Testimony by James H. Knapp, Ph.D.
U.S. House Subcommittee on Energy and Mineral Resources Oversight Hearing
"The Science behind Discovery:
Seismic Exploration and the Future of the Atlantic OCS"
10 January 2014

Good morning, Mr. Chairman and thank you both for the introduction and for the invitation to appear before this Subcommittee today. It is my great pleasure and high honor to be here, and I thank you, as well as the Ranking Member and the other members of the Committee for this opportunity. For the record, I am James H. Knapp, Professor in the Department of Earth and Ocean Sciences in the School of the Earth, Ocean, and Environment at the University of South Carolina, and I currently serve as Chair of the Faculty Senate at the University of South Carolina Columbia campus.

Educational and Professional Background

By way of background, I was born and raised in California, have lived in six and traveled to 49 states, and through my profession as an Earth scientist, have worked in or visited more than 40 countries. I hold a Bachelor of Science degree with distinction in geological sciences from Stanford University, and a Ph.D. in geology from the Massachusetts Institute of Technology. From 1988 to 1991 I worked with Shell Oil, where I participated directly in oil and gas exploration in the Gulf of Mexico. For more than twenty years since then, my research team and I have carried out both fundamental and applied research in the design, acquisition, processing, and interpretation of seismic surveys, both onshore and offshore.

Marine Seismic Surveying

Marine seismic surveys have been carried out in the U.S. and internationally for decades, and represent the single most important tool for evaluating oil and gas potential in the subsurface. These surveys employ acoustic, or sound, energy to interrogate the subsurface of the Earth, in much the same way that a doctor images the interior of a human body with a CAT (computerized axial tomography) scan (Figure 1 and 2.) In the early days of seismic surveying, the typical success rate for wildcat wells was around 3 in 10. With the advent of 3-D seismic surveys, the success rate is now typically 7 out of 10, greatly changing our ability to evaluate subsurface resources. In most cases, we now have significant confidence in not only the presence of a petroleum resource, but also the estimated volume and consequently the economic value of that resource before ever spudding a well, primarily as a result of seismic technology.

In addition, scientific work within our research group in the past several years, using onshore seismic and well data, has called into question more than 30 years of research on the Atlantic continental margin, suggesting that many previous interpretations of the geologic evolution were in error, and accordingly, so is the estimate of the resource potential.

UME (Unusual Mortality Events)

One of the most commonly cited criticisms of marine seismic operations is the putative adverse effect acoustic energy has on marine life, and in particular on marine mammals. Established in 1991, The Working Group on Marine Mammal Unusual Mortality Events under the aegis of the Office of Protected Resources with the National Oceanic and Atmospheric Administration (NOAA) has formally identified a total of 60 marine mammal UMEs in U.S. waters over the last 23 years (Figure 3.) In most cases (29) where a cause has been determined, infections and/or biotoxins were indicated (Figure 4.) Of the 60 UMEs, not a single one has been attributed to marine seismic operations.

The incidence of UMEs is statistically the same between the Atlantic, Pacific, and Gulf of Mexico regions (Figure 5), during a period when extensive commercial seismic surveys have been conducted in the GOM, but not on the Atlantic and Pacific margins. The two states with the most declared UMEs are California and Florida, neither of which has been the site of commercial marine seismic acquisition during the period in which the records have been compiled. These data, along with others (Figure 6) suggest that the contention that marine seismic surveys result in mass mortality events of marine mammals is likely a chimera.

