Sonar as a Hybrid Technology and its Effects on the Environment

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The world today is very different from what it once was; with the development of tools, expansion of knowledge, and global communication systems, our world has become much more complex and active than it was for our ancestors. We have introduced many types of different technologies into our social, personal, and even biological lives that have had beneficial and detrimental effects on ourselves and on our environments. For example, the invention of sonar, modeled after the sonar of bats and the acoustic echolocation systems in cetaceans, has been adopted as our "eyes" under water. Here, sound waves can travel for much longer distances in water than can light waves and radar, which allows us to see underwater. We have introduced a technology to the oceans that we can use to see in aquatic environments. This is a hybrid technology merging with a vast biological system (the ocean) that we may never see go away in the future.

Sonar uses an emission of high, medium, or low frequency sound waves, which are sent out into the environment. When something is in the path of those sound waves, the sound bounces back as an "echo" to the sound transducer and is then analyzed to determine the size, shape, and location of that object (http://oceanservice.noaa.gov/facts/sonar.html). Sonar has been used for many tasks such as underwater navigation, seafloor mapping and investigation, warfare, and tracking of animals and other watercrafts that we cannot see with the naked eye (http://oceanservice.noaa.gov/facts/sonar.html). By introducing methods of sonar use to the oceans, we have made many new discoveries about the underwater world. For example, NOAA (National Oceanographic and Atmospheric Administration) has been using sonar for tasks such as mapping the sea floors (McMullen, 2008) and tracking marine life throughout the world's oceans (Greene, 1999). Moreover, institutions like the military are constantly using sonar to detect underwater resonant body target such as explosive mines and submarines (Geohegan, 1984). Sonar was put to use in these ways with the intentions of better understanding the world that we cannot see, however, there have been some unexpected side effects to the use of sonar in the oceans. The sound waves and their intensities have had major detrimental effects on marine life, particularly cetaceans (Deruiter, 2013).

Cetaceans are currently one of the largest groups of animals and mammals on the planet. They have been around for millions of years inhabiting the oceans and evolving to be nearly perfectly fit for their environment. They are famous in nature for their development of "acoustic echolocation," which allows them to acoustically map out their surroundings using very similar techniques to manmade sonar (Houser, et. al, 2004). They are able to produce sounds using phonic lips near the blowhole (Madsen, et. al, 2010). They push air from their lungs through the phonic lips to create a sound, which is emitted out in front of them into the water column. Like sonar, the sound bounces off of an object in the surrounding area and comes back as an "echo" to the individual (Madsen, 2010). Through what are called "acoustic fats" in the "acoustic window," located in the lower jawbone (pan bone) of the animal, the echo is absorbed and transmitted through the inner ears to the brain where it is analyzed and the animal makes sense of the information received (Johnson, 2004). Sound is the primary sense used in the oceans by cetaceans; it is utilized for communication, foraging, swimming, migration, and even mating (Ryabov, 2014). Scientists believe that having foreign sounds similar to, yet louder than the individual animal's, most likely causes some hardships for daily life in oceanic environments.

The ocean was once a quiet environment filled only by the sounds of the creatures that live there. As the human species have advanced and technologies have expanded and grown, the oceans have become more and more noisy; filled with ambient noises and anthropogenic sounds (McCarthy, 2004). Before the introduction of sonar to the ocean, marine life forms lived fairly uninterrupted lives. Cetaceans, particularly the Odontocetes (toothed whales), have been the main victims in the introduction of this hybrid technology (Nachtigall, et. al, 1988). Sonar usage has had some very detrimental effects on these animals; from mental confusion to even as far as stress induced self-strandings (St Aubin, 2002), these animals seem to experience extreme cases of stress and the outcome of these stresses are not usually positive.

For example, one study performed by P. H. Kvadsheim and team demonstrated the effects of Mid-Frequency Active Sonar (MFAS) and Low-Frequency Active Sonar (LFAS) activity on five different species of Odontocetes (Kvadsheim, 2012). The study showed that the dive profiles have been known to change according to the sonar activity emitted in the surrounding area. The study demonstrated that the dives became shorter and less frequent in times of exposure to different frequencies of sonar activity (see Figure 1) (Kvadsheim, 2012). This is merely one of the many types of studies performed on the effects of sonar technologies on marine life. We are left to wonder how this technology is going to change and possibly be modified to increase beneficial effects and outcomes rather than detrimental ones.

