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FINAL REPORT

MARINE MAMMAL OBSERVATIONS AND MITIGATION ASSOCIATED WITH USGS SEISMIC SURVEYS IN THE SOUTHERN CALIFORNIA BIGHT IN 1998

Prepared for

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INTRODUCTION

From 9 to 22 August 1998, the U.S. Geological Survey conducted seismic surveys in the Pacific Ocean just off Los Angeles to investigate earthquake hazards. Details on the purposes and specifications of the equipment used are described below. As a part of this project, Cascadia Research was contracted by the USGS to monitor marine mammals from the survey platform and provide mitigation on impacts on marine mammals by requesting shutdown of the sound sources when marine mammals were close to the operations. We report here the results of this marine mammal mitigation and monitoring program conducted in conjunction with the USGS Los Angeles surveys.

BACKGROUND ON OVERALL PROJECT AND SOUND SOURCE DESCRIPTION

The following background on the overall project and sound source description was provided by USSGS:

The focus of the Southern California Earthquake Hazards project is to identify the landslide and earthquake hazards and related ground-deformation processes that have the potential to impact the social and economic well-being of the inhabitants of the Southern California coastal region. The primary objective is to help mitigate the earthquake hazards for the Southern California region by improving our understanding of how deformation is distributed (spatially and temporally) in the offshore with respect to the onshore region.

The active field program for the project focuses on those areas with the greatest impact potential on the Southern California populace:

1) The coastal strip (coastal zone and continental shelf) between Los Angeles and San Diego, where much of the hazard appears to be associated with strike-slip or oblique-slip faults;
2) Active faults within the Santa Monica, San Pedro, and San Diego Trough basins, where more extensive sedimentation has left a greater stratigraphic record;
3) The offshore extension into the Santa Barbara Channel of the fold and thrust belt;
4) The boundary (Channel Islands region) between the inner California Borderland (strike-slip dominated deformation) and the Santa Barbara Channel (thrust and fold deformation).

Tracklines were planned at a 2 km spacing aligned perpendicular to the shelf break and basin slope and on an "orthogonal" set aligned to intercept major structural features that are oblique to the trend of the basin slope and shelf edge.

The FY 1998 field program was conducted using a leased vessel, the 156-ft-long M/V AURIGA, owned and operated by F/V North Wind, Inc. Two sound transmissions were used:

Huntec: A high-resolution Huntec DTS boomer system, towed between 6 m and 160 m below the sea surface (depending upon the water depth), was used to image the upper few tens of milliseconds of strata with a resolution of better than 0.5 ms (0.4 m). Power output was 350 Joules (540) with a firing rate that was also dependent on water depth, ranging in 0.25 sec intervals from 0.75 sec over the shelf and upper basin slopes to 1.25 sec over the deeper parts of the basins. Returning signals were received with a 5-m-long Benthos 10-element hydrophone

array. Signals were filtered at 800-6000 Hz and recorded at a 0.25 sec sweep. The data were recorded both on paper using an EPC recorder and on magneto-optical disc. The average survey speed of about 3.8 kt (7 km/hr) resulted in a shot spacing between 1.5 and 2.5 m for the deep-tow boomer profiles.

Multichannel seismic-reflection system (MCS): As a result of equipment problems, the multichannel seismic-reflection (MCS) profiling activity during the cruise used two different sound sources and two different streamers to receive the signals. The primary sound source was a 35/35 in^3 double-chamber GI gun firing every 12 seconds at a pressure of about 3000 psi. A Sureshot system was used to fire the gun in "harmonic mode" wherein the second chamber is delayed relative to the initial trigger pulse in order to achieve the cleanest signal by minimizing the bubble pulse. The most efficient settings for the Sureshot control are given in (Table 3). The GI gun was towed 12 meters behind the vessel and suspended from a float to maintain a depth of about 1 meter. Catastrophic failure of the gun resulted in changing to the backup sound source, a 40 in^3 Bolt airgun, which was deployed for the last 48 hours of data collection. This airgun, which had a wave-shape kit to reduce the effect of the bubble pulse, was towed at a depth of about 4 meters using 2000 psi air pressure and fired at a six-second shot rate.

