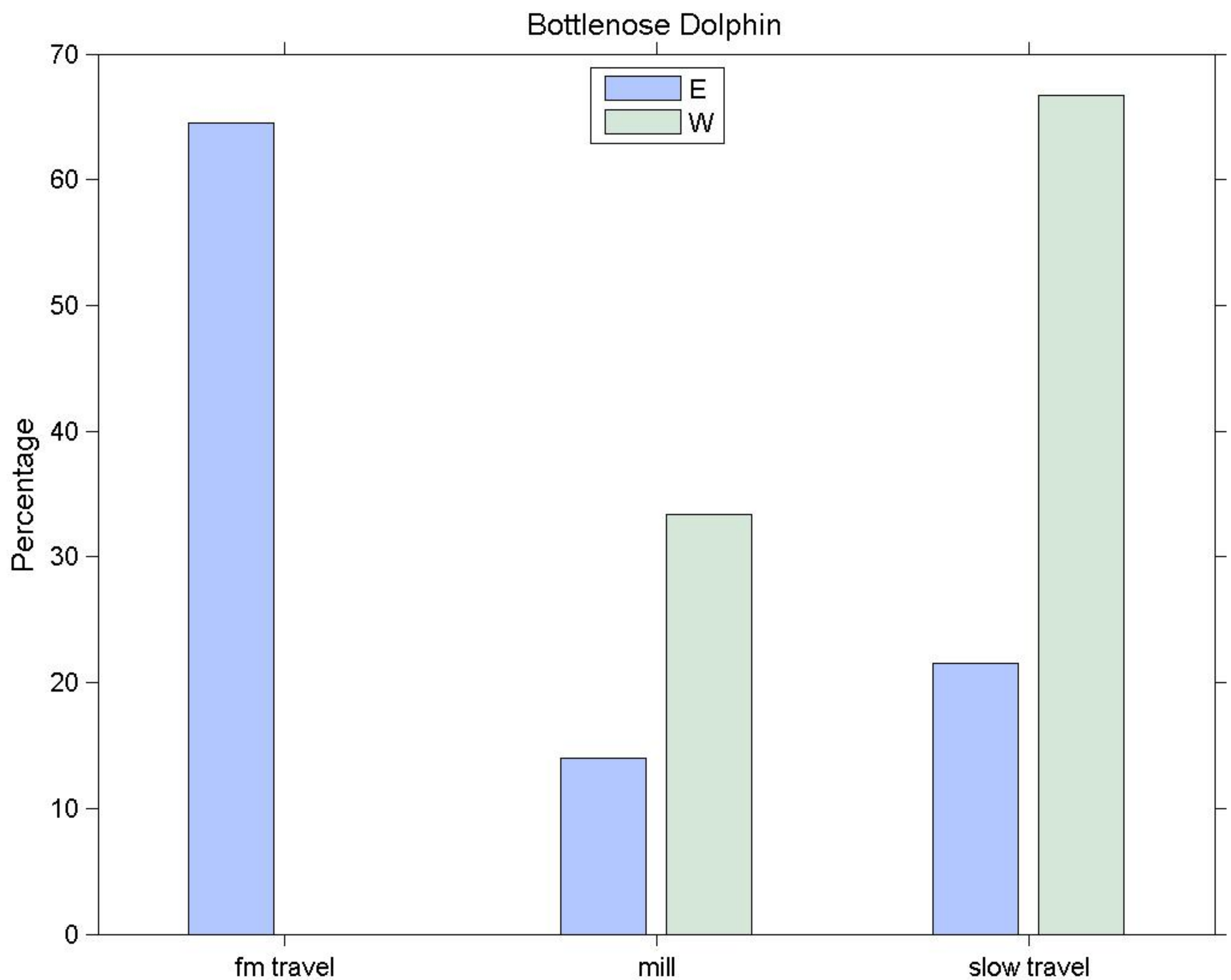

Figure B-27. Frequency of occurrence (percent of the total 96 groups observed) by subregion of first-observed behavior states of bottlenose dolphin groups sighted during Southern California Marine Mammal Aerial Surveys: 2008-2012. E = east of San Clemente Island, W = west of San Clemente Island. Percentages represented by blue and green bars sum to 100%.

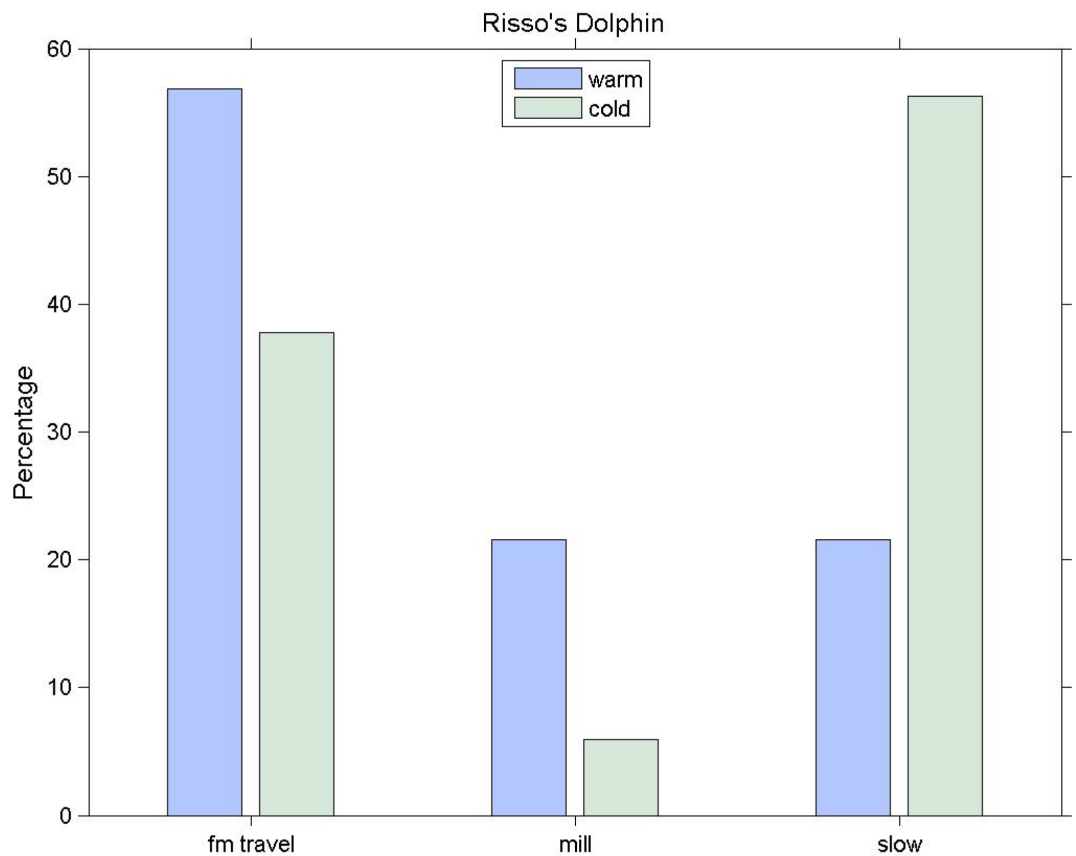

Figure B-28. Frequency of occurrence (percent of the total 290 groups observed) during the warm-water (May-October) and cold-water seasons (November-April) of first-observed behavior states of Risso's dolphin groups sighted during Southern California Marine Mammal Aerial Surveys: 2008-2012. Fm travel = medium-fast travel, mill = milling, slow travel = slow travel/rest. See ethogram in Appendix A for detailed definitions of behavior states. Percentages represented by blue and green bars sum to 100%.

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APPENDIX C: PHOTOS

Photo C-1. Two gray whales (*Eschrichtius robustus*) photographed 2 February 2012 by B. Würsig under NMFS permit 14451.

Photo C-2. Risso's dolphins (*Grampus griseus)* photographed 2 February 2012 by B. Würsig under NMFS permit 14451.

Photo C-3. Common dolphins sp. (*Delphinus *sp.) photographed 15 February 2011 by B. Würsig under NMFS permit 14451.

Photo C-4. Northern right whale dolphins (*Lissodelphis borealis*) photographed 01 April 2011 by D. Engelhaupt under NMFS permit 14451.

Photo C-5. Fin whale (*Balaenoptera physalus)* photographed 10 May 2011 by M. Smultea under NMFS permit 14451.

Photo C-6. Sperm whale (*Physeter macrocephalus)* and calf with Risso's dolphin (*Grampus griseus)* photographed 14 May 2011 by D. Steckler under NMFS permit 14451. Note sperm whale's open jaw.

Photo C-7: Sei (*Balaenoptera borealis*) /Bryde's whales (*B. Brydei/edeni*) photographed 28 September 2010 by B. Würsig under NMFS Permit 15369.

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APPENDIX D: SURVEY METHODOLOGY

SURVEY METHODOLOGY

This section summarizes the methodology and protocol used during the 15 aerial surveys conducted in 2008-2012 to monitor the baseline occurrence, distribution, and behavior of marine mammals (MM) (and sea turtles [ST]) in the Southern California (SOCAL) Range Complex on behalf of the United States (U.S.) Navy. Some changes in methodology occurred over the 5-year period in association with refining and streamlining data collection and processing, increasing safety, and adapting to changing logistics. These involved changes in data collection format/forms, software, hardware, field equipment, availability of survey aircraft, specific survey goals per U.S. Navy direction, and the required change from one pilot to two pilots beginning in 2011, due to safety concerns and National Marine Fisheries Service (NMFS)-directed. Changes also included refinement of variables, mainly during the first surveys in October 2008 as we determined what types of data could feasibility be collected. Methodology for each survey was described in each Annual Report from the U.S. Navy to the NMFS as required under U.S. Navy permits. The most extensive and detailed description of methodology was provided in Smultea et al. (2009) with later survey reports referencing the latter report. The entire survey program, methodology, and associated hypotheses were developed to meet goals identified in the U.S. Navy's SOCAL Marine Species Monitoring Plans (DoN 2009), Integrated Comprehensive Management Program (ICMP) (DoN 2010), and Scientific Advisory Group report (DoN 2011), as described below and tables and figures that follow.

Project Questions and Hypotheses

The goal of the U.S. Navy's SOCAL Marine Mammal Monitoring (M3P) Plan has been to address five questions (identified in consultation with NMFS) related to assessing potential effects of mid-frequency active sonar (MFAS) and explosives (underwater detonations) on MM/ST during U.S. Navy major training events (MTEs) (see **Table D-1**). The plan has involved a feasibility phase to identify, develop and improve upon monitoring protocol, and to gather baseline data that can be used to quantify potential effects of training activities. To this end, the aerial surveys described herein included a pilot study in October 2008 to establish methodology to address SOCAL M3P questions. This and subsequent surveys provide baseline data to describe and quantify "typical" occurrence, distribution, frequency, abundance, and behavior of the marine mammal (MM) species inhabiting the study area within the SOCAL Range Complex (i.e., study area).

It was recognized *a priori* by the U.S. Navy and survey researchers that the ability to address and answer the SOCAL M3P questions is a long-term process (**Table D-1**). This process first requires identifying feasible data collection protocols relative to species occurrence and environmental conditions in the area. It was further recognized that a statistically valid sample size was highly unlikely to be attained within each short individual MTE survey period. This was particularly true for density and abundance estimates that typically require species samples sizes of at least ≥60-80 sightings (although 40 may be enough in some circumstances) (Buckland et al. 2001). It was also recognized that safety constraints and last-minute changes in U.S. Navy MTE logistics could occur (and they did). This made it difficult to conduct surveys in preferred areas (e.g., within the active

Southern California Offshore Anti-submarine Warfare Range (SOAR) (San Nicolas Basin) range *during* the MTE) and following preferred methods (e.g., replicating transect line spacing and locations used during NMFS' Southwest Fisheries Science Center [NMFS/SWFSC] aerial surveys there in 1998-99 per Carretta et al. (2000).

An important factor limiting the ability to assess potential effects of MFAS is that the U.S. Navy has not, at the time of this report, disclosed MFAS transmission times and locations for national security reasons. Thus, it is not possible for us herein to compare data from specific operational MFAS "on" and "off" periods during MTEs nor data on distance and relative location of MFAS sources vs. sightings.

Given the above caveats project null hypotheses and predictions were developed to identify how aerial survey monitoring could contribute to addressing SOCAL M3P questions (**Table D-1**). Thus, monitoring effort focused on identifying baseline and/or typical distribution, occurrence, abundance, density, and behavior of MM and sea turtles (ST) occurring in the study area. Notably, ST were never seen during the 2008-2012 aerial surveys, although flights during some surveys included portions of San Diego Bay where ST have been documented. In light of these goals, we set out in 2008 to identify variables and methods that could be used to quantitatively and ideally statistically address the hypotheses and predictions with eventual access to MFAS-related data. However, most monitoring occurred during periods without MFAS activities, including the winter surveys (**Appendix A**, Table A-1). Limitations of study approaches were also preliminarily identified (e.g., sample size). These tactics were used to design, implement and conduct the aerial surveys as described below and in **Table D-1** in this appendix.

Approach

The approach implemented to address SOCAL M3P requirements was to conduct fixed-wing aircraft based surveys to monitor the occurrence, distribution, abundance and behavior of MM/ST in the SOCAL Range Complex to provide baseline data and as possible, relative to occasional MFAS transmission periods.

Primary monitoring goals were to:

1. Monitor the presence, occurrence, numbers and locations of MM/ST species during baseline periods with no MFAS activates but also *during* and *after* MTE periods, when possible. This was to identify potential changes in behavior, orientation, location, distribution, and relative abundance relative to U.S. Navy training activities involving MFAS;

2. Search for potential stranded, injured or behaviorally stressed animals;

3. Circumnavigate San Clemente Island (SCI) to look for floating and beached stranded or near-stranded animals;

4. Provide locations of animals to the U. S. Navy so that received MFAS sound levels could potentially be calculated and estimated by U.S. Navy personnel in post-survey analyses;

5. Assess the feasibility of monitoring near-surface and sub-surface tracking and behavior of MM/ST from the survey plane;

6. Evaluate the feasibility and effectiveness of monitoring approaches and provide recommendations for similar future efforts;

7. Opportunistically locate and describe cetacean sightings initially located acoustically with the U.S. Navy's stationary array or Scripps Institution of Oceanography (SIO's) high-frequency acoustic-recording packages (HARPS) by other research groups to visually verify species and supplement acoustic detections; and

8. Opportunistically describe potential behavioral reactions of cetaceans to the survey platform.

The above goals were addressed using the following five modes as described below and depicted in **Table D-2** and **Figure D-1**:

1. *Search Mode* to collect initial sighting, location, and behavior information via *systematic* line-transect, connector, random, and transit aerial survey observation effort (defined in **Table D-3**). Random effort included observation effort between adjacent systematic transect lines and during transits to and from line transect locations.

2. *Identify* involving circling of the sighting to photo-document and confirm species, as possible, and to estimate group size and presence/minimum number of calves.

3. *Focal Follow* involving circling of a cetacean sighting to conduct extended behavioral focal observation sampling after locating a species of interest; the aircraft was flown at ~365-455 meters (m) (1200-1500 feet [ft]) altitude and ~0.5-1.0 kilometers (km) (0.3-0.5 nautical miles [nm]) radial distance for this mode to avoid disturbing the focal animals (i.e., well outside the theoretical sound cone for air-to-water transmission of sound [**Figure D-2**]);.

4. *Shoreline Survey* involving circumnavigating clockwise around SCI ~0.5 km from shore to search for potentially stranded or near-stranded animals along the coastline and in nearshore waters.

5. *Acoustic-Visual Behavior Mode* involving simultaneous collection of both visual and acoustic behavioral data from focal groups of whales and dolphins being monitored from an aircraft circling overhead, including deployment and live-monitoring of sonobuoys from the observation aircraft.

Priority Species

- MM/ST exhibiting unusual or distressed behavior;
- Near-stranded, stranded, or dead MM/ST;
- MM/ST species listed as endangered or threatened under the Endangered Species Act (ESA) of 1973 (as amended) and any sea turtles. ESA-listed whale species include the

sperm whale (*Physeter macrocephalus*), blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), and sei whales (*Balaenoptera borealis*);

- Beaked whales (given their sensitivity to anthropogenic sounds implicated in some stranding events [e.g., Simmonds and Lopez-Jurado 1991, Frantzis 1998, Balcomb and Claridge 2001, Jepson et al. 2003, Evans and Miller 2004, Fernandez et al. 2005, Cox et al. 2006, DoN 2009]);
- Risso's dolphins (*Grampus griseus*) and dwarf or pygmy sperm whale (*Kogia* spp.), deep-diving odontocetes considered potential "surrogate" representatives for deep-diving beaked whales (see DoN 2009).

Secondary Species

Secondary species were those MM species known or suspected to occur in the study area (e.g., Carretta et al. 2000; DoN 2008; Jefferson et al. 2008) with no ESA status and/or that did not meet the priority species definition above but are protected under the Marine Mammal Protection Act (MMPA) of 1972 (as amended). Deep-diving secondary species were of higher priority than non-deep diving species, given their potential role as a surrogate representative for deep-diving beaked whales. These included:

- Common dolphins (*Delphinus* spp.);
- Other large non-ESA listed baleen whale species including Bryde's (*Balaenoptera bydei/edeni)*, minke (*Balaenoptera acutorostrata)*, and gray whales (*Eschrichtius robustus*);
- Other delphinids; and)
- Pinnipeds.

Methods

Survey Design

Survey protocols were designed to meet the U.S. Navy goals outlined above, while remaining adaptable to in-situ weather conditions and naval activities. The survey methodology and sampling design were submitted and approved in advance, to the U.S. Navy Technical Representative (NTR). As feasible, line-transect design layout followed that of previous aerial surveys conducted 1-2 times per month over ~1.5 years in part of the study area in 1998-99 by NMFS/SWFSC on behalf of the U.S. Navy (Carretta et al. 2000). Thus, as logistically possible, transect lines were positioned primarily along a WNW to ESE orientation generally perpendicular to the bathymetric contours/coastline to avoid biasing of surveys to follow depth contours (**Appendix B**, Figure B-1). Transect lines described in Carretta et al. (2000) were spaced 22 km apart. Our transect lines were also spaced ~22 km apart between the coast and SCI (**Appendix B**, Figure B-1). To the E and S of SCI our transect lines were spaced 11 km apart given the goal to intensively survey in a prescribed area.

Survey Aircraft

Surveys were undertaken from a high-wing, twin-engine, fixed-wing Partenavia P68-C or Observer, with two exceptions (**Appendix A**, Table A-1). One survey in 2011 was conducted from an Aero Commander 685 that did not have bubble windows due to logistical constraints; and a two-day feasibility survey was undertaken from a Bell 206 helicopter in July 2010 (Smultea et al. 2010). Pilots were familiar with the voice reporting procedures for the SOCAL Range Complex as well as local and regional airspace. Prior to each survey, U.S. Navy personnel installed a Position on Demand (POD) Global Positiong System (GPS) tracking device on the observation aircraft so that it could be tracked by the U.S. Navy relative to naval activities. Each morning the survey pilot filed a flight plan with air traffic control at Montgomery Airport upon departure. Our pilot also communicated with U.S. Navy air traffic control located at SCI to request local weather information, a summary of active areas to be avoided, and permission to fly within the SOCAL Range Complex to avoid potential conflict with other aircraft.

Survey Personnel

In 2008-2010, observations from the monitoring aircraft involved four personnel including the pilot and three professionally trained marine mammal biologists. At least two observers had >10 years of related experience. In 2011-2012, an additional pilot was added to the plane personnel to increase safety. This necessitated changing the seating position of the recorder/photographer/videographer from the co-pilot seat (2008-2010) to the rear left seat (a small opening porthole was installed in that window to facilitate photograph/video) (Table D-4). Two biologists served as observers in the back middle seats of the aircraft and observed through bubble windows (except for one survey in 2011 due to aircraft unavailability—see Appendix A, Table A-1). Roles and responsibilities of the positions on the aircraft during the *Search, Identify, Focal Follow, Shoreline Survey, and Acoustic-Visual Behavior Mode* modes are depicted in Table D-3.

Equipment

Survey data were collected using a Palm Pilot TX (dimensions ~7 by 12 centimeters) (2008), Apple iTouch (2009), Apple iPhone (2009-2010), or a notebook computer (2010-2012). Data collection software consisted of BioSpectator on the Palm Pilot TX, iTouch, and iPhone, a customized Excel spreadsheet on the notebook computer (2010-2011), or Mysticetus on a notebook computer (www.mysticetus.com) (2011-2012). Software was custom-designed to prompt the data recorder to select choices from pull-down menus or typed in using hot keys using a screen keyboard. Example choices were various environmental conditions, leg effort type (e.g., systematic, random), species, group size, minimum number of calves, etc. (see Table D-5 below). Each new entry was automatically assigned a time stamp. Each new sighting was automatically assigned a sequential sighting number. In addition, initially observed behavioral data were collected when a sighting was first made (see *Behavioral Sampling* below). Comments could also be entered although the small keyboard screen on the Palm Pilot, iTouch and iPhone required more time to use than, for example, the notebook computer keyboard. Hand-written notes were recorded by observers if needed for multiple simultaneous sightings.

One of three digital EOS Canon cameras with Image Stabilized (IS) zoom lenses was used to photo-document and verify species for each sighting as feasible/needed (40D with 100-400 millimeter [mm] ET-83C lens; 20D with 70-200-mm 2.8 lens and 1.4 converter; D60 with 100-400-mm lens). For focal sessions, a Canon Vixia HF10 high-definition digital video camera with a built-in optical image stabilizer and 12x optical zoom lens was used to record behaviors in real time as indicated by a time stamp on the viewfinder screen. The microphone of the video camera was connected to the audio system of the aircraft so that all vocal input (e.g., behavioral verbal descriptions) was recorded into the video camera data stream. Observers used Steiner 7 X 25 or

Swarovski 10 X 32 binoculars as needed to identify species, group size, behaviors, etc. A Suunto handheld clinometer was used to measure declination angles to sightings when the sighting was perpendicular to the aircraft. GPS locations were automatically recorded at 30-second intervals on a handheld WAAS-enabled Garmin GPS as well as by the aircraft WAAS GPS.

Field Methods

The general daily survey protocol was to depart San Diego as soon as conditions permitted. Effort (i.e., leg) type, environmental conditions, observer names and position, and general comments were entered into the data collection program as soon as the aircraft left the ground and whenever conditions changed. Chronological implementation of the survey modes were as follows and as depicted in the flow chart in **Figure D-2**:

1. Locate and follow line pre-determined transect lines and waypoints until a sighting is made. Standard line-transect protocol was followed during this type of search effort mode (**Table D-5**).

2. Upon sighting a MM group, record basic sighting information per established protocol (see **Table D-1**).

3. If the species is a Priority or Secondary Species and appears suitable for a focal follow, the aircraft increases altitude to ~365-455 m and radial distance ~0.5-1.0 km and circles the sighting to obtain detailed behavior information for a minimum of 10 min with a video camera.

4. If the species is not selected for a focal follow, and species and/or group size are unknown, the aircraft circles the sighting to obtain digital photographs and estimate group size/composition.

Behavioral Sampling

Point-sampling and zero-one sampling approaches (Altmann 1974; Shane 1990; Smultea 1994, 2008; Mann 2000) were used to record the following information on each sighting when it was first seen and subsequently, for focal groups, approximately once per circling of the aircraft (e.g., at ~1-2 minute intervals) or when parameters changed: (1) behavior state, (2) occurrence/non-occurrence and type of "conspicuous" individual behaviors (see Table 4), (3) estimated speed of travel (4) minimum and maximum dispersal distance (i.e., spacing) between individuals within a subgroup (estimated in body lengths), (5) aircraft altitude and estimated distance of the aircraft to the focal group (using a clinometer while the aircraft was level), and (6) any nearby vessels or aircraft (Table 2). For whales, continuous behavioral sampling (Altmann 1974; Smultea 1994) was used to record surface, dive, and respiration times (see Würsig et al. 1985, 1989). *Ad libitum* (Altmann 1974) detailed notes were also taken in a notebook or in the comments column of the electronic datasheet including information on school configuration, unusual behaviors or circumstances (e.g., birds feeding nearby, description of U.S. Navy activity), and/or any potential observed reactions.

DATA PROCESSING

Field data (including photos and video) were downloaded and backed up after each survey usually that evening or within 24 hours to two external hard drives. Until the use of an "all in one" data collection software (Mysticetus) in late 2011, GPS data were collected in a separate data stream using two separate handheld GPSs (one for backup in case the GPS signal was lost or the batteries failed). These two data streams were then merged into one Excel spreadsheet with the time-merge function using time as the common denominator. Data were then imported to a Geographic Information Systems (GIS) ArcInfo program to plot survey track lines and locations on three-dimensional bathymetry maps obtained online from an SIO website (http://www.sccoos.org/data/bathy/?r=0) and from Google Earth (http://www.googleearth.com). The same program was used to calculate, classify, and summarize kilometers of survey effort and sightings including by Beaufort sea state (Bf), date/time, and leg type effort. However, in late 2011 and 2012, Mysticetus software was used to collect field data (merging GPS data in the field), produce summary reports of daily effort, and plot sighting locations and associated sighting data on a map using the highest-resolution GIS data available for topography, water depth, etc. An advantage of Mysticetus was that it was capable of live-tracking plane survey tracks and sighting locations on a map on the computer screen; Mysticetus uses field data to immediately display the bearing and distance to sightings to assist in relocating sightings. The latter was especially critical in Bf >2 and for small groups of animals.

Behavioral data collected on handwritten forms and/or in a notebook were hand-entered into an Excel custom spreadsheet and/or were scanned. Videos were reviewed and both verbal and visual data were entered into the same Excel spreadsheet to supplement and/or verify information. A master Excel spreadsheet contained all the data streams.

Statistical analysis protocols are described in **Appendices E, G-I** of this report.

Post-processing of Video and Photos

For each survey, video and photographs were reviewed and logged into an inventory list that included date, time, file name, sighting identification number, group size, species, etc. Images and video were then organized into computer files based on date, survey, year, etc., using specific file-naming protocol. During video logging, video were subjectively categorized relative to their future utility for detailed transcriptions of behavior as defined in **Appendix E**, and **Table D-6** in this appendix.

Statistical Analyses

See *General Overview Summary – Statistical Analyses* and **Appendices G-I** for details of statistical analyses.

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Table D-1. Aerial survey study design, hypotheses, and response (i.e., dependent) variables examined to address the five main questions identified in the U.S. Navy's Southern California Range Complex Marine Species Monitoring Plan (DoN 2009) to assess impacts of exposure to sonar and underwater detonations on marine mammals and sea turtles. (Acronyms defined in footnote)

Monitoring Plan Question Addressed	Null Hypothesis	Prediction to Test	Variables Measured to Test Prediction	Recording Method	Limitations	Can MP Question be Addressed?
Q1: Are MM/ST exposed to MFAS? At what levels?	*No MM/ST occur within the 3 NMFS received sound level criteria1/ for MFAS*	MM/ST occur in 3 NMFS criteria isopleths	1. # anim. seen below water 2. sound RL near MM/ST	Survey search using GPS, Event Recorder.Camera , Video	1. High Bf/glare can obscure MM/ST below water 2. Sound on/off times currently unavailable to researchers 3. Best analyzed if researchers have sound data for post -field analyses	**YES** (distance vs. RLs near sightings) if sound time & RL data provided to researchers
Q2: Do exposed MM/ST redistribute? How long?	*1. # animals B/D/A MTE NS different* *2.MM/ST do not leave area D MTE*	1. Significant lower # animals D vs. B/A MTEs 2. MM/ST consistently head away from MFAS source D vs. B/A: headings significant different D vs. B/A MTE	1. Sighting rate, density, abundance, presence/ absence 2. Group *headings*	1. Line-transect Surveys 2. Focal follows: initially observed heading & focal follow reorientation rate	1. Sufficient sample size needed (>40 -80 sightings per experimental condition - 2001). 2. Need to address other explanatory (i.e., independent) variables affecting occurrence (season, water depth, etc..) 3. Can calculate min. sample size needed to determine significance (statistics using prelim./ baseline data)	**YES** if sample sizes sufficient, variance acceptable, baseline data available

Monitoring Plan Question Addressed	Null Hypothesis	Prediction to Test	Variables Measured to Test Prediction	Recording Method	Limitations	Can MP Question be Addressed?
Q3/4: Behavior response to various sound levels?	*1. Behavior state, heading, dispersal distance, group size, NS different B/D/A MTE* *2. Orientation & SAC behavior event rate, time at vs. below surface NS different B/D/A MTE*	1. Significant more animals D vs. B/A sound exposure travel vs. mill, rest; head away from sound; decrease individual space; reduce group size; dive longer, surface shorter period 2. Reorientation rate less, SAC rate higher, surface time higher D vs. B/A sound exposure *3.* Test all vs. RLs	Initial & subsequent observed behavior state, heading, spacing, group size, dive/ respiration/ surface - duration rates	1. Initially observed behavior recorded; 2. Focal follow continuous sampling as possible w video/ audio recording & data event & duration recorder	1. Sufficient sample size needed to assess significance see (3) above	**YES** – see above
Q5: Do Mitigation measures effectively avoid NMFS criteria exposure?	*1. # Dead, stranded, injured animals same B/D/A MTE* *2. # Animals in 3 NMFS criteria exposure same B/A*	1. More such animals seen D/A vs. B MTE 2. Ramp up reduces # anim. exposed to NMFS criteria: density, sighting rates sig. less in 3 NMFS criteria D vs. B/A	1. Condition/ # of such animals 2. Density, abundance sighting rate	1. GPS, event recorder,, camera, video 2. Line transect	1. Necropsies needed to ascertain death cause, difficult for floating offshore carcasses 2. *same as above*	**YES** can contribute; observers on Navy ships also important

Notes:

1/ The three underwater sound exposure criteria threshold isopleths per DoN (2009a) and NMFS (2009) are Potential Behavioral Harassment, Temporary Threshold Shift (TTS), and Permanent Threshold Shift (PTS). Full Questions: **Q1:** Are MM/ST exposed to MFAS @ NMFS' criteria for behavioral harassment, TTS or PTS? If so, at what levels are they exposed? **Q2:** If MM/ST are exposed to MFAS, do they redistribute geographically as a result of continued exposure? If so, how long does the redistribution last? **Q3/4:** If MM/ST are exposed to MFAS/explosives, what are their behavioral responses to various levels? **Q5:** Is the Navy's suite of mitigation measures for MFAS & explosives (e.g., PMAP, major MTE measures agreed to by the Navy through permitting) effective at avoiding TTS, injury, and mortality of MM/ST

Acronyms: Q=Question, A=After; B=Before; Bf=Beaufort Sea State; D=During; MM=Marine Mammal, MFAS=Mid-Frequency Active Sonar, MTE = US Navy Major Training Event, NMFS=National Marine Fisheries Service, NS=Not Significant, PMAP= Protective Measures Assessment Protocol ; PTS=Permanent Threshold Shift, RL = Estimated Received Sound Source Level, SAC=Surface Active, ST=Sea Turtle, TTS=Temporary Threshold Shift

Table D-2. Description of the five primary study modes designed to address monitoring goals of the aerial surveys.

Mode	Aircraft Speed (kt)	Aircraft Altitude (m)	Flight Pattern	Duration	Data Collected
Search	~100	~305	Systematic transect lines Short "connector" lines Transits	Until MM seen then switch to Identify or Focal Follow Mode	Time & location of sighting Species, group size, min. # calves Bearing & declination angle to sighting Behavior state Initial reaction (yes or no & type) Heading of sighting (magnetic) Dispersion distance (min. & max. in estim. body lengths)
Identify	~85	~305	Circling at ~305 m radius	<5 min	Photograph to verify species Estimate group size, min. # calves Note any apparent reaction to plane or unusual behavior
Focal Follow	~85	~365-457	Circling at ~1 km radius	≥5– 60+ min	<u>In order of priority every ~1 min:</u> Time Focal group heading (magnetic) Lat./long. (automatic GPS) Behavior state Dispersion distance Aircraft altitude (ft)(automatic WAAS GPS) Distance of aircraft to MM (declination angle) Reaction (yes or no & type) Bearing & distance to vessels <1 & <10 km away or other nearby activity Surface & dive times (whales) Respirations (whales) Individual behavior events (whales)
Shoreline Survey	~100	~305	Circumnavigate San Clemente Island in clockwise direction ~0.5 km from shoreline (random effort)	~45 min	Status (alive, dead or injured) Species, group size, min. # calves Bearing & declination angle to sighting Behavior state & heading Initial reaction (yes or no & type)

Acoustic-Visual Behavior Mode	~85	~365-457	Circling at ~1 km radius	≥5– 60+ min	Same as Focal Follow mode above plus acoustic recordings from sonobuoys deployed from the observation aircraft.

Table D-3. Definitions of leg types flown during the 2008- 2012 aerial surveys.

Leg Type	Leg Type Definition
Systematic	Pre-determined line-transect legs located in SOAR*, NAOPA† and FLETA‡ HOT
Random	Short lines connecting longer systematic lines
Transiting	Flying between the airport and the survey grid locations
Connector	Short lines connecting systematic transect lines
Navy-Directed Transiting	Flying off intended course as directed by U.S. Navy during a survey to avoid U.S. Navy activities
Circling	Flying clockwise circles around sightings to verify species and group size via photography and/or to conduct focal sessions with videography as possible
Circumnavigating Coast	Flying parallel to San Clemente Island coastline approximately 0.5 km offshore to search for potential strandings
Fog Effort	Transiting above fog layer with limited or no visibility to water

*SOAR = Southern California Offshore Anti-submarine Warfare Range (San Nicolas Basin)

†NAOPA = Northern Air Operating Area (Santa Catalina Basin)

‡FLETA = Fleet Training Area

Table D-4. Roles and responsibilities of the four personnel aboard the monitoring aircraft during *Search*, *Identify*, and *Focal Follow* modes.

Aircraft Seat Position	Role during SEARCH Mode (1000 ft Altitude)	SEARCH Mode Responsibilities	Role during FOCAL Mode (Circling) (365-457 m Alt & 0.5-1.0 km radial distance)	IDENTIFY & FOCAL Mode Responsibilities
Pilot (Left front)	Pilot	Locate & follow transect lines Maintain ~305 m altitude & ~100 kt speed Communications with civilian and Naval flight controllers	Pilot	Circle sighting clockwise @ ~365-457 m Alt & 0.5-1.0 km radial distance as directed Keep animal(s) in middle of circle Avoid flying directly overhead animals Keep track of sighting location
Right front or left rear bench seat	Recorder/ Back-up Observer	Record data Search for MM/ST Keep "big picture" perspective Guide pilot to MM/ST location(s) Photograph to verify/identify spp.	Videographer	Videotape focal group through open porthole window
Left center	Observer through bubble window	Search for MM/ST	Note taker/Recorder (when photographer on right),, or Primary Behavioral Observer when photographer on left—see below)	Note behavior data and record with time: MM heading when parallel w/ plane heading Aircraft altitude & distance to MM (w/ clinometer) once per circling as possible when plane level Call out overall big picture description when behavior observer not talking
Right center	Observer through bubble window	Search for MM/ST	Primary Behavioral Observer (or Note taker/Recorder—see above)	Keep track of focal group Call out ~1 min as possible/when changes: focal behavior & other data (see Table 1)

Table D-5. Ethogram defining behavioral states and individual behaviors (events) used during focal follows. Behavior states determined based on what ≥50% of the group was doing.

BEHAVIOR STATE (>50% of group's activity--note once per min; also note if unknown when animals not in view during that minute)	CODE	DEFINITION (e.g.,PER Encyclopedia of Marine Mammals*)
Rest/Slow Travel	RE	≥50% of group exhibiting little or no forward movement (<1 km/hr) remaining at the surface in the same location or drifting/traveling slowly with no wake
Travel	TR	≥50% of group swimming with an obvious consistent orientation (directional) and speed, no surface activity. Medium travel = 1-3 km/hr wake no white water; Fast travel = >3 km/hr with white water
Mill	MI	≥50% of group swimming with no obvious consistent orientation (non-directional) characterized by asynchronous headings, circling, changes in speed, and no surface activity. Includes feeding.
Surface-active mill	SM	While milling, occurrence of aerial behavior that creates a conspicuous splash (includes all head, tail, pectoral fin, and leaping behavior events—see below) Includes feeding.
Surface-active travel	ST	While traveling, occurrence of aerial behavior that creates a conspicuous splash (include all head, tail, pectoral fin, and leaping behavior events—see below)
Probable foraging*	PF	Apparent searching for prey; the process of finding, catching, and eating food
Unknown	UN	Not able to determine behavior state. (e.g., animals out of sight, too far to determine, on a dive, etc.)
Other	OT	Describe in notes
Individual Behavior Event		
Logging	LG	Lying at the surface with body exposed with no directed forward movement
Breach*	BR	A behavior in which a marine mammal leaps out of the water
Porpoise*	PO	The behavior of marine mammals leaping at least partially clear of the water surface during rapid swimming
Sternride	SR	The action or behavior pattern of riding on the pressure wave at the stern or abreast of a ship
Spin	SP	Leap clear of water and spin (dolphins only)

BEHAVIOR STATE (>50% of group's activity--note once per min; also note if unknown when animals not in view during that minute)	CODE	DEFINITION (e.g.,PER Encyclopedia of Marine Mammals*)
Bowride*	BO	The action or behavior pattern of riding on the pressure wave in front of the bow of a ship or the stern or abreast of a ship
Head Slap/Lunge	HS	Leap out of water w/ forward thrust or side at >40º and slap ventral surface on water creating large splash
Foraging	FO	Seen chasing fish or prey and/or zig-zag pursuit swimming
Sprint	ST	Brief increase in speed often associated with foraging /feeding
Social	SO	Two or more animals in physical contact
Roll over	RO	Animal completely rolling over
Zig Zag	ZZ	Swimming in a zig zag pattern
Tail Slap*	TS	A behavior in which a marine mammal slams its flukes down on the water, usually repeatedly
Pectoral Fin Slap	PS	Slap water surface with pectoral fin - ventral or dorsal up
Inverted Swim	IS	Animal swimming with ventral side up, dorsal side down - inverted
Unknown	UN	
Other Behavior	OB	Behavior not listed above: describe in notes
Missed Behavior	OMB	Did not see/missed a behavior
Whales Only		
Blow*	BL	Visible respiration-cloud of vapor and sea water mixed with air that is exhaled by cetaceans
No Blow Rise	NB	Surface with no visible blow/respiration
Missed Blow	MB	A blow/surfacing is suspected to have been missed/not seen
First Blow	FB	First blow of surface sequence (where surface sequence consists of closely spaced blows usually followed by a dive)
Peduncle Arch	PA	Arching of peduncle (posterior portion of the body bearing the tail or flukes) without lifting tail/flukes
Fluke up	FU	Arching of back followed by lifting tail flukes into air (fluke facing up) usually before an extended dive
Fluke down	FD	Arching of back followed by lifting tail flukes into air (fluke facing down) usually before an extended dive
Unidentified Large Splash	US	Large splash associated with an unidentified/unseen behavior

BEHAVIOR STATE (>50% of group's activity--note once per min; also note if unknown when animals not in view during that minute)	CODE	DEFINITION (e.g.,PER Encyclopedia of Marine Mammals*)
Vertical	VU	Vertical in water with head up
Vertical down	VD	Vertical in water with head down

* Perrin, W. F., B. Würsig, and J.G.M. Thewissen. Eds. 2009. Encyclopedia of marine mammals. Second edition. Academic Press. San Diego, California.

Table D-6. Video Quality/Utility Definitions used during the 2008-2012 aerial monitoring surveys.

Video Quality	Utility Definitions
Poor	Behavior and audio indiscernible. E.g., animal never seen in video or behavior cannot be determined because animal too far away, video shaky/out of focus/moving too much, Beaufort sea state too rough (i.e., can't determine dispersal distance between individuals, blows and (for whales), individual surface-active behaviors, and/or orientation of animal), and/or audio cannot be understood due to interference/static noise or was not recorded.
Fair	Some behavior and most audio discernible. E.g., animal seen in video and behavior, orientation, and dispersal can be determined but in view on video for only a short period of time (<30 sec per video clip). Most audio can be understood.
Good	Most behavior and audio discernible. Most periods animal at or near surface are captured on video and most audio is understandable. Animal seen in video for a longer length of time (e.g., >30 sec per video clip) and can determine behavior. Nearly all individual behavioral events, blows (for whales), behavior state, orientation, and dispersal distances can be determined via combined video and/or audio.
Excellent	Behavior easily discernible all times animal in view below/above surface and audio discernible. E.g., animal(s) seen throughout entire video when visible at or below the water surface and all audio can be understood. All behavioral events and blows (for whales), behavior state, heading, and dispersal distance can be determined. Video footage is relatively steady and focused. Usually occurs when Beaufort sea state is less than 3.