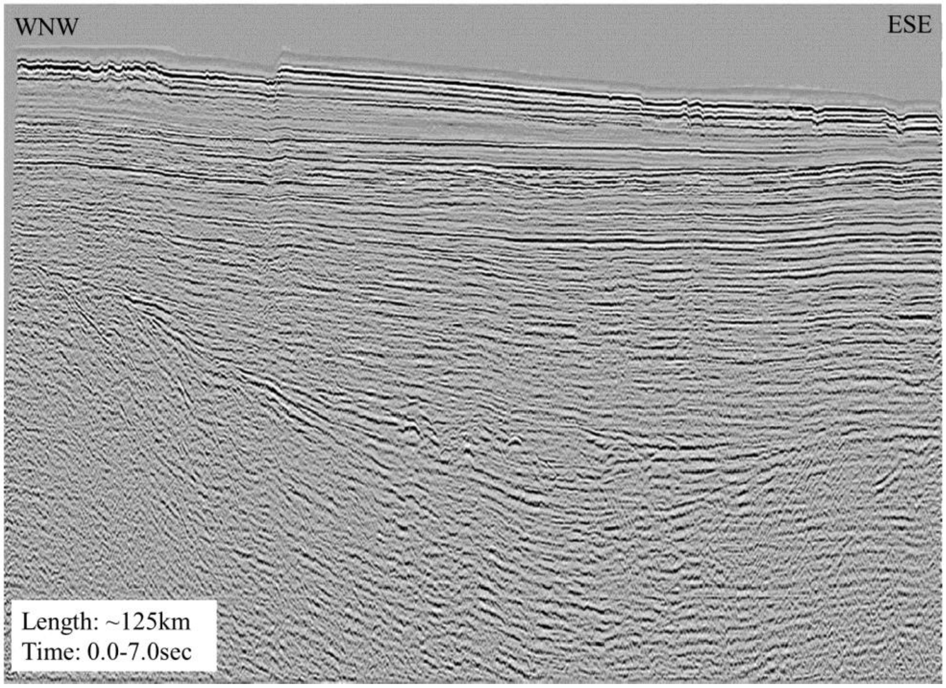
Economic Potential of the Atlantic OCS

The most recent estimates by the Bureau of Ocean Energy Management for the resource potential on the Atlantic OCS range from ~3.5-18 Bboe. Using seismic data from pre-1988, these estimates are undoubtedly conservative, and lack the analysis which would be afforded through new, state-of-the-art seismic data. We face a truly historic opportunity to fairly evaluate the energy and mineral resource base of the Atlantic OCS through acquisition of new seismic surveys. In South Carolina, we are working to establish the Atlantic Coast Center for Energy Sustainability through Science and Engineering (ACCESSE). Our vision is to develop a sustainable energy industry based on conventional, unconventional, renewable, and alternative energy for South Carolina and the southeastern region, helping to train a workforce and creating jobs based on locally-derived energy resources. There could be no more important first step than to initiate new seismic surveys on the Atlantic OCS, and we stand ready and able to help move that effort forward in the regional and national interest.

Acknowledgements

Members of the Tectonics and Geophysics Lab (TGL) (Figure 8) contributed to this document, including Mr. Andrew Pollack and Ms. Susie Boote.