The primary streamer for the mcs operation was a 24-channel ITI streamer with 10-m-long groups and 3 phones per group. This streamer was unusable for the first part of the survey because of extensive corrosion of the wiring in the termination box of the deck cable. The backup receiving system, a 24-channel ITI streamer with 6.25 m groups and 1 phone per group was used initially until repairs could be effected on the primary streamer. Failure of the GI gun late in the survey as noted above meant that three combinations of sound source and streamers were used during the operation: primary sound source with backup streamer, primary sound source and streamer, and backup sound source with primary receiver.

Data was collected using a STRATAVIEW digital recording system and a Geometrics marine controller. Shots were triggered by the YoNav system. Data was recorded in SEGD format on 2-gbyte DAT tapes using a 1 msec sample rate and a three second record length. A 60-Hz notch filter was used, otherwise all frequency bands were passed. A total of approximately 250 hours (20 gigabytes) of data were collected.

OBJECTIVES

The objectives of the marine mammal study were as follows:

1. Mitigate impacts on marine mammals by monitoring the presence of these species from the survey ship and requesting shut-down of the airgun array when marine mammals were seen within specified safety zones representing distances close enough to potentially cause physically injury.

2. Mitigate impacts by identifying potentially sensitive areas to marine mammals that should be avoided or surveyed only during daylight hours.

3. Document the number of animals of each species present in the vicinity of sound transmissions.

4. Evaluate the reactions of marine mammals to the sound transmissions at different distances from the air gun array.

METHODS

General Approach

The research effort consisted of observations made directly from the seismic vessel (*Auriga*) to provide mitigation, document marine mammals exposed to the air guns, and monitor reactions of marine mammals close to the seismic survey vessel. Observations were conducted from a platform in front of the bridge that put the observers eye level at 7.6 m above the water. This external platform provided excellent visibility to the front and sides and only slightly obscured visibility to the rear. The platform was near the front of the vessel 6.4 m behind the bow and 47 m from the stern of the vessel.

Observations were conducted from the seismic vessel (*Auriga*) 24 hours a day when seismic operations were underway. Two observers were placed about the seismic vessel to provide the mitigation described above and gather data on the species, number, and reaction o marine mammals to the seismic vessel. Each observer worked during six hours of daylight and six hours of darkness. During daylight observations, observers used *Tasco 7x50* binoculars with internal compasses and reticles to record the horizontal and vertical angle to sightings. Night-time operations were conducted with a commercial hand-held light magnification scope. Observers would search the area close forward and to either side of the ship for marine mammals.

Data on survey effort and sightings were recorded on a datasheet recording information to track survey effort which includes observer on duty and weather conditions (Beaufort sea state, wind speed, cloud cover, swell height, precipitation, visibility, etc.). For each sighting the time, bearing and reticle reading to sighting, species, group size, surface behavior and orientation were recorded.

Distances to sightings were calculated using the vertical angle to the animal (based on either the reticle reading through the binoculars or a hand help clinometer for close sightings) and the known elevation above the water. This was then used to evaluate whether a sighting was within the mitigation safety zones.

Mitigation safety zones

Two safety zones were used for this project. These were:

1. For pinnipeds and Odontocetes (toothed cetaceans) seismic operations would be shut down when an animal was seen close to a distance of 100 m or less.

2. For mysticetes (baleen whales), the safety zone was 200 m.

To allow a quick determination of status, safety zones were calculated in three arcs around the ship and the safety distance was applied using the closest part of the ship or array. Three different cut-off distances (based on distance and angle from the observers) were

calculated for off the bow (60 degrees to either side of the bow), to either side of the vessel (from 60 to 120 degrees off the bow and off the stern (120 to 180 degrees off the bow).

Observers were instructed to call for a shut-down when a marine mammal was seen inside the safety zone or close enough to the safety zone that given measurement-error, it could be within the safety zone. Shut-down was also considered when animals were ahead of the vessel path outside the safety zone, but it appeared likely that the direction of travel of the vessel would result in the marine mammal being within the safety zone shortly.

For effective mitigation, the observers needed to know very quickly whether a sighting was within the safety zone. We used a polaris (angle board) for the observers to estimate the angle to the sighting. The cut-off vertical angle, which represented each of the safety zones, was also written on the polaris, allowing quick determination of the proximity of a sighting to the safety zone.

RESULTS AND DISCUSSION

Shut-downs for marine mammal mitigation

Seismic operations were requested to be shut down on eleven occasions related to the presence of marine mammals (Table 1). All requested shutdowns were because animals were in close proximity to the seismic vessel. Eight of the shut-downs were for common dolphins (five of them approaching to bow-ride) and three were for California sea lions.