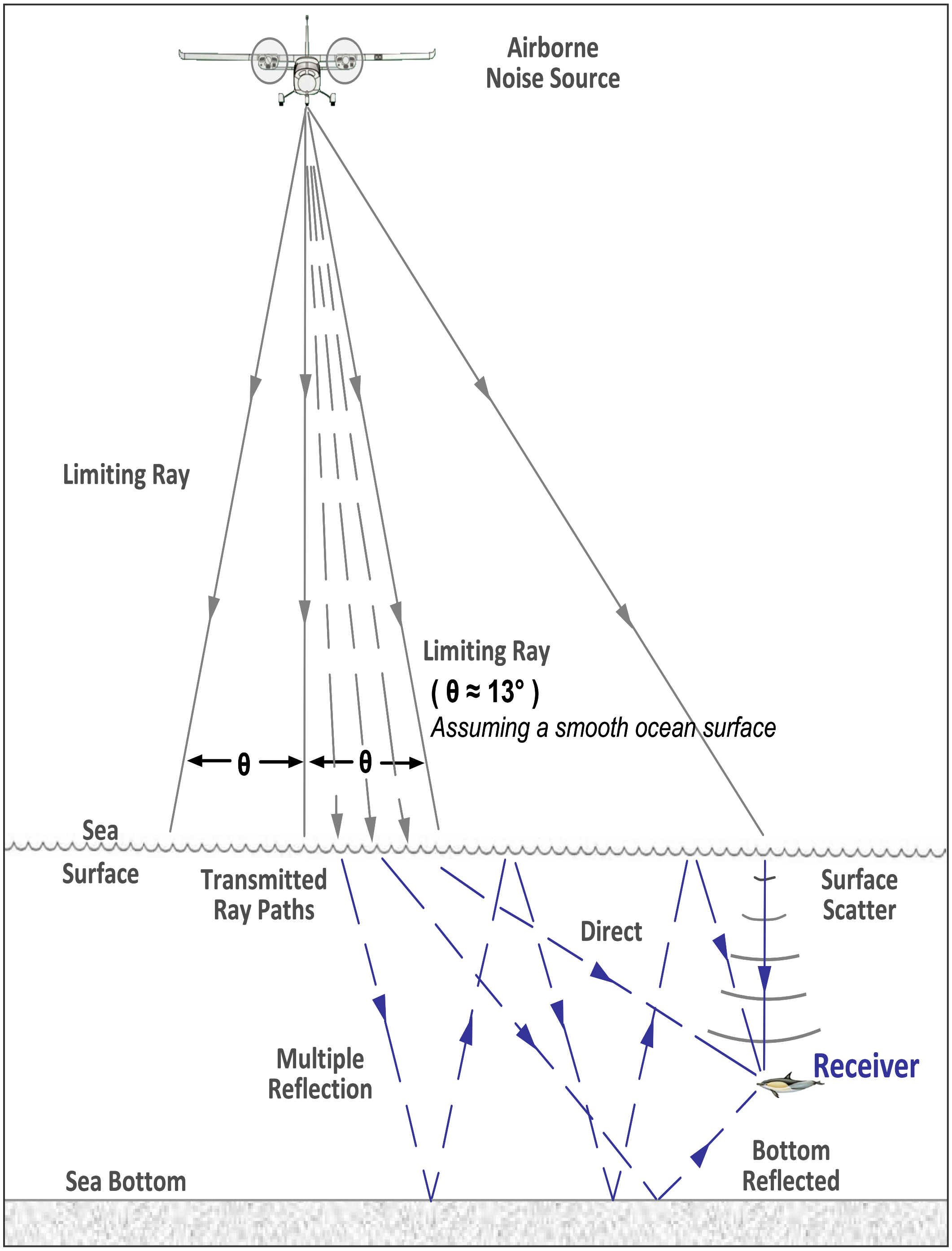

Figure D-1. Diagram illustrating the theoretical 26° inverted sound cone (radius 13°) within which the sound ray of an over-flying aircraft is limited at the sea surface under calm flat sea conditions (Beaufort 0-2). Also illustrated are ways in which the transmission of sound rays through the water surface can be influenced by water depth reflection. Increasing disturbance of surface waters (i.e., increasing Beaufort sea state) can increase the size of the radius beyond the theoretical 26-degree sound cone. (Modified from source: Richardson et al. 1995 per Urick 1972).

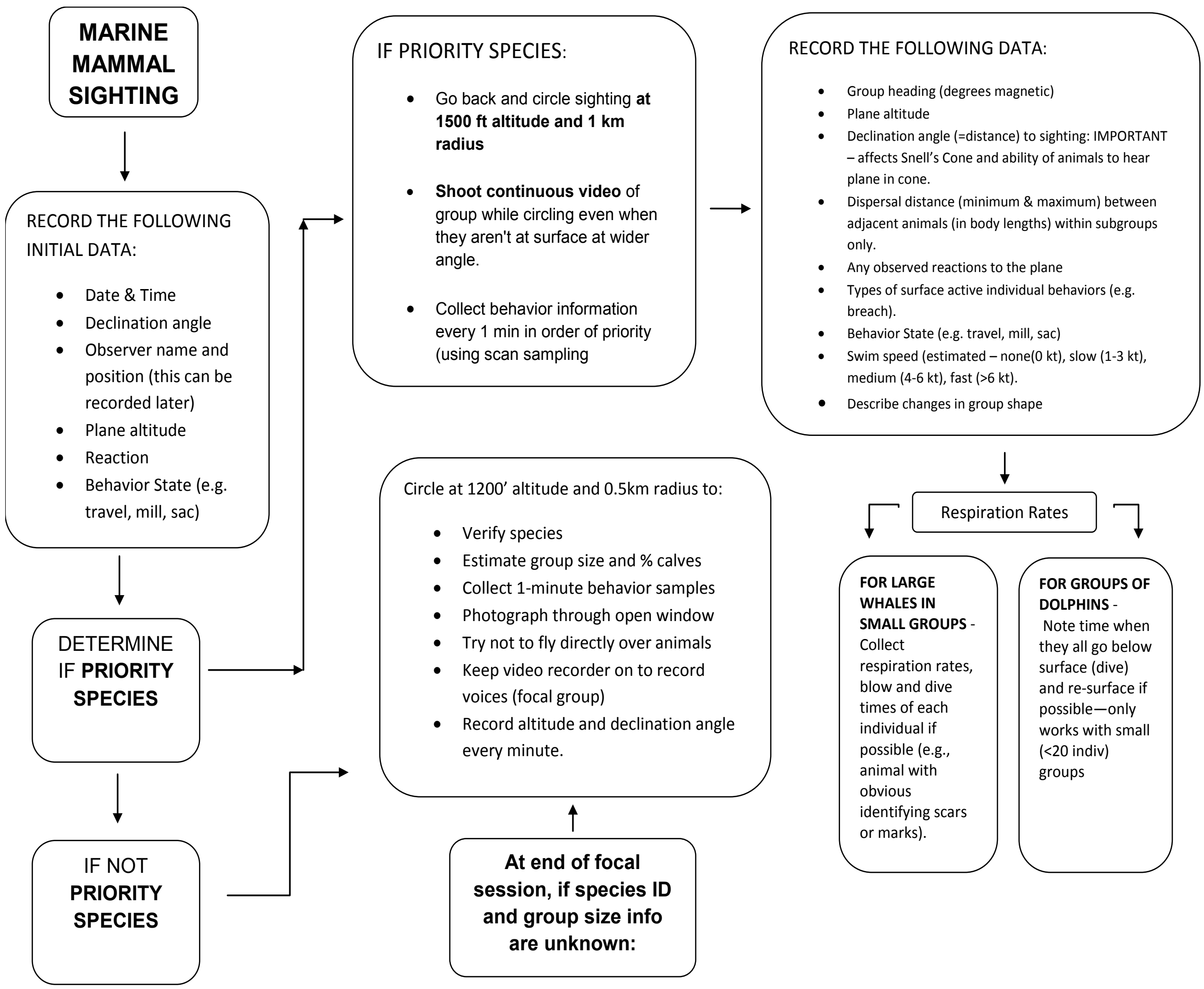

Figure D-2. Protocol decision flow chart.

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APPENDIX E: REPORT - DENSITY AND ABUNDANCE OF MARINE MAMMALS

Density and Abundance of Marine Mammals Derived from 2008-2012 Aerial Surveys Within the Navy's Southern California Range Complex

Final Report

10 September 2012

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Table of Contents

Figures

Tables

Acronyms and Abbreviations

Bf	Beaufort Sea State
ESA	Endangered Species Act
ft	foot/feet
GPS	Global Positioning System
km	kilometer(s)
km^2	square kilometer(s)
m	meter(s)
Mysticetus	Mysticetus Observation Platform software
NMFS	National Marine Fisheries Service
SCB	Southern California Bight
SOCAL	Southern California
South of SCI	South of San Clemente Island
SWFSC	Southwest Fisheries Science Center
U.S.	United States

ABSTRACT

We conducted 15 aerial surveys in the marine waters around San Clemente Island, California, during October 2008 to April 2012, to obtain both observations of marine mammal behavior and data suitable for developing marine mammal density estimates. The primary platform used was a *Partenavia* P68-C or P68-OBS (glass-nosed) high-wing, twin-engine airplane. Density and abundance estimates were made using line-transect methods and the software DISTANCE 6.0. During these surveys, 19 species of marine mammals were sighted. Due to limited sample sizes for some species, sightings were pooled to provide four estimates of the detection function for baleen whales, large delphinids, small delphinids, and California sea lions. Estimates of density and abundance were made for species observed a minimum of eight times on effort. For the warm-water season (May-October) in 2008-2012, the estimated average numbers of individuals present (in descending order) were 9894 short-beaked common dolphins (*Delphinus delphis*), 3847 long-beaked common dolphins (*D. capensis*), 1613 Risso's dolphins (*Grampus griseus*), 781 California sea lions (*Zalophus californianus*), 488 bottlenose dolphins (*Tursiops truncatus*), 317 fin whales (*Balaenoptera physalus*), 248 Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), 41 blue whales (*B. musculus*), and 18 humpback whales (*Megaptera novaeangliae*). During the cold-water season (November-April), the estimated averages were 13,547 short-beaked common dolphins, 5268 long-beaked common dolphins, 2093 California sea lions, 1087 Risso's dolphins, 639 gray whales (*Eschrichtius robustus*), 317 bottlenose dolphins, 246 fin whales, 53 Pacific white-sided dolphins, and 50 humpback whales. Blue whales were not observed during the cold-water season, and gray whales were not seen during the warm-water season. Several other species were observed for which sightings were too few to estimate numbers present and/or were seen off effort: minke whale (*B. acutorostrata*, n = 6 on-effort groups), northern elephant seal (*Mirounga angustirostris*, n = 5), northern right whale dolphin (*Lissodelphis borealis*, n = 5), Dall's porpoise (*Phocoenoides dalli*, *n* = 3), Cuvier's beaked whale (*Ziphiius cavirostris*, *n* = 2), killer whale (*Orcinus orca*, *n* = 2), harbor seal (*Phoca vitulina*, *n* = 1), Bryde's whale (*B. edeni*, n = 1), and sperm whale (*Physeter macrocephalus*, n = 1).

INTRODUCTION

Ship-based surveys of the entire U.S. West Coast exclusive economic zone have been conducted by the National Marine Fisheries Service (NMFS) since the early 1980s (with more extensive and consistent coverage since the early 1990s). These surveys have provided estimates of abundance and density, and in some cases trends, for U.S. waters of California, Oregon, and Washington (e.g., Barlow 1995, 2003, 2010; Barlow and Forney 2007; Barlow and Gerrodette 1996; Barlow and Taylor 2001; Forney 1997, 2007; Forney and Barlow 1998). These surveys generally provided data and associated densities over a very large geographic area or stratum. Smaller-scale density estimates specific to ocean areas associated with Navy at-sea training ranges are needed, but such data are more limited.

Carretta et al. (2000) conducted extensive, year-round aerial surveys of the area around San Clemente Island in 1998 and 1999 and calculated density and abundance for species seen during that time; however, these estimates are now over 13 years old and may not reflect current distribution and density numbers needed to meet Navy monitoring requirements as identified in the SOCAL Marine Species Monitoring Plan (DoN 2009).

METHODS

Data Collection

Three types of aircraft were used. Most (73) of the 84 survey days were conducted from a small high-wing, twin-engine *Partenavia* P68-C or P68-OBS (glass-nosed) airplane equipped with bubble observer windows; the remaining 11 survey days occurred from an Aero Commander (9 days) or a helicopter (2 days), both of which had flat observer windows (**Table E-1**). Survey protocol was similar to previous aerial surveys conducted to monitor for marine mammals and sea turtles in Southern California, and elsewhere, as described below (and detailed in Smultea et al. 2009a). No sea turtles were observed; however, sea turtles have been seen during monitoring surveys in Hawaii (e.g., Smultea and Mobley 2009, Smultea et al. 2009b).

Surveys were conducted in October and November 2008; June, July and November 2009; May, July and September 2010; February, March, April, and May 2011; and January, February, and March/April 2012 (**Table E-1**).

Table E-1. List of Southern California (SOCAL) aerial surveys from 2008 to 2012.

Survey Year	Survey Dates	Cold-Water Survey Days	Warm-Water Survey Days	Aircraft	Observer Window	SOCAL Sub-area Surveyed
2008	17–21 October	0	5	P	B	SCI, Santa Catalina Island, S SCI
2008	15–18 November	4	0	P	B	San Nicolas Basin, SCI, S SCI
2009	5–11 June	0	6	P	B	Santa Catalina Basin, San Nicolas Basin
2009	20–29 July	0	8	P	B	Santa Catalina Basin, San Nicolas Basin
2009	18–23 November	6	0	P	B	Santa Catalina Basin, San Nicolas Basin, SCI
2010	13–18 May 13-18	0	5	P	B	Santa Catalina Basin, San Nicolas Basin
2010	27 July–3 August	0	5	P	B	Santa Catalina Basin, San Nicolas Basin
			2	H	F	
2010	23–29 September	0	6	P	B	Santa Catalina Basin, San Nicolas Basin
2011	14–19 February	4	0	P	B	Santa Catalina Basin, San Nicolas Basin, Silver Strand
2011	29 March 29–3 April	3	0	P	B	Santa Catalina Basin, San Nicolas Basin
2011	12–20 April	9	0	AC	F	Santa Catalina Basin, San Nicolas Basin, Silver Strand
2011	9–14 May	0	6	P	B	Santa Catalina Basin, San Nicolas Basin, Silver Strand
2012	30 January–5 February	7	0	P	B	Santa Catalina Basin, San Nicolas Basin
2012	13-15 March	3	0	P	B	Santa Catalina Basin
2012	28 March–1 April	5	0	P	B	Santa Catalina Basin

P = Partenavia; H = Helicopter; AC = Aero Commander; B = Bubble; F = Flat; SCI= San Clemente Island; S SCI= ocean area south of San Clemente Island; Santa Catalina Basin (representing the area between SCI and the California mainland); San Nicolas Basin (area west of SCI)

Survey effort involved four modes as described below (see **Table E-2** and Smultea et al. 2009a):

Search to locate and observe marine mammals and sea turtles via both *systematic* line-transect and *connector* aerial survey effort. Connector effort was search effort between adjacent systematic transect lines.

Identify involving circling of a sighting to photo-document and confirm species, as possible, and to estimate group size and presence/minimum number of calves.

Focal Follow involving circling of a cetacean sighting to conduct extended behavioral observation sampling after a species of interest was located.

Shoreline Survey involving circumnavigating clockwise around San Clemente Island approximately 0.5 kilometer (km) from shore to search for potentially stranded or near-stranded animals.

One pilot (2008-2010) or two pilots (2011-2012) and three professionally trained marine mammal biologists (at least two with over 10 years of related experience) were aboard the aircraft. Two biologists served as observers in the middle seats of the aircraft; the third biologist was the recorder in the front right co-pilot seat (2008-2010) or in the rear bench seat (2011-2012). Surveys were flown at speeds of approximately 100 knots and altitudes of approximately 227-357 meters (m) (800-1000 feet [ft]). In practice, altitude at the time of sightings averaged 261 ± 49 m based on readings from a WAAS-enabled GPS. When the plane departed the survey trackline during Identify or Focal Follow modes, the pilot usually returned to the transect line within 2 km of the departure point. Occasionally, the return point was several km from the departure point.

Established line-transect survey protocol was used (see Carretta et al. 2000; Buckland et al. 2001; Smultea et al, 2009a). Parallel transect lines were positioned primarily along a WNW to ESE orientation generally perpendicular to the bathymetric contours/coastline to avoid biasing of surveys by following depth contours (**Figure E-1**). The study area within the SOCAL Range Complex (i.e., study area) overlapped transect lines of previous aerial surveys conducted 1-2 times per month over approximately 1.5 year in 1998-99 by the National Marine Fisheries Service/Southwest Fisheries Science Center (NMFS/SWFSC) on behalf of the Navy (Carretta et al. 2000) (see **Figure E-1** for comparison of the Carretta et al. [2000] study areas with ours). However, transect lines were different from and spaced closer together than the 22-km spacing used by Carretta et al. (2000). Given the goal to intensively survey in a prescribed area, we followed transect lines spaced approximately 14 km apart between the coast and San Clemente Island (the Santa Catalina Basin sub-area) (4,180 km^2) (**Figure E-1**). Our transect lines were spaced 7 km apart to the west (the San Nicolas Basin sub-area) (8,361 km^2) and south of San Clemente Island (the South SCI sub-area) (4,903 km^2).

Table E-2. Description of the four primary study modes designed to address monitoring goals of the aerial survey. Note: (MM = marine mammal)

Mode	Aircraft Speed (kt)	Aircraft Altitude (m)	Flight Pattern	Duration	Data Collected
Search	~100	~305	Systematic transect lines Short "connector" lines Transits	Until MM seen then switch to Identify or Focal Follow Mode	Time & location of sighting Species, group size, min. no. calves Bearing & declination angle to sighting Behavior state Initial reaction (yes or no & type) Heading of sighting (magnetic) Dispersion distance (min. & max. in estim. body lengths)
Identify	~85	~305	Circling at ~305 m radius	<5 min	Photograph to verify species Estimate group size, min. no. calves Note any apparent reaction to plane or unusual behavior
Focal Follow	~85	~365-457	Circling at ~1 km radius	≥5– 60+ min	<u>In order of priority every ~1 min:</u> Time Focal group heading (magnetic) Lat./long. (automatic GPS) Behavior state Dispersion distance Aircraft altitude (ft)(automatic WAAS GPS) Distance of aircraft to MM (declination angle) Reaction (yes or no & type) Bearing & distance to vessels <10 km away or other nearby activity Surface & dive times (whales) Respirations (whales) Individual behavior events (whales)
Shoreline Survey	~100	~305	Circumnavigate San Clemente Island in clockwise direction ~0.5 km from shoreline (random effort)	~45 min	Status (alive, dead or injured) Species, group size, min. no. calves Bearing & declination angle to sighting Behavior state & heading Initial reaction (yes or no & type)

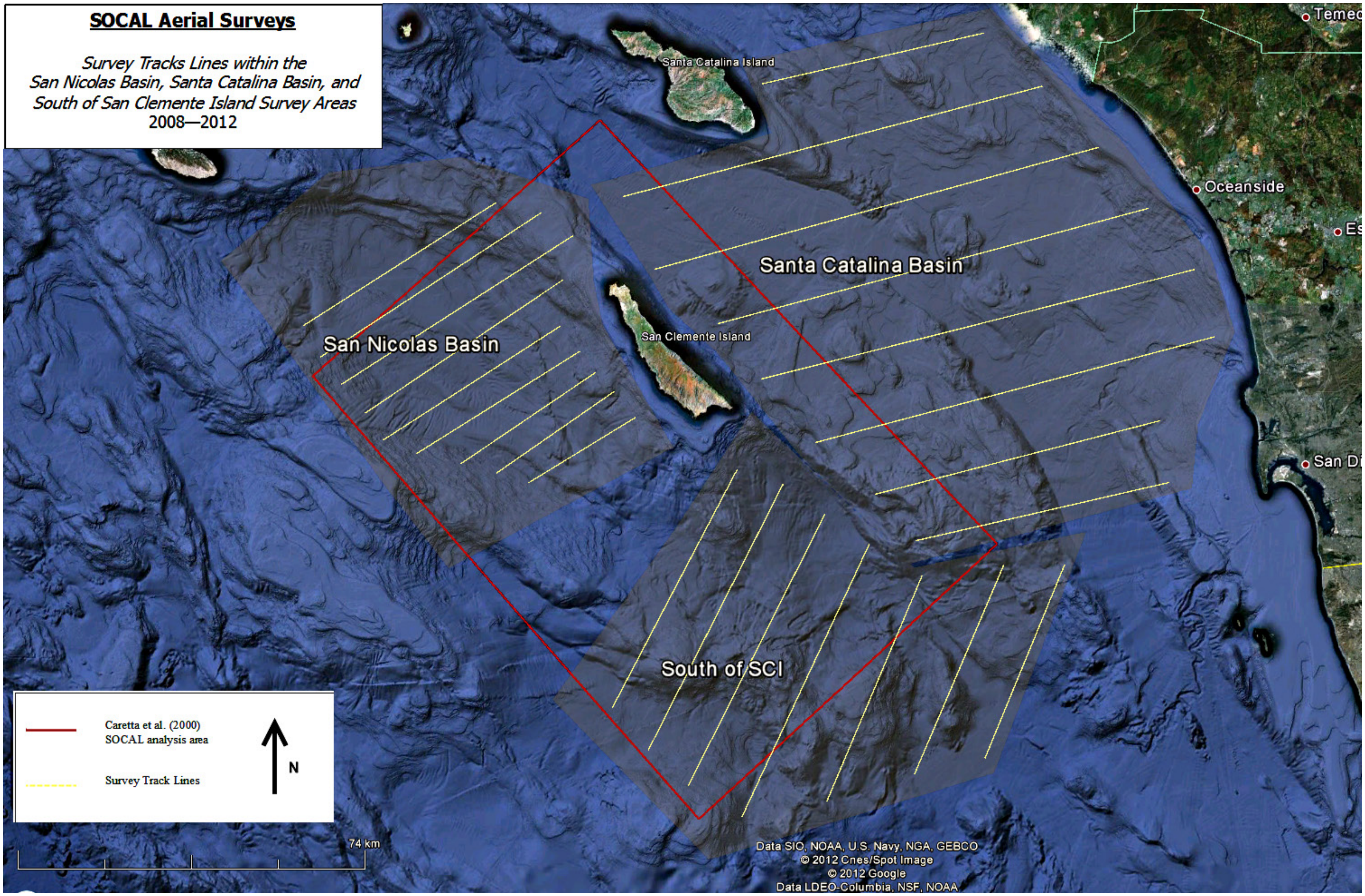


Figure E-1. Systematic survey tracklines within the three survey sub-areas off southern California 2008–2012.

We used the following hardware and software for data collection, including basic sighting and environmental data (e.g., , observation effort, visibility, glare, etc.): (1) BioSpectator on a Palm Pilot TX (pull-down menus or screen keyboard) or an Apple iPhone or iTouch in 2008 and 2009; (2) a customized Excel spreadsheet on a Windows-based notebook computer (2010, 2011); or customized Mysticetus Observation Platform (Mysticetus) software on a notebook computer (2011, 2012). Each new entry was automatically assigned a time stamp, a sequential sighting number, and a GPS position. A Suunto handheld clinometer was used to measure declination angles to sightings when the sighting was perpendicular to the aircraft (2008-2010) or in 2011-2012 at the sighting location along with a horizontal bearing from the aircraft using Mysticetus. In 2008-2010, declinations were later converted to perpendicular sighting distance; in 2011-2012, declinations were instantly converted to perpendicular and radial sightings distances by Mysticetus.

Photographs and video were taken through a small opening/porthole through either the co-pilot seat window (2008-2010) or the rear left bench-seat window (2011-2012). One of four Canon EOS or Nikon digital cameras with Image Stabilized (IS) zoom lenses was used to document and verify species for each sighting during Identify Mode, as feasible/needed (Canon 40D with 100-400 mm ET-83C lens; Canon 20D with 70-200 mm 2.8 lens and 1.4X converter; Canon 7D with 100-400 mm lens; Nikon D50 with 100-400 mm lens). A Sony Handycam HDR-XR550 or a Sony Handycam HDR-XR520 video camera was used to document behaviors during Focal Follow Mode. Observers used Steiner 7 X 25 or Swarovski 10 X 32 binoculars as needed to identify species, group size, behaviors, etc. Environmental data including Bf, glare and visibility conditions, were collected at the beginning of each leg and whenever conditions changed. The GPS locations of the aircraft were automatically recorded at 10-second intervals on WAAS-enabled GPSs: a Garmin 495 aviation or Global-Sat, a handheld Garmin 78S GPS, and the aircraft GPS. In 2008-2010, sighting and effort data were merged with the GPS data using Excel after the survey, based on the timestamp information to obtain aircraft positions and altitudes at the times of the recorded events and to calculate distances to sighted animals. In 2011-2012, Mysticetus merged these data automatically in the field.

Data Analysis

We used standard line-transect methods to analyze the aerial survey data (Buckland et al. 2001). Estimates of density and abundance (and their associated coefficient of variation) were calculated using the following formulae:

$$\hat{D} = \frac{n\ \hat{f}(0)\ \hat{E}(s)}{2\ L\ \hat{g}(0)}$$

$$\hat{N} = \frac{n\ \hat{f}(0)\ \hat{E}(s)\ A}{2\ L\ \hat{g}(0)}$$

$$C\hat{V} = \sqrt{\frac{\hat{\text{var}}\ (n)}{n^2} + \frac{\hat{\text{var}}\,[\hat{f}(0)]}{[\hat{f}(0)]^2} + \frac{\hat{\text{var}}\,[\hat{E}(s)]}{[\hat{E}(s)]^2} + \frac{\hat{\text{var}}\,[\hat{g}(0)]}{[\hat{g}(0)]^2}}$$

where D = density (of individuals),

n = number of on-effort sightings,

f(0) = detection function evaluated at zero distance,

E(s) = expected average group size (using size-bias correction in DISTANCE),

L = length of transect lines surveyed on effort,

g(0) = trackline detection probability,

N = abundance,

A = size of the study area,

CV = coefficient of variation, and

var = variance.

Line-transect parameters were calculated using the software DISTANCE 6.0, Release 2 (Thomas et al. 2010). Previous estimates used both systematic and connector lines (Jefferson et al. 2011, 2012). However, due to concerns about possible bias, only survey lines flown during systematic (the main line-transect survey lines perpendicular to the coast) transects at a planned altitude of 700-1,000 ft with both observers on-effort were used to estimate the detection function and other line-transect parameters (i.e., sighting rate, n/L, and group size). We used a strategy of selective pooling and stratification to minimize bias and maximize precision in making density and abundance estimates (see Buckland et al. 2001). Due to low sample sizes for most species, we pooled species with similar sighting characteristics to estimate the detection function. This was done to produce statistically robust values with sample sizes of at least 60-80 sightings for each group. The four species groups were: (1) baleen whales, (2) large delphinids, (3) small delphinids, and (4) California sea lions (see **Table E-3, Figure E-2a-d**).

Table E-3. Estimates of the detection function for the four species groups. In the sample size column, two numbers are given: total sample size and the sample size after truncation (in parentheses).

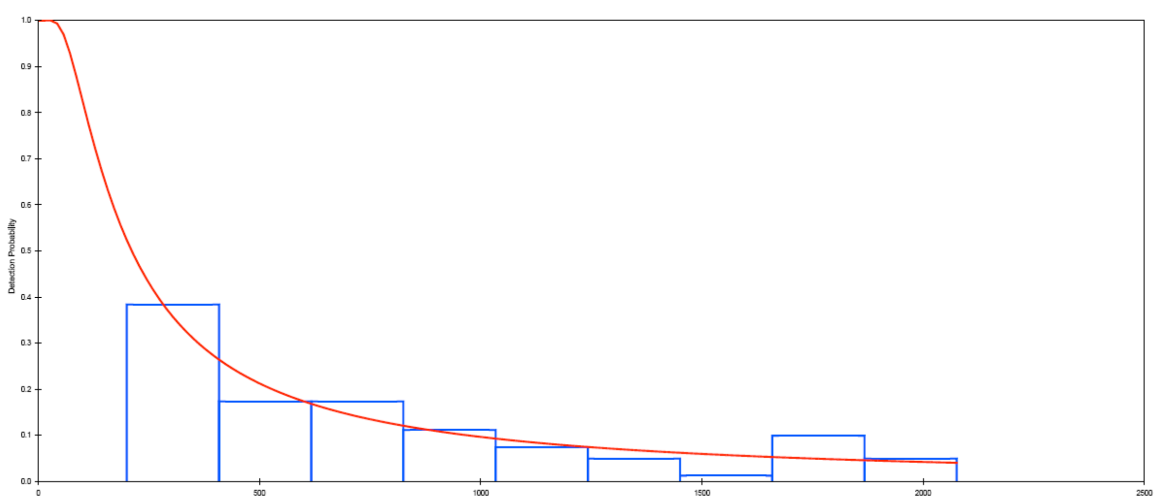
Species Group	Species Included	n	f(0)	%CV
Baleen whales	*Balaenoptera musculus, B. physalus, Balaenoptera* sp., *Megaptera novaeangliae, Eschrichtius robustus,* unidentified baleen whale	109 (91)	0.0043 Hazard Rate/Cosine	271
Large delphinids	*Grampus griseus, Tursiops truncatus*	148 (128)	0.0024 Hazard Rate/Cosine	22
Small delphinids	*Delphinus delphis, D. capensis, Delphinus* sp., *Lagenorhynchus obliquidens, Lissodelphis borealis*, unidentified small dolphin	232 (193)	0.0017 Half Normal/Cosine	9
California sea lion	*Zalophus californianus,* unidentified pinniped	147 (103)	0.0043 Uniform/Cosine	8

We used all data collected in sea state conditions of 0-4 and did not stratify estimates by sea state or other environmental parameters. We produced stratified (in terms of sighting rate and group size) estimates of density and abundance for the two survey sub-areas and two seasons, using the pooled species-group f(0) values described above. The seasons were defined as warm-water (May through October) and cold-water (November through April), after Carretta et al. (2000).

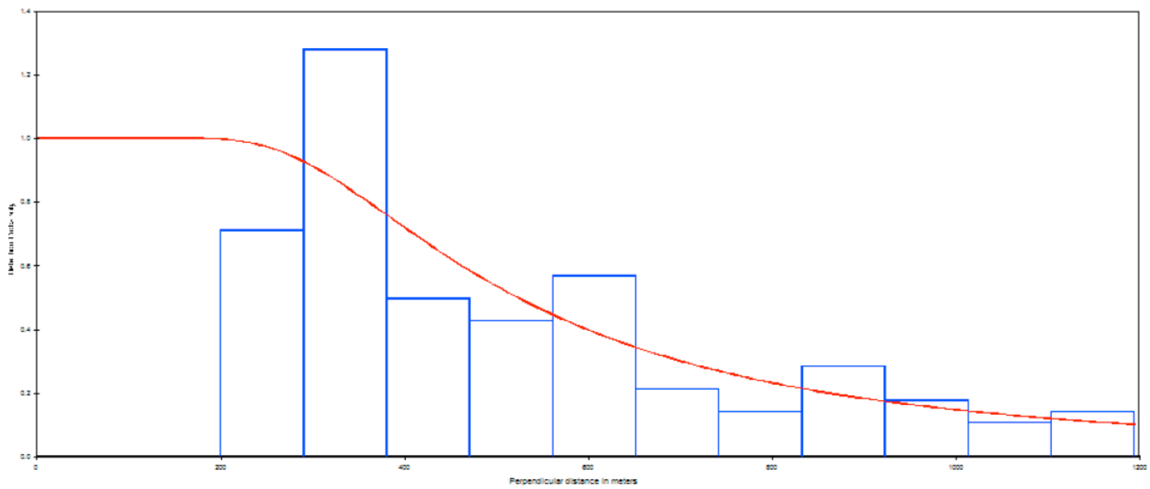
Some sightings (19 percent) were unidentified to species (although some of these were identified to a higher-level taxonomic grouping, e.g., unidentified baleen whale, unidentified small delphinid, unidentified pinniped, unidentified *Balaenoptera* sp., or unidentified *Delphinus* sp.). We thus prorated these sightings to species using the proportions of species in the identified sample, adjusted our sighting rates appropriately, and corrected the estimates with these factors. Because of the large proportion (81 percent) of sightings that were identified only to genus for *Delphinus*, we took a slightly different approach with this group. We calculated an overall estimate for *Delphinus* spp., then prorated the estimate to species (*D. delphis* and *D. capensis*), based on the proportion of each species represented in the known sample of sightings (0.72 for *D. delphis* and 0.28 for *D. capensis*).

To avoid potential overestimation of group size, we used the size-bias-adjusted estimate of average group size available in DISTANCE. In most cases, group size for each estimate was calculated using a stratified approach (i.e., only groups from within a particular stratum were used to calculate average group size for that stratum).

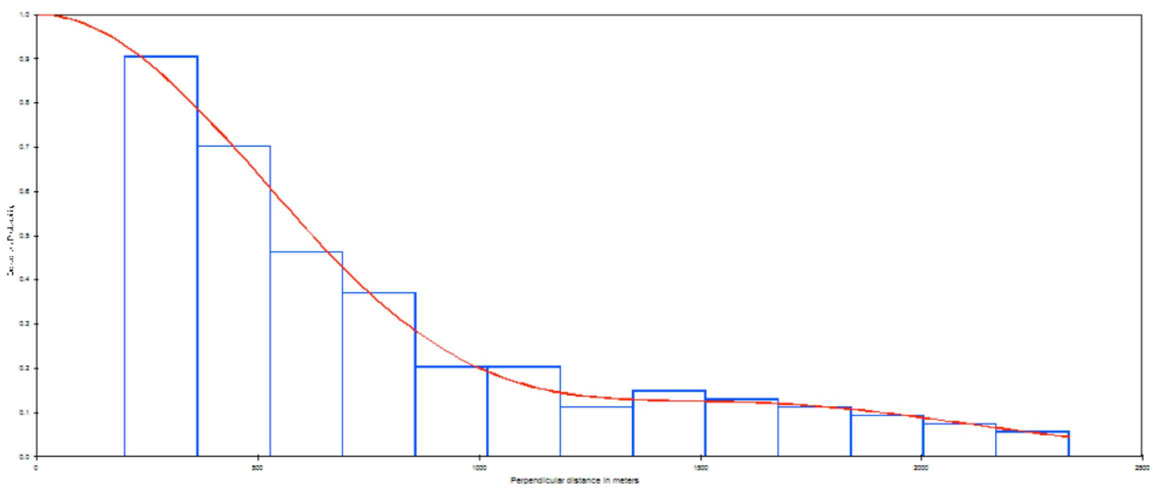
Truncation involved the most-distant 5 percent of the sightings for each species group. We also used left truncation at 200 m due to indications that poor visibility below the aircraft resulted in missed detections near the transect line (the 200 m cut-off was based on examination of the sightings by distance plots). This helped avoid potential underestimation of f(0) due to missed detection data immediately near the transect line. We modeled the data with half-normal (with hermite polynomial and cosine series expansions), hazard rate (with cosine adjustment), and uniform (with cosine and simple polynomial adjustments) models, selecting the model with the lowest value for Akaike's Information Criterion.



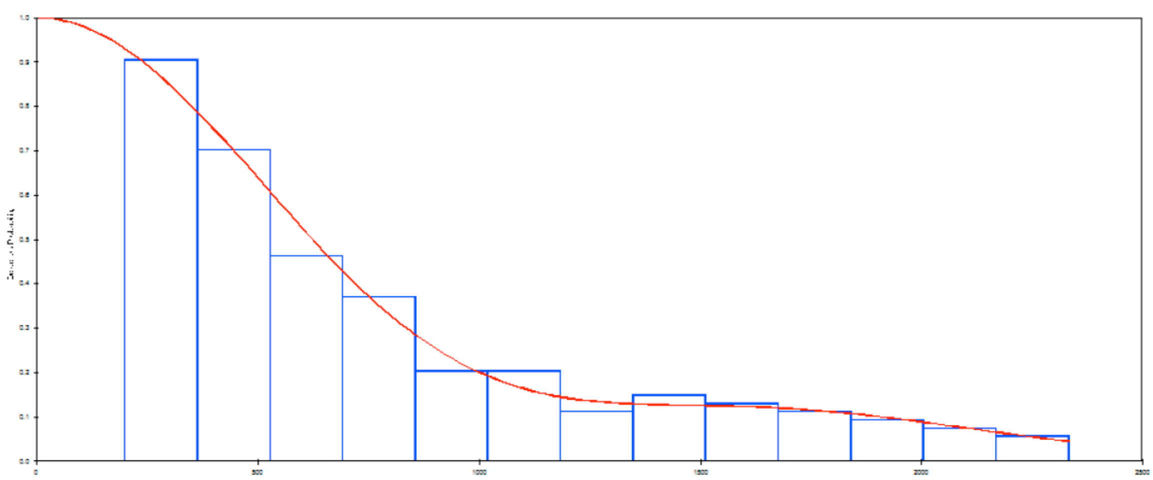
a) Baleen whales



b) Large delphinids



c) Small delphinids



d) California sea lions

Figure E-2a-d. Perpendicular distance plots and fitted detection functions for the four species groups.

We did not have data available to empirically estimate trackline detection probability [g(0)] for this study. However, since our surveys were very similar to those of Carretta et al. (2000), values for g(0) from their study were used to adjust for uncertain trackline detection. Because data for estimating g(0) came from that study, and standard errors were usually not available, we did not incorporate a variance factor for g(0) into the final estimates of abundance. This results in an underestimate of the variance for the final estimates of density and abundance. However, estimates of density and abundance were produced only for those species with at least eight useable, on-effort sightings in the line-transect database (an arbitrary cut-off, based on past experience) to address this issue.

RESULTS

Out of a total of 59,287 km flown, 31.8 percent (18,831 km) were flown during on-effort periods for line transect in good sea conditions (Bf 4 or less), during systematic lines, and thus available to estimate density and abundance. Out of the total of 2,128 marine mammal groups sighted during all survey states (on-effort, off-effort), 40.6 percent (n = 863) of these were used to estimate density and abundance in this report (**Table E-4**; **Figures E-3 and E-4**). We sighted at least 19 species of marine mammals, although not all sightings were identified to species level (**Table E-4**). The most commonly sighted marine mammals (with the number of useable sightings given in parentheses) were fin whales (n = 61), gray whales (n=39), Risso's dolphins (n=142), bottlenose dolphins (n=34), common dolphins (n=249, including both species), California sea lions (n=161), Pacific white-sided dolphins (n=11), blue whales (n=8), and humpback whales (n=8). Abundance was thus estimated for these species. Line-transect estimates of density and abundance (and their associated coefficients of variation) are shown in **Table E-5**.

Identification of common dolphins to species level was often not possible during flights;for this reason, extensive photos were taken of common dolphin schools for later detailed examination. We examined a sample of these photos to see if we could identify the species, and we could in many cases. Short-beaked common dolphins predominated these sightings. Based on the preliminary sample of photos in which we were able to determine species, 72 percent of common dolphins sighted were *D. delphis* and only 28 percent were *D. capensis*.

Table E-4. Marine mammal species observed during the surveys listed in taxonomic order, with total sightings (nT) and sightings available for line transect estimation (nD).