Figures



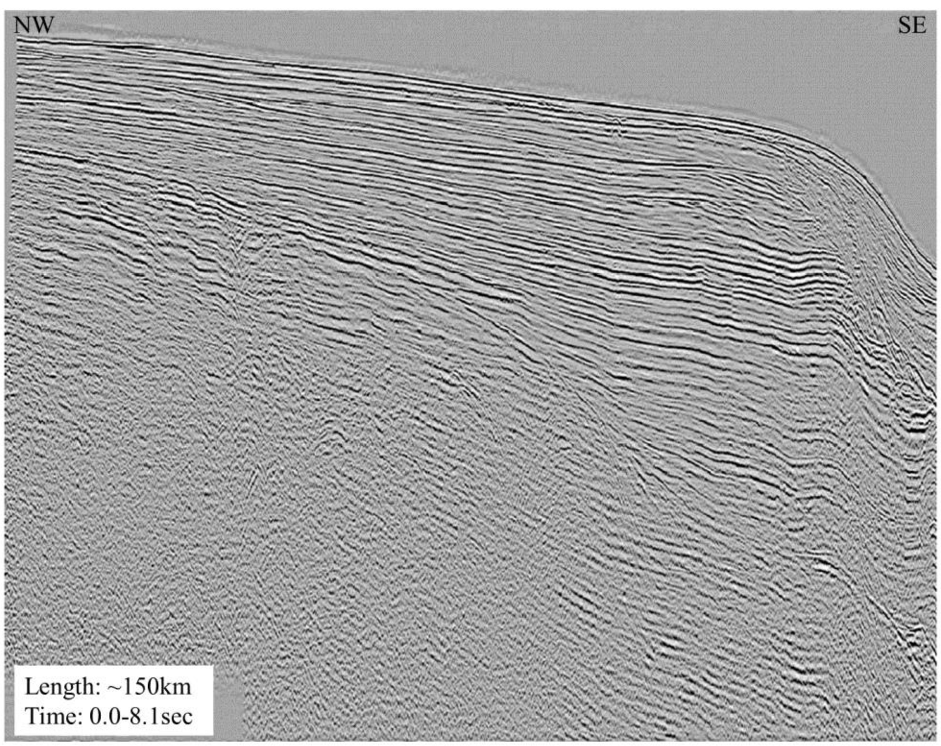


Figure 1. Examples of 2-D seismic reflection profiles showing subsurface sedimentary layers and geologic structures on the Atlantic margin, from legacy Atlantic OCS seismic surveys (courtesy of BOEM.) Approximate depths imaged are 10-12 km (6-7 miles); sections are highly vertically exaggerated (note horizontal scale.)

