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FINAL REPORT

MARINE MAMMAL OBSERVATIONS ASSOCIATED WITH SEISMIC SURVEYS OFF WASHINGTON AND BRITISH COLUMBIA IN MAY 2002

Prepared for

U.S. Geological Survey,
Geological Survey of Canada, and
National Marine Fisheries Service

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INTRODUCTION

In May 2002, the U.S. Geological Survey and Geological Survey of Canada conducted seismic surveys in the coastal waters of northern Washington and southern British Columbia. As a part of this project, Cascadia Research was contracted by the USGS and GSC to monitor marine mammals from the survey platform *J. P. Tully*, and provide mitigation on impacts on marine mammals by requesting shutdown of the sound sources when marine mammals were close to the operations. Cascadia's monitoring was only for the portion of the survey anticipated to be in U.S. waters from 15 to 17 May. The portion of the survey after this date was planned for Canadian waters only, and monitoring was handled by Canadian observers and is not included here. This report summarizes the results of marine mammal mitigation and monitoring program conducted in conjunction with these surveys and addresses the requirements of the permit from National Marine Fisheries Service. This project adds data to a project performed in 1998 in the same waters using a larger sound source and larger research platform.

SOUND SOURCE DESCRIPTION

The following sound source description was provided by USGS and is taken from their Incidental Harassment Authorization request to NMFS:

> The sound source was a 120-inch3 airgun. This sound source, as measured by the volume of the chamber, is only 2% of the size of the airgun array used in the SHIPS experiment in 1998. The airgun emits an impulsive noise burst (<10 milliseconds) with a peak-to-peak sound pressure level estimated to be 220 to 230 dB. Our best estimate is that the source will have a sound pressure level of about 225 dB. This compares to an estimated 240 dB sound pressure level for the 6730 inch^3 airgun array used in the 1998 SHIPS seismic experiment. The airgun was fired 3 to 6 times per minute. The airgun energy is concentrated below 200 Hz, with a rapid decrease in amplitude between 200 and 400 Hz. Frequencies above 400 Hz have amplitudes that are less than 10% of the lower frequencies. There is about a 16 dB difference between measuring the peak-to-peak sound pressure and the more commonly used root-mean-square (RMS) measure of continuous sound pressure: 6 dB converts peak-to-peak to peak-to-zero values, and an additional 10 dB converts peak-to-zero to RMS values. These conversions mean that our airgun will be approximately equivalent to a source with a RMS sound pressure of about 204 to 214 dB (relative to 1μPa-m), with our best estimate being about 209 dB RMS.

Additionally, the ship operated the Huntec, a lower-power sound source that was not anticipated to affect marine mammals. Monitoring included noting whether this system was in operation as well. The following is a description of the Huntec sound source:

> 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 of 0.5 sec rangiong from 1 to 10 kHz and centered around 4 kHz. Returning signals were received with a 7.6 m long 25-element hydrophone array.

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 seismic sound source when marine mammals were seen within specified safety zones representing distances close enough to potentially cause physically injury.

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

3. Evaluate the reactions of marine mammals to the sound transmissions at different distances from the sound source.

METHODS

Observation methods

Observations were conducted from the Canadian Coast Guard vessel, *J P Tully*. Observations began an hour before the sound source was operating on May 15th and continued until we were out of US waters on May 17th 2002.

A team of six observers participated in the survey, with at least two observers on effort during all hours that the acoustic sound source was operating (as well as prior to start up). Three of the observers had participated in USGS mitigation work on prior surveys. Each observer team had two, two-hour shifts during the day and a four-hour shift during the night thereby allowing more longer breaks at night. Generally, each observer worked around 10 hours a day.

During the daylight hours the two observers stood on the starboard and port sides and scanned from 10 degrees across the bow to 10 degrees across the stern. Often a third observer would stand on watch during the day to act as data recorder. The two observers were stationed on either side of the flying bridge providing them with an unobstructed view along the beam, forward, and a manageable view of the stern. Observers average eye level was at 14.5 m above the water, observers were 37.48 m forward of the stern, and 30.44 m aft of the bow. The sound source was towed off the stern at a distance of 10 m and depth of 4 m.