SPECIES	nT	nD
Blue whale, *Balaenoptera musculus*	65	8
Fin whale, *B. physalus*	121	61
Bryde's whale, *B. brydeii/edeni*	2	1
Minke whale, *B. acutorostrata*	11	6
Humpback whale, *Megaptera novaeangliae*	13	8
Gray whale, *Eschrichtius robustus*	78	39
Sperm whale, *Physeter macrocephalus*	1	1
Cuvier's beaked whale, *Ziphius cavirostris*	2	2
Killer whale, *Orcinus orca*	2	2
Pacific white-sided dolphin, *Lagenorhynchus obliquidens*	20	11
Risso's dolphin, *Grampus griseus*	286	142
Bottlenose dolphin, *Tursiops truncatus*	102	34
Short-beaked common dolphin, *Delphinus delphis*	70	42
Long-beaked common dolphin, *D. capensis*	37	16
Common dolphin, *Delphinus* sp.	456	191
Northern right whale dolphin, *Lissodelphis borealis*	12	5
Dall's porpoise, *Phocoenoides dalli*	5	3
California sea lion, *Zalophus californianus*	418	161
Harbor seal, *Phoca vitulina*	15	1
Northern elephant seal, *Mirounga angustirostris*	5	5
Unidentified (Unid.) baleen whale	48	21
Unid. delphinid	270	63
Unid. pinniped	47	17
Unid. marine mammal	42	23
TOTAL	**2,128**	**863**

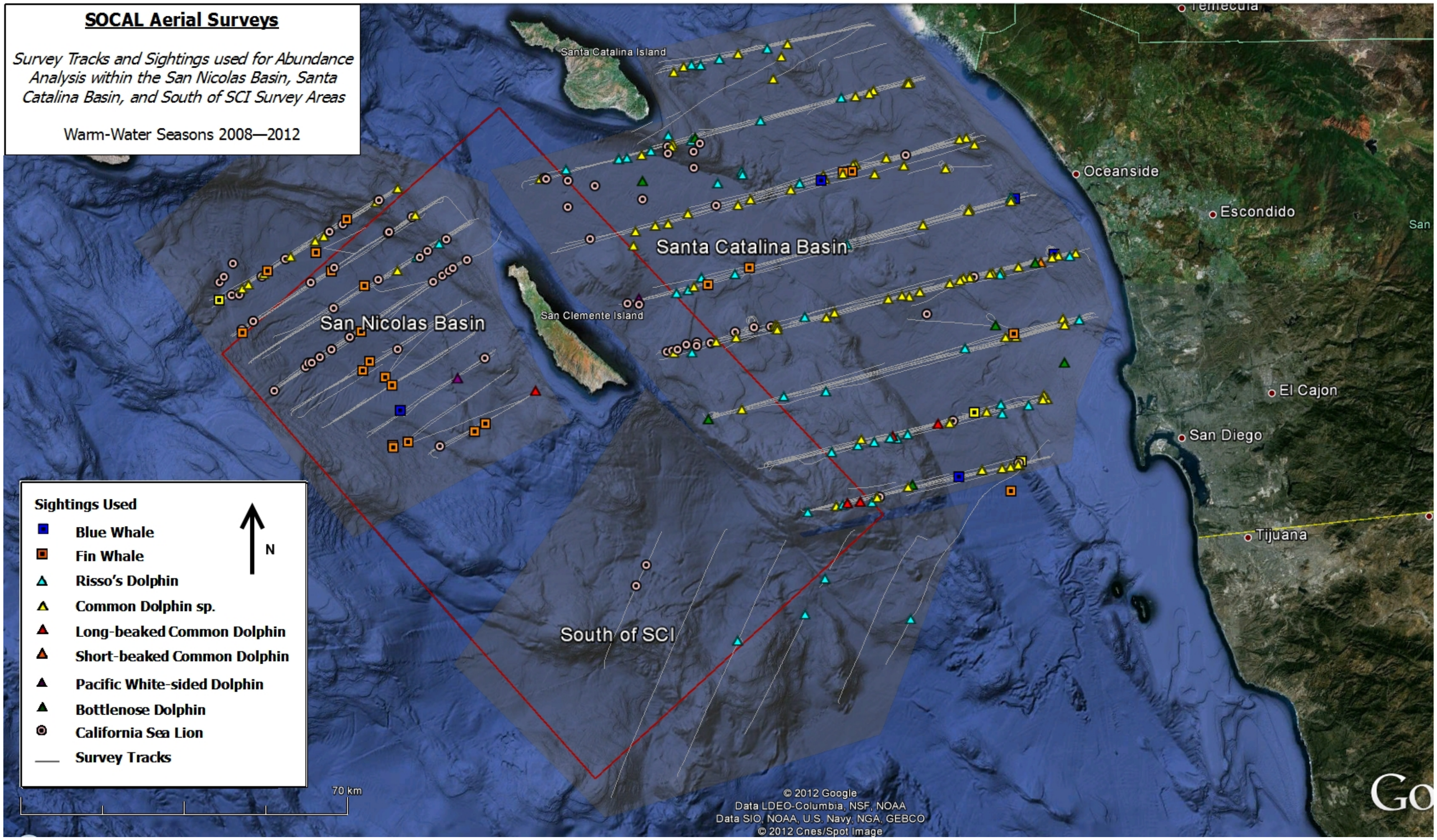


Figure E-3. Systematic survey tracks and sightings used for abundance analysis, warm-water seasons (May-October) off Southern California 2008–2012.

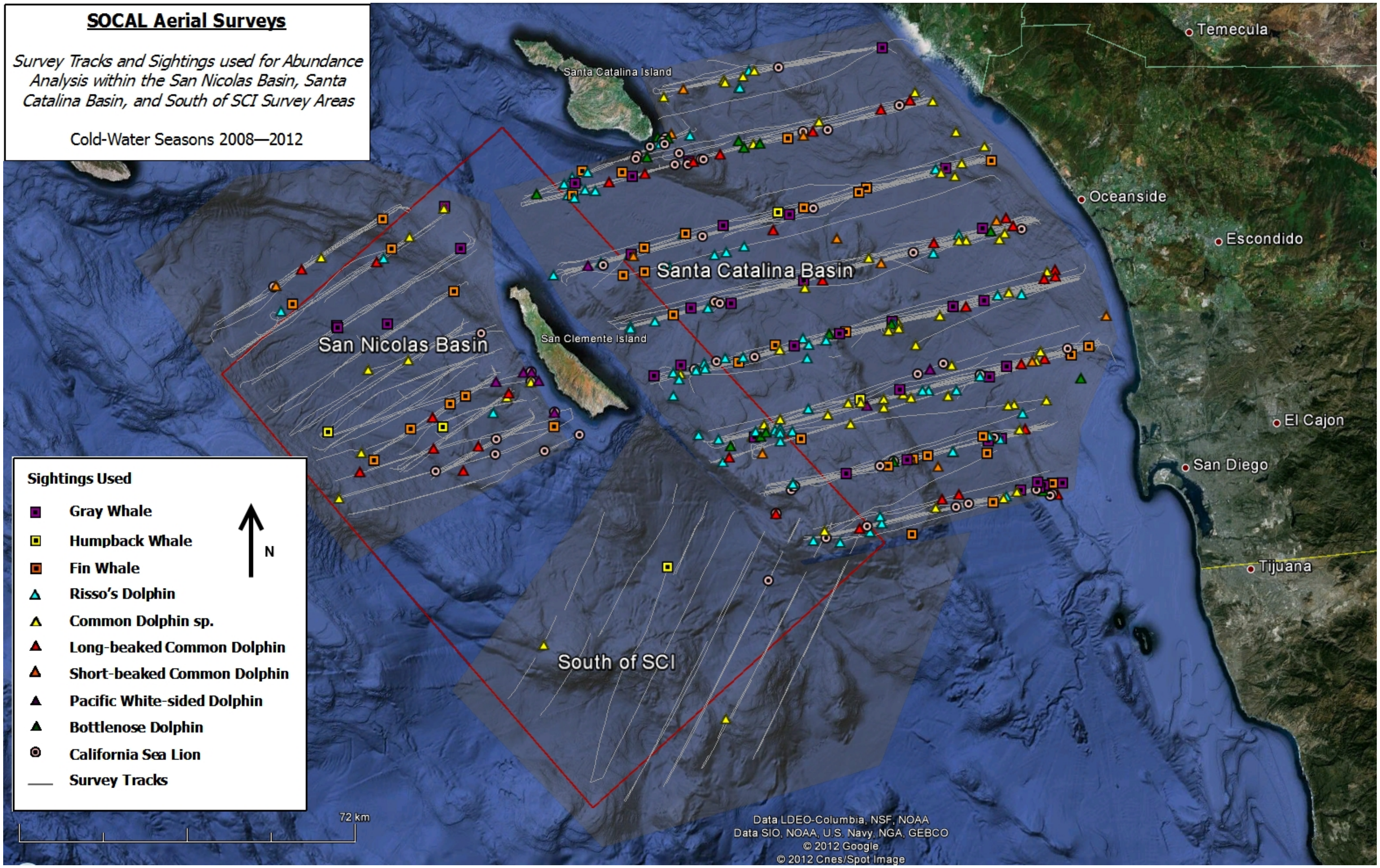


Figure E-4. Systematic survey tracks and sightings used for abundance analysis, cold-water seasons (November-April) off Southern California 2008–2012.

Table E-5. Estimates of individual density (Di), abundance (N), abundance incorporating proration of unidentified sightings (N'), and coefficient of variation (%CV) for marine mammals in the Southern California study area for the warm-water (May-October) and cold-water (November-April) seasons. Densities are in individuals per square kilometer. The first line for each species is for the entire Southern California Range Complex and the next two lines are stratified by the two survey sub-areas. The species are listed in taxonomic order.

	WARM SEASON				COLD SEASON			
SPECIES	**Di**	**N**	**N'**	**%CV**	**Di**	**N**	**N'**	**%CV**
Blue whale, *Balaenoptera musculus*	**0.00273**	**35**	**41**	**282**	**0.00000**	**0**	**0**	n/a
Santa Catalina Basin	0.00302	25	29	276	0.00000	0	0	n/a
San Nicholas Basin	0.00226	10	12	289	0.00000	0	0	n/a
Fin whale, *Balaenoptera physalus*	**0.02115**	**268**	**317**	**281**	**0.01631**	**206**	**246**	**276**
Santa Catalina Basin	0.00403	69	81	278	0.00894	76	91	273
San Nicholas Basin	0.04747	199	236	284	0.03113	130	155	278
Humpback whale, *Megaptera novaeangliae*	**0.00111**	**14**	**18**	**289**	**0.00319**	**40**	**50**	**285**
Santa Catalina Basin	0.00083	6	8	289	0.00101	8	10	280
San Nicholas Basin	0.00186	8	10	288	0.00766	32	40	289
Gray whale, *Eschrichtius robustus*	**0.00000**	**0**	**0**	n/a	**0.04461**	**564**	**639**	**306**
Santa Catalina Basin	0.00000	0	0	n/a	0.06527	554	627	273
San Nicholas Basin	0.00000	0	0	n/a	0.00268	10	12	338
Risso's dolphin, *Grampus griseus*	**0.12749**	**1,613**	**1,613**	**69**	**0.08591**	**1,087**	**1,087**	**63**
Santa Catalina Basin	0.18230	1,544	1,544	40	0.11558	980	9809	34
San Nicholas Basin	0.01639	69	69	97	0.02574	107	107	92
Bottlenose dolphin, *Tursiops truncatus*	**0.03788**	**321**	**488**	**73**	**0.02463**	**209**	**317**	**61**
Santa Catalina Basin	0.03788	321	488	73	0.02463	209	317	61
San Nicholas Basin	0.00000	0	0	n/a	0.00000	0	0	n/a
Pacific white-sided dolphin, *Lagenorhynchus obliquidens*	**0.01351**	**171**	**248**	**97**	**0.00292**	**37**	**53**	**104**
Santa Catalina Basin	0.01372	116	168	100	0.00133	11	16	81
San Nicholas Basin	0.01320	55	80	94	0.00624	26	37	127
Short-beaked common dolphin, *Delphinus* delphis	**0.78200**	**9,894**	**9,894**	**57**	**1.07071**	**13,547**	**13,547**	**46**
Santa Catalina Basin	1.12446	9,528	9,528	32	1.10450	9,358	9,358	28
San Nicholas Basin	0.08751	366	366	81	1.00235	4,189	4,189	64
Long-beaked common dolphin – *Delphinus* capensis	**0.30408**	**3,847**	**3,847**	**57**	**0.41636**	**5,268**	**5,268**	**46**
Santa Catalina Basin	0.43736	3,705	3,705	32	0.42948	3,639	3,639	28
San Nicholas Basin	0.03408	142	142	81	0.38976	1,629	1,629	64
California sea lion, *Zalophus californianus*	**0.05558**	**703**	**781**	**45**	**0.14891**	**1,884**	**2,093**	**84**
Santa Catalina Basin	0.02415	204	227	32	0.03973	337	375	41
San Nicholas Basin	0.11920	499	554	58	0.37036	1,547	1,718	126

DISCUSSION

Potential Biases of the Estimates

As is true of any statistical technique, there are certain assumptions that must hold for line-transect estimates of density and abundance to be accurate. Below we go through the various assumptions of line transect and other issues that may cause bias in our estimates.

Assumption 1: Certain Trackline Detection. Target animals on and very near the trackline must be detected to avoid estimates that are biased low (Buckland and York 2009). This is a central assumption of basic line-transect theory. However, in reality, it is often violated, especially by diving animals like marine mammals. This can be addressed by incorporating a factor into the line-transect equation that accounts for the proportion of missed animals (trackline detection probability, g(0)). We did this in the present study, by using g(0) factors from studies by other researchers of the target species. However, these often only account for part of the potential bias. Both availability bias (the proportion missed due to an animal on a dive and unavailable at the surface) and perception bias (the proportion missed despite the fact that they were available to be seen by observers) should ideally be included. However, obtaining appropriate data to model these can be difficult, and the previous studies (refs) primarily assessed availability bias. Since our estimates do not usually account for both of these types of bias, this results in some residual underestimation.

The inability to see all animals directly under the aircraft also clearly affects the trackline detection. Due to aircraft and personnel limitations, we did not always have the ability to use a belly observer. We have strived to minimize the potential effects of this limitation on the resulting density and abundance estimates by using a 200-m left truncation approach. It is uncertain how much remaining bias from this factor may affect our estimates. We propose to use a belly observer in future surveys to clarify this issue.

Assumption 2: No Responsive Movement. Although it is often stated that there must be no responsive movement to the survey platform, this is not strictly true. However, any responsive movement must occur after detection by the observers, and such movement must be slow relative to the speed of the survey platform (Buckland and York 2009). In our case, the use of a fast-moving aircraft as the survey platform minimizes the chances of this being a significant issue. This is much more of a concern with vessel surveys, and in aerial surveys is generally not considered to be a problem.

Assumption 3: No Distance Errors. Distances must obviously be measured accurately to avoid inaccuracies in the resulting estimates (Buckland and York 2009). However, in practice, distances are difficult to measure at sea, and it is likely that every marine mammal line-transect survey has suffered from some inaccuracy in distance measurement. However, small and random errors generally do not cause significant problems. It is large and/or directional errors that that cause large errors and are thus of more serious concern. We have strived to measure angles and distances as accurately as possible during this study. At this point, we have no indications that large or directional errors in distance measurement were an issue in this study, and, we are conducting studies to further examine this potential bias.

Other Factors

Besides the above-listed issues, a few other factors may cause some bias in the resulting line-transect estimates. Line placement is a factor that should be considered, as duplicate sightings on different lines on the same day can cause bias. This happened twice and was evident from the similarity of sighting data and timing, recorded activity of the animals (i.e., traveling in a direction consistent with the other sighting location), and the observed aircraft tracks (which included circling sightings) inspected on daily maps. In both cases, the sighting with the least complete data was eliminated from the data set so that the animal/group was only used once. Although we cannot be certain that there are no other instances of this in the data, the high speed of the aircraft in relation to animal movement makes it unlikely to be more than a rare event; our data checking procedures further reduce the likelihood of such instances remaining in the data set.

The sampling design and line spacing should cause no bias. Each sample (i.e., one day's effort) is an independent event, and animals redistribute themselves between samples (i.e., across days). The systematic survey lines were designed and drawn without reference to marine mammal distribution, and there is no evidence that certain lines or areas in-between lines have higher sighting rates than others. Thus, no bias should result. Furthermore, systematic lines were generally oriented perpendicular to underwater topography, similar to previous line-transect surveys conducted by the NMFS SWFSC in this region (e.g., Carretta et al. 2000).

Lack of independence of detections and non-uniform distribution of animals can sometimes cause issues. Some of the specific strategies used in this study to handle issues related to obtaining samples sizes appropriate for modeling the detection function may result in some bias (e.g., prorating unidentified sightings, left truncation, and pooling of Beaufort sea states). However, we have no reason to believe that these are major issues, and we believe that they have not caused any major bias in our estimates.

CONCLUSIONS

This report provides the most current fine-scale estimates of density and abundance within portions of the offshore marine waters in Southern California on the Navy's SOCAL Range. In particular, densities derived for the cold-water season represent seasonal data and analysis that is notably absent within the region over the last 13 years. Abundance of marine mammals is known to fluctuate from year to year based on changing and dynamic oceanographic conditions in southern California (e.g., El Niño/Southern Oscillation events, prey availability/distribution, etc.). Thus, density and abundance estimates may change as we obtain more data from future surveys and as we further perfect strategies to maximize precision and minimize bias. For instance, the National Marine Fisheries Service (NMFS) in their spatial habitat models and density estimates generally prefers to pool multi-year survey data to reduce the effect of inter-annual variation. However, based on historical data such as Carretta et al. (2000), we believe that the estimates reported in this paper are generally reflective of numbers of marine mammals within the Navy's Southern California Range Complex during the survey periods.

Overall, our results are in general agreement with those of Carretta et al. (2000), who surveyed a partially overlapping area using similar methods in the late 1990s. However, our study areas are not the same as those of Carretta et al. (2000), and therefore direct comparisons cannot be made. Our results indicate that the study area continues to be used by a substantial number of marine mammal species during the both the warm- and cold-water seasons. However, numerically, the region is dominated by only a few species. For great whale species, abundance was estimated to be in the tens (i.e., blue and humpback whales) or hundreds (fin and gray whales). Pacific white-sided and bottlenose dolphins, as well as California sea lions, numbered in the hundreds. Risso's and common dolphins numbered in the thousands (for short-beaked common dolphins, in some cases, over ten thousand). Other species were not seen frequently enough during the study period to derive reliable density or abundance estimates. We hope that future survey work will allow us to estimate abundance for all species that occur in the study area in the future.

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APPENDIX F: FIRST-OBSERVED BEHAVIORS OF MARINE MAMMALS: DETAILED STATISTICAL METHODS AND RESULTS

Analysis of Initial Observation Data from Aerial Surveys of the SOCAL Range Complex:

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INTRODUCTION

This report provides a detailed summary of the methods and results of statistical analyses conducted on selected response and explanatory variables recorded at the initial sightings of marine mammal groups during aerial survey monitoring surveys in the United States (U.S.) Navy's Southern California Range Complex (i.e., study area) in 2008-2012. It is meant to provide additional technical details, including tables and figures, for the discussion provided in the main report subsection entitled *First-Observed Behavioral Analysis*. Analyses were conducted on six species plus one species group for which adequate (n≥20) sample sizes were available: Risso's dolphin, common dolphin (long-beaked and short-beaked commons and unidentified commons, combined), bottlenose dolphin, blue whale, fin whale, gray whale, and California sea lion. A total of 4 response and 11 explanatory variables were used as listed in **Table F-1**.

METHODS

All data processing and analyses were conducted using the R program.

Data Processing

Table F-1 summarizes the explanatory and response variables used in the analyses. Sub-regions were re-classified into a binary categorical variable representing direction (East or West) relative to San Clemente Island. Northern Air Operating Area (NOAPA) and San Clemente Island (SCI) were classified as East, while the Southern California ASW Range (SOAR) and South of SCI were classified as West. The time variable (representing both date and time) was used to construct a Julian day variable which indicated the integer day number beginning with 1 on January 1 of each year of the study. A new variable representing the number of minutes from sunrise each day was calculated using sunrise tables for San Diego, California. Water depths were converted from negative values in feet to positive values in meters. Aspect in degrees was transformed into a variable pair via the cosine and sine transformations.

Pearson correlations between all pairs of continuous variables were calculated. Variable pairs with correlations greater than 0.6 in absolute value were not permitted to enter any regression model (described below) together. Each pair of categorical variables was cross-tabulated and results were examined for evidence of association; if Fisher's two-sided exact test was significant at the 5 percent (%) level, the two variables were not permitted to enter any model together. The association between each mixed pair of categorical and continuous variables was examined via an independent sample *t*-test; if the test was significant at the 5% level, the two variables were not permitted to enter any model together. The cosine and sine transformations of aspect were treated as a single variable. That is, either both transformations entered a model together or both were excluded. Similarly if either member of the pair was associated with any other variable using the criteria above, neither member of the pair was permitted to enter a model with the associated variable.

Regression Modeling

Separate regression modeling was conducted for each of the four response variables. In each case, a different type of model was used as appropriate for the type of response. In all cases, best subsets model selection was used to identify the best models. Only main effects models with five or fewer covariates were examined. As noted above, the cosine and sine transformations of aspect were treated as a single variable in the model selection process. Otherwise, candidate covariates were not transformed, quadratic and higher order effects were not considered, and interactions between covariates were not considered. An automated routine was used to generate all main effects models with 1, 2, 3, 4, or 5 covariates that met the criteria above for absence of strong pairwise associations.

Missing values occurred among both the response variables and the candidate covariates. Observations with missing values do not contribute to regression models, and because there were different patterns of missing data for many of the regression analyses, each analysis dataset was re-examined for associations among variables. As dictated by the criteria for associations among covariates, different candidate sets of models were constructed as necessary.

In all regression modeling, Akaike's Information Criterion (*AIC*) (Burnham and Anderson 2002) was calculated for each candidate model. Models were ranked from lowest (best-fitting) to highest *AIC* and the top 10 models were identified. For each of these 10 models, the difference between its value (AIC_i) and that of the top-ranked model (AIC_1) was calculated as

$$\Delta_i = AIC_i - AIC_1$$

From these differences, Akaike weights were calculated for all 10 models as

$$w_i = \frac{\exp\left(-\frac{1}{2}\Delta_i\right)}{\sum_{m=1}^{10} \exp\left(-\frac{1}{2}\Delta_m\right)}$$

Lastly, the importance value for each variable was calculated as the sum of the Akaike weights for each model in which that variable appeared. Thus, if a variable appeared in all 10 models, its importance value would equal 1; otherwise, the importance value was bounded between 0 and 1.

Behavior

The response variable *behavior* (with three categories) (**Table F-1**) was analyzed using multinomial logistic regression in which 'fm travel' was the reference category and the odds of being in either of the other two categories ('slow' or 'mill') were calculated relative to the reference.

Group Size

Because the response variable group size, *bestcnt*, was an integer count variable, log-linear models were considered appropriate. Both Poisson and negative binomial regression models were examined. Initial modeling indicated that variance was generally greater than expected under the Poisson distribution. Vuong's (1989) test was used to compare the fit of Poisson and negative binomial regression models; generally, the negative binomial model accounted for the variance better than the Poisson model. In some cases, negative binomial regression models exhibited convergence problems, and Poisson regression was used.

Maximum Dispersal

Standard multiple linear regression was used to model the relationship between *maxdsp* and the covariates. Initial examination of the response indicated that a log transformation of *maxdsp* yielded a distribution that was approximately normal.

Heading

Initial modeling used the circular regression method introduced by Fisher and Lee (1992) and implemented in the *circular* package for R. However, these models generally exhibited convergence problems. Furthermore, this approach did not allow for convenient best-subsets model selection. Therefore, multinomial logistic regression was used in preference to circular regression. All headings were categorized as either NorthEast (between 0 and 90 degrees), SouthEast (between 90 and 180 degrees), SouthWest (between 180 and 270 degrees), or NorthWest (between 270 and 360 degrees). NorthEast was the reference category such that the odds of being in one of the other three categories were calculated relative to NorthEast.

RESULTS

A detailed discussion of the results of statistical analyses of first-observed behaviors below is limited to the Risso's dolphin to assist in results interpretation of the other species addressed only in tables and figures at the end of this appendix. Instead, Section *First-Observed Behavioral Analysis* in the main body of the report provides a descriptive summary of results for all seven species, cross-referencing tables and figures herein to avoid repetitive figures and tables.

Risso's Dolphin

Behavior

The top 10 models for behavior are summarized in **Table F-2**. Note that all 10 models are fairly similar with respect to fitting the data, as $\Delta_i < 3$ in all cases. Julian day number (*datejul*) and distance from shore (*distshore_km*) appear in all 10 models; correspondingly, both variables have importance value = 1 (**Table F-3**). Estimates from the top model are shown in **Table F-4**. Odds ratios indicate that for each 100 Julian days, dolphins are 1.67 times more likely to exhibit behavior categorized as 'mill' than they are to exhibit 'fm travel'. Conversely, for each 100 days, dolphins are 0.28 times as likely (i.e., *less* likely) to exhibit 'slow' behavior than they are to exhibit 'fm travel'. As time progresses within a day, dolphins are less likely to exhibit either 'mill' or 'slow' than 'fm travel'. The *minfromsun* odds ratios show that for each hour (60 minutes) after sunrise, dolphins are 0.93 times as likely to exhibit behavior classified as 'mill' and 0.89 times as likely to exhibit 'slow' behavior, both relative to 'fm travel'. With each 10 km increase in distance from shore, dolphins are 1.39 times more likely to exhibit 'mill' behavior than 'fm travel', while 0.84 times as likely to exhibit 'slow' behavior, based on estimated odds ratios for *distshore_km*.

Group Size

Table F-5 summarizes the best 10 models for group size. Importance values (**Table F-6**) show that three variables (*calf*, *mixedgrp*, and *datejul*) receive most of the weight among the 10 models. The top-ranked model contains these same three variables (**Table F-7**). The positive coefficients for all three parameters indicate increase in group size is associated with presence of calves and other species and with increase in Julian day. Note that confidence intervals for all four coefficients do *not* contain 0 (**Table F-7**), providing firmer evidence of positive effects. Predicted group size increases from approximately 15 to 25 with the presence of calves and from approximately 15 to 26 with the presence of other species (**Figure F-1**). As Julian day number increases in the period from February to late-November, predicted group size increases linearly (on a log scale) from approximately 12 to 23 (**Figure F-1**).

Maximum Dispersal

Table 8 shows shows somewhat greater differences in fit among the top10 models for maximum dispersal (log-transformed). In particular, $\Delta_i > 3$ for the four worst-fitting models among the 10. All 10 models contain *datejul* and *minfromsun* (**Table F-9**), and the importance value for *depth_m* (0.88) also indicates strong support for that variable among these models. Furthermore, these are the three variables appearing in the top-ranked model (**Table F-10**). Note that log(maximum dispersal) decreases with increases in time since sunrise, while it increases with increases in both depth and Julian date (**Table F-10** and **Figure F-2**). Again, none of the coefficient confidence intervals contain 0.

Heading

The top 10 models for heading show little variation in fit (**Table F-11**). The fact that markedly different one- and two-variable models predominate among these top 10 suggests that variation in Risso's dolphin heading is not well-explained by any of the available covariates. That conclusion is also supported by the low importance values among all variables appearing in these models (**Table F-12**). The best model contains only slope (**Table F-13**). Estimated odds ratios indicate that as slope increases, heading is less likely to be NorthEast; that is, headings of NorthWest, SouthEast, and SouthWest are all more likely than headings in the reference category.

Common Dolphin

Behavior

The top 10 models for behavior are summarized in **Table F-14**. Of these, the top 2 models receive most of the weight. The variable *season* appears in all 10 models and correspondingly has importance value = 1 (**Table F-15**). The variable *subregion* also has high importance value (0.91) and appears in most of the top 10 models. The top model contains both these variables; their estimates are shown in **Table F-16**. Recalling that fm travel represents the reference response category, the odds of milling are 1.93 times greater in the warm season than in the cold season. The odds of slow travel in the warm season are 0.95 times the odds in the cold season, i.e., slightly lower in the warm season, though given that the 95% confidence interval for this coefficient is (-1.1032, 0.9921) and thus includes 0, the evidence indicates that this odds ratio is not different from 1. In other words, there is no effect of season on the odds ratio for slow travel. Note that, in general, the odds ratio should be interpreted with appropriate caution in those cases when the corresponding confidence interval for the coefficient includes 0. The odds of slow travel in the West subregion are 4.15 times greater than the odds in the East subregion.

Group Size

The top 10 models for group size (**Table F-17**) all contain *calf* and aspect (represented jointly by *cos_asp* and *sin_asp*). Correspondingly, these three variables all have importance values of 1 (**Table F-18**). The variable *datejul* also has high importance value (0.92), and appears in most of the top 10 models including the best model. Coefficient estimates and associated confidence intervals indicate that presence of calves is positively associated with group size, while group size decreases with increases in Julian date (**Table F-19**). Predicted group size reflects the coefficient values; marginal effects plots show that predicted group size is larger with calf presence and decreases over calendar time (**Figure F-3**). Coefficients of *cos_asp* and *sin_asp* (**Table F-19**) are not directly interpretable, but when transformed back into aspect, they show that predicted group size is highest for north-facing slopes and lowest for south-facing slopes (Figure 3).

Maximum Dispersal

Table F-20 shows the top 10 models for maximum dispersal. *Calf* and *minfromsun* (time since sunrise) appear in all 10 models and correspondingly each has importance value = 1.0 (**Table F-21**). The best model contains these two variables alone. Coefficient estimates (**Table F-22**) and marginal effects plots for the predicted response (**Figure F-4**) show that maximum dispersal is greater with calf presence and decreases with increases in time since sunrise.

Heading

Among the candidate covariates, *depth_m* and *minfromsun* appear most frequently in the top 10 models for heading (**Table F-23**). These two variables have fairly high importance values (**Table F-24**) and together represent the best model for heading. Recalling that NE is the reference heading, **Table F-25** shows that the odds of heading in all three remaining directions (NW, SE, and SW) are lower as depth increases. For example, for each 100 m increase in depth, the odds of heading NW decrease by a factor of 0.90. Because confidence intervals include 0, there is weak evidence that minfromsun has any relationship with NW and SW headings. Otherwise, the odds of heading SE increase by a factor of 1.19 for each 60 minute increase in time since sunrise.

Bottlenose Dolphin

Behavior

The top 10 models for behavior tend to have 3 – 5 covariates (**Table F-26**); simpler models did not perform as well. The variables *depth_m*, *cos_asp*, and *sin_asp* appear in all 10 models; each has importance value = 1.0 (**Table F-27**). The variable *datejul* also has fairly high importance (0.70), as it occurs in most of the top-ranked models. The best model includes these four variables along with *minfromsun*, which otherwise appears in few models and has lower importance. **Table F-28** shows that the odds of slow travel increase by a factor of 1.32 for each 100 meter increase in depth. The odds of milling increase by a factor of 2.96 for an increase of 100 Julian days. Otherwise, coefficient confidence intervals for depth_m, datejul, and minfromsun include 0; there is limited evidence that the corresponding odds ratios differ significantly from 1. For aspect, the odds are difficult to interpret from estimated coefficients. However, **Figure F-5** presents the relative change in odds ratios with change in aspect. The odds of milling increase progressively as aspect changes from approximately 125° (where the odds are at a minimum) to approximately 300°, by a factor of 100 at the maximum. The odds of slow travel increase progressively as aspect changes from approximately 160° to 340°, by a factor of 12 at the maximum.

Group Size

The best models for bottlenose dolphin group size tend to be relatively simple; all contain three or fewer terms (**Table F-29**). Calf presence appears in all these models and has importance of 1.0 (**Table F-30**). Furthermore, *calf* is the only variable in the best model. The estimated coefficient for *calf* is positive, indicating that calf presence is positively associated with group size (**Table F-31**). Similarly, the marginal effects plot for *calf* shows that when calves are present, predicted group size is approximately twice as great as when calves are absent (**Figure F-6**).

Maximum Dispersal

Table F-32 shows the top-ranked multiple linear regression models for maximum dispersal. No variables appear in all 10 models, but the three variables in the best model (*datejul*, *minfromsun*, and *distshore_km*) occur most frequently, and these three have relatively high importance (**Table F-33**). Parameter estimates show that maximum dispersal is positively associated with *datejul* and negatively associated with both *minfromsun* and *distshore_km* (**Table F-34**). These relationships are confirmed by the marginal effects plots (**Figure F-7**). Over the range of observed data, these plots indicate that *datejul* has the largest effect on maximum dispersal while *distshore_km* has the smallest effect.

Heading

The top-ranked models for heading are shown in **Table F-35**. The variable *distshore_km* appears in most, though not all, of these models, including the best model; correspondingly, it has the highest importance value (0.94), while the remaining variables have moderate or low importance (**Table F-36**). Parameter estimates, confidence intervals, and odds ratios are shown in **Table F-37**. Generally, the odds of heading in any of the three non-reference directions decrease as distance from shore increases. However, only the odds for heading SW are significantly different from 1; in that case, with each 10 km increase in distance from shore, the odds of heading SW decrease by a factor of 0.35.

Blue Whale

Behavior

The highest-ranked multinomial logistic regression models for behavior tend to be relatively simple, with just one or two covariates (**Table F-38**). None of the variables has high importance (**Table F-39**). The best models contains only *slope*, which has importance = 0.41, reflecting the facts that *slope* does not appear in many models and that the top model is not substantially better than the other models (**Table F-38**). Confidence intervals for the estimated coefficients of *slope* both contain 0 (**Table F-40**). Thus, even though the odds ratios suggest that the odds of both milling and slow travel increase with increases in slope, the evidence indicates that slope does not have an effect on the likelihood of either behavior.

Group Size

Negative binomial regression models exhibited convergence problems, so standard Poisson regression was used as an alternative even though there was some evidence of overdispersion (suggesting that negative binomial models *should* have fit better than Poisson models). The best Poisson regression model contained the covariates *datejul* and *depth_m* (**Table F-41**). Of these two variables, *datejul* occurred most commonly among the top 10 models, and had importance value = 0.95. In contrast, *depth_m* had much lower importance (0.42) (**Table F-42**) and occurred in fewer models, generally models with lower weight (**Table F-41**). **Table F-43** shows the coefficients and associated confidence intervals for the two covariates in the best model. The negative coefficient for *depth_m* indicates that group size decreases with increases in depth, though the fact that the 95% confidence interval includes 0 (**Table F-43**) indicates weak evidence for that relationship. In contrast, group size increases with increases in *datejul* (indicated by the positive coefficient) and there is stronger evidence for the relationship (because the confidence interval does not include 0). Marginal effects plots show that over the observed range of the data, *depth_m* has a relatively small effect on predicted group size compared to the effect of *datejul* (**Figure F-8**).

Maximum Dispersal

The top-ranked regression models for maximum dispersal have small values of Δ_i (all ≤ 1.62) indicating that all are relatively similar in predictive power (**Table F-44**). Furthermore, none of the covariates in these models have high importance values (**Table F-45**) suggesting further that none of the candidate covariates account well for variation in maximum dispersal. The best model contains only *slope*, which has importance = 0.62. The estimated coefficient for slope is positive, though the associated 95% confidence interval includes 0 (**Table F-46**), indicating that the coefficient is not significantly different from 0 at $\alpha = 0.05$. The marginal effects plot (**Figure F-9**) further confirms the weak relationship; predicted maximum dispersal shows essentially no change with increases in slope.

Heading

The top-ranked models for blue whale heading all have either one or two covariates (**Table F-47**). As is the case for maximum dispersal, none of the covariates in these models have high importance values (all ≤ 0.5) (**Table F-48**). The single covariate in the best model is *datejul*. Note that the confidence intervals for the coefficients of *datejul* include 0 in all cases, i.e., for all of the response categories (**Table F-49**). Thus, the evidence indicates that the corresponding odds ratios are not different from 1 and, equivalently, that *datejul* has little relationship with heading.

Fin Whale

Behavior

The best multinomial logistic regression model for fin whale behavior contains *datejul* and *distshore_km* (**Table F-50**). Both variables are common in the top 10 models, with *datejul* occurring in all models and *distshore_km* appearing in all but one model. These two variables have high importance (1.0 for *datejul*, 0.96 for *distshore_km*), while the remaining variables all have low importance (**Table F-51**). **Table F-52** shows estimated coefficients, confidence intervals and odds ratios. The odds of milling decrease with increases in distance from shore; in particular, for each 10 km increase in distance, the odds of milling decrease by a factor of 0.20. The odds of slow travel decrease with Julian date; in particular, the odds decrease a factor of 0.22 for each 100 days. Otherwise, confidence intervals include 0 and provide little evidence that distance from shore is related to the likelihood of slow travel, or that Julian date is related to the likelihood of milling.

Group Size

As was the case for blue whales, Poisson regression was used to model group size for fin whales due to convergence problems with negative binomial models. The best model includes *calf* and *minfromsun* (**Table F-53**). As seen in **Table F-54**, *calf* has importance = 1.0 (since it appears in all 10 of the top-ranked models) and *minfromsun* has importance = 0.59, indicating moderate predictive power among these models. The remaining covariates all have low importance. Estimated coefficients show that *calf* is positively associated with group size, while *minfromsun* is negatively associated (**Table F-55**). While the confidence interval for the coefficient of *minfromsun* includes 0, most of the interval spans negative values; while not significant at the 5% level, the result indicates 'near significance'. Marginal effects plots are consistent with these patterns – predicted group size is approximately doubled by presence of calves (compared to absence), and group size decreases moderately with increasing time since sunrise (**Figure F-10**).

Maximum Dispersal

The variable *calf* occurs in all but 1 of the top 10 linear regression models for maximum dispersal (**Table F-56**). The best model also includes subregion, but this variable otherwise occurs in few models. Correspondingly, importance values are high for *calf* (0.93) and moderately low for *subregion* (0.41) (**Table F-57**). Coefficient estimates for the top model (**Table F-58**) show that maximum dispersal is negatively associated with calf presence and positively associated with the subregion West of San Clemente Island (because the indicator variable *subregion* equals 0 for East and 1 for West). Note that the 95% confidence interval for the coefficient includes 0, though the great majority of the interval spans negative values (**Table F-58**), suggesting 'near significance'. Predicted values of maximum dispersal reflect the coefficient values in that maximum dispersal is higher when calves are absent and when fin whales are west of San Clemente Island (**Figure F-11**).

Heading

Model selection for fin whale heading tends to favor simpler one- and two-variable models (**Table F-59**). The best model contains only *slope*, which also appears in most of the remaining top 10 models and has importance value = 0.90 (**Table F-60**). The other variables in the top models all have low importance. Irrespective of its importance value, 95% confidence intervals for the coefficients of slope all include 0 (**Table F-61**), indicating that the coefficients are not significantly different from 0 at $\alpha = 0.05$ and, correspondingly, that the odds ratios are not different from 1. Thus, there is only weak evidence for a relationship between slope and fin whale heading.

Gray Whale

Behavior

Gray whale behaviors were practically limited to 'fm travel' and 'slow travel'. Milling behavior was rare; there was only 1 occurrence of 'mill' after data processing, not a sufficient number for multinomial modeling. Therefore, the single 'mill' observation was dropped and standard binomial logistic regression was used to model behavior. As with multinomial models, 'fm travel' was the reference category. The best model contains only aspect (*cos_asp* and *sin_asp*) (**Table F-62**). These paired variables had moderately high importance values (0.72), while all other variables that appeared in the top 10 models had low importance (**Table F-63**). Coefficients for the two components of aspect are shown in **Table F-64**, though, as noted above, odds ratios are difficult to interpret from these tabulated values. Nonetheless, **Figure F-12** shows the effect of aspect on the odds ratio. In brief, the odds of slow travel (relative to fm travel) are 5 times greater at an approximate aspect of 170° than at 350°.

Group Size

Aspect (*cos_asp* and *sin_asp*) and *subregion* represent the best negative binomial regression model for gray whale group size (**Table F-65**). These 3 variables also occur in most of the other top-ranked models and have moderately high to high importance values (0.72 for *cos_asp* and *sin_asp*, 0.92 for *subregion*) (**Table F-66**). The other variables in the top-ranked models all have low importance. The estimated coefficient for *subregion* is positive (**Table F-67**), indicating that group size was higher in the West of San Clemente Island subregion. While the 95% confidence interval for the *subregion* coefficient includes 0, only a small portion of the interval's span is negative, indicating 'near significance' at the 5% level. As shown in **Figure F-13**, predicted group size is greater in the West than in the East subregion, consistent with the positive effect (**Table F-67**). Predicted group size as a function of aspect shows that highest group size is predicted at approximately 75°, i.e., for slopes facing East-Northeast (**Figure F-13**). Correspondingly, lowest predicted group size occurs at approximately 255°, or for slopes facing West-Southwest.

Maximum Dispersal

As is the case for the best group size model (above), the best maximum dispersal model for gray whales contains *subregion* and aspect (*cos_asp* and *sin_asp*), as well as *datejul* (**Table F-68**). These four variables occur commonly among the top 10 models. Correspondingly, they have moderately high to high importance values (≥ 0.72) (**Table F-69**). Estimated coefficients show that maximum dispersal is positively associated with *subregion* (i.e., with West of San Clemente Island) and negatively associated with *datejul* (**Table F-70**). In the latter case, the associated confidence interval includes 0, though most of the interval's span is negative (**Table F-70**), suggesting 'near significance'. Predicted maximum dispersal in marginal effects plots is consistent with the coefficients (**Figure F-14**), i.e., higher in the West than in the East, and decreasing with increasing Julian date. Aspect is difficult to interpret from coefficient values (**Table F-70**), but the marginal effects plot shows that predicted maximum dispersal is greatest at approximately 340° and lowest at approximately 160° (**Figure F-14**). That is, maximum dispersal is predicted to be highest for slopes facing North-Northwest and lowest for South-Southeast slopes.

Heading

More complicated four- and five-variable models are favored among the top-ranked gray whale heading models (**Table F-71**). The best model contains *calf*, *depth_m*, *datejul*, *minfromsun*, and *distshore_km*. Most of these variables have moderately high to high importance (≥ 0.73), though *calf* importance is lower (0.53) (**Table F-72**). Parameter estimates and associated statistics are shown in **Table F-73**. The odds of heading SE decrease by a factor of 0.874 for each Julian day. In general, the odds of heading in all three of the non-reference directions decrease with increases in distance from shore, though in all three cases coefficient confidence intervals include 0 indicating limited evidence for an effect. Otherwise, all coefficients in **Table F-73** have confidence intervals that include 0 and in a few cases the estimated standard errors are very large. Thus, in general, estimates do not appear to be reliable. This result is likely a consequence of the combined effects of small sample size for gray whales, highly variable heading observations, and little real relationship between heading and any of the candidate covariates.

California Sea Lion

Behavior

The best multinomial logistic regression model for sea lion behavior contains *datejul*, *subregion*, and *mixedgrp* (**Table F-74**). Of these three variables, only *datejul* appears in all of the top 10 models, while *subregion* and *mixedgrp* appear in most models. Importance values are 1.0 for *datejul*, 0.68 for *subregion*, and 0.61 for *mixedgrp* (**Table F-75**). Estimated coefficients, confidence intervals, and odds ratios are shown in **Table F-76**. The odds of milling are 2.42 times greater in the West subregion than in the East. Furthermore, the odds of slow travel decrease by a factor of 0.61 with each 100 Julian days. Otherwise, confidence intervals for coefficients include 0 indicating little evidence for the effect of *mixedgrp* on the likelihood of either non-reference behavior, or the effect of *datejul* on milling, or of *subregion* on slow travel.

