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Beneath the Silent Sea

The Department of the Navy is up to something mysterious and it has me troubled. My usual suspicion of their incentives drives this concern, but this new project seems particularly sinister, and I believe it will impact our global quality of life as deeply as our fearful web of nuclear deterrence. While the proposed project may not immediately thicken the winds of anxiety that blew through Los Alamos a half-century ago, it will spread that anxiety into our oceans, sharing it with whales, dolphins, pelagic (deep ocean) fish and countless other species that inhabit the sea. The consequences of this may not become immediately apparent to us, but as the project develops it will surely compromise the health of our co-species around the globe and coincidentally the availability of our own food supply.

What the Navy is proposing – and to some extent already doing, involves generating extremely loud noises in the ocean, loud enough to be heard hundreds to thousands of miles across the sea. While they have some history with this technique in a questionable program named Acoustic Thermography of Ocean Climate (ATOC,) purportedly monitoring the long term temperature trends of the deep ocean, the new proposal threatens to ratchet up the overall human generated noise in the oceans to an unprecedented degree. The program is named Surveillance Towed Array Sonar System (SURTASS) utilizing Low Frequency Active Sonar (LFAS.) The Navy's stated objective is to monitor hostile submarine activity using long wavelength sonar in a crude adaptation of a communication and navigation technique used by whales, schooling fish and other deep water organisms. The Navy will be doing this without regard for the existing web of sounds that keep the ocean creatures in touch with their kin, their surroundings and their food sources. So far they have been able to roll their proposals forward with limited resistance from the public because few people are conversant in the issues and people by-and-large consider the deep ocean a silent expanse of uninhabited water. While polluting the seas with extreme noise seems intuitively inadvisable, in order

to really understand the issues we need to overcome our anthropocentricity – we need to consider the possibilities of things outside of our usual range of perception and we need to recognize that often our most “cutting edge” technologies are only rough approximations of the elegant natural phenomena that weave the fabric of our universe together.

The “Silent Sea”

The ocean is not a visual place. Under the best of circumstances underwater visibility is 100 feet; sunlight does not penetrate down below a few hundred feet from the surface, much less when the water is teeming with plankton, algae and other food sources. The perceptual vocabulary of the sea is auditory, chemical and electrical. We don’t realize this because our organs of auditory, electrical and chemical perceptions are poorly adapted to underwater use. We are not likely to sniff for underwater odors, trying to speak underwater is almost as futile, and our ears don’t translate underwater sounds well in a submerged pressure gradient. Much of the sounds we do “hear” underwater such as those generated by whales and dolphins, we hear through our bodies – and then only within our auditory range of 20Hz – 20kHz. We know that dolphins sing in pitches well above 120kHz and whales sound in deep tones as low as a few cycles/second, though acoustical energy generated by the bodies of whales or even large schools of fish can be lower still.

Over the past few decades we have developed an understanding of the properties of the higher frequencies used by dolphins. Due to their short wavelength, we use these high frequencies in ultrasonic imaging. Soft tissue does not resonate and interfere with short wavelengths, this allows high frequency sound to “see” through skin, muscle and fat. Dolphins use ultrasound to help distinguish soft tissue from bone in their prey – enabling them to feed effectively. It is likely that they use this imaging in the complex array of their communication as well. Lower frequency “infrasound” use by animals is more of a mystery to us. One of the properties of infrasound is that the longer wavelengths tend to adhere to the curvature of the globe. Longer wavelengths are also less subject to diffusion and absorption by obstacles in the water. The large wave fronts are too large to “see”

anything but the largest geographical features. Sea mounts, islands and continents are distinguishable, boats and kelp beds are not. This makes low frequency ideal for navigation and long distance communication. We know that elephants use infrasound to communicate and navigate over land distances of up to ten kilometers, and while nobody has asked them, informed speculation would indicate that whales use their low frequency sounds to communicate and navigate over long distances as well.