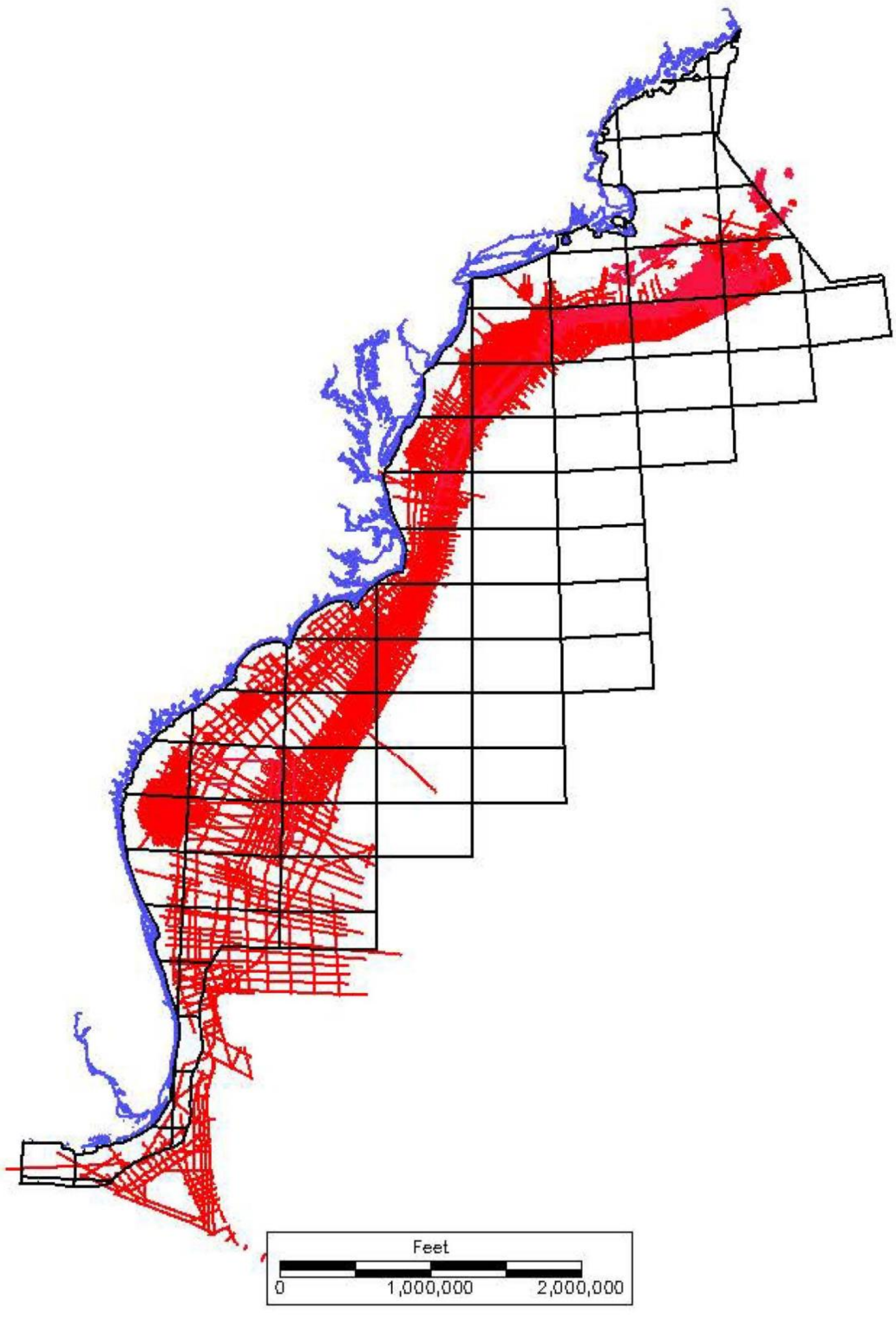


Figure 2. Map of legacy 2-D seismic data on the Atlantic OCS (courtesy of BOEM.) Approximately 380,000 line km (240,000 line miles) of 2-D seismic data were collected in the Atlantic OCS between 1966 and 1988.