Only 3 of the 11 shut-downs were requested at night. This likely reflected the poorer sighting conditions at night that made it hard to spot marine mammals even within the safety zones. Two of these three shut-downs were due the presence of dolphins riding the bow wave of the vessel.

Sightings made by vessel

There were 133 sightings of 6,313 marine mammals not including the 98 re-sightings made from the *Auriga* during the surveys (Table 2). These represented at least eight species of marine mammals. Common dolphins and California sea lions were most frequently sighted. Other large whale species included humpback and minke whales and several sightings of blue and possibly fin whales made at long distances from the vessel. Other smaller cetaceans besides common dolphins included Cuvier's beaked whale, Risso's dolphin, and either a Dall's or harbor porpoise. The only other pinniped seen beside California sea lions was northern fur seals.

Sightings at night were far less common with only the three sightings close to the boat that resulted in shut-downs. These involved common dolphins bowriding that could be heard and a California sea lion.

Orientation and behavior of marine mammals

A disproportionate number of marine mammals were headed away from the vessel as opposed to toward the vessel or perpendicular to the direction to the vessel (Table 4). For both sightings and resightings animals were headed away about twice as often as any of the other three direction quadrants. Most of the survey effort was conducted with either the Huntec operating or both the Huntec and airgun operating. This makes it hard to evaluate whether animals were reacting to the vessel or one or both of the sounds generated.

Marine mammals were sighted engaged in a variety of behaviors (Table 5). The majority of sightings and resightings were of animals judged to be either fast or slow traveling. The next most common behavior was hauled (many of the California sea lions). Animals were also seen milling, surfacing in the same area, and likely indicating feeding. Common dolphins were seen bowriding on six occasions. A number of less common behaviors were seen including a minke whale lunge feeding and a humpback that was seen breaching on five occasions. It was not possible to judge if any of these behaviors could have been related to survey activities.

DISCUSSION

The species encountered during the surveys is consistent with what would be expected in the region. Both common dolphins and California sea lions are considered the most common marine mammals in nearshore waters of Southern California. Sightings of unidentified dolphins were also likely common dolphins seen at distances that did not allow species identification. Both Risso's dolphins and Cuvier's beaked whales, seen a few times in the study, are more typical of deeper waters off the continental shelf edge. The sighting of a potential harbor porpoise was surprising and was scored as a possible Dall's porpoise primarily because harbor porpoise are generally considered to not occur south of Point Conception.

The sightings of several large balaenopterid whales are of interest and indicate these species were present in the study area despite the proximity of the surveys to shore. Humpback, blue, and fin whales are the most common large baleen whales that feed off California. Recent photographic identification research conducted by Cascadia has indicated a population of about 800 humpback whales feeding off California each summer (Calambokidis et al. 1996, 1997). Most of these are generally concentrated from the Santa Barbara Channel north during the summer. About 2,000 blue whale are estimated to feed off California, one of the areas of highest blue whale density anywhere in the world (Calambokidis and Steiger 1995, 1997).

CONCLUSSIONS AND RECOMMENDATIONS

Overall, the surveys provided valuable information on the species of marine mammals present in the survey area. They also provided some protection from potential impacts through shut-downs when marine mammals were observed close to the survey vessel. Although sample size was small these surveys yielded data on the reactions of several species to a survey vessel. Night-time operations were of limited value in sighting marine mammals or making observations of reactions of marine mammals. The few sightings made at night resulted in three shut-downs, which provided some mitigation of impacts. The low number of sightings and shut-downs at night, however, indicated these observations were of only limited effectiveness. In the future it would be more effective to better staff daylight shifts and not risk compromising these observations for the limited effectiveness of night observations.

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Table 1. Cases where air gun/Huntec shut-downs were requested due to marine mammal occurrence.