So what about the “less complex” organisms; the schooling fish, sea turtles, pelagic crabs, jellyfish, shrimp and the panoply of other denizens that migrate seasonally around the seas? While it is likely that these migrations are informed by factors such as temperature, salinity and the magnetic flux of the earth, it is just as reasonable to assume that underwater acoustics also plays a part; that the low frequency sounds of waves undulating and hitting the shores, submarine tectonic and volcanic activity and acoustical ambience also details the maps that migrating creatures follow.

In the cases of tuna and other schooling fish, the acoustical energy generated by their bodies helps the individual fish synchronize with the low frequency swimming oscillations of the entire school. The lateral line and swim bladder of the fish is an evolutionary adaptation of our own ears – a sensor of vibration and an organ of balance and motion. These organs allow a fish to sense or “hear” motion by way of pressure gradients in their surroundings. When individuals at the perimeter of the school respond to exterior movement such as that generated by a predator, their evasive action transmits the pressure gradient of the predator’s motion into the body of the school, informing the school of the appropriate evasive action – without the individual’s need to communicate the specifics of the threat. By this mechanism a school of fish – as a body –will respond to motion in less than $1/50^{th}$ of a second.

While the energy sensed by schooling fish is not “sound” in the general sense that we perceive it – i.e. vibrational energy that *we* can hear, it is none-the-less acoustical energy. It is low frequency energy that these animals rely on to establish their placement within the body of the school. These fish may even get acoustical feedback in this range from their environment as the long wavelength, low frequency energy of the school reflects off

of the sea mounts, islands and continents, helping the school establish their placement in the ocean.

This may all seem a bit too speculative; this line of conjecture is not firmly supported by a general body of scientific inquiry – I can only leave that judgement to the scientific community and their funding sources. Meanwhile we have a military program of global oceanic consequences rolling ahead with a dearth of public information or understanding. It might be prudent to speculate a bit in hopes that we avoid learning the truth the hard way, and too late.

So what is the Navy Really up to?

What the Navy is proposing is a system of very high powered sound generators placed in various places around the oceans – some stationary, others towed behind ships. These sound generators are capable of generating 250 dB (re: 1 mPa) noise, noise that is 100,000 to 1 million times louder than the loudest whale and perhaps a billion times louder than the subtle acoustical signals used by other animals. The Navy wants to generate a thrum of noise in all oceans where they have interest in submarine activity. They claim that their long wave sonar system will allow them to keep track of hostile submarine activity throughout the seas, though the physics of this is questionable.

The sounds that SURTASS LFA generates includes pulsed and swept tones between 100Hz and 10 kHz. The underwater wavelength of these fundamental tones are between 50 feet for 100 Hz and 6 inches for 10 kHz. These wavelengths even at high volume would only be suitable for sonar detection within a few miles of the source due to diffusion and the curvature of the earth. Though by combining and sweeping these tones, combination tones with wavelengths of hundreds to thousands of feet can be created. This is somewhat akin to Frequency Modulated (FM) radio waves creating lower frequency artifacts that can be translated into audio band information. Herein lies the crux of the technology: Combing higher frequencies in various ways will create low frequency, long wavelength tones. These longer wavelengths adhere to the curvature of the earth, “seeing” over the underwater horizon, enabling the system to broadcast and compromise thousands of cubic miles of ocean. By structure, these long wavelengths are too long to

detect small objects; detecting a 200’ submarine across thousands of cubic miles of ocean with a 500’ wave front is akin to searching for amoebas in a swimming pool with a telescope.