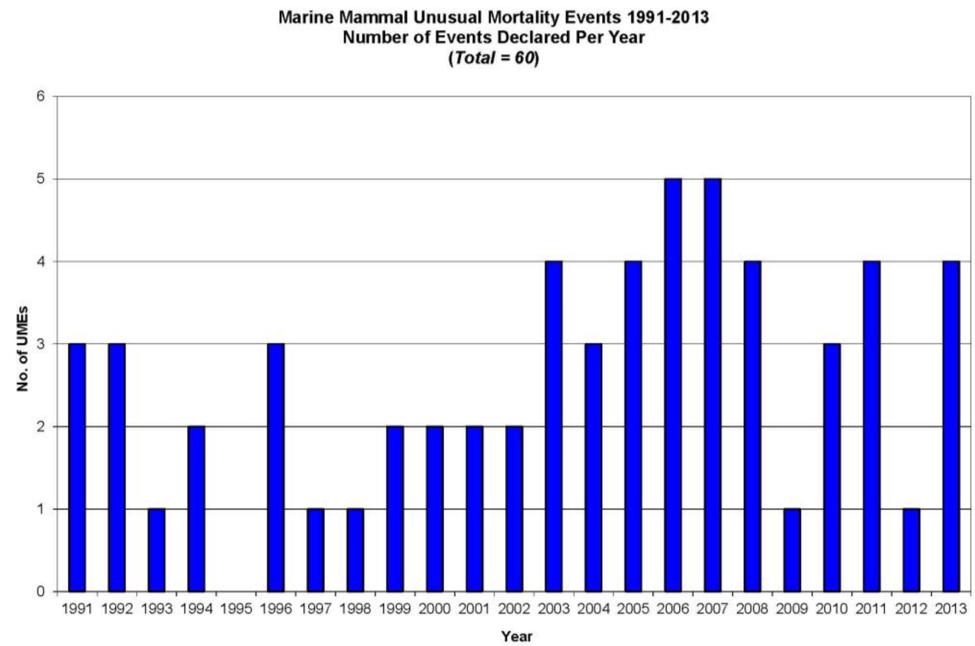


Figure 3. Number of reported Unusual Mortality Events (UME) in U.S. waters by year between 1991 and 2013 (NOAA Fisheries Office of Protected Resources; downloaded on 03 Dec 2013 from http://www.nmfs.noaa.gov/pr/health/mmume/)