Group Size

The variables *mixedgrp* and *depth_m* represent the best group size model, and occur in all other top-ranking models (**Table F-77**). The importance value for each of these two variables is 1.0 (**Table F-78**). Remaining variables have substantially lower importance. Estimated coefficients show that group size is positively associated with *mixedgrp* and negatively associated with *depth_m* (**Table F-79**). In both cases, the associated 95% confidence intervals do not include 0, providing evidence that the estimates are significantly different from 0 at the 5% level. Predicted group size when other species are present in sea lion groups is approximately twice the group size when other species are absent (**Figure F-15**). As depth increases, predicted group size decreases moderately (**Figure F-15**).

Maximum Dispersal

The best linear regression model for sea lion maximum dispersal contains *subregion* and *distshore_km* (**Table F-80**). The importance value of *subregion* is 1.0 (**Table F-81**), since it appears in all 10 of the top models, while *distshore_km* has importance = 0.62, as it appears in fewer models. Parameter estimates indicate that maximum dispersal is positively associated with *subregion* (i.e., with West of San Clemente Island) and negatively associated with *distshore_km* (**Table F-82**). However, the confidence interval for the coefficient of *distshore_km* includes 0 (**Table F-82**); thus, there is limited evidence for an effect of distance from shore on maximum dispersal. Marginal effects plots show that predicted maximum dispersal is greater West of San Clemente Island than East, and that maximum dispersal decreases moderately as distance from shore increases (**Figure F-16**).

Heading

Most of the top-ranked multinomial logistic regression models for sea lion heading contain just one or two variables (**Table F-83**). The top model includes *minfromsun* and *season*, with importance values of 0.77 and 0.44, respectively (**Table F-84**). Thus, *minfromsun* has moderately strong support among the set of 10 models, while the support for *season* is lower. **Table F-85** shows that the odds of heading SE are 0.17 times lower in the warm season than are the odds in the cold season. Also, the odds of heading SW increase by a factor of 1.52 for each additional 60 minutes since sunrise. Otherwise, coefficient confidence intervals in **Table F-85** include 0, and thus provide limited evidence for the associated effects; for example, the likelihood of heading NW appears unrelated to either *season* or *minfromsun*.

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Table F-1. Variables used in analyses.

Variable Name	Description
Explanatory variables	
subregion	direction relative to San Clemente Island (E, W) = (0,1)
calf	absent or present (0, 1)
mixedgrp	other species absent or present (0,1)
season	cold water or warm water (cold, warm) = (0,1)
depth_m	water depth in meters, positive-valued
minfromsun	time in minutes since sunrise
datejul	Julian day number (1 = January 1, each year)
slope	degrees
distshore_km	distance from shore in kilometers
cos_asp	cosine of aspect
sin_asp	sine of aspect
Response variables	
bestcnt	group size
maxdsp	maximum dispersal
behavior	'fm travel', 'slow', or 'mill'
heading	NorthEast, NorthWest, SouthEast, SouthWest

Table F-2. Top 10 multinomial logistic regression models for Risso's dolphin behavior. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*datejul, minfromsun, distshore_km*	491.81	0.00	0.1903
2	*datejul, distshore_km*	491.91	0.10	0.1811
3	*calf, datejul, distshore_km*	492.82	1.01	0.1147
4	*slope, datejul, minfromsun, distshore_km*	493.31	1.51	0.0897
5	*slope, datejul, distshore_km*	493.34	1.54	0.0883
6	*calf, slope, datejul, distshore_km*	493.60	1.79	0.0777
7	*subregion, datejul, minfromsun, distshore_km*	493.81	2.00	0.0699
8	*subregion, datejul, distshore_km*	493.97	2.16	0.0645
9	*mixedgrp, datejul, distshore_km*	494.04	2.23	0.0624
10	*mixedgrp, datejul, minfromsun, distshore_km*	494.07	2.26	0.0614

Table F-3. Importance values for all variables in the top 10 models for Risso's dolphin behavior.

Variable	Importance
datejul	1.00
distshore_km	1.00
minfromsun	0.41
slope	0.26
calf	0.19
subregion	0.13
mixedgrp	0.12

Table F-4. Parameter estimates and odds ratios for the top-ranked Risso's dolphin behavior model.

Logit	Parameter	Estimate	Std Err	L95	U95	Odds Ratio
mill	*Intercept*	-2.1866	0.8994	-3.9493	-0.4238	
	datejul	0.0052	0.0028	-0.0003	0.0106	1.67[1]
	minfromsun	-0.0012	0.0012	-0.0036	0.0012	0.93[2]
	distshore_km	0.0331	0.0133	0.0071	0.0591	1.39[3]
slow	*Intercept*	2.8055	0.6080	1.6139	3.9971	
	datejul	-0.0129	0.0026	-0.0180	-0.0078	0.28[1]
	minfromsun	-0.0020	0.0010	-0.0040	0.0000	0.89[2]
	distshore_km	-0.0174	0.0109	-0.0388	0.0040	0.84[3]

[1]Odds ratio for 100 days
[2]Odds ratio for 60 minutes
[3]Odds ratio for 10 kilometers

Table F-5. Top 10 negative binomial regression models for Risso's dolphin group size. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*calf, mixedgrp, datejul*	2082.00	0.00	0.2321
2	*calf, mixedgrp, slope, datejul*	2083.07	1.06	0.1364
3	*calf, mixedgrp, depth_m, datejul*	2083.17	1.17	0.1294
4	*calf, mixedgrp, datejul, distshore_km*	2083.55	1.55	0.1069
5	*calf, mixedgrp, subregion, datejul*	2083.87	1.86	0.0914
6	*calf, mixedgrp, slope, datejul, distshore_km*	2084.27	2.27	0.0745
7	*calf, mixedgrp, slope, depth_m, datejul*	2084.49	2.49	0.0670
8	*calf, mixedgrp, depth_m, datejul, distshore_km*	2084.59	2.59	0.0635
9	*calf, mixedgrp, subregion, slope, datejul*	2084.84	2.83	0.0562
10	*calf, mixedgrp, subregion, datejul, distshore_km*	2085.40	3.40	0.0424

Table F-6. Importance values for all variables in the top 10 models for Risso's dolphin group size.

Variable	Importance
calf	1.00
mixedgrp	1.00
datejul	1.00
slope	0.33
distshore_km	0.29
depth_m	0.26
subregion	0.19

Table F-7. Parameter estimates for the top-ranked Risso's dolphin group size model.

Parameter	Estimate	Std Err	L95	U95
Intercept	2.3718	0.1124	2.1627	2.5854
calf	0.5155	0.1511	0.2284	0.8214
mixedgrp	0.5638	0.2386	0.1184	1.0670
datejul	0.0024	0.0007	0.0011	0.0037

Table F-8. Top 10 multiple linear regression models for Risso's dolphin maximum dispersal. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*depth_m, datejul, minfromsun*	652.19	0.00	0.3027
2	*slope, depth_m, datejul, minfromsun*	653.81	1.62	0.1346
3	*mixedgrp, depth_m, datejul, minfromsun*	654.17	1.98	0.1124
4	*depth_m, datejul, minfromsun, distshore_km*	654.19	2.00	0.1116
5	*datejul, minfromsun*	654.88	2.68	0.0791
6	*depth_m, datejul, minfromsun, cos_asp, sin_asp*	655.01	2.82	0.0739
7	*slope, depth_m, datejul, minfromsun, distshore_km*	655.78	3.59	0.0503
8	*mixedgrp, slope, depth_m, datejul, minfromsun*	655.80	3.61	0.0498
9	*slope, datejul, minfromsun*	656.04	3.85	0.0441
10	*mixedgrp, depth_m, datejul, minfromsun, distshore_km*	656.17	3.98	0.0414

Table F-9. Importance values for all variables in the top 10 models for Risso's dolphin maximum dispersal.

Variable	Importance
datejul	1.00
minfromsun	1.00
depth_m	0.88
slope	0.28
mixedgrp	0.20
distshore_km	0.20
cos_asp	0.07
sin_asp	0.07

Table F-10. Parameter estimates for the top-ranked Risso's dolphin maximum dispersal model.

Parameter	Estimate	Std Err	L95	U95
Intercept	1.31000	0.29581	0.72714	1.89286
depth_m	0.00042	0.00019	0.00004	0.00080
datejul	0.00313	0.00100	0.00116	0.00509
minfromsun	-0.00169	0.00042	-0.00252	-0.00087

Table F-11. Top 10 multinomial logistic regression models for Risso's dolphin heading. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*slope*	587.90	0.00	0.2188
2	*datejul*	588.66	0.76	0.1494
3	*minfromsun*	589.41	1.51	0.1030
4	*calf*	589.69	1.79	0.0896
5	*slope, datejul*	589.70	1.80	0.0889
6	*season*	589.86	1.96	0.0821
7	*subregion*	589.99	2.09	0.0768
8	*slope, minfromsun*	590.26	2.36	0.0673
9	*distshore_km*	590.28	2.38	0.0667
10	*datejul, minfromsun*	590.58	2.68	0.0574

Table F-12. Importance values for all variables in the top 10 models for Risso's dolphin heading.

Variable	Importance
slope	0.38
datejul	0.30
minfromsun	0.23
calf	0.09
season	0.08
subregion	0.08
distshore_km	0.07

Table F-13. Parameter estimates and odds ratios for the top-ranked Risso's dolphin heading model.

Logit	Parameter	Estimate	Std Err	L95	U95	Odds Ratio
NW	*Intercept*	-2.1866	0.8994	-3.9493	-0.4238	
	slope	0.0052	0.0028	-0.0003	0.0106	2.15[1]
SE	*Intercept*	-0.0012	0.0012	-0.0036	0.0012	
	slope	0.0331	0.0133	0.0071	0.0591	1.94[1]
SW	*Intercept*	2.8055	0.6080	1.6139	3.9971	
	slope	-0.0129	0.0026	-0.0180	-0.0078	1.16[1]

[1]Odds ratio for 10 degrees

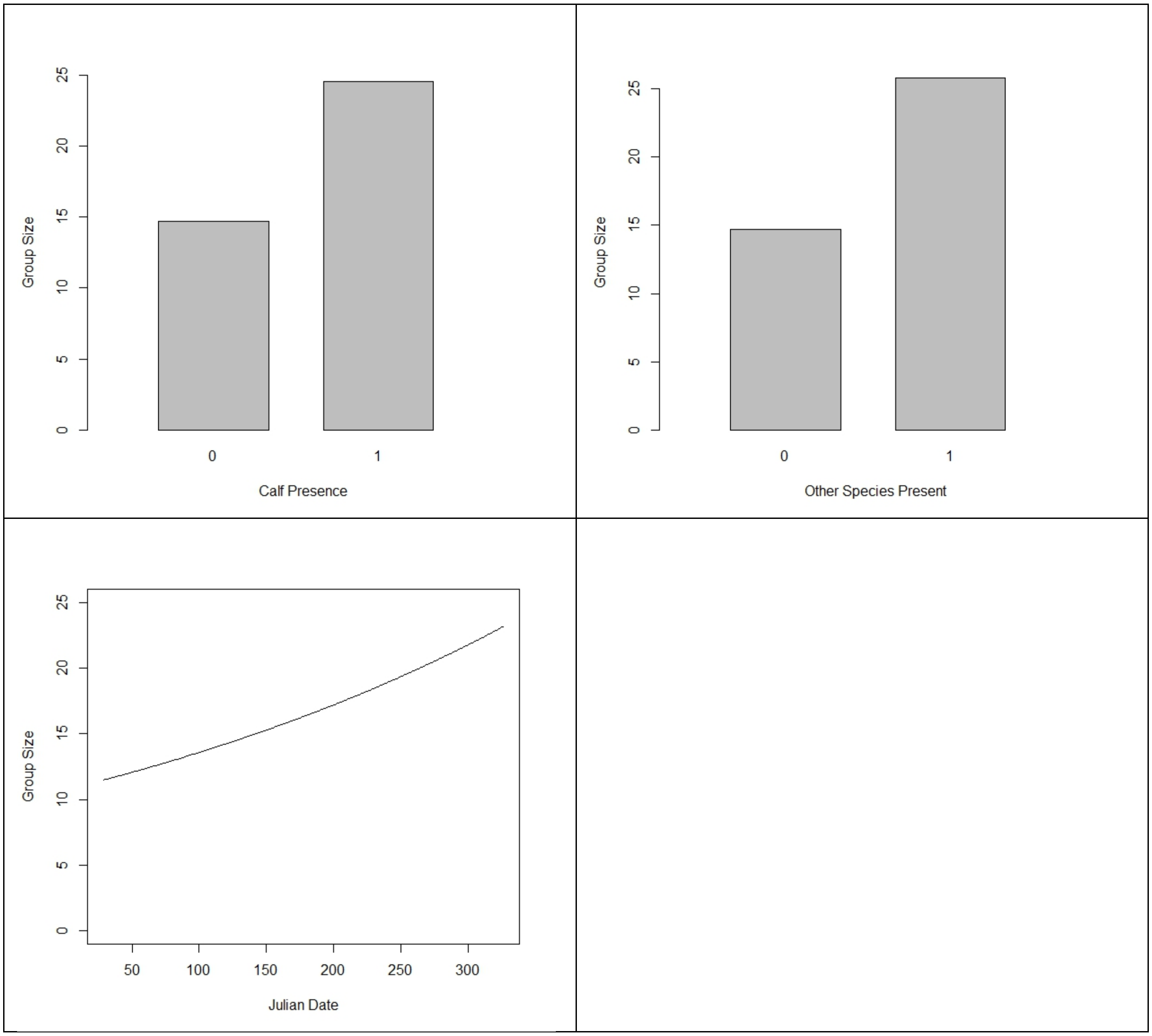

Figure F-1. Marginal effects plots for best Risso's dolphin group size model. For each plot, the covariates not shown were held at their median values: *calf* ('absent'); *mixedgrp* ('absent'); *datejul* (133).

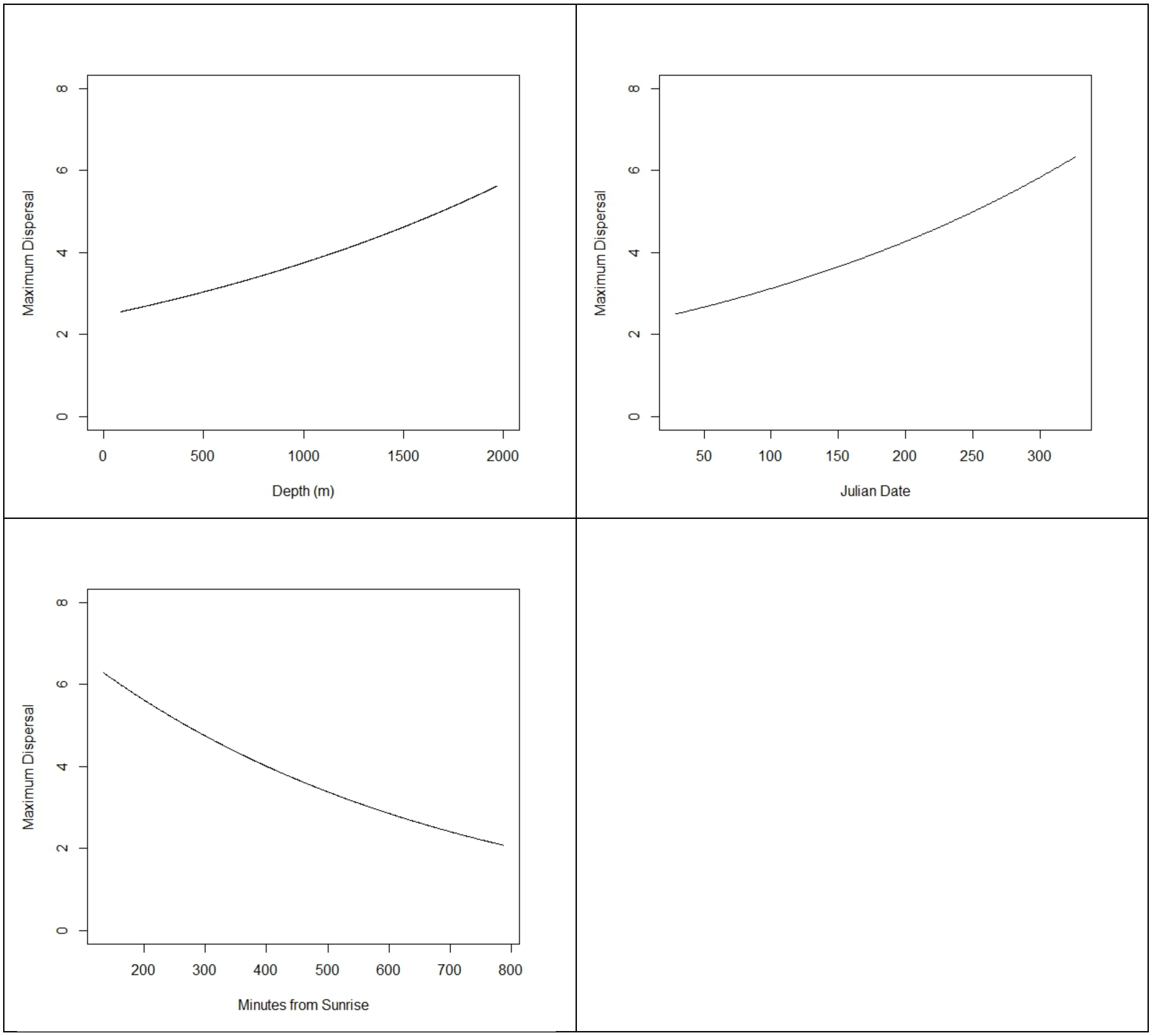

Figure F-2. Marginal effects plots for best Risso's dolphin maximum dispersal model. For each plot, the covariates not shown were held at their median values: *depth_m* (810); *datejul* (133): and *distshore_km* (20.4).

Common Dolphin

Table F-14. Top 10 multinomial logistic regression models for common dolphin behavior. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*season, subregion*	803.91	0.00	0.4560
2	*mixedgrp, season, subregion*	805.50	1.59	0.2058
3	*calf, season, subregion*	807.34	3.43	0.0821
4	*season, subregion, slope*	807.40	3.49	0.0797
5	*season*	808.45	4.54	0.0472
6	*mixedgrp, season, subregion, slope*	808.84	4.93	0.0387
7	*calf, mixedgrp, season, subregion*	808.95	5.04	0.0367
8	*mixedgrp, season*	809.95	6.04	0.0223
9	*season, depth_m*	810.44	6.53	0.0174
10	*calf, season, subregion, slope*	810.85	6.95	0.0141

Table F-15. Importance values for all variables in the top 10 models for common dolphin behavior.

Variable	Importance
season	1.00
subregion	0.91
mixedgrp	0.30
calf	0.13
slope	0.13
depth_m	0.02

Table F-16. Parameter estimates and odds ratios for the top-ranked common dolphin behavior model.

Logit	Parameter	Estimate	Std Err	L95	U95	Odds Ratio
mill	*Intercept*	-0.7829	0.1486	-1.0742	-0.4916	
	season	0.6586	0.1875	0.2911	1.0260	1.93
	subregion	-0.2764	0.2585	-0.7830	0.2303	0.76
slow	*Intercept*	-3.4391	0.4390	-4.2995	-2.5788	
	season	-0.0555	0.5345	-1.1032	0.9921	0.95
	subregion	1.4220	0.5388	0.3660	2.4781	4.15

Table F-17. Top 10 negative binomial regression models for common dolphin group size. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*calf, datejul, cos_asp, sin_asp*	6981.47	0.00	0.2234
2	*calf, slope, datejul, cos_asp, sin_asp*	6982.48	1.01	0.1349
3	*calf, datejul, distshore_km, cos_asp, sin_asp*	6982.66	1.19	0.1235
4	*calf, datejul, minfromsun, cos_asp, sin_asp*	6983.39	1.91	0.0858
5	*calf, mixedgrp, datejul, cos_asp, sin_asp*	6983.40	1.93	0.0850
6	*calf, depth_m, datejul, cos_asp, sin_asp*	6983.46	1.98	0.0828
7	*calf, cos_asp, sin_asp*	6983.60	2.13	0.0770
8	*calf, slope, datejul, distshore_km, cos_asp, sin_asp*	6983.77	2.30	0.0707
9	*calf, depth_m, datejul, distshore_km, cos_asp, sin_asp*	6983.95	2.48	0.0646
10	*calf, slope, depth_m, datejul, cos_asp, sin_asp*	6984.37	2.90	0.0523

Table F-18. Importance values for all variables in the top 10 models for common dolphin group size.

Variable	Importance
calf	1.00
cos_asp	1.00
sin_asp	1.00
datejul	0.92
distshore_km	0.26
slope	0.26
depth_m	0.20
minfromsun	0.09
mixedgrp	0.08

Table F-19. Parameter estimates for the top-ranked common dolphin group size model.

Parameter	Estimate	Std Err	L95	U95
Intercept	5.69773	0.11726	5.47723	5.92773
calf	0.88634	0.13851	0.62281	1.16668
datejul	-0.00103	0.00053	-0.00203	-0.00004
cos_asp	0.22697	0.07785	0.07630	0.38091
sin_asp	0.02252	0.08094	-0.13451	0.18299

Table F-20. Top 10 multiple linear regression models for common dolphin maximum dispersal. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*calf, minfromsun*	1059.65	0.00	0.1905
2	*calf, depth_m, minfromsun, distshore_km*	1060.28	0.63	0.1388
3	*calf, minfromsun, distshore_km*	1060.56	0.91	0.1207
4	*calf, depth_m, minfromsun*	1061.17	1.52	0.0891
5	*calf, slope, minfromsun*	1061.19	1.54	0.0883
6	*calf, datejul, minfromsun*	1061.23	1.58	0.0864
7	*calf, mixedgrp, minfromsun*	1061.27	1.62	0.0846
8	*calf, depth_m, datejul, minfromsun, distshore_km*	1061.44	1.79	0.0778
9	*calf, mixedgrp, depth_m, minfromsun, distshore_km*	1061.85	2.20	0.0635
10	*calf, slope, depth_m, minfromsun, distshore_km*	1061.95	2.30	0.0604

Table F-21. Importance values for all variables in the top 10 models for common dolphin maximum dispersal.

Variable	Importance
calf	1.00
minfromsun	1.00
distshore_km	0.46
depth_m	0.43
datejul	0.16
slope	0.15
mixedgrp	0.15

Table F-22. Parameter estimates for the top-ranked common dolphin maximum dispersal model.

Parameter	Estimate	Std Err	L95	U95
Intercept	1.60925	0.10210	1.40862	1.80987
calf	0.40737	0.08892	0.23264	0.58210
minfromsun	-0.00076	0.00020	-0.00115	-0.00037

Table F-23. Top 10 multinomial logistic regression models for common dolphin heading. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*depth_m, minfromsun*	826.57	0.00	0.3550
2	*depth_m*	827.83	1.26	0.1890
3	*minfromsun, distshore_km*	829.15	2.58	0.0977
4	*depth_m, minfromsun, distshore_km*	829.53	2.96	0.0806
5	*slope, depth_m, minfromsun*	830.21	3.65	0.0573
6	*depth_m, datejul, minfromsun*	830.28	3.72	0.0553
7	*depth_m, distshore_km*	830.61	4.04	0.0470
8	*calf, depth_m, minfromsun*	830.83	4.27	0.0420
9	*datejul, minfromsun, distshore_km*	830.88	4.32	0.0410
10	*distshore_km*	831.19	4.62	0.0352

Table F-24. Importance values for all variables in the top 10 models for common dolphin heading.

Variable	Importance
depth_m	0.83
minfromsun	0.73
distshore_km	0.30
datejul	0.10
slope	0.06
calf	0.04

Table F-25. Parameter estimates and odds ratios for the top-ranked common dolphin heading model.

Logit	Parameter	Estimate	Std Err	L95	U95	Odds Ratio
NW	*Intercept*	0.4097	0.5945	-0.7555	1.5749	
	depth_m	-0.0010	0.0004	-0.0019	-0.0002	0.90[1]
	minfromsun	0.0014	0.0010	-0.0006	0.0034	1.09[2]
SE	*Intercept*	-0.4508	0.6743	-1.7723	0.8708	
	depth_m	-0.0014	0.0005	-0.0023	-0.0004	0.87[1]
	minfromsun	0.0029	0.0011	0.0007	0.0051	1.19[2]
SW	*Intercept*	0.4682	0.6298	-0.7662	1.7026	
	depth_m	-0.0015	0.0005	-0.0024	-0.0006	0.86[1]
	minfromsun	0.0012	0.0011	-0.0009	0.0033	1.08[2]

[1]Odds ratio for 100 meters

[2]Odds ratio for 60 minutes

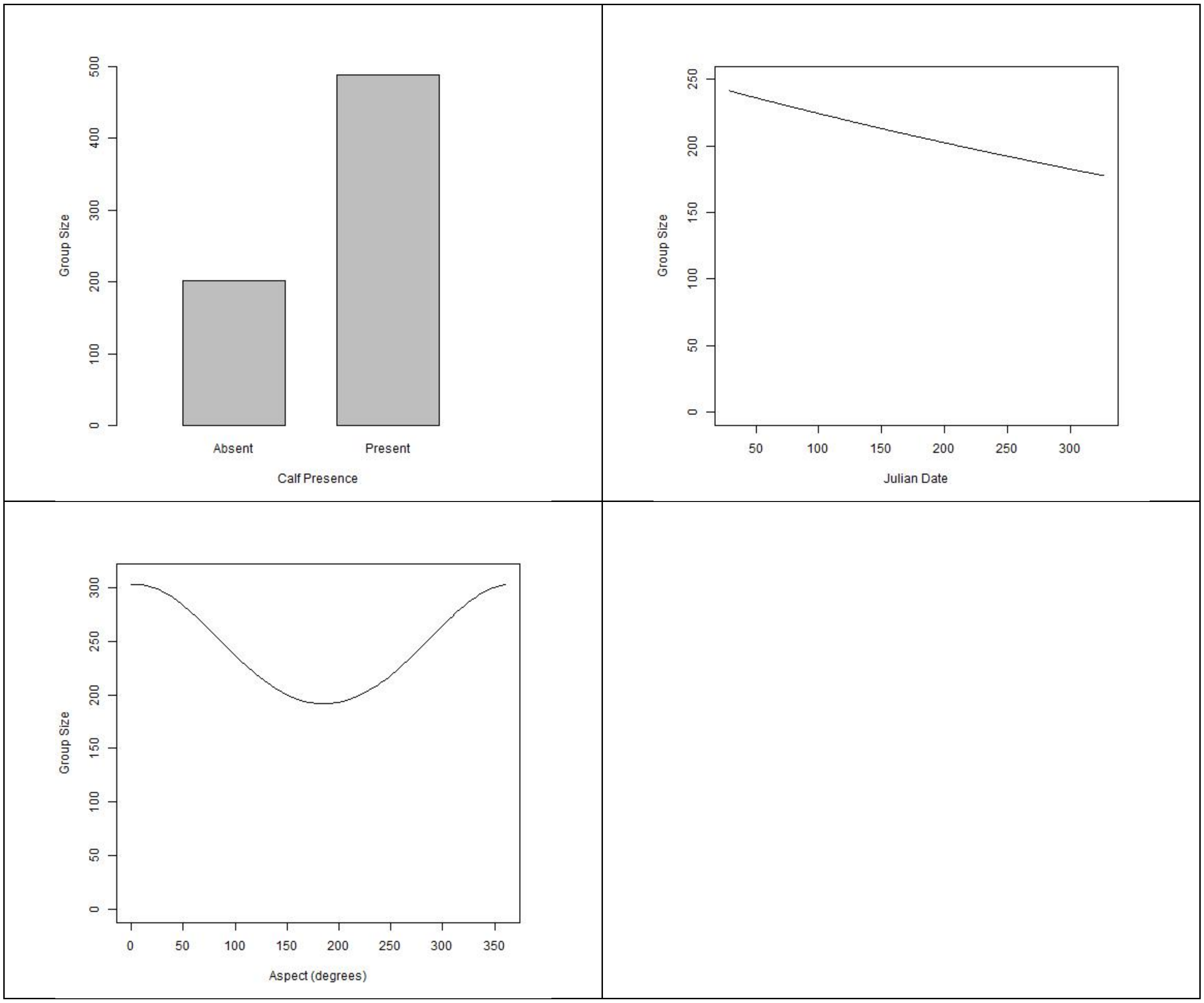

Figure F-3. Marginal effects plots for best common dolphin group size model. For each plot, the covariates not shown were held at fixed values: *calf* (median = 0, or 'absent'); *datejul* (median = 207); aspect (mean = 223°).

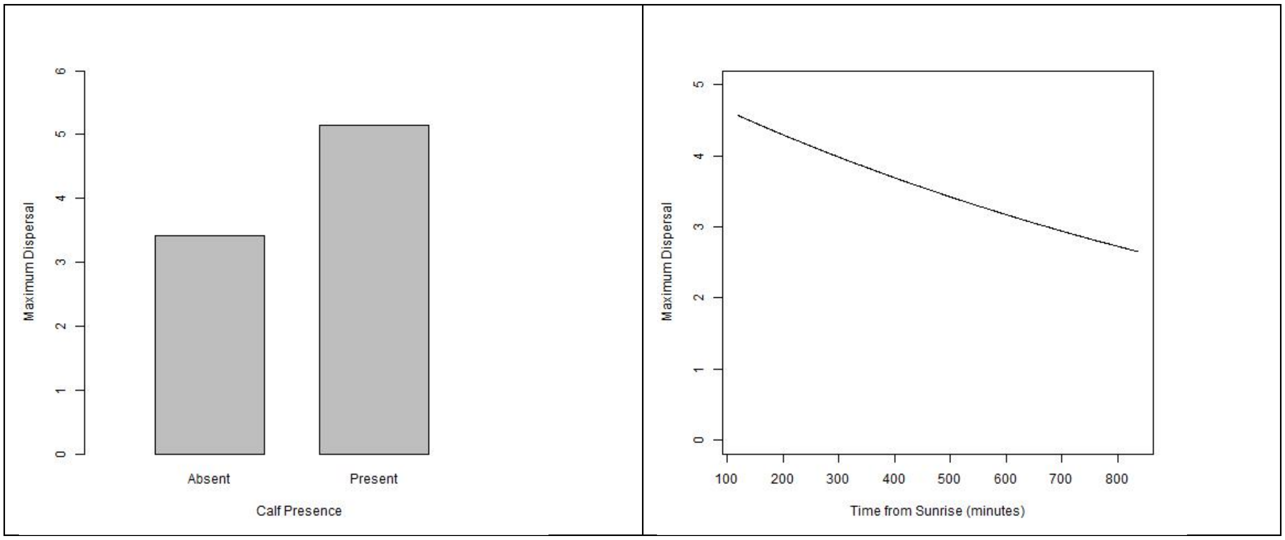

Figure F-4. Marginal effects plots for best common dolphin maximum dispersal model. For each plot, the covariates not shown were held at fixed values: *calf* (median = 0, or 'absent'); *minfromsun* (median = 500).

Bottlenose Dolphin

Table F-26. Top 10 multinomial logistic regression models for bottlenose dolphin behavior. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*depth_m, datejul, minfromsun, cos_asp, sin_asp*	154.53	0.00	0.2321
2	*slope, depth_m, datejul, minfromsun, cos_asp, sin_asp*	155.02	0.49	0.1816
3	*depth_m, datejul, cos_asp, sin_asp*	155.31	0.78	0.1570
4	*season, depth_m, cos_asp, sin_asp*	155.87	1.34	0.1185
5	*slope, depth_m, datejul, cos_asp, sin_asp*	156.29	1.76	0.0961
6	*season, slope, depth_m, cos_asp, sin_asp*	157.13	2.60	0.0632
7	*depth_m, cos_asp, sin_asp*	157.44	2.91	0.0541
8	*slope, depth_m, cos_asp, sin_asp*	158.22	3.70	0.0366
9	*mixedgrp, depth_m, datejul, cos_asp, sin_asp*	158.26	3.73	0.0359
10	*mixedgrp, season, depth_m, cos_asp, sin_asp*	158.98	4.46	0.0250

Table F-27. Importance values for all variables in the top 10 models for bottlenose dolphin behavior.

Variable	Importance
depth_m	1.00
cos_asp	1.00
sin_asp	1.00
datejul	0.70
minfromsun	0.41
slope	0.38
season	0.21
mixedgrp	0.06

Table F-28. Parameter estimates and odds ratios for the top-ranked bottlenose dolphin behavior model.

Logit	Parameter	Estimate	Std Err	L95	U95	Odds Ratio
mill	*Intercept*	-2.3042	1.1161	-4.4917	-0.1168	
	depth_m	-0.0001	0.0011	-0.0023	0.0022	0.99[1]
	datejul	0.0109	0.0051	0.0009	0.0209	2.96[2]
	minfromsun	-0.0038	0.0026	-0.0088	0.0012	0.80[3]
	cos_asp	1.2410	0.6594	-0.0515	2.5334	
	sin_asp	-1.9531	0.8461	-3.6114	-0.2949	
slow	*Intercept*	-2.4078	1.0225	-4.4119	-0.4037	
	depth_m	0.0027	0.0009	0.0009	0.0046	1.32[1]
	datejul	-0.0090	0.0061	-0.0211	0.0030	0.41[2]
	minfromsun	0.0023	0.0020	-0.0016	0.0062	1.15[3]
	cos_asp	1.2076	0.4661	0.2941	2.1212	
	sin_asp	-0.3965	0.4653	-1.3084	0.5154	

[1]Odds ratio for 100 meters

[2]Odds ratio for 100 days

[3]Odds ratio for 60 minutes

Table F-29. Top 10 negative binomial regression models for bottlenose dolphin group size. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*calf*	719.77	0.00	0.2381
2	*calf, season*	720.89	1.12	0.1362
3	*calf, distshore_km*	721.27	1.50	0.1127
4	*calf, datejul*	721.73	1.96	0.0893
5	*calf, depth_m*	721.75	1.98	0.0885
6	*calf, slope*	721.75	1.98	0.0885
7	*calf, mixedgrp*	721.77	2.00	0.0878
8	*calf, season, depth_m*	722.64	2.86	0.0569
9	*calf, mixedgrp, season*	722.85	3.07	0.0512
10	*calf, season, slope*	722.86	3.09	0.0509

Table F-30. Importance values for all variables in the top 10 models for bottlenose dolphin group size.

Variable	Importance
calf	1.00
season	0.30
depth_m	0.15
slope	0.14
mixedgrp	0.14
distshore_km	0.11

datejul	0.09

Table F-31. Parameter estimates for the top-ranked bottlenose dolphin group size model.

Parameter	Estimate	Std Err	L95	U95
Intercept	2.8122	0.1097	2.6037	3.0342
calf	0.8428	0.3432	0.2202	1.5804

Table F-32. Top 10 multiple linear regression models for bottlenose dolphin maximum dispersal. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*datejul, minfromsun, distshore_km*	218.51	0.00	0.3154
2	*slope, datejul, minfromsun, distshore_km*	219.66	1.15	0.1776
3	*datejul, minfromsun*	220.95	2.44	0.0929
4	*datejul, minfromsun, distshore_km, cos_asp, sin_asp*	221.21	2.71	0.0815
5	*minfromsun, distshore_km*	221.26	2.75	0.0798
6	*slope, datejul, minfromsun*	221.94	3.43	0.0568
7	*minfromsun*	221.94	3.44	0.0566
8	*slope, datejul, minfromsun, distshore_km, cos_asp, sin_asp*	222.25	3.74	0.0486
9	*slope, minfromsun, distshore_km*	222.28	3.77	0.0479
10	*calf, datejul, distshore_km*	222.49	3.99	0.0430

Table F-33. Importance values for all variables in the top 10 models for bottlenose dolphin maximum dispersal.

Variable	Importance
minfromsun	0.96
datejul	0.82
distshore_km	0.79
slope	0.33
cos_asp	0.13
sin_asp	0.13
calf	0.04

Table F-34. Parameter estimates for the top-ranked bottlenose dolphin maximum dispersal model.

Parameter	Estimate	Std Err	L95	U95
Intercept	1.6910	0.3523	0.9888	2.3932
datejul	0.0037	0.0017	0.0003	0.0072
minfromsun	-0.0019	0.0007	-0.0033	-0.0004
distshore_km	-0.0208	0.0100	-0.0408	-0.0009

Table F-35. Top 10 multinomial logistic regression models for bottlenose dolphin heading. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*distshore_km*	202.07	0.00	0.1945
2	*mixedgrp, distshore_km*	202.20	0.13	0.1819
3	*slope, distshore_km*	202.86	0.79	0.1311
4	*mixedgrp, slope, distshore_km*	203.20	1.13	0.1105
5	*calf, distshore_km*	203.49	1.42	0.0954
6	*calf, mixedgrp, distshore_km*	203.94	1.87	0.0763
7	*mixedgrp*	204.36	2.30	0.0617
8	*minfromsun, distshore_km*	204.56	2.50	0.0558
9	*datejul, distshore_km*	204.93	2.86	0.0465
10	*mixedgrp, minfromsun, distshore_km*	204.94	2.88	0.0461

Table F-36. Importance values for all variables in the top 10 models for bottlenose dolphin heading.

Variable	Importance
distshore_km	0.94
mixedgrp	0.48
slope	0.24
calf	0.17
minfromsun	0.10
datejul	0.05

Table F-37. Parameter estimates and odds ratios for the top-ranked bottlenose dolphin heading model.

Logit	Parameter	Estimate	Std Err	L95	U95	Odds Ratio
NW	*Intercept*	0.7982	0.5098	-0.2011	1.7974	
	distshore_km	-0.0342	0.0273	-0.0876	0.0193	0.71[1]
SE	*Intercept*	0.3705	0.5355	-0.6790	1.4201	
	distshore_km	-0.0164	0.0266	-0.0686	0.0357	0.85[1]
SW	*Intercept*	1.0903	0.5517	0.0090	2.1717	
	distshore_km	-0.1055	0.0450	-0.1938	-0.0172	0.35[1]

[1]Odds ratio for 10 kilometers

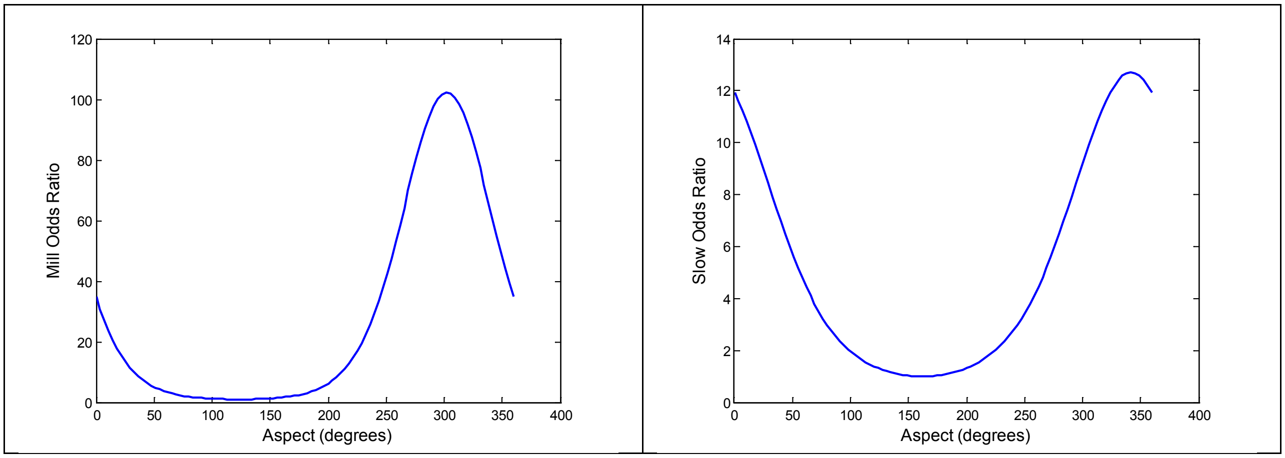

Figure F-5. Aspect odds ratios for best bottlenose dolphin behavior model.