All daytime observations and distances were made with the use of reticle *Tasco 7x50* binoculars and handheld clinometers. Two observers conducted night observations, one facing forward with night vision goggles (Generation 3) and one roaming the deck and primarily facing the stern where visibility was not possible with the night vision goggles. Daytime operations began about half an hour before sunrise and were conducted until the lighting conditions became

too dark for sightings to be made within the mitigation zone without the use of the night vision goggles.

Data on survey effort and sightings were recorded on a datasheet and included survey effort, observers 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. Whenever possible resightings were made of the animal(s), which included direction of travel and behavior as, the vessel proceeded along the track line.

Distances to sightings were calculated using the vertical angle to the animal (based on either the reticle reading through the binoculars or a hand held clinometer for close sightings) and the known elevation above the water. The angle of the animal from the sound source was found using a polaris board at the observer's feet. These values were then used to evaluate whether a sighting was within the mitigation safety zones.

Mitigation safety zones

The mitigation safety zone was set at 100 m based on consultations between USGS and NMFS. To allow a quick determination of whether and animal was approaching this safety zone, we used the vertical angle to the sighting (indicating distance) and horizontal angle to instantly determine if a sighting was near the safety zone. Horizontal angles were pooled into three arcs around the ship; 1) 0-60 degrees off the bow or ahead of the ship, 2) 60-120 degrees off the bow or to the side of the ship, and 3) 120 to 180 degrees off the bow or astern of the ship. In addition to the 100 m safety zone we added a small buffer for measurement error and also increased the cut-off-distance astern of the ship (to account for the source being towed behind the ship) and ahead of the ship (to add a margin of safety for animals lying in the path of the vessel and therefore likely to be approached).

Using the above considerations, animals were judged to be near or in the safety zone if the vertical angle from the observer to the sighting was greater than 5 degrees for animals ahead or behind (distance of 160 m from the observer) the ship and greater than 7 degrees abeam of the vessel (117 m from observer).

Observers were instructed to call for a shutdown 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. Marine mammals were tracked until they were outside the safety zone at which time seismic operations resumed.

For effective mitigation, the observers needed to know very quickly whether a sighting was within the safety zone. Observers used a polaris (angle board) 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

Marine mammal mitigation – Shut-downs

Marine mammals were never sighted by the observer team within the safety zones during airgun operations and hence no shut downs were called throughout the survey period. The observers requested that the ships course be altered to avoid a pod of killer whales that were initially 2,700 m ahead of the vessel and traveling across the bow.

Marine mammal sightings

There were a total of 75 sightings (not including re-sightings), comprised of 400 marine mammals during daytime observations (Table 1). Almost 99% of the sightings were made while either the airgun or airgun/huntec were in operation (Table 2). Of the above sightings, the observers were able to make 27 "resightings" following the initial documentation of the animals. Six species of marine mammals were sighted during this survey. Dall's porpoise was most commonly observed throughout the study area, and comprised 48% of the sightings. Harbor seals were also seen throughout the study area making up 35% of the total number of sightings. Other small cetaceans sighted were California sea lions and harbor porpoise. A single pod of killer whales was sighted, as well as a single false killer whale. There were 5 sightings of unidentified pinnipeds that were probably California sea lions or possible Steller sea lions, none of these animals came close enough to the ship to be identified.

During night time operation May 16th a crew member on the bridge told the on effort observer team that an “animal 3.5 ft. wide, all black, tall dorsal fin had approached the ship and traveled alongside,” at a distance of 5 m. The sighting occurred sometime between 2130h-2200h while the airgun was operational. A false killer whale had been sighted in the same area at 1833h May 15th and had approached the Tully to a distance of 5m. The seismic sound source had shut down 13 minutes prior to the false killer sighting on May 15th.

Orientation and behavior of marine mammals

Marine mammals were observed exhibiting a variety of behaviors in the presence of the survey vessel (Table 3). The most common behavior for all species observed was classified as slow travel. Other behaviors were milling, which can indicate feeding activity, hauled (pinniped), fast travel and stationary (pinniped). Dive behaviors were categorized separately since they can reflect a reaction to the survey vessel following the initial sighting (Table 4). The most common dive behavior was slow roll; other dive behavior observed was splash, vertical sink, rooster tail, and vertical rise. Marine mammal orientation to the survey ship was observed during sightings and resightings both when the seismic source was operational and when it was off (Table 5). In 14% of the sightings, animals appeared to be headed away from survey vessel while 2% were headed toward the vessel, in most of the sightings animals appeared headed on a tangent to the direction to the vessel (68%). The remaining sightings were of either stationary or hauled marine mammals.