Date	Time	Resume firing	Firing	Reason for request	Comments
08/11/98	9:31:00	9:36:00	Huntec	Proximity of California sea lion	
08/12/98	3:16:00		Huntec	Bowriding dolphins	Auth. shut-down personnel not in lab
08/12/98	18:50:00	18:59:00	Huntec	Bowriding common dolpins	
08/15/98	2:06:00	2:09:00	Huntec	Proximity (<100m) of California sea lion	
08/15/98	21:55:00	21:57:00	Huntec/Airgun	Bowriding dolphins	
08/16/98	9:32:00	9:35:00	Huntec/Airgun	Proximity of California sea lions	
08/17/98	11:34:00	11:40:00	Huntec/Airgun	Proximity of common dolphins	
08/17/98	11:59:00	12:07:00	Huntec/Airgun	Proximity of common dolphins	
08/21/98	9:18:00	9:26:00	Huntec	Proximity of common dolphins	
08/21/98	17:58:00	18:04:00	Huntec/Airgun	Bowriding common dolpins	
08/22/98	12:12:00	12:16:00	Huntec/Airgun	Bowriding common dolpins	

Table 2. Summary of sightings and resightings of difference species during daylight and night observations.

	Daylight observations				Night obs.		Total day and night	
	Sighting		Resighting		Sightings		Sightings	
Species	**Sight.**	**Anim.**	**Sight.**	**Anim.**	**Sight.**	**Anim.**	**Sight.**	**Anim.**
Humpback whale	1	1	6	6			1	1
Minke whale	4	4	2	2			4	4
Large Balaenopterid (blue or fi	3	3	4	4			3	3
Cuvier's beaked whale	1	1					1	1
Unidentified whale	1	1					1	1
Common dolphin	32	3,981	48	6,555			32	3,981
Risso's dolphins	1	8	1	8			1	8
Unidentified porpoise	1	5	1	5			1	5
Unidentified dolphin	22	2,155	18	1,746	2	4	24	2,159
California sea lion	61	144	18	43	1	2	62	146
Northern fur seal	2	2					2	2
Unidentified pinniped	1	2					1	2
Grand Total	130	6,307	98	8,369	3	6	133	6,313

Table 3. Daytime sightings (not including resightings) by operational status of airgun and Huntec.

	None firing		Huntec only		Airgun only		Huntec & airgun		Total	
Species	**Sight.**	**Anim.**	**Sight.**	**Anim.**	**Sight.**	**Anim.**	**Sight.**	**Anim.**	**Sight.**	**Anim.**
Humpback whale							1	1	1	1
Minke whale			1	1			3	3	4	4
Large Balaenopterid (blue or fin)			2	2			1	1	3	3
Cuvier's beaked whale							1	1	1	1
Unidentified whale							1	1	1	1
Common dolphin	3	498	11	1620	2	95	16	1768	32	3981
Risso's dolphins							1	8	1	8
Unidentified porpoise							1	5	1	5
Unidentified dolphin	1	40	9	652			12	1463	22	2155
California sea lion	28	101	16	21	1	2	16	20	61	144
Northern fur seal							2	2	2	2
Unidentified pinniped							1	2	1	2
Grand Total	32	639	39	2296	3	97	56	3275	130	6307
Hours of daylight operation		19.8		61.4		0.6		101.4		183.2

Table 4. Headings of marine mammals sighted from survey vessel in relation to sighting type and firing status.

	Heading relative to direction to boat				
Firing status	**away**	**left**	**right**	**toward**	**Total**
	Sightings				
None				1	1
Airgun only				2	2
Huntec only	11	4	6	7	28
Huntec & airgu	16	10	9	7	42
Total for sightin	27	14	15	17	73
	Resightings				
None	2				2
Airgun only					0
Huntec only	6	1	4	2	13
Huntec & airgu	22	8	5	9	44
Total for resight	30	9	9	11	59
Grand total	57	23	24	28	132

Table 5. Behavior of marine mammals sighted or resighted during daylight hours during surveys. Behaviors were clasified based on primary behavior seen during observation.

Behavior	Sightings					Resightings					Both Total
	Firing status					Firing status					
	Airgun	Huntec	A&H	None	Total	Airgun	Huntec	A&H	None	Total	
Fast travel		13	16	1	30		11	23	1	35	65
Slow travel	1	14	19	1	35		3	11		14	49
Hauled		3	1	25	29				8	8	37
Milling		5	8	1	14		2	13		15	29
Stationary		2	3		5			2		2	7
Bow riding	2			2	4		1		1	2	6
Breaching			1		1			4		4	5
Pec slaping					0			2		2	2
Surface lunge-feed			1		1					0	1
Feeding				1	1					0	1
Total	3	37	49	31	120	0	17	55	10	82	202