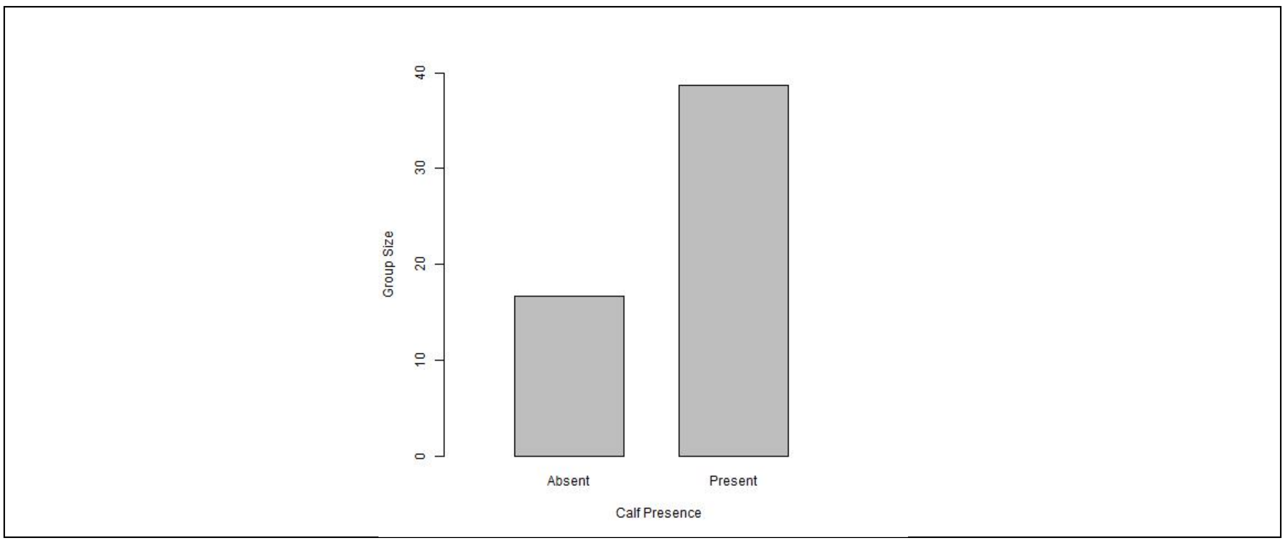

Figure F-6. Marginal effects plots for best bottlenose dolphin group size model (*calf* was the only term in the model).

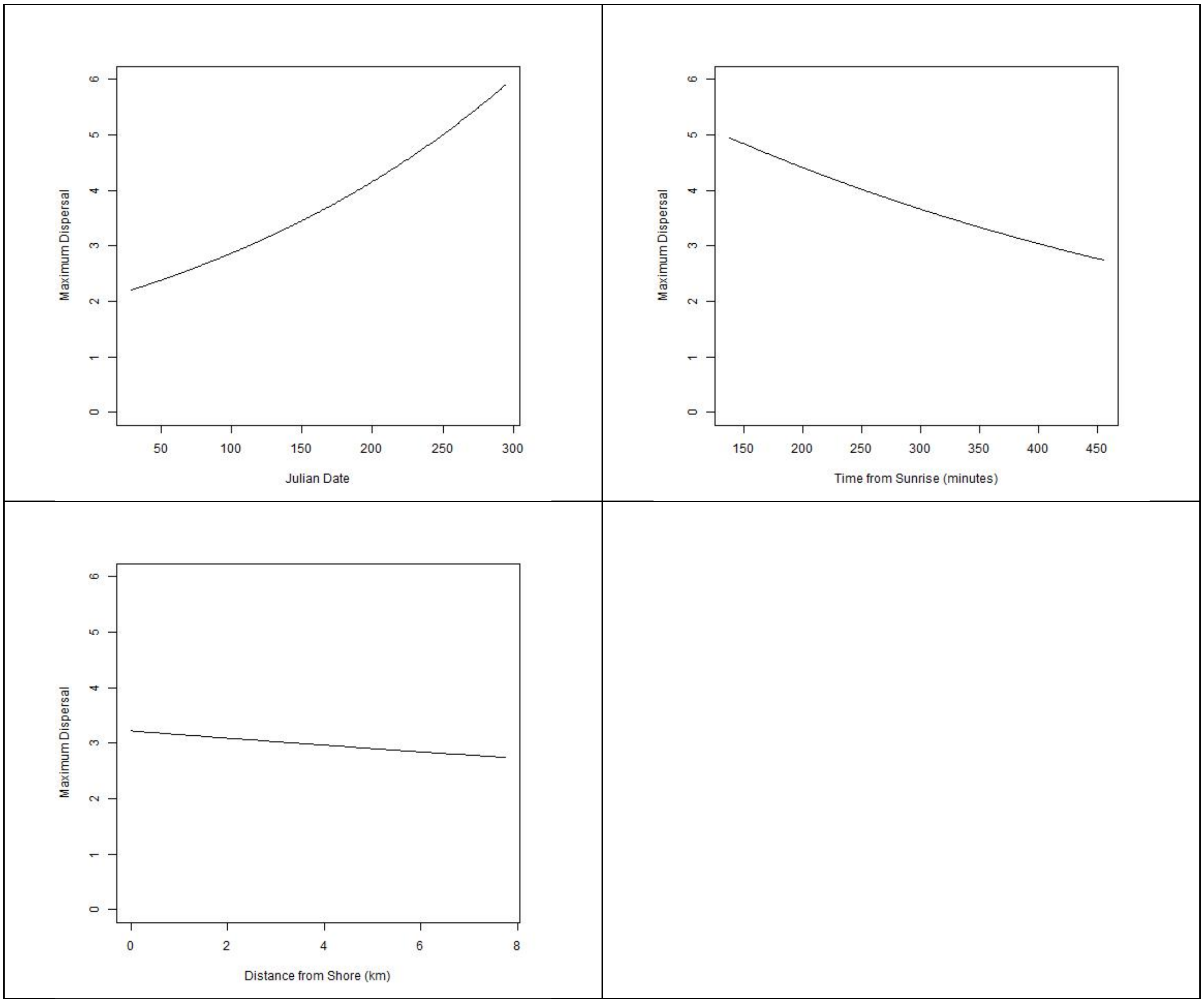

Figure F-7. Marginal effects plots for best bottlenose dolphin maximum dispersal model. For each plot, the covariates not shown were held at fixed values: *datejul* (median = 88); *minfromsun* (median = 455.5); *distshore_km* (median = 7.74).

Blue Whale

Table F-38. Top 10 multinomial logistic regression models for blue whale behavior. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*slope*	88.66	0.00	0.1916
2	*depth_m*	88.88	0.22	0.1717
3	*datejul*	89.12	0.47	0.1516
4	*minfromsun*	90.12	1.46	0.0922
5	*slope, datejul*	90.15	1.49	0.0908
6	*slope, depth_m*	90.67	2.02	0.0700
7	*depth_m, datejul*	90.70	2.04	0.0691
8	*distshore_km*	90.84	2.18	0.0643
9	*slope, distshore_km, cos_asp, sin_asp*	91.09	2.43	0.0567
10	*depth_m, minfromsun*	91.69	3.04	0.0420

Table F-39. Importance values for all variables in the top 10 models for blue whale behavior.

Variable	Importance
slope	0.41
depth_m	0.35
datejul	0.31
minfromsun	0.13
distshore_km	0.12
cos_asp	0.06
sin_asp	0.06

Table F-40. Parameter estimates and odds ratios for the top-ranked blue whale behavior model.

Logit	Parameter	Estimate	Std Err	L95	U95	Odds Ratio
mill	*Intercept*	-2.0987	0.5829	-3.2411	-0.9562	
	slope	0.0783	0.0509	-0.0214	0.1781	2.19[1]
slow	*Intercept*	-1.2989	0.4454	-2.1719	-0.4259	
	slope	0.0554	0.0481	-0.0389	0.1498	1.74[1]

[1]Odds ratio for 10 degrees

Table F-41. Top 10 Poisson regression models for blue whale group size. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*depth_m, datejul*	145.35	0.00	0.2023
2	*datejul*	145.57	0.22	0.1816
3	*datejul, cos_asp, sin_asp*	146.73	1.38	0.1015
4	*slope, datejul*	146.91	1.56	0.0927
5	*slope, depth_m, datejul*	146.95	1.60	0.0909
6	*depth_m, datejul, minfromsun*	147.25	1.90	0.0782
7	*datejul, distshore_km*	147.35	2.00	0.0743
8	*datejul, minfromsun*	147.45	2.10	0.0707
9	*slope, datejul, cos_asp, sin_asp*	147.72	2.37	0.0620
10	*depth_m*	148.32	2.97	0.0458

Table F-42. Importance values for all variables in the top 10 models for blue whale group size.

Variable	Importance
datejul	0.95
depth_m	0.42
slope	0.25
cos_asp	0.16
sin_asp	0.16
minfromsun	0.15
distshore_km	0.07

Table F-43. Parameter estimates for the top-ranked blue whale group size model.

Parameter	Estimate	Std Err	L95	U95
Intercept	-0.50121	0.61001	-1.72979	0.65687
depth_m	-0.00061	0.00043	-0.00151	0.00018
datejul	0.00672	0.00304	0.00081	0.01271

Table F-44. Top 10 multiple linear regression models for blue whale maximum dispersal. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*slope*	69.67	0.00	0.1664
2	*slope, minfromsun*	70.14	0.47	0.1317
3	*minfromsun*	70.71	1.04	0.0989
4	*distshore_km*	70.78	1.11	0.0954
5	*depth_m*	70.80	1.12	0.0949

6	*slope, distshore_km*	70.94	1.27	0.0881
7	*datejul*	70.97	1.30	0.0871
8	*slope, depth_m*	71.05	1.37	0.0837
9	*slope, depth_m, minfromsun*	71.14	1.47	0.0798
10	*slope, minfromsun, distshore_km*	71.29	1.62	0.0740

Table F-45. Importance values for all variables in the top 10 models for blue whale maximum dispersal.

Variable	Importance
slope	0.62
minfromsun	0.38
depth_m	0.26
distshore_km	0.26
datejul	0.09

Table F-46. Parameter estimates for the top-ranked blue whale maximum dispersal model.

Parameter	Estimate	Std Err	L95	U95
Intercept	1.3647	0.4404	0.4310	2.2983
slope	0.0342	0.0312	-0.0319	0.1004

Table F-47. Top 10 multinomial logistic regression models for blue whale heading. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*datejul*	113.70	0.00	0.3238
2	*slope*	115.54	1.84	0.1289
3	*distshore_km*	115.57	1.87	0.1271
4	*cos_asp, sin_asp*	115.93	2.23	0.1062
5	*depth_m*	116.17	2.47	0.0942
6	*datejul, distshore_km*	117.28	3.58	0.0540
7	*slope, datejul*	117.33	3.63	0.0526
8	*minfromsun*	117.70	4.00	0.0438
9	*depth_m, datejul*	118.00	4.31	0.0376
10	*datejul, minfromsun*	118.35	4.65	0.0316

Table F-48. Importance values for all variables in the top 10 models for blue whale heading.

Variable	Importance
datejul	0.50
slope	0.18
distshore_km	0.18
depth_m	0.13

cos_asp	0.11
sin_asp	0.11
minfromsun	0.08

Table F-49. Parameter estimates and odds ratios for the top-ranked blue whale heading model.

Logit	Parameter	Estimate	Std Err	L95	U95	Odds Ratio
NW	*Intercept*	3.3772	2.3558	-1.2402	7.9946	
	datejul	-0.0182	0.0128	-0.0432	0.0068	0.16[1]
SE	*Intercept*	-0.7676	2.4664	-5.6016	4.0664	
	datejul	0.0049	0.0125	-0.0196	0.0294	1.63[1]
SW	*Intercept*	1.0334	2.7793	-4.4138	6.4807	
	datejul	-0.0083	0.0147	-0.0371	0.0206	0.44[1]

[1]Odds ratio for 100 days

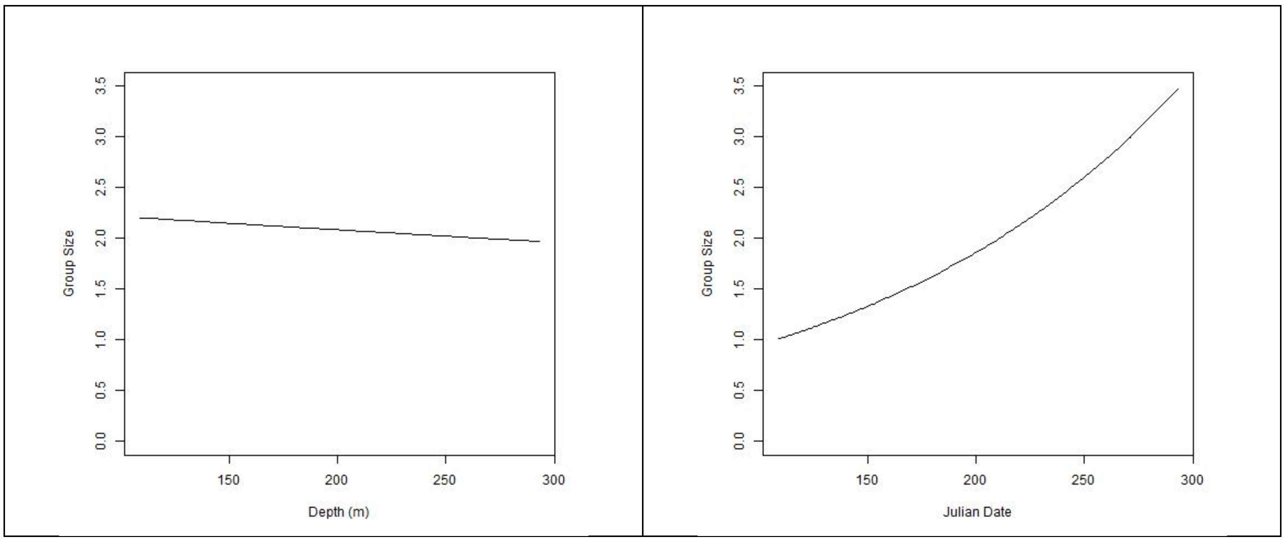

Figure F-8. Marginal effects plots for best blue whale group size model. For each plot, the covariates not shown were held at fixed values: *depth_m* (median = 366); *datejul* (median = 202).

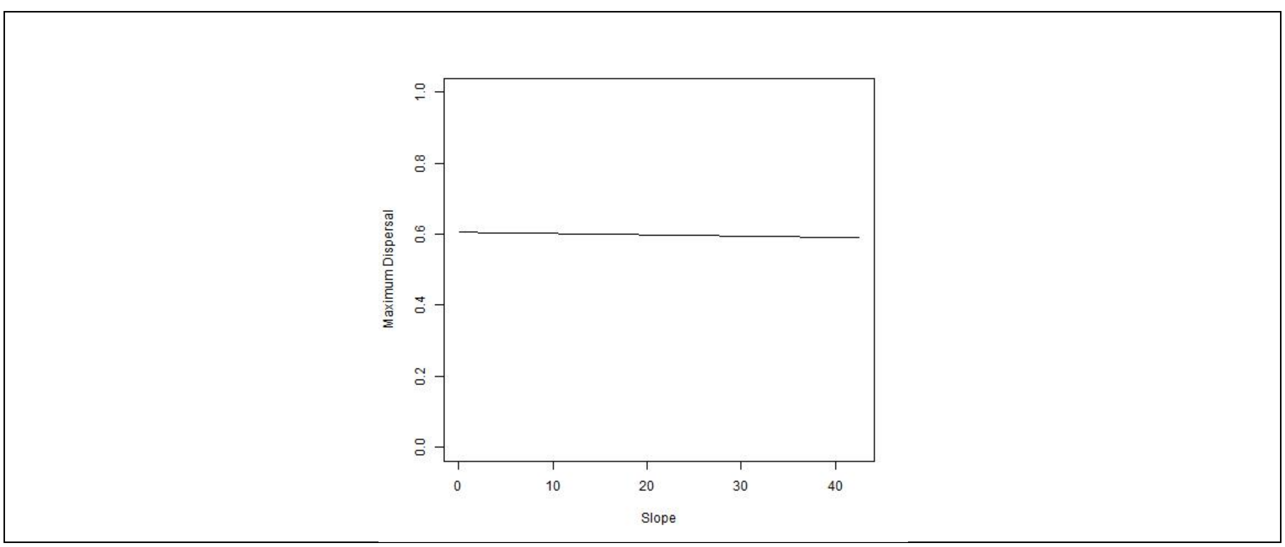

Figure F-9. Marginal effects plots for best blue whale maximum dispersal model (*slope* was the only term in the model).

Fin Whale

Table F-50. Top 10 multinomial logistic regression models for fin whale behavior. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*datejul, distshore_km*	147.09	0.00	0.3541
2	*mixedgrp, datejul, distshore_km*	148.47	1.37	0.1784
3	*datejul, minfromsun, distshore_km*	149.41	2.32	0.1111
4	*calf, datejul, distshore_km*	150.29	3.19	0.0718
5	*depth_m, datejul, distshore_km*	150.32	3.22	0.0707
6	*slope, datejul, distshore_km*	150.42	3.33	0.0670
7	*mixedgrp, slope, datejul, distshore_km*	151.45	4.36	0.0401
8	*depth_m, datejul*	151.49	4.39	0.0394
9	*calf, mixedgrp, datejul, distshore_km*	151.76	4.67	0.0343
10	*mixedgrp, depth_m, datejul, distshore_km*	151.83	4.74	0.0331

Table F-51. Importance values for all variables in the top 10 models for fin whale behavior.

Variable	Importance
datejul	1.00
distshore_km	0.96
mixedgrp	0.29
depth_m	0.14
minfromsun	0.11
slope	0.11
calf	0.11

Table F-52. Parameter estimates and odds ratios for the top-ranked fin whale behavior model.

Logit	Parameter	Estimate	Std Err	L95	U95	Odds Ratio
mill	*Intercept*	0.9422	1.2454	-1.4987	3.3831	
	datejul	-0.0044	0.0055	-0.0150	0.0063	0.65[1]
	distshore_km	-0.1614	0.0697	-0.2981	-0.0248	0.20[2]
slow	*Intercept*	1.5175	0.7328	0.0813	2.9537	
	datejul	-0.0149	0.0046	-0.0239	-0.0060	0.22[1]
	distshore_km	-0.0252	0.0213	-0.0669	0.0166	0.78[2]

[1]Odds ratio for 100 days

[2]Odds ratio for 10 kilometers

Table F-53. Top 10 Poisson regression models for fin whale group size. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*calf, minfromsun*	291.45	0.00	0.2414
2	*calf*	292.53	1.09	0.1403
3	*calf, minfromsun, distshore_km*	293.03	1.58	0.1095
4	*calf, season*	293.07	1.63	0.1070
5	*calf, depth_m, minfromsun*	293.43	1.98	0.0898
6	*calf, datejul, minfromsun*	293.45	2.00	0.0888
7	*calf, subregion*	294.29	2.84	0.0583
8	*calf, distshore_km*	294.34	2.89	0.0568
9	*calf, minfromsun, cos_asp, sin_asp*	294.38	2.93	0.0558
10	*calf, depth_m*	294.51	3.06	0.0522

Table F-54 Importance values for all variables in the top 10 models for fin whale group size.

Variable	Importance
calf	1.00
minfromsun	0.59
distshore_km	0.17
depth_m	0.14
season	0.11
datejul	0.09
subregion	0.06
cos_asp	0.06
sin_asp	0.06

Table F-55. Parameter estimates for the top-ranked fin whale group size model.

Parameter	Estimate	Std Err	L95	U95
Intercept	0.8746	0.2206	0.4309	1.2963
calf	0.6737	0.2430	0.1650	1.1228
minfromsun	-0.0008	0.0005	-0.0017	0.0001

Table F-56. Top 10 multiple linear regression models for fin whale maximum dispersal. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*calf, subregion*	160.97	0.00	0.1646
2	*calf, season*	161.50	0.53	0.1263
3	*calf, season, depth_m*	161.54	0.57	0.1241
4	*calf, subregion, slope*	161.64	0.67	0.1176
5	*calf, season, slope*	161.70	0.73	0.1145
6	*calf, depth_m*	162.28	1.31	0.0854
7	*calf, season, depth_m, distshore_km*	162.55	1.58	0.0748
8	*subregion*	162.76	1.79	0.0671
9	*calf, season, slope, depth_m*	162.87	1.90	0.0637
10	*calf, mixedgrp, subregion*	162.92	1.95	0.0620

Table F-57. Importance values for all variables in the top 10 models for fin whale maximum dispersal.

Variable	Importance
calf	0.93
season	0.50
subregion	0.41
depth_m	0.35
slope	0.30
distshore_km	0.07
mixedgrp	0.06

Table F-58. Parameter estimates for the top-ranked fin whale maximum dispersal model.

Parameter	Estimate	Std Err	L95	U95
Intercept	0.9091	0.1803	0.5469	1.2712
calf	-0.8810	0.4574	-1.7997	0.0377
subregion	0.6678	0.3157	0.0337	1.3019

Table F-59. Top 10 multinomial logistic regression models for fin whale heading. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*slope*	267.67	0.00	0.3729
2	*season, slope*	269.96	2.29	0.1186
3	*subregion, slope*	270.02	2.35	0.1150
4	*slope, datejul*	270.05	2.38	0.1133
5	*calf*	271.28	3.62	0.0612
6	*slope, minfromsun*	271.71	4.04	0.0494
7	*mixedgrp, slope*	271.82	4.15	0.0468
8	*slope, distshore_km*	271.88	4.21	0.0454
9	*slope, depth_m*	272.01	4.34	0.0426
10	*distshore_km*	272.41	4.74	0.0349

Table F-60. Importance values for all variables in the top 10 models for fin whale heading.

Variable	Importance
slope	0.90
season	0.12
subregion	0.12
datejul	0.11
distshore_km	0.08
calf	0.06
minfromsun	0.05
mixedgrp	0.05
depth_m	0.04

Table F-61. Parameter estimates and odds ratios for the top-ranked fin whale heading model.

Logit	Parameter	Estimate	Std Err	L95	U95	Odds Ratio
NW	*Intercept*	-0.2292	0.3692	-0.9528	0.4944	
	slope	0.0742	0.0583	-0.0401	0.1885	2.10[1]
SE	*Intercept*	-0.0171	0.4158	-0.8320	0.7978	
	slope	-0.1126	0.1132	-0.3345	0.1092	0.32[1]
SW	*Intercept*	0.5629	0.3524	-0.1279	1.2537	
	slope	-0.0880	0.0848	-0.2543	0.0782	0.41[1]

[1]Odds ratio for 10 degrees

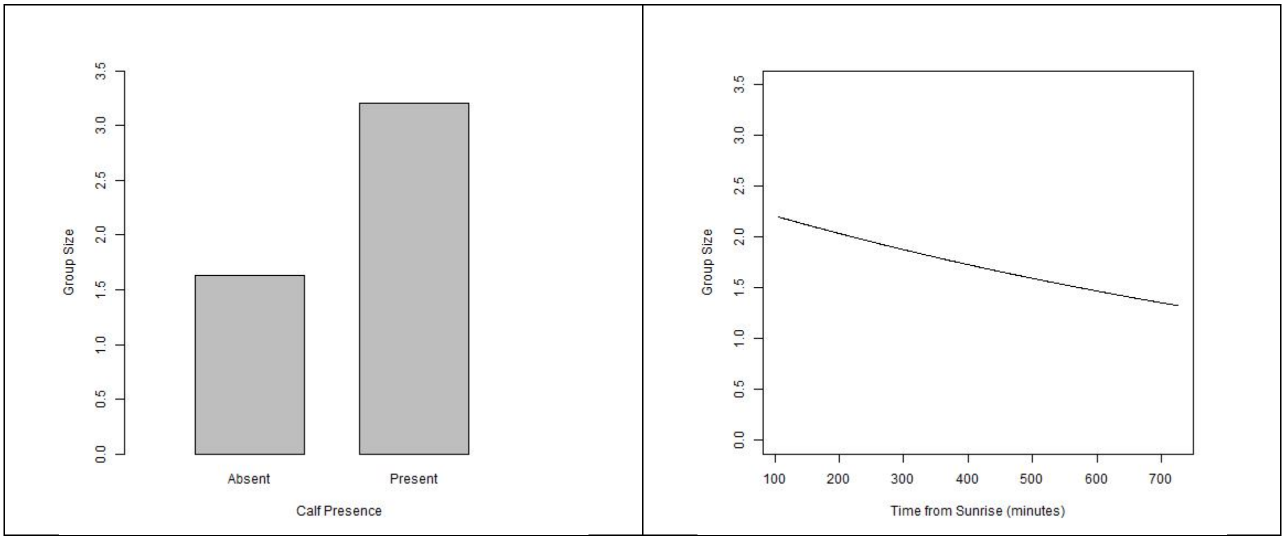

Figure F-10. Marginal effects plots for best fin whale group size model. For each plot, the covariates not shown were held at fixed values: *calf* (median = 0, or "absent"); *minfromsun* (median = 470.5).

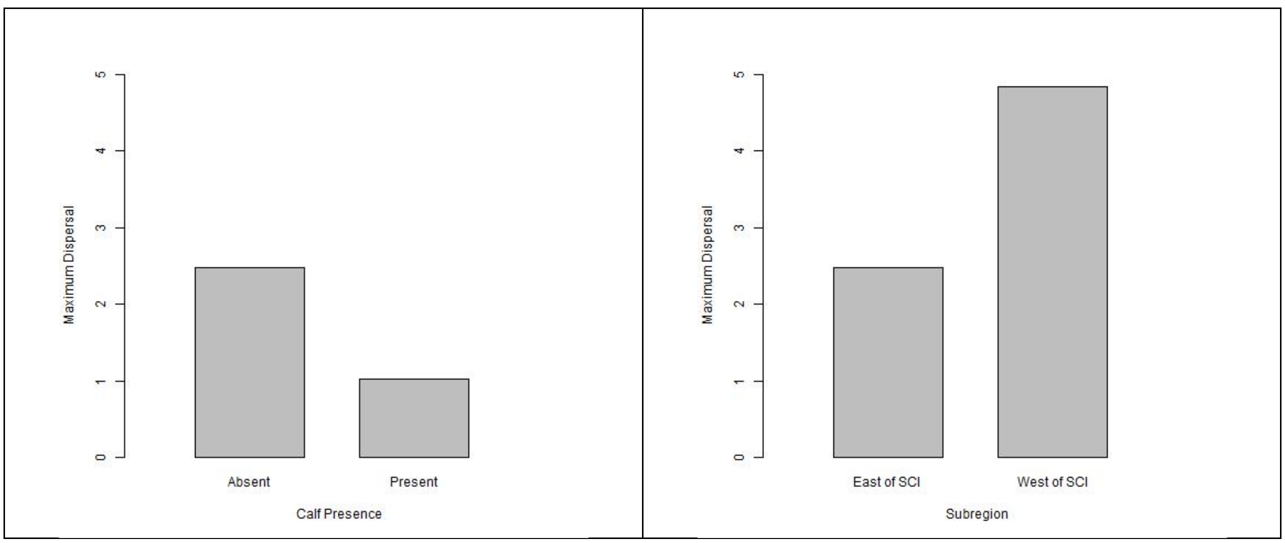

Figure F-11. Marginal effects plots for best fin whale maximum dispersal model. For each plot, the covariates not shown were held at fixed values: *calf* (median = 0, or "absent"); *subregion* (median = 0, or "east").

Gray Whale

Table F-62. Top 10 binomial logistic regression models for gray whale behavior (binomial logistic because there were only 2 behaviors – fm travel and slow). Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*cos_asp, sin_asp*	101.31	0.00	0.1999
2	*subregion, cos_asp, sin_asp*	102.28	0.97	0.1229
3	*calf*	102.53	1.22	0.1086
4	*depth_m, cos_asp, sin_asp*	102.83	1.52	0.0936
5	*minfromsun, cos_asp, sin_asp*	103.03	1.72	0.0848
6	*depth_m*	103.05	1.74	0.0839
7	*subregion*	103.06	1.75	0.0834
8	*slopeindex, cos_asp, sin_asp*	103.26	1.95	0.0754
9	*distshore_km, cos_asp, sin_asp*	103.30	1.99	0.0739
10	*datejul, cos_asp, sin_asp*	103.31	2.00	0.0735

Table F-63. Importance values for all variables in the top 10 models for gray whale behavior.

Variable	Importance
cos_asp	0.72
sin_asp	0.72
subregion	0.21
depth_m	0.18
calf	0.11
minfromsun	0.08
slopeindex	0.08
distshore_km	0.07
datejul	0.07

Table F-64. Parameter estimates and odds ratios for the top-ranked gray whale behavior model.

Parameter	Estimate	Std Err	L95	U95
Intercept	-0.1422	0.2696	-0.6824	0.3844
cos_asp	-0.7771	0.3903	-1.5734	-0.0311
sin_asp	0.1957	0.3434	-0.4790	0.8792

Table F-65. Top 10 negative binomial regression models for gray whale group size. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*subregion, cos_asp, sin_asp*	253.39	0.00	0.1840
2	*subregion, slopeindex, cos_asp, sin_asp*	254.10	0.72	0.1286
3	*subregion*	254.11	0.73	0.1279
4	*subregion, depth_m, cos_asp, sin_asp*	254.70	1.32	0.0952
5	*cos_asp, sin_asp*	255.05	1.66	0.0802
6	*subregion, slopeindex*	255.07	1.68	0.0793
7	*subregion, distshore_km, cos_asp, sin_asp*	255.13	1.74	0.0770
8	*subregion, datejul, cos_asp, sin_asp*	255.14	1.75	0.0766
9	*subregion, distshore_km*	255.15	1.76	0.0764
10	*subregion, slopeindex, depth_m, cos_asp, sin_asp*	255.19	1.80	0.0748

Table F-66 Importance values for all variables in the top 10 models for gray whale group size.

Variable	Importance
subregion	0.92
cos_asp	0.72
sin_asp	0.72
slopeindex	0.28
depth_m	0.17
distshore_km	0.15
datejul	0.08

Table F-67. Parameter estimates for the top-ranked gray whale group size model.

Parameter	Estimate	Std Err	L95	U95
Intercept	0.7696	0.0900	0.5877	0.9411
subregion	0.4631	0.2291	-0.0086	0.8940
cos_asp	0.0628	0.1248	-0.1836	0.3061
sin_asp	0.2413	0.1119	0.0192	0.4591

Table F-68. Top 10 multiple linear regression models for gray whale maximum dispersal. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*subregion, datejul, cos_asp, sin_asp*	109.24	0.00	0.1638
2	*subregion, slopeindex, datejul, cos_asp, sin_asp*	109.67	0.43	0.1324
3	*subregion, slopeindex, cos_asp, sin_asp*	109.95	0.70	0.1151
4	*subregion, slopeindex, depth_m, datejul, cos_asp, sin_asp*	110.14	0.90	0.1045
5	*subregion, depth_m, datejul, cos_asp, sin_asp*	110.55	1.31	0.0850
6	*subregion, cos_asp, sin_asp*	110.58	1.34	0.0838
7	*subregion, datejul, distshore_km, cos_asp, sin_asp*	110.59	1.35	0.0835
8	*subregion, slopeindex, datejul, distshore_km, cos_asp, sin_asp*	110.61	1.37	0.0825
9	*subregion, slopeindex, distshore_km, cos_asp, sin_asp*	110.66	1.42	0.0807
10	*calf, subregion, slopeindex, depth_m, datejul*	110.98	1.74	0.0688

Table F-69. Importance values for all variables in the top 10 models for gray whale maximum dispersal.

Variable	Importance
subregion	1.00
cos_asp	0.93
sin_asp	0.93
datejul	0.72
slopeindex	0.58
depth_m	0.26
distshore_km	0.25
calf	0.07

Table F-70. Parameter estimates for the top-ranked gray whale maximum dispersal model.

Parameter	Estimate	Std Err	L95	U95
Intercept	0.3384	0.2983	-0.2649	0.9417
subregion	0.7282	0.3305	0.0598	1.3966
datejul	-0.0081	0.0046	-0.0175	0.0012
cos_asp	0.4548	0.1881	0.0744	0.8352
sin_asp	-0.1100	0.1656	-0.4451	0.2251

Table F-71. Top 10 multinomial logistic regression models for gray whale heading. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*calf, depth_m, datejul, minfromsun, distshore_km*	91.68	0.00	0.3170
2	*depth_m, datejul, minfromsun, distshore_km, cos_asp, sin_asp*	92.40	0.72	0.2206
3	*calf, depth_m, datejul, distshore_km*	93.57	1.89	0.1232
4	*depth_m, datejul, distshore_km, cos_asp, sin_asp*	94.21	2.54	0.0891
5	*datejul, minfromsun, distshore_km, cos_asp, sin_asp*	94.27	2.59	0.0869
6	*calf, datejul, minfromsun, distshore_km*	95.15	3.47	0.0559
7	*depth_m, datejul, distshore_km*	96.29	4.61	0.0316
8	*calf, subregion, depth_m, datejul, distshore_km*	96.45	4.78	0.0291
9	*depth_m, datejul, minfromsun, distshore_km*	96.55	4.88	0.0277
10	*datejul, minfromsun, distshore_km*	97.32	5.64	0.0189

Table F-72. Importance values for all variables in the top 10 models for gray whale heading.

Variable	Importance
datejul	1.00
distshore_km	1.00
depth_m	0.84
minfromsun	0.73
calf	0.53
cos_asp	0.40
sin_asp	0.40
subregion	0.03

Table F-73. Parameter estimates and odds ratios for the top-ranked gray whale heading model.

Logit	Parameter	Estimate	Std Err	L95	U95	Odds Ratio
NW	*Intercept*	32.2803	23.3271	-13.4401	78.0007	
	calf	-12.4125	11.0722	-34.1135	9.2885	0.000
	depth_m	-0.0025	0.0039	-0.0102	0.0052	0.779[1]
	datejul	0.0202	0.0624	-0.1022	0.1425	1.020[2]
	minfromsun	-0.0133	0.0135	-0.0398	0.0132	0.923[3]
	distshore_km	-0.5809	0.3826	-1.3309	0.1690	0.003[4]
SE	*Intercept*	42.8640	23.5193	-3.2330	88.9609	
	calf	-11.0608	8.7780	-28.2654	6.1438	0.000
	depth_m	-0.0019	0.0045	-0.0107	0.0069	0.826[1]
	datejul	-0.1350	0.0634	-0.2592	-0.0107	0.874[2]
	minfromsun	-0.0134	0.0136	-0.0400	0.0132	0.923[3]
	distshore_km	-0.6413	0.3856	-1.3970	0.1144	0.002[4]
SW	*Intercept*	43.4894	23.6157	-2.7966	89.7753	
	calf	-28.8462	2034.2	-4015.8	3958.1	0.000
	depth_m	-0.0069	0.0042	-0.0152	0.0014	0.502[1]
	datejul	-0.0605	0.0684	-0.1945	0.0734	0.941[2]
	minfromsun	-0.0242	0.0144	-0.0524	0.0040	0.865[3]
	distshore_km	-0.5815	0.3842	-1.3346	0.1716	0.003[4]

[1]Odds ratio for 100 meters
[2]Odds ratio for 1 day
[3]Odds ratio for 60 minutes
[4]Odds ratio for 10 kilometers

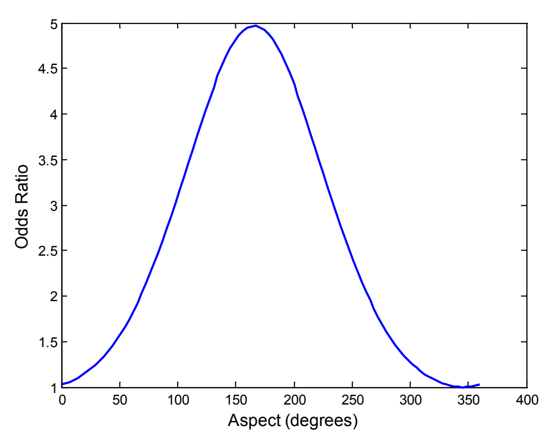

Figure F-12. Aspect odds ratios for best gray whale behavior model. Y-axis represents odds of *slow travel* relative to *fm travel* (*mill* behavior did not occur).

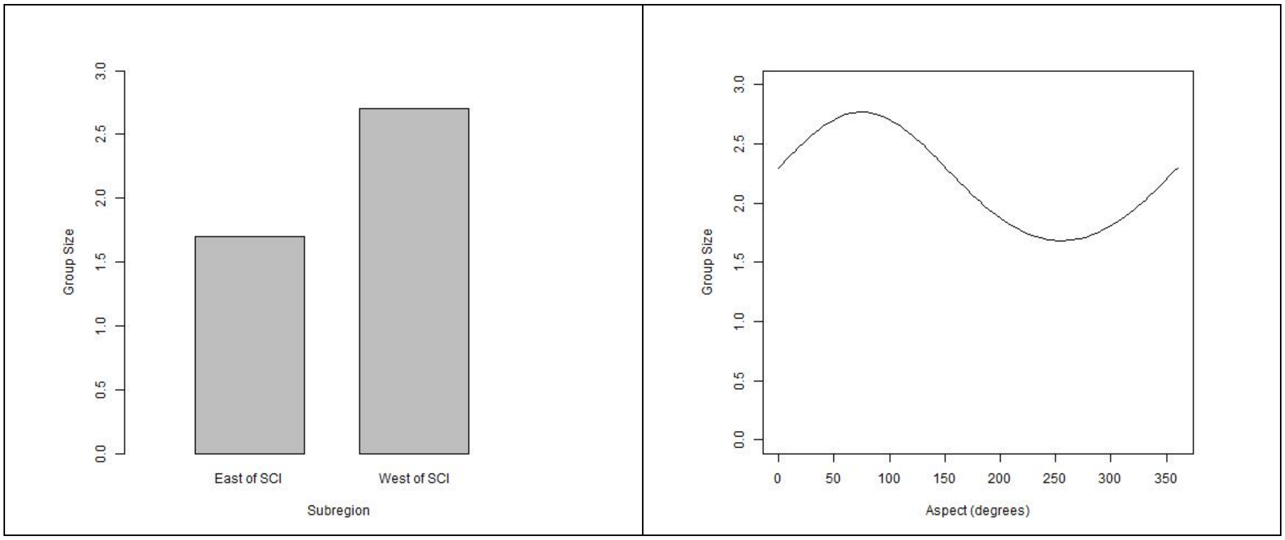

Figure F-13. Marginal effects plots for best gray whale group size model. For each plot, the covariates not shown were held at fixed values: *subregion* (median = 0, or "east"); *aspect* (mean = 237.4°).

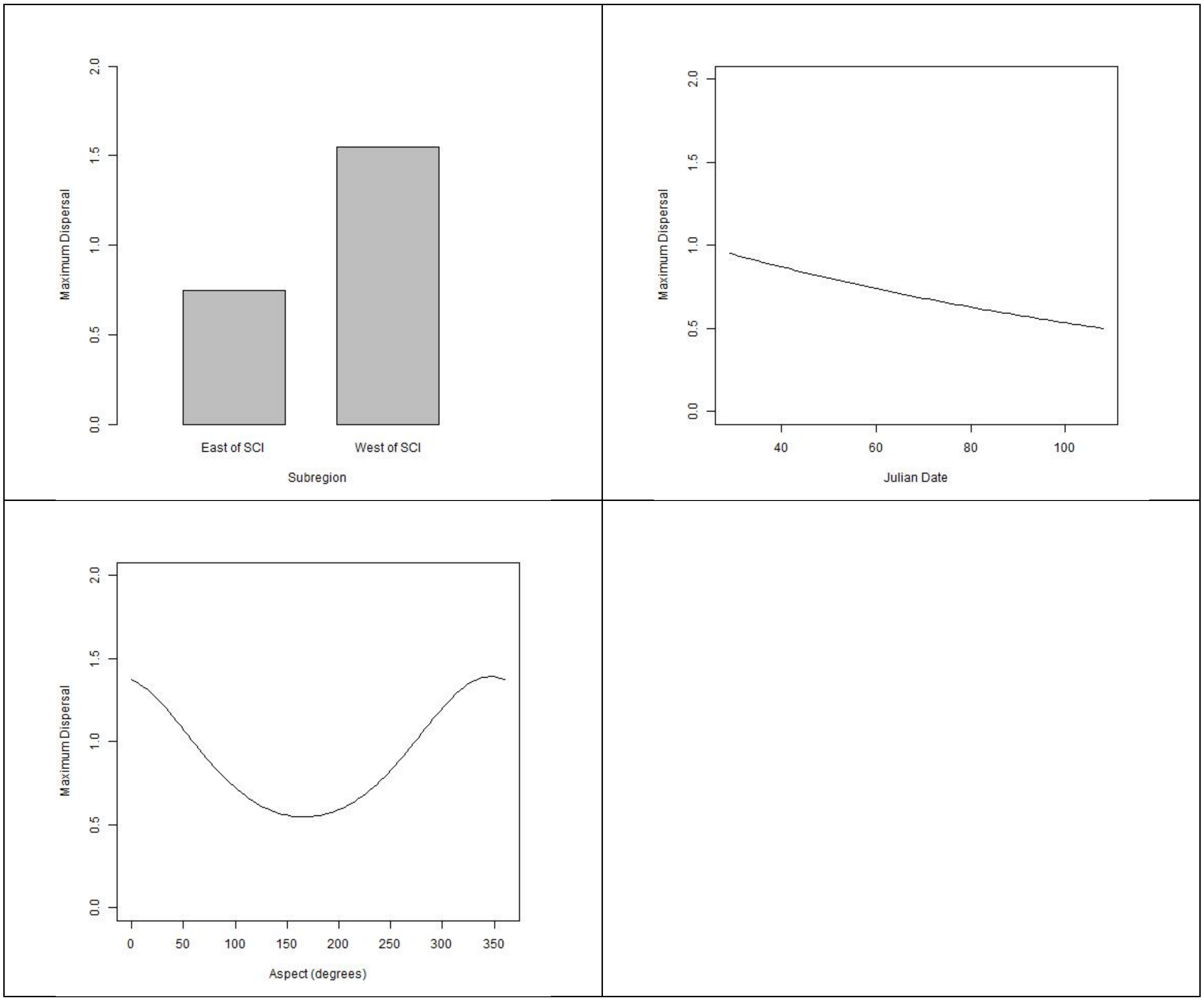

Figure F-14. Marginal effects plots for best gray whale maximum dispersal model. For each plot, the covariates not shown were held at fixed values: *subregion* (median = 0, or "east"); *datejul* (median = 58.5); *aspect* (mean = 237.4°).