Evolution is not likely going to provide humans with their own personal/biological form of sonar anytime soon; therefore, we are most likely not going to see sonar go away within the next ten to one hundred years. There has been some research on technologies that use both array designs and electronic beam forming implementations to limit noise from technologies like sonar in the ocean (Loggins, 2001). Some other alternatives to the use of sonar seem to most often be thermal imaging, and magnetic sensory technologies (Haacke, et. al, 1999). However, studies have shown that acoustic illumination by ambient noise can be used to "illuminate" an object in the water column, which is then transferred to an image on a monitor screen (Buckingham, et. al, 1992). Finally, a potential alternative could be the more frequent use of passive sonar when appropriate. Passive sonar is a type of sonar that does not emit sound but rather listens to the noises of the environment around it (http://oceanservice.noaa.gov/facts/sonar.html). This may not be an alternative to all sonar uses in general, but it may be a useful solution if used when possible to reduce detrimental effects on the environment. As mentioned before, sound waves travel much farther in water than do light or radar, therefore, sound seems to be our most efficient tool for interacting with aquatic environments. We have introduced the technological system of sonar to the biological system of the ocean to form a merging of systems that has enhanced our abilities to interact with aquatic ecosystems. Sonar is unique in the sense that it uses sound to allow us to see objects in the environment that we cannot necessarily see, and a technology like that is not likely to disappear anytime in the near future.

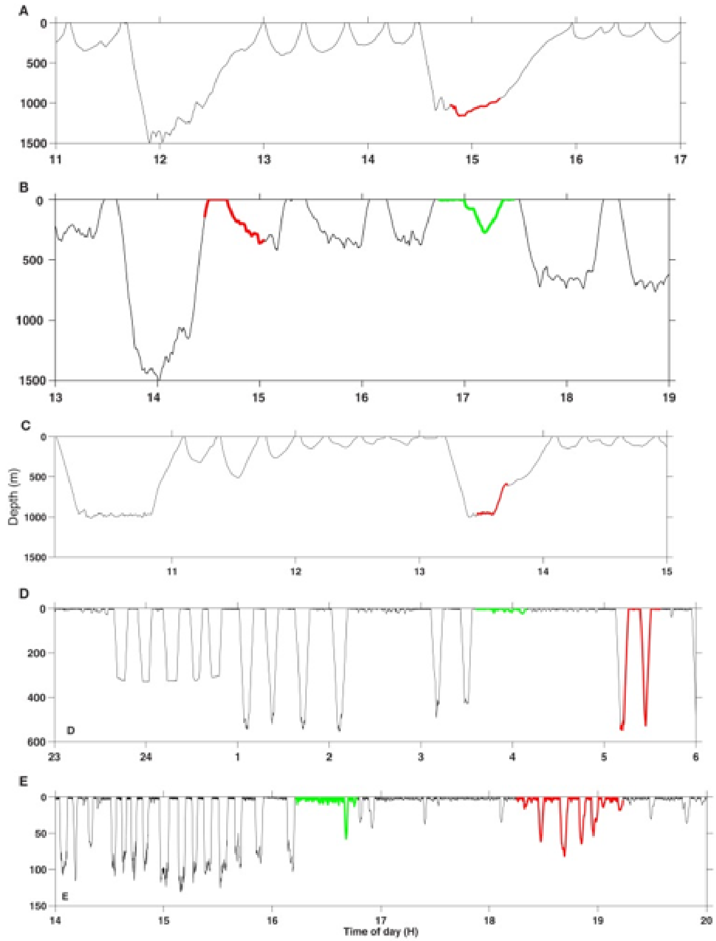

Figure 1. Dive Profile for five individual whale species. This figure shows the change in dive times and depths over a period of several hours and depth in meters. The red sections demonstrate dives exposed to MFAS and the green sections demonstrate the dive profile during exposure to LFAS. We see here that some of the exposures to MFAS result in a shorter dive depths and times, and exposure to LFAS results in similar reactions. (Kvadsheim, et. al, 2012)

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