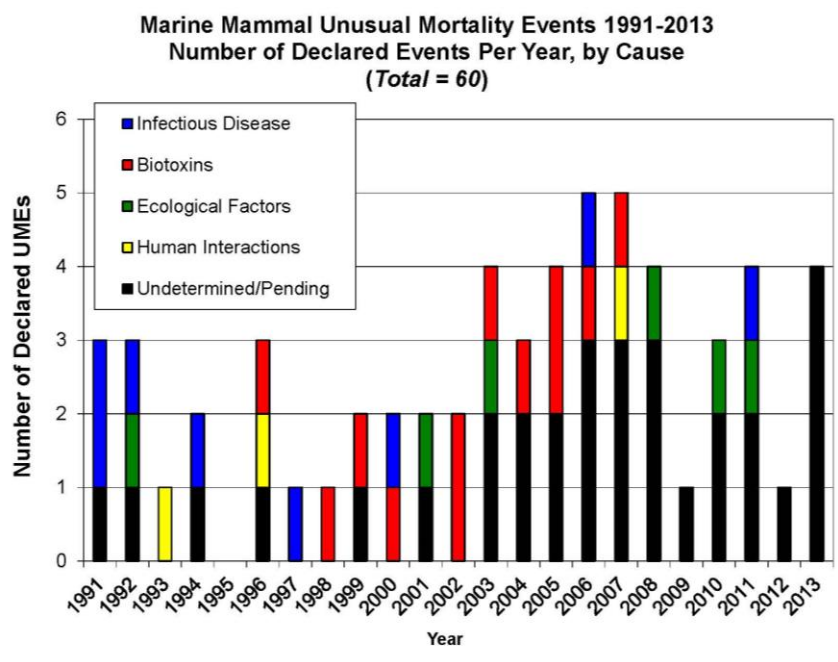


Figure 4. Cause of reported Unusual Mortality Events (UME) in U.S. waters (60 total) between 1991 and 2013 (NOAA Fisheries Office of Protected Resources; downloaded on 03 Dec 2013 from http://www.nmfs.noaa.gov/pr/health/mmume/)

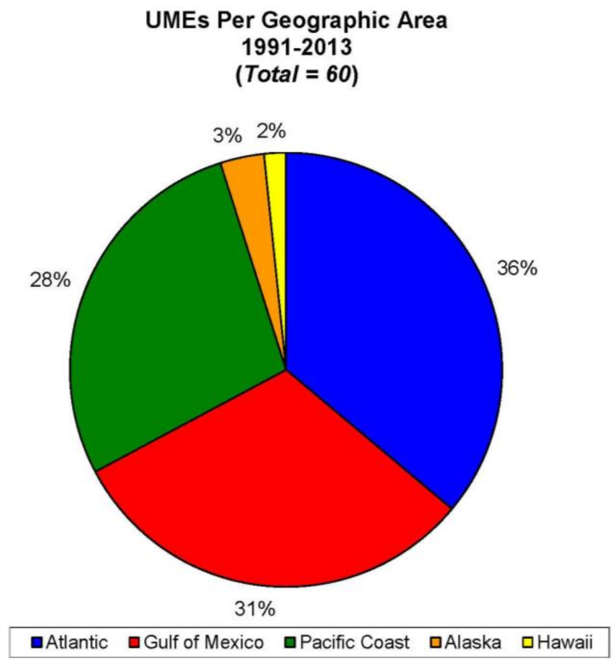
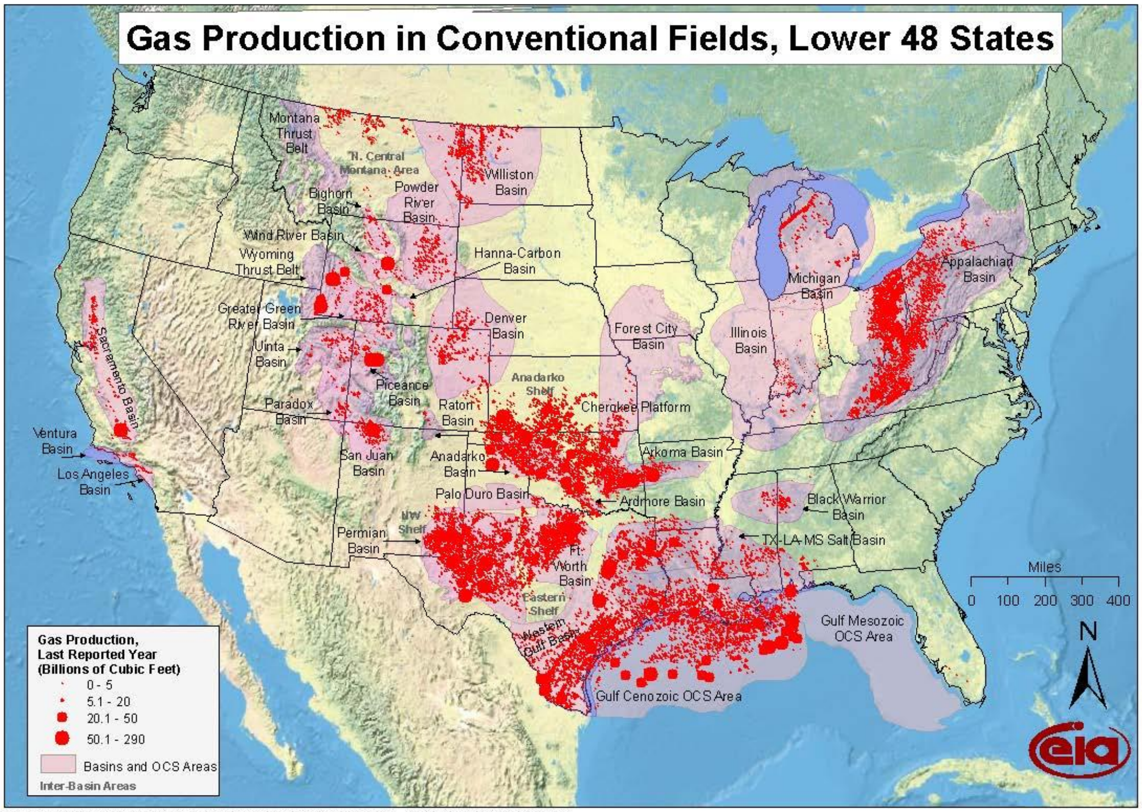