California Sea Lion

Table F-74. Top 10 multinomial logistic regression models for CA sea lion behavior. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*mixedgrp, subregion, datejul*	460.14	0.00	0.2781
2	*subregion, datejul*	460.89	0.76	0.1906
3	*mixedgrp, subregion, datejul, distshore_km*	462.33	2.19	0.0928
4	*mixedgrp, datejul, minfromsun*	462.61	2.47	0.0810
5	*datejul, minfromsun*	462.75	2.61	0.0754
6	*subregion, datejul, distshore_km*	463.04	2.90	0.0654
7	*mixedgrp, depth_m, datejul, minfromsun*	463.33	3.19	0.0564
8	*mixedgrp, datejul*	463.36	3.22	0.0557
9	*datejul*	463.41	3.27	0.0542
10	*mixedgrp, subregion, slope, datejul*	463.55	3.41	0.0504

Table F-75. Importance values for all variables in the top 10 models for CA sea lion behavior.

Variable	Importance
datejul	1.00
subregion	0.68
mixedgrp	0.61
minfromsun	0.21
distshore_km	0.16
depth_m	0.06
slope	0.05

Table F-76. Parameter estimates and odds ratios for the top-ranked CA sea lion behavior model.

	Parameter	Estimate	Std Err	L95	U95	Odds Ratio
mill	*Intercept*	0.2938	0.3540	-0.4000	0.9877	
	mixedgrp	1.6445	1.1568	-0.6229	3.9119	5.18
	subregion	0.8831	0.3353	0.2260	1.5403	2.42
	datejul	-0.0026	0.0016	-0.0056	0.0005	0.77[1]
slow	*Intercept*	0.4049	0.3766	-0.3331	1.1429	
	mixedgrp	-14.25	1862.41	-3664.51	3636.01	<0.01
	subregion	0.4397	0.3822	-0.3094	1.1888	1.55
	datejul	-0.0049	0.0018	-0.0084	-0.0014	0.61[1]

[1]Odds ratio for 100 days

Table F-77. Top 10 negative binomial regression models for CA sea lion group size. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*mixedgrp, depth_m*	1262.95	0.00	0.2286
2	*mixedgrp, depth_m, distshore_km*	1263.31	0.36	0.1907
3	*mixedgrp, depth_m, minfromsun*	1264.60	1.64	0.1005
4	*mixedgrp, depth_m, cos_asp, sin_asp*	1264.85	1.90	0.0885
5	*mixedgrp, slope, depth_m*	1264.92	1.97	0.0854
6	*mixedgrp, depth_m, distshore_km, cos_asp, sin_asp*	1264.99	2.04	0.0823
7	*mixedgrp, depth_m, minfromsun, distshore_km*	1265.13	2.18	0.0769
8	*mixedgrp, slope, depth_m, distshore_km*	1265.24	2.28	0.0729
9	*mixedgrp, slope, depth_m, minfromsun*	1266.58	3.62	0.0374
10	*mixedgrp, depth_m, minfromsun, cos_asp, sin_asp*	1266.61	3.65	0.0368

Table F-78 Importance values for all variables in the top 10 models for CA sea lion group size.

Variable	Importance
mixedgrp	1.00
depth_m	1.00
distshore_km	0.42
minfromsun	0.25
cos_asp	0.21
sin_asp	0.21
slope	0.20

Table F-79. Parameter estimates for the top-ranked CA sea lion group size model.

Parameter	Estimate	Std Err	L95	U95
Intercept	1.1960	0.0998	1.0084	1.3876
mixedgrp	0.9381	0.3475	0.2934	1.6826
depth_m	-0.0003	0.0001	-0.0005	-0.0001

Table F-80. Top 10 multiple linear regression models for CA sea lion maximum dispersal. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*subregion, distshore_km*	100.24	0.00	0.1529
2	*season, subregion, slope, distshore_km*	100.64	0.40	0.1252
3	*season, subregion, distshore_km*	100.68	0.43	0.1231
4	*subregion*	100.78	0.54	0.1168
5	*subregion, slope*	101.06	0.82	0.1016
6	*subregion, slope, distshore_km*	101.08	0.84	0.1006
7	*season, subregion, slope*	101.22	0.97	0.0939
8	*season, subregion*	101.85	1.61	0.0685
9	*subregion, minfromsun, distshore_km*	102.08	1.84	0.0611
10	*subregion, datejul, distshore_km*	102.24	2.00	0.0563

Table F-81. Importance values for all variables in the top 10 models for CA sea lion maximum dispersal.

Variable	Importance
subregion	1.00
distshore_km	0.62
slope	0.42
season	0.41
minfromsun	0.06
datejul	0.06

Table F-82. Parameter estimates for the top-ranked CA sea lion maximum dispersal model.

Parameter	Estimate	Std Err	L95	U95
Intercept	0.8595	0.2997	0.2543	1.4648
subregion	0.7554	0.2236	0.3038	1.2070
distshore_km	-0.7163	0.4590	-1.6433	0.2108

Table F-83. Top 10 multinomial logistic regression models for California sea lion heading. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC	Δ_i	w_i
1	*season, minfromsun*	245.99	0.00	0.2497
2	*minfromsun*	246.02	0.04	0.2452
3	*depth_m, minfromsun*	248.04	2.06	0.0893
4	*season*	248.06	2.08	0.0884
5	*minfromsun, distshore_km*	248.69	2.70	0.0647
6	*season, minfromsun, distshore_km*	248.69	2.70	0.0646
7	*distshore_km*	248.87	2.88	0.0592
8	*datejul, minfromsun*	248.93	2.94	0.0573
9	*season, distshore_km*	249.56	3.57	0.0418
10	*depth_m*	249.66	3.68	0.0397

Table F-84. Importance values for all variables in the top 10 models for California sea lion heading.

Variable	Importance
minfromsun	0.77
season	0.44
distshore_km	0.23
depth_m	0.13
datejul	0.06

Table F-85. Parameter estimates and odds ratios for the top-ranked California sea lion heading model.

Logit	Parameter	Estimate	Std Err	L95	U95	Odds Ratio
NW	*Intercept*	0.1466	1.1018	-2.0129	2.3060	
	season	-0.5115	0.6592	-1.8035	0.7806	0.60
	minfromsun	0.0024	0.0028	-0.0030	0.0078	1.16[1]
SE	*Intercept*	-0.4213	1.2386	-2.8489	2.0062	
	season	-1.7591	0.8001	-3.3272	-0.1910	0.17
	minfromsun	0.0036	0.0031	-0.0025	0.0096	1.24[1]
SW	*Intercept*	-1.9464	1.2295	-4.3562	0.4633	
	season	-0.9068	0.7176	-2.3133	0.4998	0.40
	minfromsun	0.0070	0.0029	0.0013	0.0127	1.52[1]

[1]Odds ratio for 60 minutes

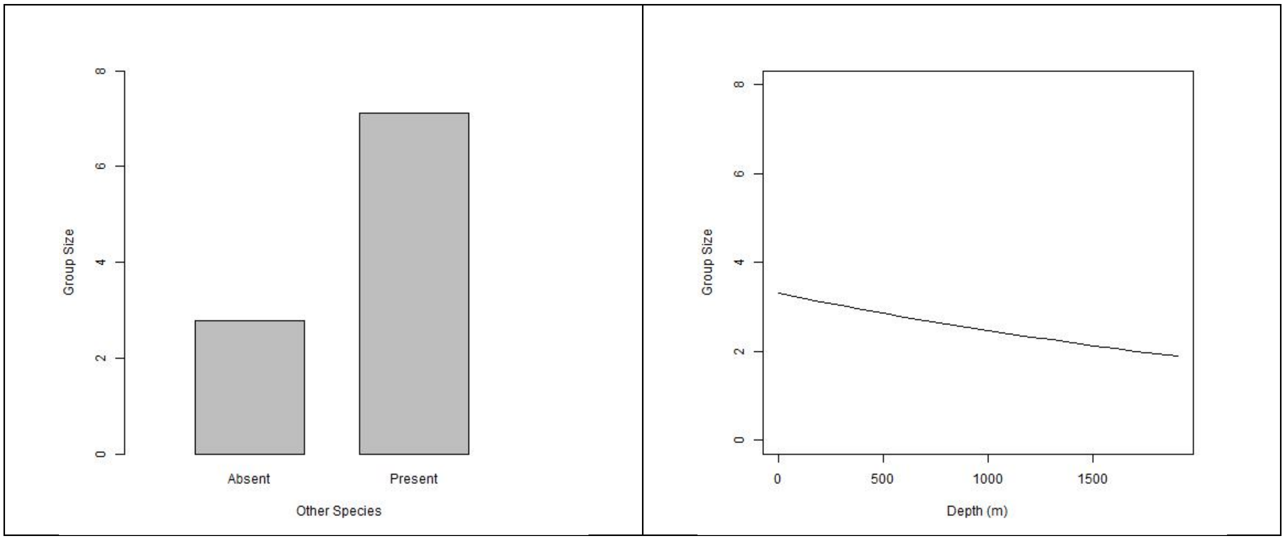

Figure F-15. Marginal effects plots for best California sea lion group size model. For each plot, the covariates not shown were held at fixed values: *mixedgrp* (median = 0, or "absent"); *depth_m* (median = 586.5).

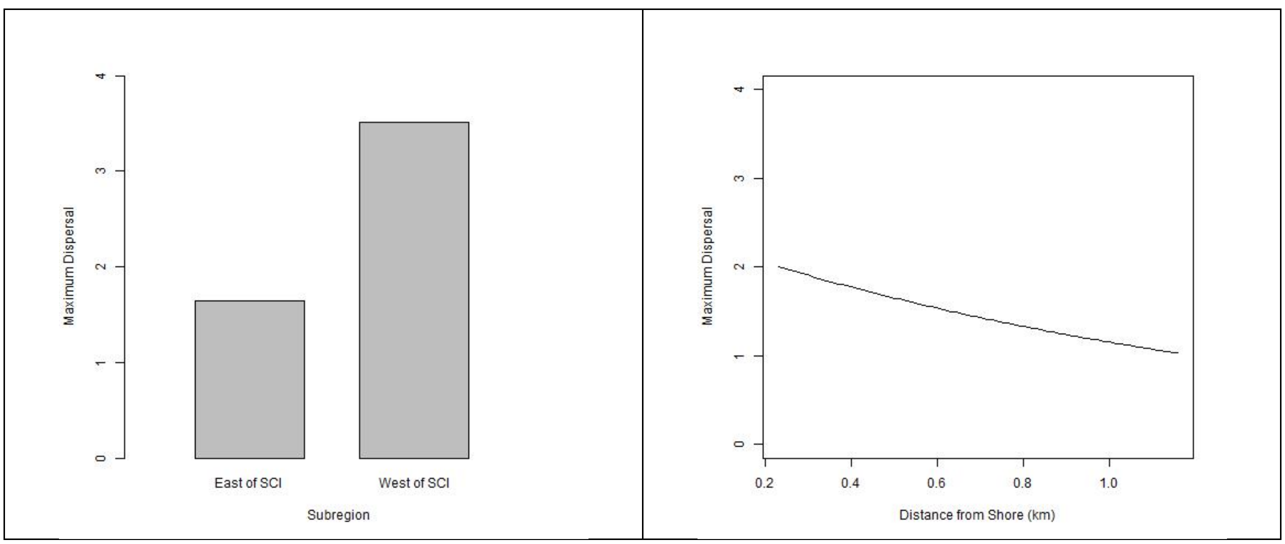

Figure F-16. Marginal effects plots for best California sea lion maximum dispersal model. For each plot, the covariates not shown were held at fixed values: *subregion* (median = 0, or "east"); *distshore_km* (median = 0.5).

APPENDIX G: FOCAL FOLLOWS OF RISSO'S DOLPHINS: DETAILED STATISTICAL METHODS AND RESULTS

FOCAL FOLLOWING ANALYSIS

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FOCAL FOLLOWING ANALYSIS

INTRODUCTION

Focal follow data selected for analyses consisted of sequential observations on groups of Risso's dolphins. Selected response variables were recorded once every 30-sec period that a group of dolphins was view. Each focal follow session lasted approximately 10 – 60 minutes, typically 15 – 20 minutes. Data collected included time, behavior state, heading, and maximum dispersal, that is maximum distance between "nearest neighbor" individuals within a group (see ethogram in Table D-4 of **Appendix D** for definitions).

Three separate analyses were conducted using these data.

1. *Reorientation rate* was defined as change in heading per minute. Standard multiple linear regression models were used to examine the relationship between heading and several candidate explanatory variables including presence of calves, presence of other marine mammal species within the Risso's dolphin group, presence of nearby boats, season, and time of day.
2. *Splitting-joining* was defined as variability in intra-group distances, in particular, the standard deviation in maximum dispersal. Multiple linear regression was conducted, as for reorientation rate, with log-transformed standard deviation as the response. In addition, standard deviation of maximum dispersal was transformed into a binomial response variable (low and high standard deviation) and analyzed using logistic regression.
3. *Sequential analysis of behavior*. This analysis examined the transitions between behavior categories among successive observations. Behaviors were categorized as either 'fm travel' (medium-fast travel), 'milling', or 'slow travel' (slow travel/rest) (see ethogram in Table D-4 of **Appendix D**). Multinomial logistic regression was used to examine the functional dependence of transitions between categories on several covariates including calf presence, season, and period of the day.

METHODS

Reorientation Rate

Data Processing

Observations within each focal follow session were sorted by observation time. Observation times were converted to "scan times" by rounding to the next 30-second interval (e.g., observation times of 11:15:11 and 11:15:41 were assigned scan times of 11:15:30 and 11:16:00, respectively). This procedure sometimes produced pairs of observations with duplicate scan times. In these cases, one member of the pair was deleted using the following two rules applied successively: (1) if the group's heading was missing for exactly one member of the pair, that member was deleted; otherwise, (2) the first member (i.e., the member with the earlier observation time) of the pair was deleted.

First differences (i.e., differences between each successive pair of time-ordered observations) were calculated for scan time and, separately, for heading within each focal follow session. Differences were discarded if they met at least one of the following three criteria: (1) either observation contributing to the difference had behavior classified as milling; (2) either observation contributing to the difference had heading with a missing value; or, (3) the time difference was greater than 5 minutes. Thus, the remaining differences were all non-missing, never included milling behavior, and represented successive observations occurring close in time. Reorientation rate, *rrate*, for each focal follow session was calculated as the average ratio:

$$rrate = \frac{\sum_{i=1}^{n} \Delta h_i / \Delta t_i}{n}$$

where Δh_i was the difference in heading and Δt_i was the difference in scan time.

Explanatory variables (**Table G-1**) included two derived variables – *month* and *tfsun*. Month was intended as a more detailed alternative to season. Most observations were made in the period February – May, so each of these months was retained as a category. The remaining cold water months (November – January) and warm water months (June – October) were collapsed into separate categories. Time from sunrise, *tfsun*, used local sunrise tables and was calculated as the fraction of a day that elapsed between sunrise and the first observation of a focal follow session. For *calf*, *othergrp*, and *boat*, if a calf (or another species, or a nearby boat) was observed at least once during a focal follow session, then the variable was assigned a value of 1, indicating presence.

Model Selection

Candidate explanatory variables were examined for evidence of association so that variable pairs that were associated were not allowed to enter models together. Association for pairs of categorical variables (the first six variables in **Table G-1**) was evaluated via cross-tabulation. If the chi-squared test for independence was significant at the 5% level, then variables were judged to be associated. Association between categorical variables and *tfsun* (the only continuous variable) was assessed using either two-sample *t*-tests (for binomial variables *calf*, *othergrp*, *boat*, and *season*) or one-way ANOVA (for *month* and *timecat*). Again, if the test for a particular variable pair was significant at the 5% level, then those variables were judged to be associated.

Potential dependence of *rrate* on the set of explanatory variables was evaluated using multiple linear regression models. The distribution of *rrate* was right-skewed, but log-transformation yielded a left-skewed distribution, so *rrate* was not transformed. A stepwise procedure based on AIC was used to evaluate candidate models and automatically select the model with lowest AIC. To avoid problems due to strong associations among explanatory variables, several alternate stepwise runs were conducted with different initial sets of variables.

Splitting/Joining

Data Processing

In the first stage of data processing, all observations with missing value for maximum dispersal were deleted. Pairs of observations with duplicate scan times were identified, and the first member of each pair was deleted. For each focal follow session, the standard deviation of maximum dispersal was calculated. Two alternative response variables were created from the standard deviation. For analysis via multiple linear regression, to ensure approximate normality the standard deviation was log-transformed creating variable *logsd*. For analysis via logistic regression, a binomial response variable, *sd3*, was created such that *sd3* = 1 if standard deviation of maximum dispersal ≥ 3, and *sd3* = 0 if standard deviation < 3. The set of explanatory variables was the same as for reorientation rate (**Table G-1**).

Model Selection

Candidate explanatory variables were re-examined for evidence of association since the analysis dataset was not identical to the reorientation rate dataset. Models were selected via a stepwise AIC-based procedure as described above, though model selection was conducted independently for *logsd* using multiple linear regression, and *sd3* using logistic regression.

Sequential Analysis

Data Processing

As for the previous analyses, observations were sorted by time within each focal follow session. Observations with missing value for behavior were deleted. Then, pairs of observations with duplicate scan times were identified, and the first member of each pair was deleted. Transitions between behaviors in each successive pair of observations were identified within each focal follow session. A given observation at time *t*-1 would have behavior categorized as either 'fm travel', 'milling', or 'slow travel'. Hereafter, these are referred to, respectively, as 'fm', 'mill', and 'slow'. The subsequent observation at time *t* would have behavior in any one of the same three categories. Thus, there were nine possible behavior transitions: (1) fm – fm, (2) fm – mill, (3) fm – slow, (4) mill – fm, (5) mill – mill, (6) mill – slow, (7) slow – fm, (8) slow – mill, and (9) slow – slow. If there were *n* observations for a focal follow session, after the removal processes described above, then there were *n* – 1 transitions for that session. The set of explanatory variables (**Table G-2**) differed somewhat from the variables used in the other two analyses. The variable *year* was initially considered but was dropped after preliminary analyses showed that models containing *year* failed to converge. Time category had 3 possible values: 'am', 'early pm', and 'late pm'. Therefore, 2 indicator variables (*timecat1* and *timecat2*) were used to represent time, with 'late pm' serving as the reference category.

Model Selection

Candidate explanatory variables were re-examined for evidence of association using cross-tabulation. Any pair of variables showing significant association (via a chi-squared test) was prevented from entering any model together. All possible models were constructed from the set of candidate variables (**Table G-2**) (excluding *year*, and any associated variable pairs). Multinomial logistic regression was used to model the relationship ship between the response (behavioral transitions) and the covariates. The slow – slow transition was used as the reference category; coefficients were estimated for the remaining eight categories. Akaike's Information Criterion corrected for small sample size (AIC_c) was calculated for each model:

$$AIC_c = AIC + \frac{2p(p+1)}{n-p-1}$$

where p was the number of parameters in the model and n was the number of observations. Models were ranked from lowest $AICc$ (best) to highest (worst) and the top 10 models were identified. For each of these 10 models, the difference between its value ($AIC_{c(i)}$) and that of the top-ranked model ($AIC_{c(1)}$) was calculated as

$$\Delta_i = AIC_{c(i)} - AIC_{c(1)}$$

From these differences, Akaike weights were calculated for all 10 models as

$$w_i = \frac{\exp\left(-\frac{1}{2}\Delta_i\right)}{\sum_{m=1}^{10}\exp\left(-\frac{1}{2}\Delta_m\right)}$$

Lastly, the importance value for each variable was calculated as the sum of the Akaike weights for each model in which that variable appeared. Thus, if a variable appeared in all 10 models, its importance value would equal 1; otherwise, the importance value was bounded between 0 and 1.

RESULTS

Reorientation Rate

Of 1544 observations in the original dataset, there were 98 with duplicate scan times leaving 1446 observations for further analysis. Among these observations, there were 51 focal follow sessions. Three of these sessions (R33, R45, and R46) were not considered further due to disqualification of all first differences (see Methods). One focal follow session (R21) had an unusually high average reorientation rate (*rrate* = 92). Initial model fitting revealed that this single value had strong influence on the estimated regression; therefore, it was removed from the analysis dataset. Removal of these four sessions left 47 focal follow sessions for analysis.

The only explanatory variable pairs showing evidence of strong association with each other were time-related: *season* and *month*, *season* and *tfsun*, and *timecat* and *tfsun*. To prevent these variable pairs from simultaneously entering any model, three stepwise runs were conducted with the following sets of candidate variables: (1) *calf*, *boat*, *othergrp*, *season*, and *timecat*; (2) *calf*, *boat*, *othergrp*, *month*, and *tfsun*; and (3) *calf*, *boat*, *othergrp*, *month*, and *timecat*. All three stepwise runs resulted in selection of the same model, in which the only covariate was *othergrp*.

The fitted model was

$$rrate = 10.822 + 5.5201 \times othergrp$$

The 90% confidence interval for *othergrp* was (-0.34, 11.38). As this confidence interval includes 0, there is limited evidence for an effect of *othergrp*. The estimated coefficient is positive indicating that when other species are present in dolphin groups average reorientation rate is higher than when other species are absent (**Figure G-1**).

Splitting/Joining

Of 1544 observations in the original dataset, 191 were removed because maximum dispersal was missing, and another 78 observations were removed because of duplicate scan times. The remaining 1275 observations represented 51 focal follow sessions. The standard deviation of maximum dispersal and all explanatory variables were calculated for each of these 51 sessions. Before log transformation, two sessions were removed because the standard deviation of maximum dispersal was zero (either because the session had only one observation, or because there were few observations all with the same value of maximum dispersal). As for reorientation rate, the variable pairs that showed evidence of association were *season* and *month*, *season* and *tfsun*, and *timecat* and *tfsun*. Consequently, stepwise model selection was conducted in three separate runs for both the linear regression and logistic regression.

In all cases, the best-fitting model was the intercept-only model. That is, none of the candidate explanatory variables was found to improve model fit for either *logsd* or *sd3*.

Sequential Analysis

Counts of behavior transitions (**Table G-3**) show that the most frequently observed behavior was slow travel, followed by fm travel. Milling behavior was infrequently observed compared to the other two behavior categories. Furthermore, it is clear that any particular behavior observed at time *t*-1 is most likely to be followed by the same behavior at time *t*. All possible transitions do occur in the focal follow data, but transitions from one behavior category to another are infrequent. The top 10 models (**Table G-4**) show pronounced differences in Δ_I and w_i, such that only the top 2 models have any appreciable weight. Correspondingly, only the three variables in these two models have non-zero importance values (**Table G-5**). These three variables (*calf*, *timecat1*, and *timecat2*) also represent the top-ranked model (**Table G-4**).

Estimated regression coefficients and odds ratios for the best model are shown in **Table G-6**. All odds ratios for calf are greater than 1, though confidence intervals for the associated regression coefficients do not include 0 for only three of the response categories (fm – fm, fm – mill, and mill – fm). In the remaining cases, the confidence intervals for the calf coefficients include 0, indicating that the corresponding odds ratios are not different from 1. In any case, an odds ratio greater than 1 indicates an increase in relative odds. As an example, consider for *calf* in the fm - fm response category (**Table G-6**). Its odds ratio is 4.28 which means that when calves are present, an fm-fm transition is 4.28 times more likely than when calves are absent, relative to the likelihood of a slow-slow transition. Similarly, calf presence increases the odds of fm-mill and mill-fm transitions (relative to slow-slow transitions). For the remaining response categories in **Table G-6**, where the confidence intervals for the calf coefficient include 0, there is little evidence for an effect of calf presence.

Note that the three of the four coefficients in the fm-slow response category in **Table G-6** have extremely large standard errors (and, thus, very wide confidence intervals). The estimated coefficients and odds ratios are not reliable.

Confidence intervals for the coefficients of the paired time category variables (*timecat1* and *timecat2*) generally include 0, indicating that the associated odds ratios are not different from 1 and, thus, that time category does not have a significant effect on these transitions. The exceptions in **Table G-6** are the coefficients in the fm-fm response category. The odds ratio for *timecat1* is 0.50 indicating that in the morning fm-fm transitions are less likely than at other times of day, relative to slow-slow transitions. Conversely, the odds ratio for *timecat2* is 6.06, which indicates that in the early afternoon fm-fm transitions are more likely than at other times of day.

Table G-1. Explanatory variables used in Risso's dolphin focal follow analyses (reorientation rate, splitting/joining).

Variable Name	Description
Response Variables	
bestcnt	best estimate of group size
maxdsp	maximum dispersal distance between nearest neighbors within a subgroup, estimated in adult body lengths
hdg	Heading (in degrees magnetic) while traveling
Explanatory Variables	
calf	absent or present (0, 1)
othergrp	other species absent or present (0,1)
boat	nearby boat(s) (< 1 km) absent or present (0, 1)
season	cold-water (Nov-April) or warm-water (May-Oct) season (cold, warm) = (0,1)
month	categorical month (1=Nov-Jan, 2=Feb, 3=Mar, 4=Apr, 5=May, 6=Jun-Oct)
timecat	categorical time of day ('am'[8:00-12:00], 'early pm'[12:01-16:00], 'late pm' [16:01-dusk])
tfsun	time (minutes) since sunrise, fraction of a day

Table G-2. Explanatory variables used in sequential behavior state analyses.

Variable Name	Description
calf	absent or present (0, 1)
boat	absent or present (0, 1)
mixedgrp	other species absent or present (0,1)
season	cold water or warm water (cold, warm) = (0,1)
timecat	time category: 'am', 'early pm', 'late pm'
year	year, categorical (2008 … 2012)

Table G-3. Counts of behavior transitions.

		Time *t*-1		
		fm travel	**mill**	**slow travel**
Time *t*	fm travel	405	12	29
	mill	15	55	20
	slow travel	21	19	783

Table G-4. Top 10 multinomial logistic regression models for Risso's dolphin sequential behaviors. Δ_i is the difference $AIC_i - AIC_1$ and w_i is the Akaike weight.

Model Rank	Model	AIC$_c$	Δ_i	w_i
1	*calf, timecat1, timecat2*	1,643.6	0.0	0.9997
2	*timecat1, timecat2*	1,659.9	16.3	0.0003
3	*season, timecat1, timecat2*	1,720.5	76.9	0
4	*mixedgrp, timecat1, timecat2*	1,742.8	99.2	0
5	*calf*	1,774.6	131.0	0
6	*calf, boat*	1,783.6	140.0	0
7	*calf, season*	1,784.5	140.9	0
8	*season*	1,791.2	147.6	0
9	*boat*	1,797.9	154.3	0
10	*boat, season*	1,806.4	162.8	0

Table G-5. Importance values for all variables in the top 10 models for Risso's dolphin sequential behaviors.

Variable	Importance
timecat1, timecat2	1.00
calf	0.97
season	0.00
mixedgrp	0.00
boat	0.00

Table G-6. Parameter estimates and odds ratios for the top-ranked Risso's dolphin sequential model.

Logit	Parameter	Estimate	Std Err	L95	U95	Odds Ratio
fm – fm	*Intercept*	-2.1670	0.2813	-2.7558	-1.5783	
	calf	1.4544	0.1617	1.1159	1.7928	4.28
	timecat1	-0.6957	0.3191	-1.3635	-0.0278	0.50
	timecat2	1.8022	0.2844	1.2069	2.3975	6.06
fm – mill	*Intercept*	-5.2649	1.0730	-7.5108	-3.0190	
	calf	1.7839	0.5514	0.6298	2.9379	5.95
	timecat1	-0.1371	1.1297	-2.5015	2.2273	0.87
	timecat2	1.2238	1.0681	-1.0117	3.4593	3.40
fm – slow	*Intercept*	-27.8	66097.	-138370.	138315.	
	calf	0.5972	0.5163	-0.4835	1.6779	1.82
	timecat1	23.7	66097.	-138319.	138366.	2.03×10^{10}
	timecat2	24.5	66097.1	-138318.	138367.	4.34×10^{10}
mill – fm	*Intercept*	-5.7907	1.1328	-8.1616	-3.4198	
	calf	2.4950	0.6389	1.1577	3.8324	12.12
	timecat1	-0.8800	1.2378	-3.4709	1.7108	0.41
	timecat2	1.2736	1.0766	-0.9797	3.5269	3.57
mill – mill	*Intercept*	-3.2639	0.5248	-4.3624	-2.1654	
	calf	0.6194	0.3026	-0.0139	1.2527	1.86
	timecat1	0.6989	0.5447	-0.4412	1.8390	2.01
	timecat2	0.1641	0.5693	-1.0274	1.3556	1.18
mill – slow	*Intercept*	-4.4672	1.0176	-6.5971	-2.3373	
	calf	0.0499	0.5910	-1.1871	1.2869	1.05
	timecat1	0.5879	1.0771	-1.6664	2.8422	1.80
	timecat2	0.9621	1.0547	-1.2454	3.1697	2.62
slow – fm	*Intercept*	-3.5461	0.6098	-4.8224	-2.2698	
	calf	0.6051	0.4299	-0.2947	1.5048	1.83
	timecat1	-0.2059	0.6714	-1.6111	1.1993	0.81
	timecat2	0.3313	0.6463	-1.0214	1.6839	1.39
slow – mill	*Intercept*	-4.4570	1.0168	-6.5852	-2.3288	
	calf	0.0104	0.5868	-1.2178	1.2386	1.01
	timecat1	0.5912	1.0770	-1.6630	2.8454	1.81
	timecat2	1.0435	1.0509	-1.1560	3.2431	2.84

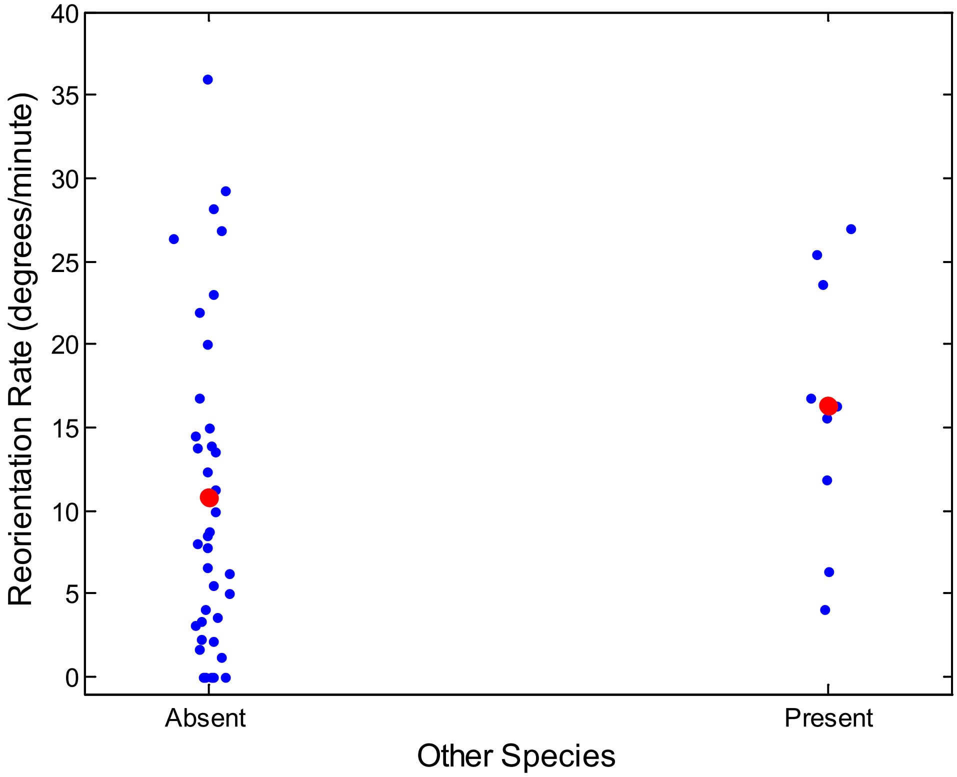

Figure G-1. Average reorientation rate as a function of presence/absence of other species within dolphin groups: observed reorientation rate for 47 focal follow sessions (small blue circles); rate predicted by linear regression model (large red circles). Blue circles have been jittered along the horizontal axis for greater clarity.

APPENDIX H: A CASE STUDY OF THE BEHAVIOR OF A FOCAL GROUP OF RISSO'S DOLPHINS BASED ON VIDEO DATA

Behavior of Dolphins and Whales: Focal Follow Data from Aerial Platforms

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Introduction and Rationale

Behavior of cetaceans tends to be described as a) group behaviors such as foraging, socializing, traveling, resting or combinations of these (Shane et al. 1990); or b) more specific behaviors such as surface time/dive time/respiration interval and number per time, surface-active, inter-animal interactions, etc. (Würsig et al. 1986). Both of these levels of behavioral data gathering are fraught with observational difficulties, in large part because observers tend to see the animals only while they are at or close to the surface, and interruptions in the data are common. Statistical evaluations can be difficult, and proper protocols of analysis have not always been followed (Mann 1999).

Visual observations are made from a) surface vessels at close range and with possible photographic identification of individuals, but usually low vantage points and with the vessel itself potentially a source of disturbance (Constantine 2001); b) underwater with often excellent but extremely close range viewing, but only possible where water is clear and animals stay in a particular area for some time, for social activities (Herzing et al. 2003) or baitball or other near-stationary feeding (Vaughn et al. 2010); c) shore with the advantage of a higher viewing platform, capability of using binoculars, telescopes, and theodolite tracking, and definite non-disturbance of the animals by the observer, yet limited to animals that habitually come within shore (Lundquist et al. 2012); or d) aerial platforms (e.g., fixed wing, helicopter, dirigible or blimp), with advantages of seeing somewhat below the water , seeing "all" near-surface numbers of animals, orientations, dispersion and behavior, etc. (Smultea et al. 2009). This latter technique has the further advantage of not being disturbing when proper protocols of height, flying outside of the air-to-water cone of sound, and other precautions such as not letting the shadow of the airplane fall on members of the group, for example, are diligently followed. One can remain with the animals, individual (whale) or group as they travel along, but it is generally advisable to obtain only about 30 min. of detailed data on a focal group before going to another one. Expense is a disadvantage relative to small boat, most underwater, and shore-based studies.

In all cases, modern visual observations are aided when high definition video recording is accomplished in conjunction with behavioral descriptions (generally into an acoustic recorder in real time), so that later detailed analyses of all observed members of the group, interactions, etc., are possible (Smultea et al. 2009). As well, and used ever-more, underwater sound (and concurrent other ambient sounds, including anthropogenic noise) recording can take place during visual observations, by hydrophones, di-far or other sonobuoy techniques, and passive acoustic devices on the bottom. Frankel (2009) provides a modern overview.

Different types of cetaceans provide different – yet all worthwhile – descriptions of behavior from aerial platforms. Thus, a) generally large groups of delphinids, such as *Delphinus* sp., S*tenella* sp., and *Lagenorhynchus* sp., often of hundreds (to several thousands!) of animals, can provide information on travel speeds, inter-individual distances, orientations and re-orientations of parts or all of the group (generally termed school in such a situation), and general behavior characteristics of the school and distinct subgroups. However, such large schools, reminiscent of herds of ungulates such as wildebeest or caribou (Cords 2000), cannot presently provide detailed information on each individual, as they are not individually recognizable and are (generally but not always) lost to sight as they move below the waves. On the other extreme are b) single to small groups of animals, which can be of any species but tend to be large whales such as (in the Southernn California Bight) gray (*Eschrichtius robustus*), sei (*Balaenoptera borealis*), Bryde's (*Balaenoptera brydei/edeni*), fin (*Balaenoptera physalus*), blue (*Balaenoptera musculus*), and humpback whales (*Megaptera novaeangliae*). These are individually recognizable and under appropriately good conditions, every animal, every respiration, inter-animal distances, and social interactions can be documented in real time and by video. Recently, Smultea et al. (2012) described behaviors of fin whales while video-recording them and simultaneously obtaining their vocalizations with di-far directionalizing hydrophones. Although this collaborative work, supported by the U.S. Navy, is just beginning, it promises to provide scientists and managers with more thorough descriptions of the behavioral life of animals relative to their natural environment and potential anthropogenic effects. Finally, we have groups of animals in the c) intermediate group size range, such as many bottlenose dolphin schools, for example. In the SCB, Rissos' dolphins tend to occur in group sizes of about 10-50 (although smaller and larger schools occur, Smultea et al. 2009), and because of detailed high-resolution video, still photography, and the fact that the general lightness of Risso's dolphin s allows researchers to track them even when they are quite far (perhaps about 20 meters) below the surface, a good audio/video data sample can provide group dispersion, social interaction information, surfacing and dive data, orientations and re-orientations (zig-zags, and by how many degrees), relative speeds, distances made good vs. zig-zags, and more, throughout a behavioral observation session. We provide one example of preliminary analyses of one such group below.

A primary rationale for behavioral observations (and sound data gathering when possible) is to obtain enough information on behavior of animals -- per the vagaries of physical and biological potentially dependent variables -- to assess whether there is disturbance from such anthropogenic activities as tourism, fishing, industrial, research, or Navy, and the concomitant noises that these activities cause. Proper analyses warrant at-times sophisticated ("complicated") multivariate or model-driven statistical evaluations (Gailey et al. 2007, Nations et al. 2012) but present excellent data on generally short-term changes in behaviors relative to said activities do not necessarily translate to long term ("biologically meaningful") effects. The next and important question is whether short-term reactions, if there are enough of them much of the time, affect the health and well-being – i.e. immune responses, social cohesion, effective communication, reproductive parameters, longevity, and a host of related more life history than behavioral parameters. This is an area rife for exploration; although some indications of short term reactions affecting long term parameters of health and well-being have already been postulated to exist (Lusseau 2004 and Visser et al. 2011 provide meaningful examples). It is out opinion that short term changes in behaviors can provide indicators of stress and overall population well-being.

Materials and Methods

Eight aerial surveys were conducted from 2008-2010 in October and November 2008; June, July and November 2009; and May, July and September 2010 (**Table H-1**). The observation platform was a high-wing, twin-engine, fixed-wing Partenavia P68 or Observer (OBS) aircraft. Survey methods were consistent with current accepted Distance Sampling theory (Buckland et al. 2001) and followed general protocol used for surveys SOCAL (e.g., Carretta et al. 2000). Survey lines consisted of generally E-W-oriented lines perpendicular to bathymetric contours (see **Appendix B**, Figure B-1). Surveys were flown at a speed of 100 knots from an altitude of approximately 357 m (1,000 ft). Previous studies indicate that bowhead whales (e.g., Richardson et al. 1985a,b; Patenaude et al. 2002), adult humpback whales (e.g., Smultea et al. 1995), and bottlenose dolphins (Smultea and Würsig 1995) show little or no detectable reaction to small fixed-wing aircraft circling at these altitudes and radial distances (also see review in Richardson et al. 1985 a,b; 1995). Preliminary data support these results (SES unpublished data). These parameters are well outside the Snell's Cone theoretical range of air-to-water sound transmission angle associated with over-flying aircraft (Urick 1972, 1983; Richardson et al. 1995). Thus, staying outside these parameters was anticipated to avoid the potential for the aircraft to affect the behavior of the observed animals.

The survey team consisted of a pilot and three marine mammal biologists experienced in line-transect survey methodology; identification of Pacific marine mammals; and marine mammal observations from aircraft. Two observers were in the back seats of the aircraft, while the third sat in the front right co-pilot seat, serving as the recorder and photographer.

The general survey approach was to: (1) follow survey lines until a sighting was made; (2) record basic sighting information per established protocol; and (3) circle the sighting to photo-document and confirm species and group size and take digital photographs as needed; or (4) increase altitude to ~365-455 m and radial distance ~0.5-1.0 km to conduct a detailed focal behavioral follow involving videography. Geographical Positioning System (GPS) locations were automatically recorded at 10-sec intervals on a handheld, WAAS-enabled Garmin 495 aviation GPS as well as by the aircraft WAAS GPS. A Suunto handheld clinometer was used to measure declination angles to a sighting when it was perpendicular to the aircraft. Steiner 7 x 25 or Swarovski 10 x 32 binoculars were used as needed to identify species, group size, and behaviors.

Data were recorded using a Palm Pilot TX, Apple iTouch, or an Acer netbook laptop computer. Data recording software consisted of SpectatorGo or custom-designed Excel datasheets. Recorded variables included environmental data (Beaufort sea state, glare, visibility conditions); leg effort type (e.g., systematic line transect, connector (i.e., shorter) lines connecting systematic lines, random, transect, circling); species; estimated group size; and number of calves observed.

Modified scan sampling and zero-one sampling approaches (Altmann 1974; Smultea 1994, 2008; Mann 2000) were used to record: (1) behavioral state; (2) minimum and maximum dispersal distance between nearest individuals within a subgroup (i.e., spacing estimated in body lengths [BL]); and (3) heading (in degrees magnetic).

