Sounds from airguns and fin whales recorded in the mid-Atlantic Ocean, 1999–2009

Sharon L. Nieukirk[a] and David K. Mellinger
Cooperative Institute for Marine Resources Studies, Oregon State University and NOAA Pacific Marine Environmental Laboratory, 2030 SE Marine Science Drive, Newport, Oregon 97365

Sue E. Moore
NOAA Fisheries Office of Science and Technology, 7600 Sand Point Way NE, Bldg. 3, Seattle, Washington 98115-6349

Karolin Klinck and Robert P. Dziak
Cooperative Institute for Marine Resources Studies, Oregon State University and NOAA Pacific Marine Environmental Laboratory, 2030 SE Marine Science Drive, Newport, Oregon 97365

Jean Goslin
UMR 6538, Domaines Océaniques, Institut Universitaire Europeen de la Mer, Université de Bretagne Occidentale, Technopole Brest-Iroise, 29280 Plouzané Cedex, France

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Between 1999 and 2009, autonomous hydrophones were deployed to monitor seismic activity from 16° N to 50° N along the Mid-Atlantic Ridge. These data were examined for airgun sounds produced during offshore surveys for oil and gas deposits, as well as the 20 Hz pulse sounds from fin whales, which may be masked by airgun noise. An automatic detection algorithm was used to identify airgun sound patterns, and fin whale calling levels were summarized via long-term spectral analysis. Both airgun and fin whale sounds were recorded at all sites. Fin whale calling rates were higher at sites north of 32° N, increased during the late summer and fall months at all sites, and peaked during the winter months, a time when airgun noise was often prevalent. Seismic survey vessels were acoustically located off the coasts of three major areas: Newfoundland, northeast Brazil, and Senegal and Mauritania in West Africa. In some cases, airgun sounds were recorded almost 4000 km from the survey vessel in areas that are likely occupied by fin whales, and at some locations airgun sounds were recorded more than 80% days/month for more than 12 consecutive months. © *2012 Acoustical Society of America*. [DOI: 10.1121/1.3672648]

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I. INTRODUCTION

Passive acoustic surveys have become an effective means of monitoring both the natural and anthropogenic contributions to ambient noise levels in the world's oceans. Autonomous and cabled hydrophones are now used widely to study the sounds generated by undersea earthquakes, ice noise, and marine animals. Research has also confirmed that low-frequency (<1000 Hz) human sources of noise pollution have dramatically increased over the last 50 years (Andrew *et al.*, 2002; McDonald *et al.*, 2008). The primary sources of low-frequency anthropogenic noise are the sounds associated with shipping, military and research activities, and oil and gas exploration and development (Richardson *et al.*, 1995; Croll *et al.*, 2001; Hildebrand, 2009). Of growing concern is the effect these increasing levels of low-frequency noise have on protected species, such as baleen whales that are acoustically sensitive and use low-frequency sound for communication and possibly navigation or prey-finding (Richardson *et al.*, 1995; Clark *et al.*, 2009). In particular, the sounds from airgun surveys have been the focus of several recent marine mammal investigations (e.g., Di Iorio and Clark, 2010; Madsen *et al.*, 2006; Weir, 2008a,b), and the potential and observed effects have been reviewed [e.g., National Research Council (NRC), 2003, 2005; Gordon *et al.*, 2004; Bradley and Stern, 2008]. To assess the potential effects of airgun sounds on whales, the temporal and geographical occurrence of this sound and the distribution of species that are potentially impacted must be described.

In 1999, a consortium of U.S. investigators deployed an array of autonomous hydrophones (Fox *et al.*, 2001) to monitor seismic activity along the Mid-Atlantic Ridge (Smith *et al.*, 2002; Dziak *et al.*, 2004). Although this experiment was designed to monitor the low-frequency signals of earthquakes, the instruments were also capable of recording the low-frequency calls of several species of baleen whales, as well as anthropogenic sounds such as ship noise and seismic airgun pulses. These instruments were located within potential migratory routes for fin (*Balaenoptera physalus*) and blue (*B. musculus*) whales and were in a remote region that rarely if ever is included in marine mammal surveys (Mellinger and Barlow, 2003).

[a]Author to whom correspondence should be addressed. Electronic mail: sharon.nieukirk@noaa.gov