All animals were sighted outside the predetermined safety zones, except for a false killer whale that was sighted when the airguns were already turned off (Table 6). Including sightings and resightings while the seismic survey was operating, 21% of sightings were at 200-500m, 34 % at 5001-1000m, and 44 % were documented at greater than 1000m from the vessel.

Of the 75 sightings made during this project there were two instances where the animals sighted may have changed their behavior in reaction to the survey vessel. One group of Dall's porpoise were initially sighted as traveling "slowly" to the right of the vessel, resights were made of the group three and nine minutes after the initial sighting, by then the animals had begun "fast travel" and "rooster tailing". The killer whales sighted on the last day of effort were originally sighted as traveling "slowly" across the track line outside of the safety zone. The ship altered course to give the killer whales a greater margin for travel. Seven minutes after the initial sighting the killer whales were resighted "fast traveling" angling away from the ship. Over the three subsequent resightings the killer whales were traveling slowly on a parallel course along Sucia Island at a distance of 4, 902 m.

DISCUSSION AND CONCLUSIONS

The lack of any shutdowns requested during the 2002 seismic survey of northern Washington and southern British Columbia is perhaps not surprising given some of the past surveys. The March 1998 seismic survey conducted from the *Thomas G. Thompson* by USGS in greater Puget Sound had five instances where it was necessary to shut down the airgun array for either an animal near the zone or as a preventative measure. The 1998 study lasted two weeks and encompassed a larger portion of the Puget Sound than the 2002 project. Eight species and 1,326 animals were observed in the 1998 study including minke and gray whale. Six species, made up of an estimated 400 animals were identified by the observer team from the *Tully* 2002 survey. An average of 35 animals/day was sighted on the 1998 cruise and 25 animals/day on the 2002 cruise. Seasonal differences and a broader survey area could have been responsible for the higher sighting rate in 1998.

While the two instances when animals were thought to have altered their behavior from the original sighting were of special interest it is not certain whether this was a reaction to the airguns, the vessel, or something else. It is not uncommon for Dall's porpoise to increase speed and rooster tail away from approaching vessels, so this behavior cannot be clearly linked to effects of the seismic survey. The killer whales increased their travel speed after the initial sighting, then returned to slow travel once they had reached the shore of an island. Returning to slow travel suggests that they had reached a distance that they were comfortable with, but the fact that Sucia Island blocked any further retreat may also be relevant to future analysis.

The observers did not see the false killer whale that was apparently exposed to the seismic sound source at night. A crewmember of the *Tully* related his description of the animal that he sighted while on watch after its occurrence. From the description of the animal and the location of sighting, the species identification was most likely a false killer whale. The Tsawwassen Landing false killer whale is believed by some people to have arrived with a small group of false killer whales that stranded in Southern Puget Sound ten years ago. Shortly after the stranding a lone false killer whale appeared in the Port of Tacoma, and became a familiar

presence in the port. A few years later the false killer whale who had been fondly named "Foster" disappeared from Tacoma and was reportedly resighted around the Tsawwassen Landing where it continues to be seen by boaters and residents. Since a false killer whale approached the survey vessel the day before as we passed the Landing we assume that this was the same animal that was sighted the night of the 16th. This encounter highlights the uncertainty of mitigation for marine mammals at night given that it went undetected by the observers at such close proximity to the survey vessel.

ACKNOWLEDGEMENTS

A number of people and organizations assisted in the completion of this project. Thanks to observers on the *Tully* Lisa Schlender, Cody Massing, Suzanne Stricker, Nora Maloney, Jenny Balke, and Annie Douglas. The captain and crew of the *J. P. Tully* had excellent marine mammal sighting skills, and were extremely helpful throughout the surveys.