Photographs to confirm species identifications were taken using a digital camera with Image Stabilized (IS) zoom lenses (a Canon 40D with 100-400 mm ET-83C lens, a 20D with 70-200 mm 2.8 lens and 1.4x converter; or a D60 with 100-400mm lens). For focal follow sessions, a Canon Vixia HF10 or Sony HDR-XR550 12.0 megapixels high-definition (HD) digital video camera with a built-in optical image stabilizer and 12x optical zoom lens were used to record behaviors. Software vATS was used to convert video camera lapsed time to real-time. The microphone of the video camera was connected to the audio system of the aircraft so that all vocal input (i.e., behavioral verbal descriptions) was recorded into the video camera data stream.

Sighting rates (number of sightings per unit effort) were calculated for on-effort periods involving "point-to-point" effort (i.e., systematic, connector and transit leg types) (Smultea et al. 2009, Jefferson et al. 2011). Statistical analyses were conducted using Excel or SPSS software. Video analyses involved reviewing video and transcribing observed behaviors and recorded audio from the video onto a customized Excel spreadsheet (Smultea and Bacon 2011); the latter results are not included here.

The Risso's dolphin example: A short case study

Risso's dolphins in the Southern California Bight belong to the California/Oregon/Washington stock inhabiting shelf, slope and offshore waters within the SCB, and ranging into more northern slope and offshore waters into Washington (Carretta et al. 2011). Historical, year-round aerial surveys in the region indicate that this stock occurs most commonly off California during the colder water months then appears to generally shift northward primarily into Oregon and Washington waters during the warmer-water periods in late spring and summer (Green et al. 1992; Carretta et al. 2011). However, the abundance and distribution of this species appears vary with changes in seasonal and inter-annual oceanographic conditions (Forney and Barlow 1998).

Based on surveys between 1991 and 2008, Barlow and Forney (2007) and Barlow (2010) report abundance estimates ranging from approximately 4,000 to 11,000 animals in California waters, with no apparent consistent trend in abundance. However, In the SCB, Risso's dolphins appear to have been increasing in abundance over the last few decades (e.g., Leatherwood et al. 1980; Shane 1995; Forney et al. 1995; Carretta et al. 2000; Smultea et al. 2009, 2010, 2011 a,b; Jefferson et al. 2011), before which they were considered relatively rare. Their influx was correlated with the apparent near abandonment of SCB waters by short-finned pilot whales in the early 1980s in association with a severe ENSO and drop in squid abundance (Barlow 1995; Shane 1995). Within the SCB, Risso's dolphins have been consistently associated with shelf-edge habitats and other steep underwater topographical features from the mainland coast to waters west of San Clemete

Island (SCI) (Carretta et al. 2000; Carretta et al. 2011; Forney and Barlow 1998; Smultea et al. 2009, 2010, 2011 a,b), usually over water depths of 400-1000 m (Baird 2008).

The social, feeding, and diving behavior of Risso's dolphins are little described. Reported typical group sizes for Risso's dolphins off California range from about 10-50 individuals (Forney and Barlow 1998, Baird 2008). In areas outside the SCB, stable groups of adults have been reported within larger aggregations. Limited data from a school killed in a drive fishery in Japan, it has been hypothesized that mature males travel between groups.

Of the 39 Risso's dolphin videos and commentaries at least 10 minutes in length in the course of our SCB studies, we chose one from 11 May, 2011, to illustrate general undisturbed traveling behavior. The group of 7 animals was followed visually from 15hr 05min 00sec to 15hr 25min 00sec, so for 20 minutes. However, for detailed analyses useful for overall comparisons to other Risso's dolphins groups, we chose a subset of that time, as 30 minute scans, from 15hr 05min 30sec to 15hr. 14min 30sec. (**Table H-1**).

Overall, the seven Risso's dolphins, no calves but with one appearing somewhat smaller (a juvenile, perhaps) than the rest, travelled slowly during the first part of the full 20 minutes of video, but then slowed to almost no forward motion during the second part. Surfacing and dives were not fully synchronized, but most were subsurface for about 3.5, 2.5, and 1.5 min. while most were at the surface for 2.0, 6.0, and 2.0 min. Times at the beginning of observation and when the airplane left were not used, so these values add to less than 20.0 min. There was one strong reorientation (of about 150 degrees to the right) three minutes into the observations, but distances apart and slow speed of travel did not change, and this was not likely a response to some outside disturbance.

The scan subsample of these data (**Table H-1**) shows that while animals were spaced a minimum distance of 1 body length (BL) apart, individuals could be as far from others as 3 BL, with a mean maximum dispersal of 1.69 BL (n=16 samples, S.D. = 0.79). While only one change in heading occurred, it was a strong change of 150 degrees.

These data are broadly similar to those obtained for slowly traveling/resting non-disturbed Risso's dolphins from other studies, but with more inter-animal details here (Kruse 1991, off Santa Cruz, CA; Shane 1995 off Santa Catalina Island, CA; Visser et al. 2011 in the Azores).

With this kind of information, also integrated with multi-variate approaches over our entire data sets (Nations et al. 2012) we look forward to comparisons with autonomous acoustic recording data gathered in the same SCB areas (Soldevilla et al. 2010), both to help describe acoustics relative to group sizes and behavior, as well as to work towards an integrated model of natural behavior and behaviors of reactions to disturbance, both short term and chronic.

Table H-1. Video subsample used for case study.

Unique Analysis ID -ALL	Daily Sgt Id	Total Grp Size	Date	Time	Modified Scan Sample Time	Heading (degrees magnetic)*	Change in Heading†	Min Disp (BL)‡	Max Disp (BL)
R25	9	7	5/11/2011	15:05:29	15:05:30	210	0	1	3
R25	9	7	5/11/2011	15:05:59	15:06:00	210	0	1	2
R25	9	7	5/11/2011	15:06:29	15:06:30	210	0	1	3
R25	9	7	5/11/2011	15:06:59	15:07:00	210	0	1	3
R25	9	7	5/11/2011	15:07:29	15:07:30	210	0	1	2
R25	9	7	5/11/2011	15:07:59	15:08:00	210	0	1	1
R25	9	7	5/11/2011	15:08:20	15:08:30	210	0	1	1
R25	9	7	5/11/2011	15:10:29	15:10:30	60	150	1	2
R25	9	7	5/11/2011	15:10:59	15:11:00	60	0	1	2
R25	9	7	5/11/2011	15:11:29	15:11:30	60	0	1	2
R25	9	7	5/11/2011	15:11:50	15:12:00	60	0	1	1
R25	9	7	5/11/2011	15:12:29	15:12:30	60	0	1	1
R25	9	7	5/11/2011	15:12:55	15:13:00	60	0	1	1
R25	9	7	5/11/2011	15:13:29	15:13:30	60	0	1	1
R25	9	7	5/11/2011	15:13:59	15:14:00	60	0	1	1
R25	9	7	5/11/2011	15:14:29	15:14:30	60	0	1	1

*degrees magnetic = degrees magnetic means that magnetic North is different by 12 degrees declination from True North; †Heading = in degrees magnetic, the direction or course the animals are moving; ‡Dispersal distance (minimum & maximum) between adjacent animals (in body lengths) within subgroups only

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APPENDIX I: MARINE MAMMAL RESOURCE SELECTION FUNCTION ANALYSES: DETAILED STATISTICAL METHODS AND RESULTS

Marine Mammal Resource Selection

for HDR, Inc. and Smultea Environmental Sciences

Shay Howlin

Trent McDonald

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October 8, 2012

INTRODUCTION

Resource Selection Functions (RSF) were developed for five species of marine mammal using locations obtained along systematic and connector survey transects. Standard logistic regression models were developed to estimate a linear function of site characteristics that reliably predicts observed use from 2008 to 2012. The model results in estimates of the relative probability of use at a location in the Southern California (SOCAL) Range Complex (i.e., study area), as a function of the site characteristics (Manly et al. 2002). Bottlenose dolphin (*Tursiops truncatus*), California sea lion (*Zalophus californianus*), fin whale (*Balaenoptera physalus*), gray whale (Eschrichtius robustus), and Risso's dolphin (*Grampus griseus*) were detected during the surveys in adequate abundance to support the development of an RSF model. The travel speed of individuals was recorded during the surveys and provided information to conduct separate modeling for four travel speed classes: mill, slow travel, medium and fast travel.

METHODS

The basic premise of resource selection modeling (Manly et al. 2002) is that resources (which may be food items, land cover types, or any quantifiable habitat characteristic) that are important to individuals will be "used" disproportionately to the availability of those resources in the environment. In this analysis, the characteristics at the used locations were contrasted to characteristics at randomly selected "available" locations in the SOCAL Range Complex. The available set of points for the resource selection was obtained through a systematic grid placed at a random location. We removed all observations on land (with depth greater than 0) and outside the main study areas. Most species were modeled within the Northern Air Operating Area (NAOPA) and Southern California Anti-Submarine Warfare Range (SOAR) regions using a set of 35,167 available points, but the bottlenose dolphin was modeled only in NAOPA region with a set of 23,455 available points.

RSFs were estimated using the standard logistic regression model to predict the probability of the species being detected at a sampled site, Π, as a function of p variables x_1, x_2, ..., x_p that describe the habitat at the site. The form of a logistic regression model is

$$\Pi(x_1,x_2,...,x_p) = \exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p)$$

where the β values are parameters that are estimated from the data. There were seven covariates available for inclusion in each model: latitude, longitude, depth (meters [m]), northness calculated as the cosine of aspect, eastness calculated as the sine of aspect, slope, and distance from shore (kilometers [km]). There are 127 models that can be created from all possible combinations of the seven covariates. We fit all 127 models and ranked the models with Akaike's Information Criterion (AIC) (Burnham and Anderson 2002), a statistic that evaluates model fit based on the log likelihood. Observations with missing values for any of the seven covariates were removed from the analysis.

We present the top AIC model for each species and travel speed. The direction of the parameter estimate indicates whether the relationship between the variable and use is positively or negatively correlated. The test for the significance of the parameter estimate, ie. null hypothesis of the parameter estimate equals zero, is summarized with the p-value of the test. The RSF models were used to predict the relative probability of selection for areas within the SOCAL

Range Complex. These values were mapped spatially and color coded to indicate the relative value of the resource selection prediction.

RESULTS

RSF models for each of 3 travel speeds (mill, slow travel, medium and fast travel) and all observations combined were fit for the five species when sample sizes allowed (**Table I-1**). In 3 cases, bottlenose dolphin, fin whale, and gray whale, low samples sizes required mill observations to be combined with slow observations and a model was made for the combined set of observations.

Bottlenose Dolphin

Observations used in the RSF models are shown in **Figure I-1** and a summary of the models is in **Table I-2**. The RSF model for **mill/slow** travel combined did not account for a significant amount of variation in the data. The top model contained the variable for latitude but the p-value for the test of the significance of the coefficient was 0.1328, which was not significant at the alpha equal to 0.10 level of significance.

The RSF model for **medium/fast** travel contained the variables longitude, depth, and distance from shore. Longitude was found to be negatively correlated with use, meaning that higher values of longitude were associated with lower use (p=0.0302). Depth was also found to be negatively correlated with use, meaning that higher values of depth (deeper waters) were associated with lower use (p=0.0003). Distance from shore was found to be negatively correlated with use, meaning that larger distances (farther from shore) were associated with lower use (p=0.0201).

The RSF model for **all** travel speeds contained the same variables as the medium and fast travel model with the same interpretation. Predictions for each of the 3 models are in **Figure I-6**.

California Sea Lion

Observations used in the RSF models are shown in **Figure I-2** and a summary of the models is in **Table I-4**. The RSF model for **mill** travel contained the variable longitude, and was found to be negatively correlated with use, meaning that higher values of longitude were associated with lower use (p=0.0090).

The RSF model for **slow** travel contained the variables eastness and distance from shore. Eastness was found to be positively correlated with use, meaning that higher values (more east facing aspects) were associated with higher use (0.0863). Distance from shore was found to be negatively correlated with use, meaning that larger distances (farther from shore) were associated with lower use (p=0.1573).

The RSF model for **medium/fast** travel contained the variables longitude, depth, and distance from shore. Longitude was found to be negatively correlated with use, meaning that higher values of longitude were associated with lower use (p=0.0023). Depth was also found to be negatively correlated with use, meaning that higher values of depth (deeper waters) were associated with lower use (p=0.0297). Distance from shore was found to be negatively correlated with use, meaning that larger distances (farther from shore) were associated with lower use (p=0.0917).

The RSF model for **all** travel speeds contained the longitude and distance from shore. Longitude was found to be negatively correlated with use, meaning that higher values of longitude were associated with lower use (p<0.0001). Distance from shore was found to be negatively correlated with use, meaning that larger distances (farther from shore) were associated with lower use (p=0.0213). Predictions for each of the 4 models are in **Figure I-7.**

Fin Whale

Observations used in the RSF models are shown in **Figure I-3** and a summary of the models is in **Table I-3**. The RSF model for **mill/slow** travel combined did not account for a significant amount of variation in the data. The top model contained the variable for distance from shore but the p-value for the test of the significance of the coefficient was 0.3970 which was not significant at the alpha equal to 0.10 level of significance.

The RSF model for **medium/fast** travel contained the variables longitude, and depth. Longitude was found to be positively correlated with use, meaning that higher values of longitude were associated with higher use (p=0.0276). Depth was also found to be positively correlated with use, meaning that higher values of depth (deeper waters) were associated with higher use (p=0.0017).

The RSF model for **all** travel speeds contained the variables latitude, longitude, depth and distance from shore. Latitude was found to be negatively correlated with use, meaning that higher values of latitude were associated with lower use (p=0.0413). Longitude was found to be positively correlated with use, meaning that higher values of longitude were associated with higher use (p=0.0517). Depth was found to be positively correlated with use, meaning that higher values of depth (deeper waters) were associated with higher use (p=0.0053). Distance from shore was found to be negatively correlated with use, meaning that larger distances (farther from shore) were associated with lower use (p=0.0359). Predictions for each of the 3 models are in **Figure I-8**.

Gray Whale

Observations used in the RSF models are shown in **Figure I-4** and a summary of the models is in **Table I-4**. The RSF model for **mill/slow** travel contained the variables longitude and northness. Longitude was found to be positively correlated with use, meaning that higher values of longitude were associated with lower use (p=0.0639). Northness was found to be negatively correlated with use, meaning that higher values of northness (more northerly aspects) were associated with lower use (p=0.0958).

The RSF model for **medium/fast** travel combined did not account for a significant amount of variation in the data. The top model contained the variables longitude, and distance from shore but the p-value for the test of the significance of each coefficient was 0.1630 and 0.1480 respectively, neither of which were significant at the alpha equal to 0.10 level of significance.

The RSF model for **all** travel speeds contained the variable longitude, and was found to be positively correlated with use, meaning that higher values of longitude were associated with higher use (p=0.0074). Predictions for each of the 3 models are in **Figure I-9**.

Risso's Dolphin

Observations used in the RSF models are shown in **Figure I-5** and a summary of the models is in **Table I-5**. The RSF model for **mill** travel combined did not account for a significant amount of variation in the data. The top model contained the variable for longitude but the p-value for the test of the significance of the coefficient was 0.2370, which was not significant at the alpha equal to 0.10 level of significance.

The RSF model for **slow** travel contained the variables longitude, depth, and distance from shore. Longitude was found to be positively correlated with use, meaning that higher values of longitude were associated with higher use (p=0.0149). Depth was also found to be positively correlated with use, meaning that higher values of depth (deeper waters) were associated with higher use (p=0.0803). Distance from shore was found to be negatively correlated with use, meaning that larger distances (farther from shore) were associated with lower use (p=0.0378).

The RSF model for **medium/fast** travel contained the variables latitude, longitude, depth and distance from shore. Latitude was found to be negatively correlated with use, meaning that higher values of latitude were associated with lower use (p=0.0192). Longitude was found to be positively correlated with use, meaning that higher values of longitude were associated with higher use (p=0.0259). Depth was found to be negatively correlated with use, meaning that higher values of depth (deeper waters) were associated with lower use (p=0.1298). Distance from shore was found to be negatively correlated with use, meaning that larger distances (farther from shore) were associated with lower use (p=0.0378).

The RSF model for **all** travel speeds contained the variables latitude, longitude, and distance from shore. Latitude was found to be negatively correlated with use, meaning that higher values of latitude were associated with lower use (p=0.0190). Longitude was found to be positively correlated with use, meaning that higher values of longitude were associated with higher use (p=0.0001). Distance from shore was found to be negatively correlated with use, meaning that larger distances (farther from shore) were associated with lower use (p=0.0006). Predictions for each of the 4 models are in **Figure I-10**.

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Table I-1. Sample sizes for each species modeled. Not all models were it for all species and travel speeds, see notes column.

Species	All Observations	Mill	Slow	Fast/ Med.	Missing	Notes
Blue Whale	5	0	2	3		No models fit
Bottlenose Dolphin	31	1	11	19		Mill & Slow combined
CA Sea Lion	125	41	18	34	32	
Fin Whale	59	2	20	36	1	Mill & Slow combined
Gray Whale	40	1	18	21		Mill & Slow combined
Risso's Dolphin	134	14	63	56	1	All 4 models estimated

Table I-2. Bottlenose dolphin RSF model covariates (direction of effect; p-value). Positive coefficients are positively related to selection, negative coefficients are negatively related to selection.

Travel Speed	Variables in Model (Direction of Coefficient; p-value)
Mill/Slow*	Latitude (+; 0.1328)
Medium/Fast	Longitude (-; 0.0302), Depth (-; 0.0003), Distance from Shore (-;0.0419)
All Travel	Longitude (-;< 0.0579), Depth (-; 0.0003), Distance from Shore (-;0.0201)

* Small sample sizes lead to a lack of significance in all covariates.

Table I-3. California sea lion RSF model covariates (direction of effect, p-value). Positive coefficients are positively related to selection, negative coefficients are negatively related to selection.

Travel Speed	Variables in Model (Direction of Coefficient; p-value)
Mill	Longitude (-; 0.0090)
Slow	Eastness (+; 0.0863), Distance from Shore (-; 0.1573)
Medium/Fast	Longitude (-; 0.0023), Depth (-; 0.0297), Distance from Shore (-;0.0917)
All Travel	Longitude (-;< 0.0001), Distance from Shore (-;0.0213)

Table I-4. Fin whale model covariates (direction of effect, p-value). Positive coefficients are positively related to selection, negative coefficients are negatively related to selection.

Travel Speed	Variables in Model (Direction of Coefficient; p-value)
Mill/Slow*	Distance from Shore (-;0.3970)
Medium/Fast	Longitude (+; 0.0276), Depth (+; 0.0017)
All Travel	Latitude (-; 0.0413), Longitude (+; 0.0517), Depth (+; 0.0053), Distance from Shore (-; 0.0359)

* Small sample sizes led to a lack of significance in all covariates.

Table I-5. Gray whale RSF model covariates (direction of effect, p-value). Positive coefficients are positively related to selection, negative coefficients are negatively related to selection.

Travel Speed	Variables in Model (Direction of Coefficient; p-value)
Mill/Slow	Longitude (+; 0.0639), Northness (-; 0.0958)
Medium/Fast*	Longitude (+; 0.1630), Distance from Shore (-;0.1480)
All Travel	Longitude (+;<0.0074)

* Small sample sizes led to a lack of significance in all covariates.

Table I-6. Risso's dolphin RSF models. Positive coefficients are positively related to selection, negative coefficients are negatively related to selection.

Travel Speed	Variables in Model (Direction of Coefficient; p-value)
Mill*	Longitude (+;0.2370)
Slow	Longitude (+; 0.0149), Depth (+; 0.0803), Distance from Shore (-;0.0084)
Medium/Fast	Latitude (-; 0.0192), Longitude (+; 0.0259), Depth (-; 0.1298), Distance from Shore (-; 0.0378)
All Travel	Latitude (-; 0.0190), Longitude (+; 0.0001), Distance from Shore (-; 0.0006)

* Small sample sizes led to a lack of significance in all covariates.

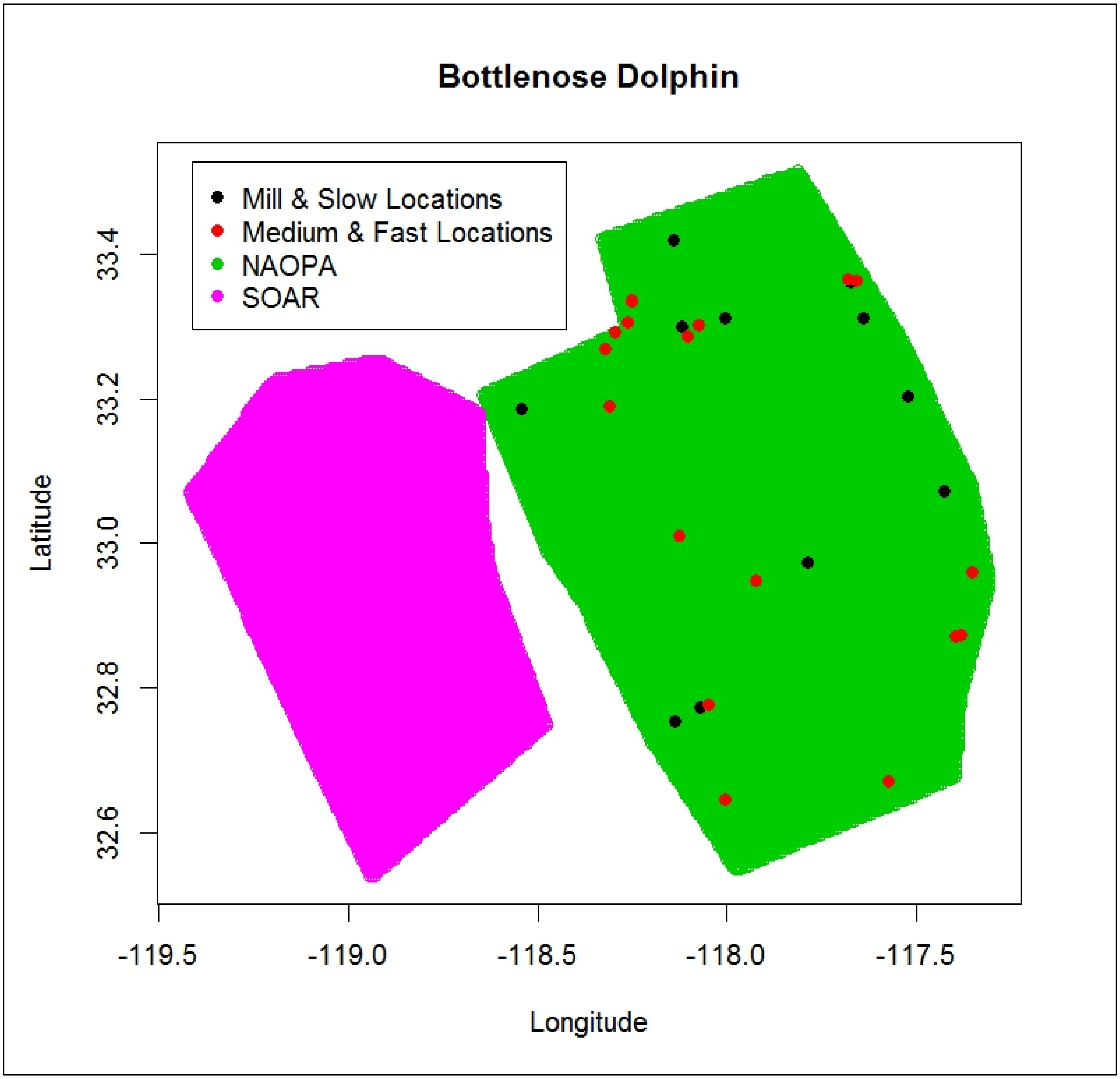

Figure I-1. Bottlenose dolphin locations in the resource selection analysis

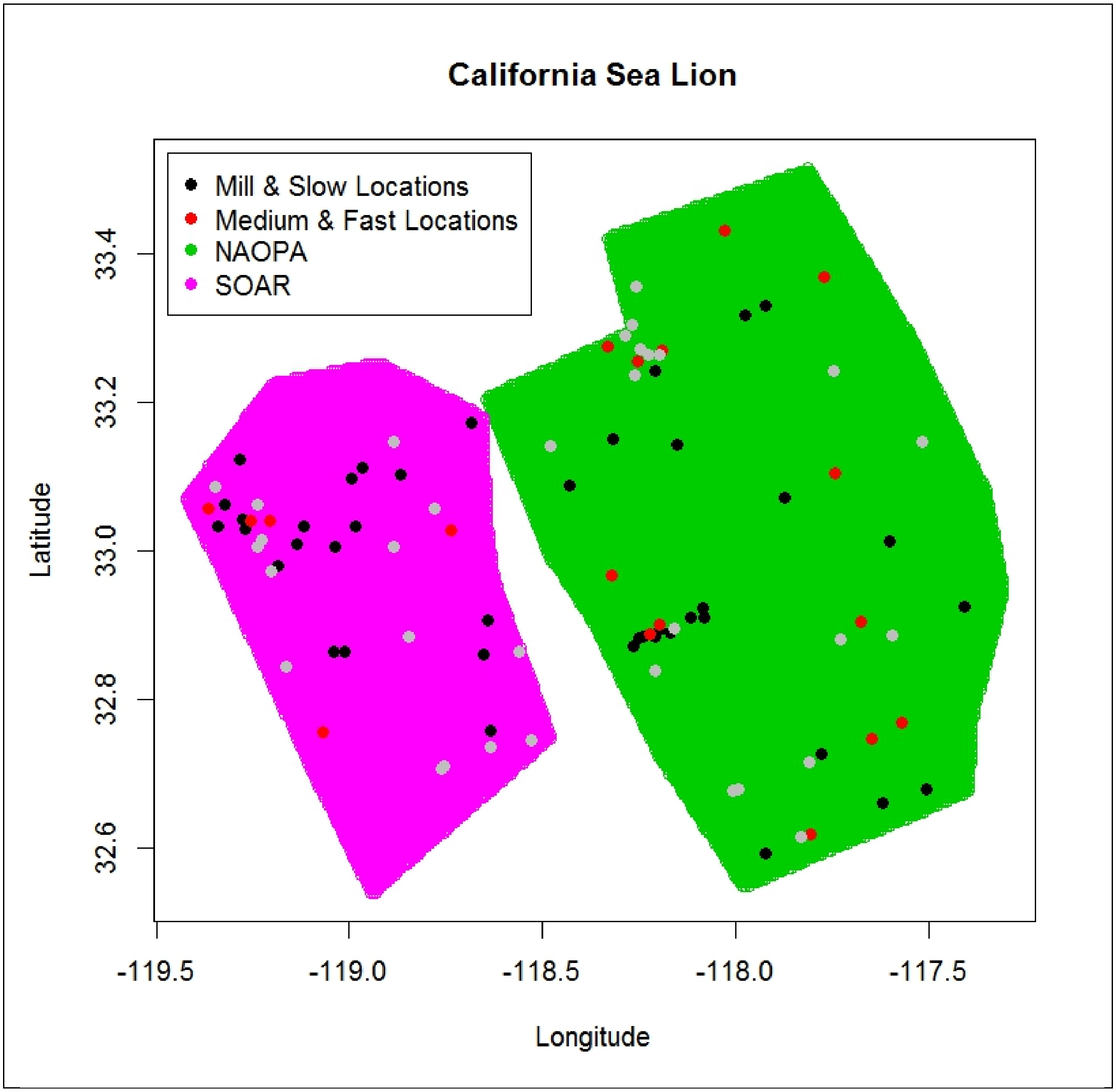

Figure I-2. California sea lion locations in the resource selection analysis

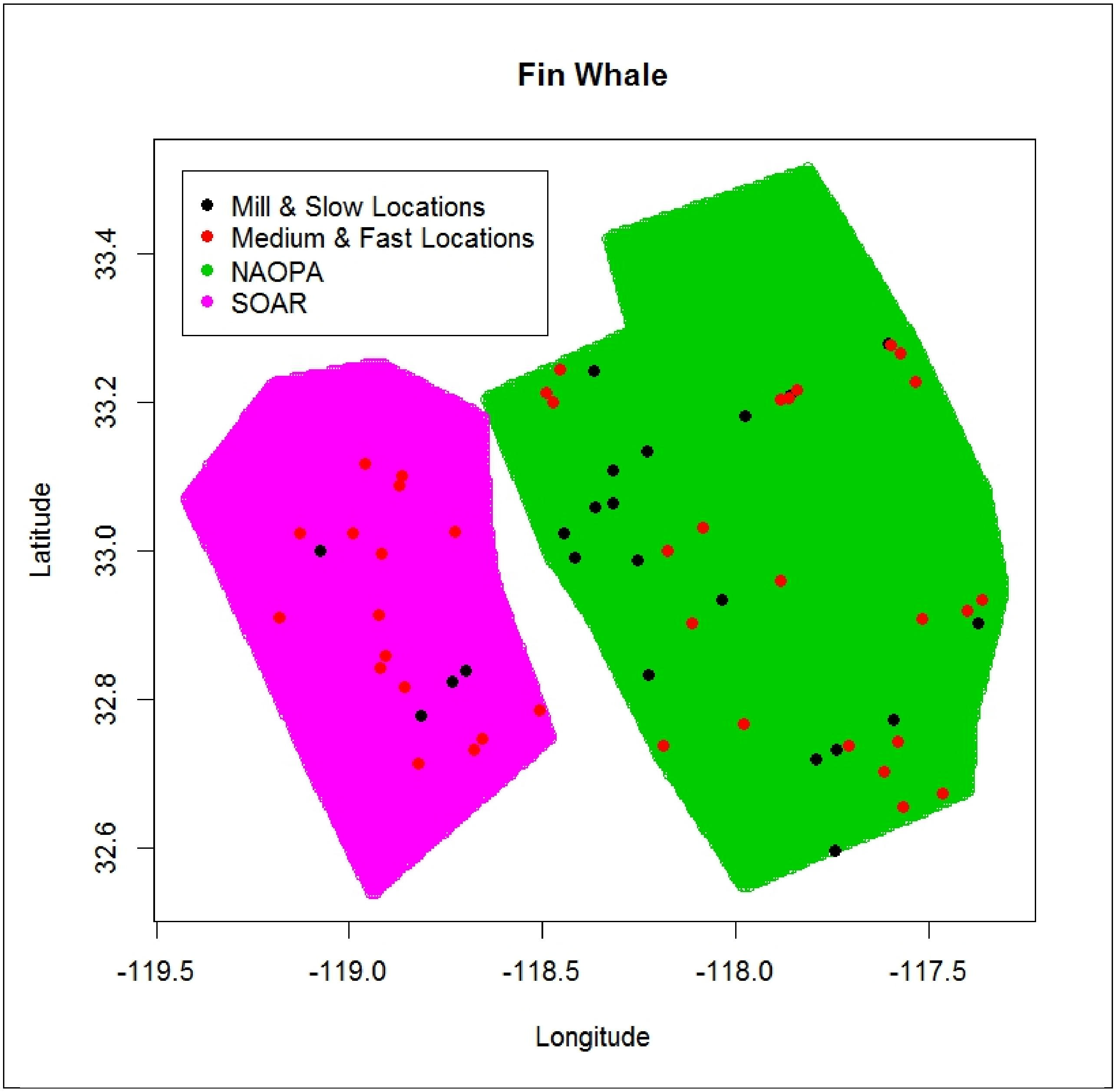

Figure I-3. Fin whale locations in the resource selection analysis.

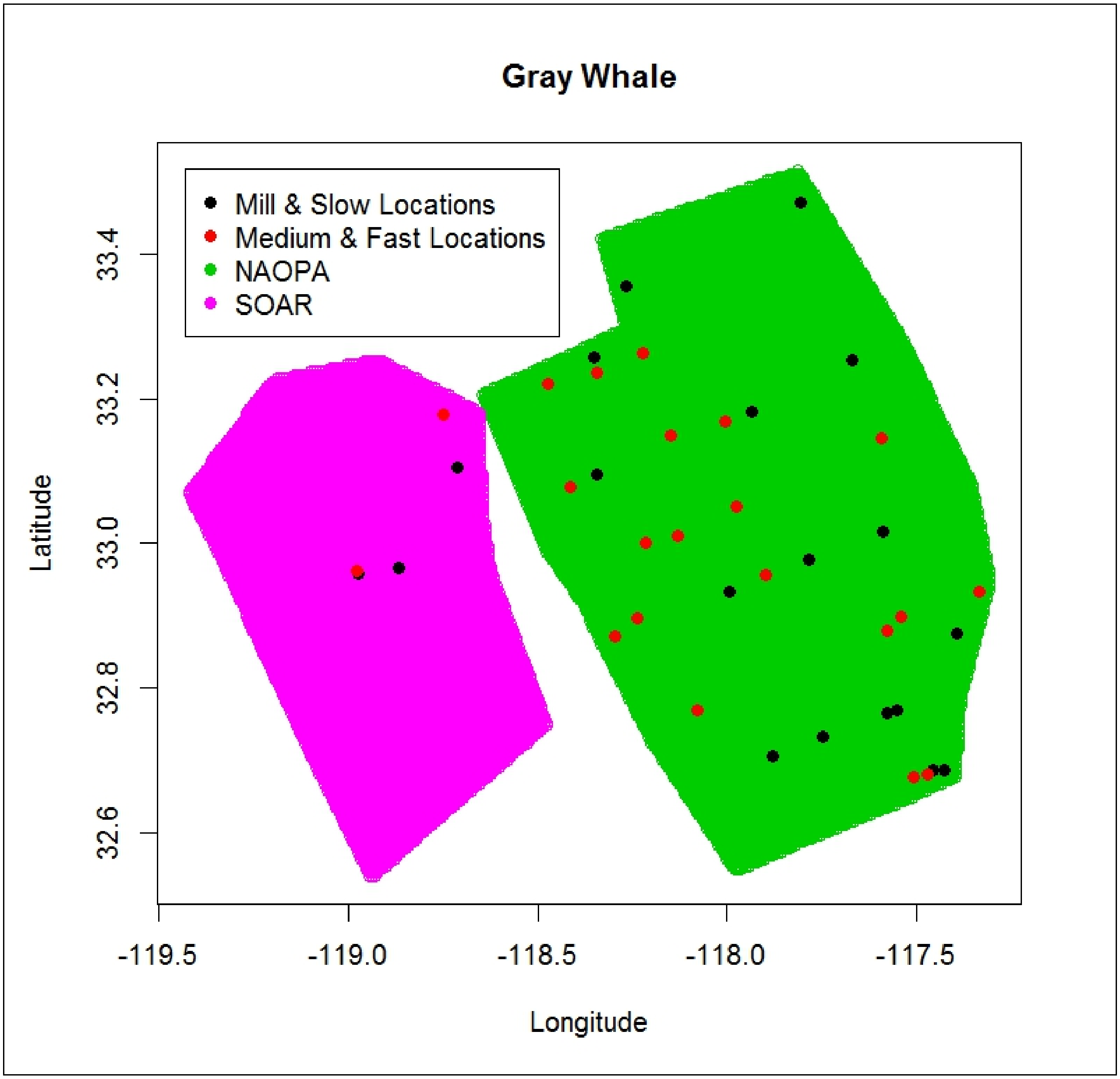

Figure I-4. Gray whale locations in the resource selection analysis.

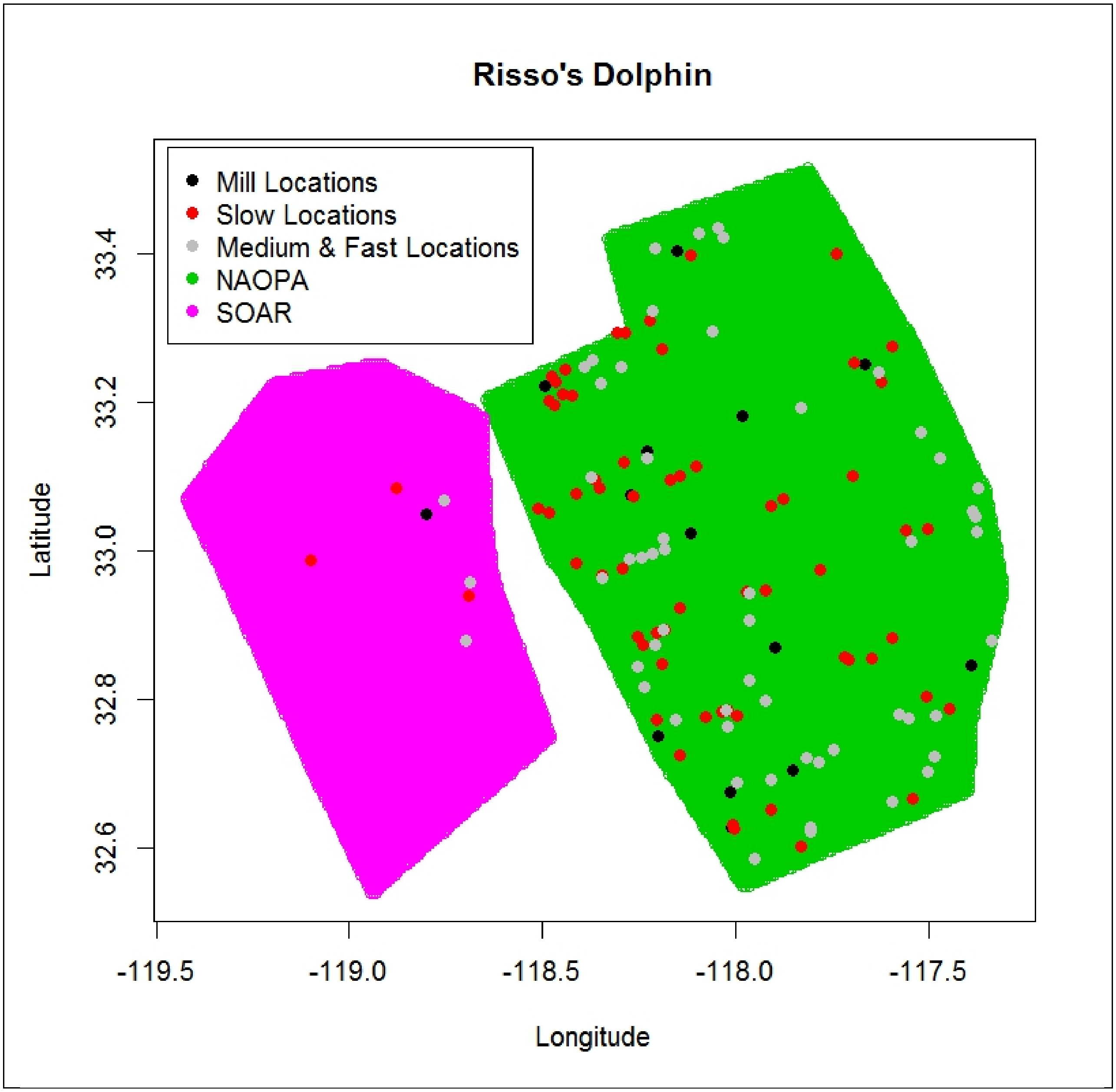

Figure I-5. Risso's dolphin locations in the resource selection analysis.

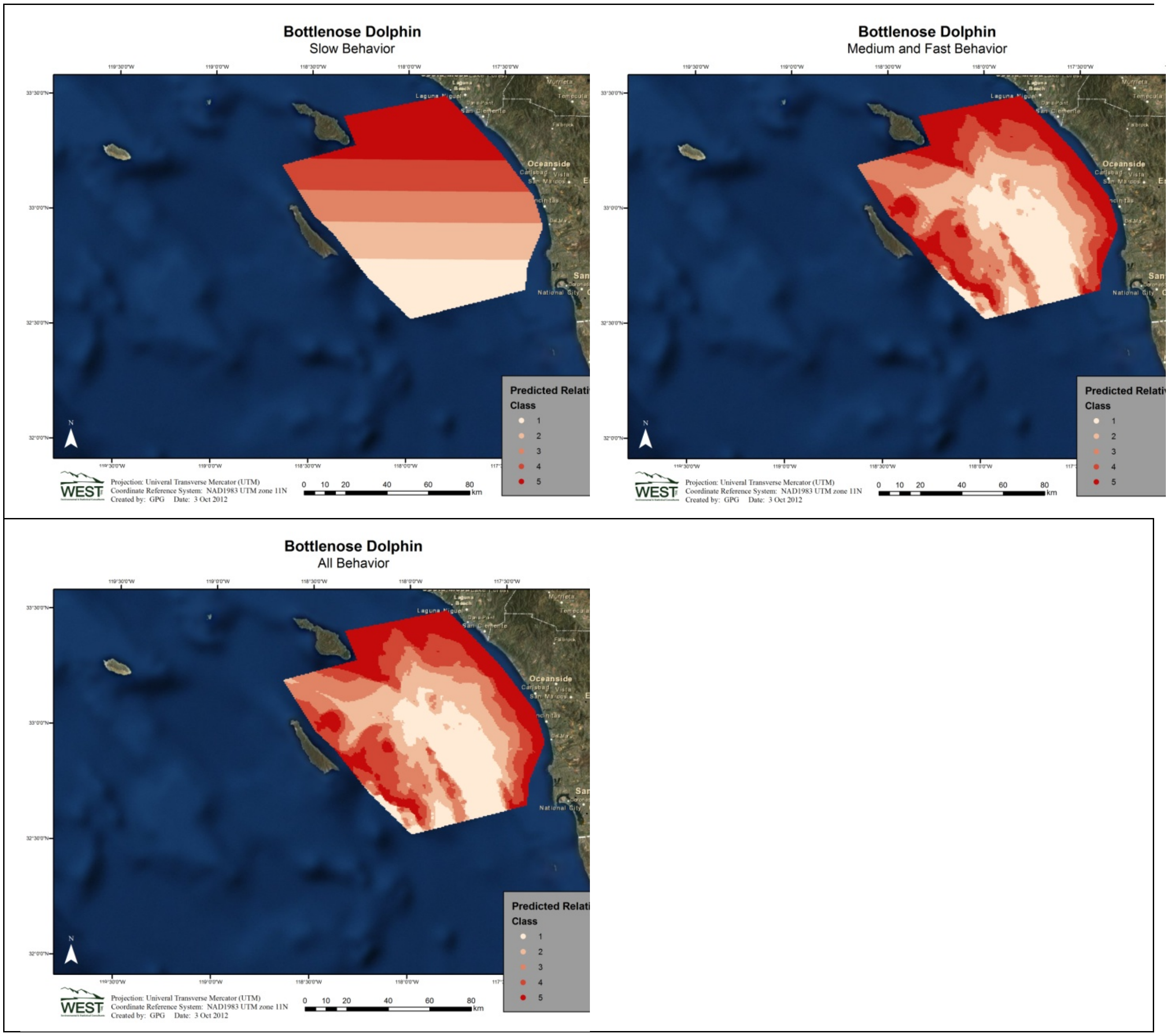

Figure I-6. Predicted relative probability of selection for bottlenose dolphin. Areas with highest probability of selection are represented by red; areas with lowest probability of selection are represented by white.