Figure 5. Percentage of reported Unusual Mortality Events (UME) in U.S. waters (60 total) by geographic area between 1991 and 2013 (NOAA Fisheries Office of Protected Resources; downloaded on 03 Dec 2013 from http://www.nmfs.noaa.gov/pr/health/mmume/)

Summary of observations of behavioural change in marine mammals in response to air guns and seismic surveys

Species	Location	Observation	Source	Received level	Range	Behaviour	Water depth	Prop.Model	Reference
Common dolphin	Irish Sea	Operating seismic	2D Seismic 2,120 cu. In.		>1 km	Reduced vocalisation rate within vocal range and/or exclusion within 1 km.	50-100 m		Goold (1996)
Bottlenose dolphin	Captivity		1 sec 20 kHz pulse	· 178 (75 kHz) dB-186 (3 kHz dB		Behavioural avoidance responses at 178 dB			Ridgeway et al. (1996)
Sperm whales	Southern Ocean	Opportunistic	Seismic 8x16l (263 dB re. 1 μPa –m)	· 112 dB	>300 km	Cessation of vocalisation in response to some instances of air gun activity	>500 m 50-100 m		Bowles et al. (1994)
Gray whales	California	Experimental playback	Seismic array	· 180 dB · 170 dB · 164 dB	1.2 km 2.5 kmc c.3.6 km	90% avoidance 50% avoidance 10 % avoidance by migrating whales			Malme et al. (1983, 1984)
Gray whales	Bering Sea	Experimental playback	Seismic array 1.64l, 226 dB	· 173 dB · 163 dB		50% avoidance 10% avoidance by summering whales			Malme et al. (1986, 1988)
Gray whales (western)	Sakhalin Island, Russia	Operating seismic		· <163db		Whales abandoned foraging site close to survey area and moved to main foraging area			Johnson (2002)
Bowhead whale	Beaufort Sea	Operating seismic	Seismic array	· 142-157	8.2 km	Behavioural changes. Changes in blow rates and dive patterns.			Various studies in Richardson et al. (1995)
Bowhead whale	Beaufort Sea	Operating seismic		· 152-178		Active avoidance. Swimming away from the guns and behaviour disrupted for 1-2 hrs.	30-60 m		"
Bowhead whale	Beaufort Sea	Operating seismic		· 125-133 dB	54-73 km	No avoidance behaviour but significantly shorter dives and surfacing periods.			"
Bowhead whale	Beaufort Sea	Operating seismic	560-1500 cu. in	· 120-130db	20-30km	Avoidance			
Humpback whale	S.E. Alaska	Experimental playback	Seismic gun 1.64L (226 dB)	· 150-169	<3.2 km	Short-term startle response. No clear avoidance at levels up to 172 dB re. 1m Pa effective pulse pressure level.			Malme et al. (1985)
Humpback whale	North West Cape, W. Australia	Operating seismic	Seismic array 44l (258 dB re. 1 μPa^2-m p-p)	· 170 dB P-P · 162 dB P-P · 157 dB P-P	3- 4 km 5 km 8 km	Stand-off (General avoidance) Avoidance manoeuvres Avoidance manoeuvres	100-120 m	25 logR	McCauley et al. (1998)
Humpback whale	Exmouth Gulf, W. Australia	Experimental playback	Seismic gun 0.33L, (227 dB re. 1 μPa^2-m p-p)	· 168 dB P-P · 159 dB P-P	1 km 2 km	General avoidance Course alterations begin	10-20 m		McCauley et al. (1998)
Blue whale	North Pacific Ocean	Operating seismic	Seismic source 1,600 cu. in. (215 dB re. 1 μPa 1-m p-p).	· 143 dB P-P	10 km	Closest approach 10 km? Cessation of vocalisations for c.1 hr. Resumption of vocalisations and movement away from source.	2,400 m		Macdonald et al. (1995)
Grey seal	Scotland and Sweden	Experimental playback. 1 hr exposure	Single gun or small array (215-224 dB re. 1μPa-1 m)			Avoidance. Change from feeding to transiting behaviour. Haulout. Apparent recovery c 20 mins after trial.	20-100 m		Thompson et al. (1998)
Common seal	Scotland and Norway	Experimental playback 1 hr exposure	Single gun or small array (215-224 dB re. 1 μPa-1 m)			Initial fright reaction. Bradycardia. Strong avoidance behaviour Cessation of feeding	20-100 m		Thompson et al. (1998)
Ringed Seal	Prudhoe Bay, Alaska	Operating Seismic	Array, 21.6L (236 dB re. 1μ Pa- 1 m p-p horizontal)	200 dB rms 190 dB rms 180 dB rms 160 dB rms	.03 km .24 km .96 km 2.6 km	Partial avoidance at <150mMore seals seen swimming away while guns firing	3-17m		Harris et al. (2001)

Figure 6. Review of seismic survey effects on marine mammals (from Gordon et al, 2004), suggesting that the most commonly observed response is avoidance.



Source: Energy Information Administration based on data from HPDI, IN Geological Survey, USGS
Updated: April 8, 2009

Figure 7. Distribution of producing gas fields (as of 2009) in the continental 48 states of the U.S. Based on the abundance of natural gas in onshore sedimentary basins, the lack of production in the Atlantic OCS is unlikely the result of the absence of a commercial resource base. (Downloaded from the Energy Information Administration 16 October 2013)

Figure 8. Members of the Tectonics and Geophysics Lab (TGL) and Geophysical Exploration Lab (GEL) in the Department of Earth and Ocean Sciences, Spring 2013. (Front row: Prof. C. Knapp, D. Terry, M. Akintunde, E. Derrick, C. Cunningham, Prof. J. Knapp; Back row: W. Anderson, D. Heffner, A. Simonetti, N. Robinson, K. McCormack; not pictured: A. Bayou, S. Boote, R. Kabila, A. Pollack, J. Salazar, A. Williams)