The project was funded and organized by the U.S. Geological Survey and Geological Survey of Canada. While in US waters Thomas Pratt directed the geological survey and impressed the mitigation team with his interest and cooperation in adapting the survey design so that the requirements for marine mammal monitoring and research could be met. Michael Reidel was equally helpful and accommodating of the marine mammal monitoring effort.

LIST OF TABLES

Table 1. Number of sightings and resightings of species observed during 2002 seismic survey in North Puget Sound.

Species	Number of Sightings	Number of Resightings	Total Number of Animals
Cetaceans			
Dall's Porpoise	35	15	190
Harbor Porpoise	3	0	5
False Killer Whale	1	0	1
Killer Whale	1	4	6
Pinnipeds			
Harbor Seal	26	7	178
California Sealion	5	1	15
Unid. Pinniped	4	0	5
Total	75	27	400

Table 2. Summary of sightings and total number of animals observed with the operating sound seismic sound source. Resightings are not included.

	Airgun		Airgun/Huntec		None	
Species	**# Sit**	**# Anim**	**# Sit**	**# Anim**	**# Sit**	**# Anim**
Cetaceans						
Dall's porpoise	4	12	31	178		
Harbor porpoise	1	2	2	3		
False killer whale					1	1
Killer whale	1	6				
Pinnipeds						
Harbor seal	8	72	18	106		
California sea lion			5	15		
Unid. Pinniped			4	5		

Table 3 . Behavior of marine mammals sighted or resighted during daylight hours during surveys. Behaviors were classified based on primary behavior observed during a sighting.

Behavior	**Sightings**				**Resightings**				
	Airgun	**A&H**	**None**	**Total**	**Airgun**	**A & H**	**None**	**Total**	**Total both**
Fast travel	2	1		3	2	2		4	7
Slow Travel	5	48	1	54	5	16		21	75
Hauled	4	3		7		1		1	8
Milling	3	6		9		1		1	10
Stationary		2		2					2
Total	14	60	1	75	7	20		27	102

Table 4. Summary of the dive behaviors observed during sightings and resightings of species during daylight hours.

Species	Dive behavior					
	Rooster tail	Splash	Slow roll	Vertical rise	Vertical sink	No dive/NA
Sightings						
Cetaceans						
Dall's porpoise	1		28			6
Harbor porpoise			3			
False killer whale			1			
Killer whale			1			
Pinnipeds						
Harbor seal		3	6		3	14
California sea lion			3			2
Unid. Pinniped			1	1		2
Resightings						
Cetaceans						
Dall's porpoise	3		11			1
Harbor porpoise						
False killer whale						
Killer whale			4			
Pinnipeds						
Harbor seal			2		1	4
California sea lion		1				
Unid. Pinniped						

Table 5. Headings of marine mammals sighted from survey vessel in relation to sighting type and firing status. Animals that were hauled, stationary or had no travel direction were categorized as hauled/stat.

	Heading relative to direction to boat					
Firing status	**Away**	**Left**	**Right**	**Toward**	**Hauled/stat**	**Total**
Sightings						
None				1		1
Airgun only		4	2	1	7	14
Airgun and Huntec	10	15	24		11	60
Resightings						
None						
Airgun only	2	2	3			7
Airgun and Huntec	2	5	11		2	20
Grand total	14	26	40	2	20	102

Table 6 . Orientation and distance of the four most abundant species of marine mammals sighted from the *J. P. Tully* . Includes sightings and resightings during seismic operations.

	Distance (m)	**Percentage of sightings by orientation**				
Species		away	left	right	towards	n
Dall's porpoise	200-500	0%	20	80	0	5
	501-1000	18	6	76	0	17
	>1000	14	24	62	0	21
Subtotal		14	16	70	0	43
Harbor seal	200-500	20	40	40	0	10
	501-1000	0	100	0	0	7
	>1000	33	33	17	17	6
Subtotal		17	57	22	4	23
California sea lion	200-500	0	100	0	0	1
	501-1000	100	0	0	0	2
	>1000	0	100	0	0	2
Subtotal		40	60	0	0	5
Killer whale	200-500	0	0	0	0	0
	501-1000	0	0	0	0	0
	>1000	0	40	60	0	5
Subtotal		0	40	60	0	5
Total		16	33	50	1.3	76