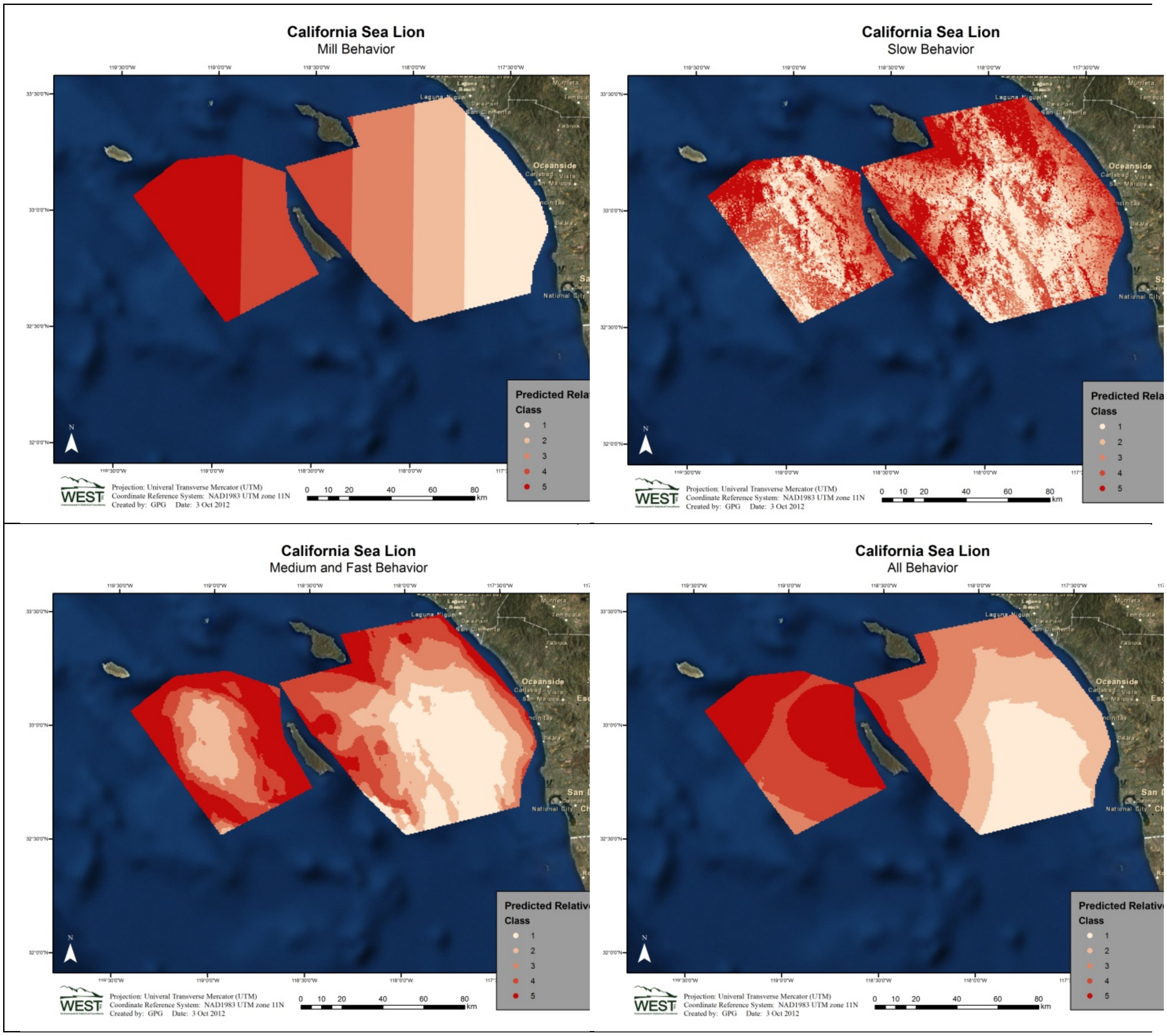

Figure I-7. Predicted relative probability of selection for California sea lion. Areas with highest probability of selection are represented by red; areas with lowest probability of selection are represented by white.

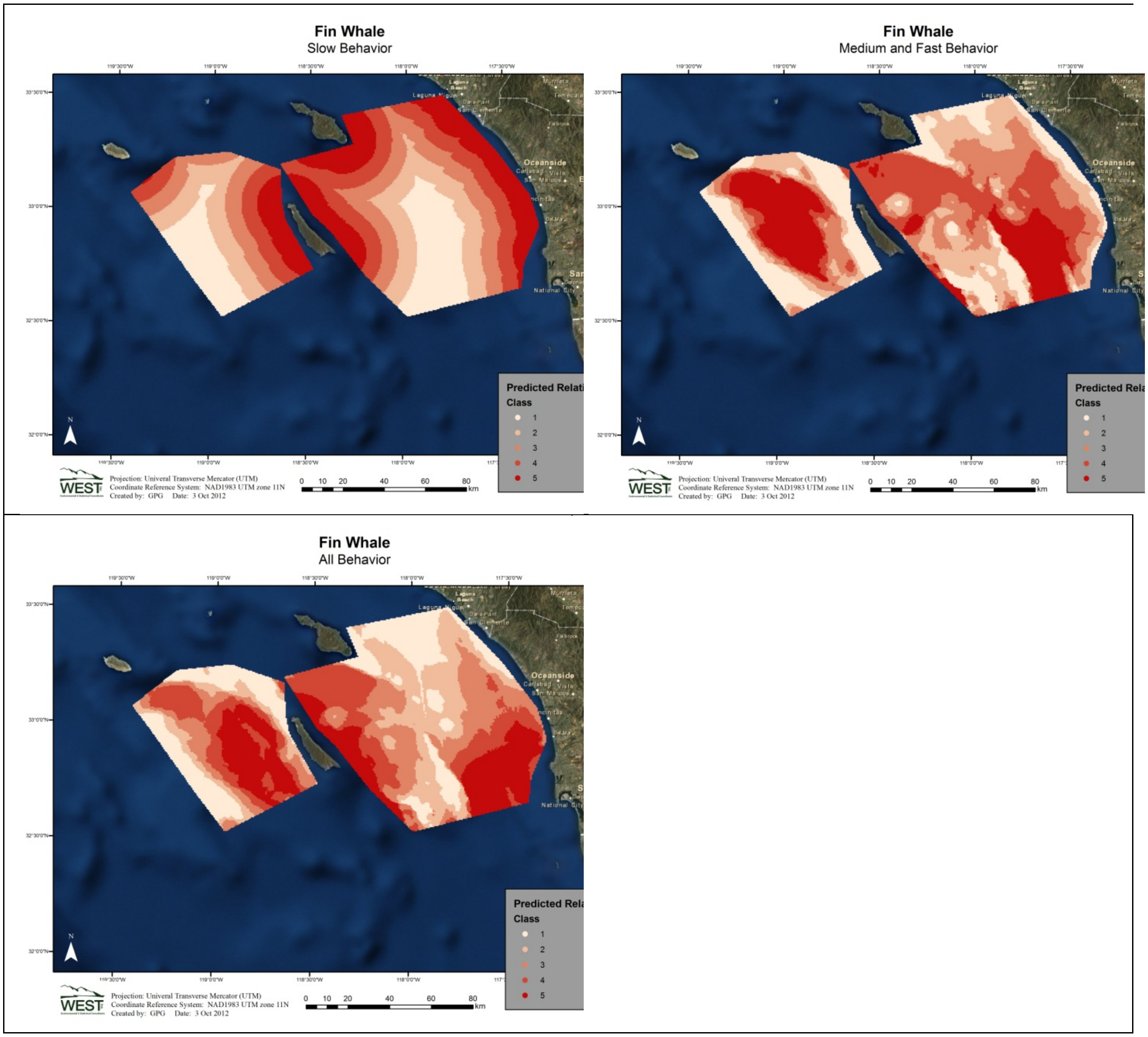

Figure I-8. Predicted relative probability of selection for fin whale. Areas with highest probability of selection are represented by red; areas with lowest probability of selection are represented by white.

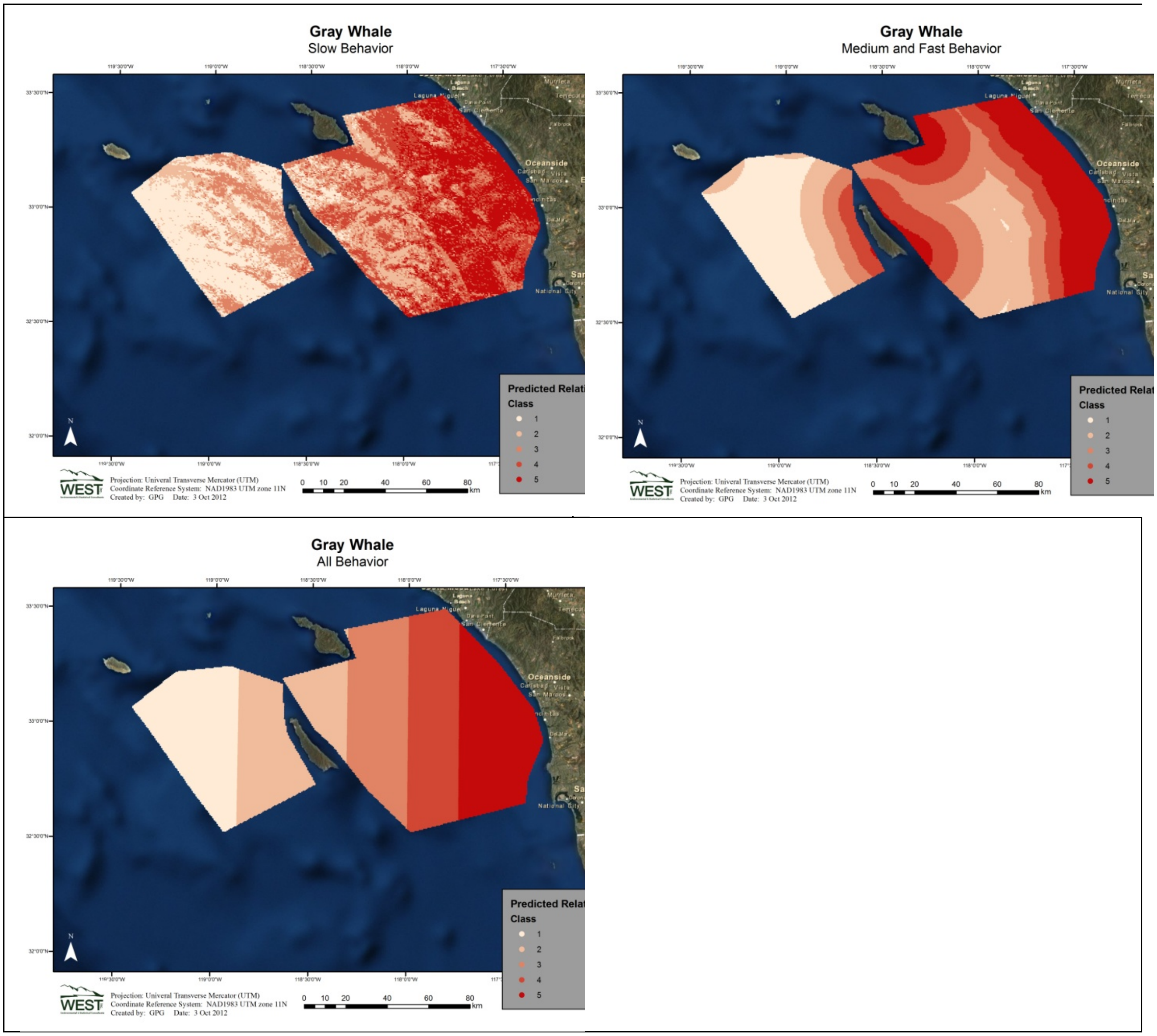

Figure I-9. Predicted relative probability of selection for gray whale. Areas with highest probability of selection are represented by red; areas with lowest probability of selection are represented by white.

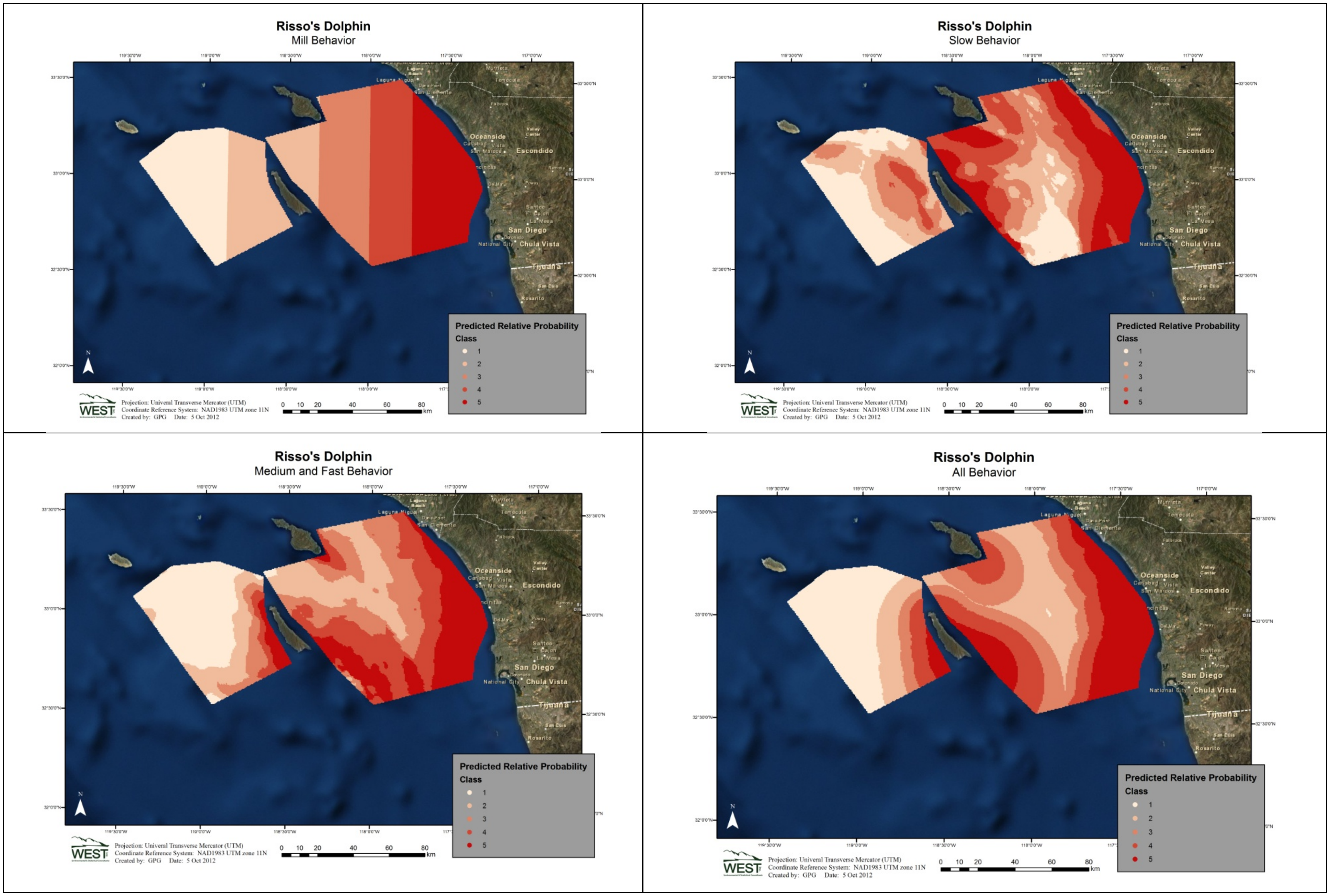

Figure I-10. Predicted relative probability of selection for Risso's dolphin. Areas with highest probability of selection are represented by red; areas with lowest probability of selection are represented by white.

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APPENDIX J: HISTORICAL CHANGES IN THE RELATIVE OCCURRENCE OF MARINE MAMMALS IN THE SOUTHERN CALIFORNIA BIGHT INCLUDING RELATIVE TO THE 2008-2012 AERIAL MARINE MAMMAL MONITORING SURVEYS CONDUCTED ON BEHALF OF THE U.S. NAVY

Changes in Relative Occurrence of Marine Mammals in the Southern California Bight: A Comparison of Recent Aerial Survey Results with Historical Data Sources

Thomas A. Jefferson and Mari A. Smultea

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INTRODUCTION

Systematic surveys for marine mammals of Southern California (SOCAL) have only been conducted since the mid-1970s (e.g., Dohl et al. 1981; Carretta et al. 1995, 2000; Jefferson et al. 2012). These have provided useful information on the relative occurrence and abundance of the various species that occur there. However, the detection of historical changes has been difficult to explore due to the lack of systematic surveys before the mid-1970s. However, many of the pre-1970s surveys searched large areas for marine mammals, and kept good records of what they detected. In certain cases, these surveys do provide useful information about the relative occurrence and abundance of marine mammals from the 1950s to 1960s.

Herein, we examine these older datasets, extract relative occurrence information (species rankings), and compare that information to more recent surveys that calculate relative abundance quantitatively. We are aware that there are many differences in the various surveys that make conclusions regarding changes in occurrence difficult (e.g., different platforms; observer experience; searching methods; biases related to season, area, and survey focus). However, since these are virtually the only sources of information available to examine trends over the last 50-60 years in this area, we believe this attempt is worthwhile. We restrict our conclusions to only those species in which fairly clear and dramatic differences are observed.

METHODS

We examined available literature and extracted species rankings from at-sea studies conducted in the SCB from the 1950s to 2012. We compared the results of our 2008-2012 systematic aerial surveys to several other studies, each of which we considered to best represents the relative abundance of the cetacean fauna of the southern California Bight that we could find for specific time periods back to the mid-1950s. These survey efforts are described in detail below.

1) *Brown and Norris (1956) surveys* – During the first months of operation of Marineland of the Pacific, between March 1954 and September 1955, aquarium staff made observations of cetaceans in waters of southern California. This effort was probably biased towards the area off the Palos Verdes Peninsula and around Catalina Island. Searching was not systematic and was mostly from the vessel *Geronimo*. Observations were mostly subjective; virtually no quantitative data were presented. Effort was focused on species that were desirable for live-capture, including killer whales and pilot whales. Interestingly, Brown and Norris (1956) did not mention observation of wild bottlenose dolphins.
2) *Norris and Prescott (1961) surveys* – From 1958 to 1961, capture crews from Marineland of the Pacific made observations on marine mammals throughout the SCB, mostly between

Los Angeles and Santa Catalina Island, as well as around and inside San Diego Bay. Most survey effort was conducted aboard the vessel *Geronimo*, and search effort was not quantified. There may have been some bias toward species that were desired for capture (e.g., pilot whales and bottlenose dolphins), but data were collected on all species encountered.

3) *Fiscus and Niggol (1965) surveys* – During pelagic fur seal investigations in 1958 to 1961 along the west coast of the United States, Fiscus and Niggol spent significant amounts of time searching for marine mammals in the SCB. Most effort occurred in offshore waters and with no effort off San Diego. Several vessels were used and search effort was not quantified. Observations occurred from November through April, with no summer effort.

4) *Dohl et al. (1981) aerial surveys* – Between 1975 and 1978, Dohl et al. conducted 96,889 km of aerial surveys in the SCB, the most extensive marine mammal surveys of this area up to that time. Search effort was systematic and estimates of density were calculated. Surveys occurred throughout the year in both nearshore and offshore waters, although effort focused in deeper waters.

5) *Dohl et al. (1981) ship surveys* - Dohl et al. also conducted shipboard surveys in the SCB in 1975 to 1978 using a variety of vessels. A total of 14,255 km of surveys were done and search effort was quantified. However, the offshore surveys were plagued with poor weather and did not produce much in the way of meaningful results.

6) *Carretta et al. (1995) aerial surveys* – From 1993 to 1994, the Southwest Fisheries Science Center (SWFSC) conducted 13,734 km of line transect surveys, mostly in offshore waters west of San Nicholas Island (in a portion of the U.S. Navy Outer Sea Test Range). Surveys covered all seasons, sighting effort was quantified, and estimates of density were calculated. There was no effort off San Diego.

7) *Carretta et al. (2000) aerial surveys*- From 1998 to 1999, a total of 7,732 km of line transect survey effort was conducted by the SWFSC, mostly in the area around San Clemente Island. All four seasons were represented, effort was quantified, and estimates of density were made. Shallow waters near the island were surveyed, as well as deeper waters offshore, but there was little effort conducted off the San Diego mainland coast.

8) *Jefferson et al*. (2012) *aerial surveys* - The present set of surveys was designed to replicate the Carretta et al. (2000) surveys as closely as was feasible, and their methods used were loosely followed. The surveys took place from 2008-2012 and covered all four seasons. Fifteen aerial surveys were completed, mostly in the region surrounding San Clemente Island in the San Nicolas Basin and offshore of the San Diego County coastline in the Santa Catalina Basin. In total 59,287 km of survey effort was undertaken, effort was quantified, and seasonal estimates of density were calculated. These surveys currently represent the most up-to-date evaluations of species occurrence and density/abundance for the southern portion of the SCB region.

9) *San Diego Cetacean Stranding Database* – Although not using actual sighting surveys, Danil et al. (2010) analyzed and summarized the San Diego Cetacean Stranding Database. All known strandings of cetaceans in San Diego County between 1851 and 2008 were analyzed and relative rankings of species were summarized. There was no intentional geographical and seasonal bias, although it is likely that summer (when more people are at the beach) and coastal species (which are more likely to strand) are somewhat over-represented in the database.

RESULTS AND DISCUSSION

Summaries of the surveys and relative species rankings from the various sets of surveys evaluated are presented in **Table J-1**. An evaluation of whether there is evidence for an increase or a decrease in abundance is also discussed below by species. Discussion is focused on 16 species that we saw during the present set of surveys plus one species for which there is clear evidence of a decline in frequency of occurrence.

Common dolphins (*Delphinus* spp.)

Due to the confused taxonomy of North Pacific common dolphins until 1994, and the continued difficulty in distinguishing the two species in the field (Heyning and Perrin 1994), we treat the two species together as a single unit. Historically, the majority of common dolphins in the San Diego area appeared to be *D. delphis*, but in recent years there has been an increase in the abundance and the proportion of *D. capensis* (Carretta et al. 2011). Most surveys (ours included) have had difficulty distinguishing the two species of common dolphins in many sightings (Jefferson et al. 2012), and therefore they are treated together in this analysis. Although we have been taking photographs of all common dolphin sightings, as feasible, during line-transect surveys, we have correctly identified only a portion of the sightings (see Jefferson et al. 2012).

Common dolphins were the most commonly observed 'species' (really, there are two species involved) in the present survey, as well as the most abundant (Jefferson et al. 2012). This is in agreement with virtually all previous surveys in the SCB, which also identified common dolphins as the most common species (Norris and Prescott 1961; Dohl et al. 1981; Carretta et al. 1995; Carretta et al. 2000). Brown and Norris (1956) recorded them as the third most common species from the mid-1950s. Fiscus and Niggol (1965) reported them at a lower rank (tied for #2); this may have had to do with the offshore location of their surveys, much of it west of the Channel Islands. Danil et al. (2010) also found common dolphins to rank #1 in the stranding record. Overall, there is not any indication of a major change in the frequency of occurrence of common dolphins from this study, and it appears that the two species together have long been the most abundant species of cetaceans in the SCB.

Risso's dolphin (*Grampus griseus*) and short-finned pilot whale (*Globicephala macrorhynchus)*

The second most commonly observed species in the present surveys was the Risso's dolphin (Jefferson et al. 2012). All available evidence seems to point to the Risso's dolphins comprising an increasingly important part of the southern California fauna in recent years. Surveys conducted in the late 1950s and early 1960s did not report any sightings of this species (Brown and Norris 1956; Norris and Prescott 1961; Fiscus and Niggol 1965). Surveys in the 1970s reported this species to be the #4 or #6 species (Dohl et al. 1981). Those in the 1990s placed it at #3 or #4 (Carretta et al. 1995, 2000). The stranding record, representing about 150 years of history, shows them to be a low-ranking species overall (#11) (Danil et al. 2010); this may largely reflect their historical rarity.

The dramatic increase in occurrence and abundance of Risso's dolphins in the SCB has been mirrored by a corresponding decrease in the occurrence and abundance of short-finned pilot whales (*Globicephala macrorhynchus*). The latter species was never observed in the present set of surveys. This species was apparently very common in the 1950s to the 1970s, generally ranking from #2 to #5 in sightings (Norris and Prescott 1961; Dohl et al. 1981). They were the most common species reported by Brown and Norris (1956), although their survey effort may have been biased. By the 1990s, short-finned pilot whales had become rare in the SCB, and they were not observed on surveys during that time period conducted by Carretta et al. (1995, 2000). Their ranking as #5 in the stranding record suggests that for much of the past 150 years pilot whales have been relatively common. It is only in the last few decades that they have become rare. There appears to be a strong negative correlation in the relative abundance of these two species. Shane (1991, 1994, 1995) suggested that pilot whales moved away from the Channel Islands in the early 1980s and were essentially replaced (or displaced) thereafter by Risso's dolphins, which have remained very common ever since. The exact reasons for this are unknown. However, this event may be related to the shift from a cool-water 'anchovy regime' to a warm-water 'sardine regime' that occurred in the mid/late 1970s (Chavez et al. 2003). It may also be related to a strong El Niño event that occurred in the early 1980s and its corresponding effects on stocks of squid, which form the main food base for both species (Rebstock 2003).

Fin whale (*Balaenoptera physalus*)

The fin whale was the third most common species of cetacean in the present surveys, and the most common baleen whale (Jefferson et al. 2012). This represents an increase from its ranking in previous surveys, ranging from not observed at all (Brown and Norris 1956; Norris and Prescott 1961) to rankings from #5-11 (Fiscus and Niggol 1965; Dohl et al. 1981; Carretta et al. 1995, 2000). Danil et al. (2010) found the fin whale to rank #12 in the stranding record, indicative of its relative rarity throughout much of the last century and a half. This apparent increase is expected. Fin whales were heavily depleted in the North Pacific by commercial whaling operations in the early twentieth century, and are now clearly recovering from the impacts of that exploitation. Recent research shows strong evidence of an increasing trend for fin whales in California waters over the past several decades (Moore and Barlow 2011), and our analysis is consistent with that.

Bottlenose dolphin (*Tursiops truncatus*)

The bottlenose dolphin is ranked #4 overall in the present surveys (Jefferson et al. 2012). Most surveys since the 1950s ranked this species at a similar place, ranging from #5 to #7 (Norris and Prescott 1961; Dohl et al. 1981; Carretta et al. 2000). However, two surveys did not observe this species, and this is not too surprising as both studies that occurred largely in very deep waters west of the Channel Islands (Fiscus and Niggol 1965; Carretta et al. 1995). In the stranding record, the bottlenose dolphin ranks #2; this is probably related to a bias towards the favored recording of coastal species of cetaceans in stranding records (Danil et al. 2010). The bottlenose dolphin is much more common in coastal waters than in offshore regions. There is no good evidence of a trend in numbers from our analysis.

Gray whale (*Eschrichtius robustus*)

Gray whales are a winter/spring visitor to southern California, and were thus not observed in the warm-water season. However, they were still ranked #5 overall during surveys for this project (Jefferson et al. 2012). They migrate through the area between December and April each year. In the cool-water season coinciding with these months, the gray whale ranked a tie for #3 (with the fin whale). In past studies, this species generally ranked between #2 and #8 for projects that included coastal waters (Fiscus and Niggol 1965; Dohl et al. 1981; Carretta et al. 2000). Gray whales have been recovering from past whaling activities, and are now nearing their carrying capacity in the Eastern North Pacific. Much of the recovery may have occurred before most of these surveys were done, and there is no strong evidence of a positive trend from our analysis.

Blue whale (*Balaenoptera musculus*)

Blue whales ranked #6 in the present set of surveys (Jefferson et al. 2012). This represents a clear increase from historical records. Surveys conducted in the 1950s and 1960s did not sight any blue whales (Brown and Norris 1956; Norris and Prescott 1961; Fiscus and Niggol 1965). Surveys in the 1970s and 1990s reported blue whales among the lower-ranking species, ranging from #7 to #12 (Dohl et al. 1981; Carretta et al. 1995, 2000). The stranding record also indicates a low occurrence for blue whales, with a ranking of #14 (tied) (Danil et al. 2010). The general increase in the occurrence and abundance of blue whales in the SCB is expected. The species was severely depleted (and at one time thought to be nearly extinct) by pelagic whaling operations in the North Pacific. Protection by the International Whaling Commission in 1966 has apparently resulted in a recovery of this species, and this analysis appears to reflect this.

Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)

The Pacific white-sided dolphin is ranked #7 in the present surveys (Jefferson et al. 2012). This is somewhat lower than the results of previous surveys, which placed the Pacific white-sided dolphin at the ranking of #2 to #4 (Norris and Prescott 1961; Dohl et al. 1981; Carretta et al. 1995, 2000). Brown and Norris (1956) ranked them as the most commonly seen species from their surveys. Although Fiscus and Niggol (1965) found Pacific white-sided dolphins to be the most common species in the southern California portion of their study area, it is possible that species identification issues may have affected their data. Danil et al. (2010) found this species to rank #4 in the stranding record. There is some slight suggestion of a decrease in occurrence in recent surveys. However, overall there is no strong indication of a change in the occurrence or abundance of this species in the SCB.

Humpback whale (*Megaptera novaeangliae*)

In the present set of surveys, the humpback whale was observed relatively infrequently, ranking #8 (Jefferson et al. 2012). This represents a clear increase from previous surveys, however. Humpback whales were not reported in early southern California surveys (Brown and Norris 1956; Norris and Prescott 1961; Fiscus and Niggol 1965). They were ranked low in surveys in the 1970s and 1990s, ranging from #11 to #14 (Dohl et al. 1981; Carretta et al. 2000). Their ranking in the stranding record is similar, a tie for #14 (Danil et al. 2010). Clearly, humpback whales have increased their representation in the SCB cetacean fauna over the last several decades. This is in agreement with the very strong recovery of North Pacific humpback whale populations, evidenced by increased abundance after the cessation of heavy commercial whaling operations on this species throughout the twentieth century (Calambokidis et al. 2009).

Northern right whale dolphin (*Lissodelphis borealis*)

The northern right whale dolphin ranked #9 in the present set of surveys (Jefferson et al. 2012). Their ranking in previous sets of surveys has been quite variable, ranging from not being seen at all (Fiscus and Niggol 1965) to rankings from #2 to #8 (Norris and Prescott 1961; Dohl et al. 1981;

Carretta et al. 1995; Carretta et al. 2000). Their representation in the stranding record was #9, concurring with the present study results. Northern right whale dolphins favor colder waters and there is generally an influx of this species into southern California waters during periods of cool water (Leatherwood and Walker 1979). We do not see any strong indication of a change in the abundance of this species in southern California from the present analysis.

Common minke whale (*Balaenoptera acutorostrata*)

Minke whales ranked #10 in occurrence in the present set of surveys (Jefferson et al. 2012). This is broadly similar to their occurrence in previous sets of surveys in southern California, which ranged from #7 to #12 (Norris and Prescott 1961; Dohl et al. 1981; Carretta et al. 1995; Carretta et al. 2000). However, they were not reported by Brown and Norris (1956) and Fiscus and Niggol (1965). The offshore waters surveyed by Fiscus and Niggol (1965) generally have rough sea conditions unfavorable to sighting this cryptic species. Danil et al. (2010) reported that the minke whale ranked #14 in the stranding record, which is somewhat lower than would be expected from the sightings. There is not strong evidence of any major changes in occurrence or abundance of minke whales in the North Pacific. This species was never depleted to such low levels as were the larger rorquals (blue, fin, sei, and humpback whales).

Dall's porpoise *(Phocoenoides dalli)*

Dall's porpoise ranked #11 overall in the present set of surveys (Jefferson et al. 2012). It was fairly common on all previous surveys analyzed here (Brown and Norris 1956; Norris and Prescott 1961; Fiscus and Niggol 1965), generally ranging from #10-12 (Dohl et al. 1981; Carretta et al. 1995, 2000). Somewhat surprisingly, the species was common, in strandings in San Diego County, ranking #6 (Danil et al. 2010). However, the Dall's porpoise is also largely seasonal, with greatest numbers in southern California during cold-water periods. During our cold-water season surveys, it ranked tied for #8. Overall, there appears to have been a general decrease in the occurrence of Dall's porpoise in southern California from the present analysis.

Killer whale (*Orcinus orca*)

The killer whale was tied for ranking #12 in the present set of surveys (tied with Cuvier's beaked and Bryde's whales). This is generally below the range of rankings from previous surveys, ranging from #4-6 (Brown and Norris 1956; Norris and Prescott 1961; Fiscus and Niggol 1965) to #10-12 (Dohl et al. 1981; Carretta et al. 1995). Killer whales were not observed in surveys by Carretta et al. (2000), and were also not represented in the stranding record from San Diego County (Danil et al. 2010). Clearly, killer whales are not regular or common components of the southern California cetacean fauna, but pods do move through the area sporadically. Overall, there is no compelling evidence from the present study of any major changes in the occurrence or abundance of this species in southern California.

Cuvier's beaked whale (*Ziphius cavirostris*)

In the present set of surveys, Cuvier's beaked whales ranked #12 in a tie with the killer and Bryde's whales – see above and below. This species ranked #8 in the stranding record, which suggests that they are not at all uncommon off the San Diego coast (Danil et al. 2010). Cuvier's have been observed increasingly in at-sea surveys over the last few decades. They were not reported in early surveys (Brown and Norris 1956; Norris and Prescott 1961; Fiscus and Niggol 1965), ranked #14-17 in surveys in the 1970s (Dohl et al. 1981), and ranked #9-10 in surveys in the 1990s (Carretta et al. 1995, 2000). Recent small-vessel surveys west of San Clemente Island regularly see this species, and currently have a photo-identification catalog (Falcone et al. 2009). Whether this is due to an actual increase in abundance of this species in the area, or rather just an increased ability to detect and identify this cryptic species, remains unknown.

Bryde's whale (*Balaenoptera edeni*)

Bryde's whales were only observed twice in the present set of surveys and their ranking was 3-way tied for #12. This is a species that has normally not been considered part of the southern California cetacean fauna, and it was not observed on most of the previous surveys analyzed in this paper (Brown and Norris 1956; Norris and Prescott 1961; Fiscus and Niggol 1965; Dohl et al. 1981; Carretta et al. 1995, 2000). There are, in fact, only a small handful of previous records of Bryde's whales in California (see Smultea et al. 2012), and they are not represented in the San Diego stranding record (Danil et al. 2010). This species becomes common only south along the coast of Baja California, Mexico. However, the small number of records of Bryde's whales from recent years in southern California has been interpreted as indicative of an increase in this species' presence in the area (Smultea et al. 2012; Kerosky et al. 2012). The reasons for this increase are unknown, but possible explanations are offered by Smultea et al. (2012) and Kerosky et al. (2012).

Sperm whale (*Physeter macrocephalus*)

Only one sperm whale group was observed in the present set of surveys, making it ranked #13. Sperm whales are known to be rare near the continental shelf and slope off southern California. This species has only been reported in a few of the previous surveys discussed here, where they ranked from #8-16 (Dohl et al. 1981; Carretta et al. 1995). In the stranding record, the sperm whale ranks tied for #15, but this may be partially a representation of the preferred deep-water and offshore habitat of the sperm whale in this area (Danil et al. 2010).

Other species

A number of other cetacean species are known to occur in the SCB but are considered rare. Therefore, it is not surprising that we did not observe them in the present set of surveys. This includes the sei whale (*Balaenoptera borealis*), pygmy and dwarf sperm whales (*Kogia* spp.), several species of the beaked whale genus *Mesoplodon*, false killer whales (*Pseudorca crassidens*), striped dolphins (*Stenella coeruleoalba*), and harbor porpoises (*Phocoena phocoena*). Some of these species may be fairly common further offshore, but not in the relatively nearshore waters of the present SOCAL Range Complex (e.g., sperm whales, *Mesoplodon* spp., and striped dolphins). Other species are found generally north of the region (e.g., harbor porpoise) or south of the region (e.g., false killer whale), and probably only occur in southern California occasionally as extralimital strays.

Table J-1. Species rankings* from various studies of the cetaceans of the southern California Bight.

SPECIES	Danil et al. 2010	Brown & Norris (1956)	Norris & Prescott (1961)	Fiscus & Niggol (1965)	Dohl et al. 1981	Dohl et al.1981	Carretta et al. 1995	Carretta et al.2000	Jefferson et al. 2012	Change
Blue whale - *Balaenoptera musculus*	14 (tie)				12	10	7	8	6	Increase
Fin whale - *Balaenoptera physalus*	12			3 (tie)	9	11	5	5	3	Increase
Sei whale - *Balaenoptera borealis*						16				
Bryde's whale - *Balaenoptera brydeii/edeni*									12 (tie)	Increase
Minke whale - *Balaenoptera acutorostrata*	14		7		11	9	11 (tie)	12	10	
Humpback whale - *Megaptera novaeangliae*	14 (tie)				13	14		11	8	Increase
Gray whale - *Eschrichtius robustus*	3		common	3 (tie)	6	8	11 (tie)	2	5	
Sperm whale - *Physeter macrocephalus*	15 (tie)				16	15	8		13	
Pygmy/dwarf sperm whales - *Kogia* sp.	7									
Cuvier's beaked whale - *Ziphius cavirostris*	8				14	17	9	10	12 (tie)	
Mesoplodont beaked whales - *Mesoplodon* sp.	10				15	13	11 (tie)			
Killer whale - *Orcinus orca*		5	6		10	12	10		12 (tie)	
Short-finned pilot whale - *Globicephala macrorhynchus*	5	1	2	3 (tie)	5	2				Decrease
False killer whale - *Pseudorca crassidens*			9							
Risso's dolphin - *Grampus griseus*	11				4	6	3	4	2	Increase
Pacific white-sided dolphin - *Lagenorhynchus obliquidens*	4	2	4	1	2	4	4	3	7	Decrease
Northern right whale dolphin - *Lissodelphis borealis*	9		8		3	3	2	7	9	
Bottlenose dolphin - *Tursiops truncatus*	2		5		7	5		6	4	
Common dolphins - *Delphinus* sp.	1	3	1	2 (tie)	1	1	1	1	1	
Striped dolphin - *Stenella coeruleoalba*	13									
Dall's porpoise - *Phocoenoides dalli*	6	4	3	2 (tie)	8	7	6	9	11	Decrease
Harbor porpoise - *Phocoena phocoena*	15 (tie)									
Survey Type	Strandings	Ship	Ship	Ship	Aerial	Ship	Aerial	Aerial	Aerial	
Area	San Diego City	SoCal Bight	SoCal Bight	SoCal Bight	SoCal Bight	SoCal Bight	W of San Nicholas	San Clemente Island	San Diego City	
Depths	Shoreline	Shallow-deep	Shallow-deep	Deepwater	Mainly deep	Mainly deep	Deepwater	Shallow-deep	Mainly deep	
Time Period	1851-2008	1954-1955	1958-1961	1958-1961	1975-1978	1975-1978	1993-1994	1998-1999	2008-2012	
Months	All	All	All	Nov-April	All	All	All	All	All	
Major Biases	Coastal spp.	Los Angeles to Catalina	Los Angeles to Catalina	No summer	None	None	None	None	None	

*Simple ranking of how frequently different species were sighted . 1 is the most commonly sighted, 2 is the second, etc.

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