So while the Navy is portraying SURTASS as a surveillance tool, it is more likely that they are setting up a global submarine communication system that will enable them to keep in constant contact with the entire nuclear fleet – in a crude approximation of how a school of fishes keep in contact. Up until recently submarines relied upon low frequency radio waves for communication. These long wavelength radio waves also adhered to the curvature of the globe allowing over-the-horizon capabilities. Radio waves don’t penetrate the ocean surface, so in order to receive these long radio waves, the submarines need to tow long antennae – a mile or more in length – on the ocean surface. With recent advances in satellite surveillance these antennae are fairly easy to spot making the system unworkable for clandestine deployment of our nuclear arsenal. On the other hand, underwater sound communication is completely clandestine to current surveillance technologies – it can’t be detected from above the ocean surface and the long wavelengths make the source difficult to pinpoint underwater. With the volume levels and wavelengths currently used in the ATOC system, long distance communication between Monterrey and Hawai’i is possible – a distance of about 3000 miles. For these reasons, sound communication “beneath the silent sea” is irresistible to the Navy – particularly if they keep the public in the dark about the true nature of their work.

Is it more sinister to use this pernicious technology for communication rather than using it for surveillance? From my perspective any reason is the wrong one for violating the sanctity of the sea, but what irks me most about it is that while the Navy is portraying their system as a defensive system, it is in fact an offensive tool – they are torquing up the global fear with the justification that danger is everywhere. Is this a justification for environmental disruption at this scale?

Sidebars:

Why the confusion?

Perhaps the greatest source of confusion around the discussion of underwater acoustics lies in how we quantify and qualify the submarine environment. The terms used are the same as terms used in an air environment, but the properties of water and air differ significantly. Air is compressible, water is not; sound travels five time faster in water than in air, and thus the wavelengths are 5 times longer; the ocean has a distinct sound reflective boundary at the surface that channels longer wavelength sound. The deep ocean has a thermoclime akin to the stratosphere that also enables “channeling” of acoustical energy.

The decibel (dB) is used to evaluate energy levels in both environments, but a dB is not a specific quantity of energy, rather it is an expression of relative energy levels. The decibel is a logarithmic scale, so every increase of 10 dB represents a tenfold increase of energy. 10 dB indicates ten times more energy than 0 dB, 20 dB is 100 times more, 30 dB a thousand, 60 dB a million and so forth. In air the reference level of 0 dB equates to the energy level at the lowest threshold of human hearing. This measure has no significance underwater, so the reference level shifts down to a mathematically more convenient number, resulting is a 60 dB relative difference between air and water decibel measurements.

There they go again…

It is hard to conceive the extent of damage that extreme acoustical energy can cause. The noises generated by SURTASS LFA are the loudest noises ever generated by humans with the possible exception of the noise at nuclear “Ground Zero.” Since the beginning of the Navy’s use of this technology, environmental scientists have advised against it. It is not surprising that after almost every known Navy test, whales and dolphins show up on beaches for “mysterious reasons,” some with bleeding eyes, damaged and infected cochlea and other unusual tissue damage. It would be hard to determine the extent of sea life that sinks to the ocean floor once killed by Low Frequency Active Sonar.

The Canary Islands - A total of 21 whale strandings in 1985, 1988, and 1989 were linked to visible US Navy maneuvers. These were the only times whales were reported to strand in the Canary Islands. (*Nature*, 1991)

The Atlantic Coast - In a 1987 Navy experiment, dolphins exposed to 235 decibels of sonar stranded and were found to suffer from lung tissue explosion. Since this revelation, there has been a great deal of resistance to obtain autopsies that check for this particular problem.

Northern California -The first public test of ATOC in November of 1995 was followed by the beaching of three humpback whales – all buried before autopsies could be performed.

The Haro Strait, San Juan Islands - In the Summer of 1996, 195 decibels were sent into this key waterway used by orcas, porpoises, seals and other mammals, followed by an increase in strandings of these mammals. *ABC News* recently reported that the previously thriving orca population from this area is now in enough trouble to be considered eligible for the Endangered Species list.

The Mediterranean Sea near Greece - In 1996, twelve Cuvier beaked whales exposed to NATO sonar were found stranded. At the same time 200 stranded dolphins and were suspected of suffering from tissue explosion. (*Nature*, 1996)

The Hawaiian Islands - In 1998, three whale calves and one dolphin calf were found dead or abandoned during and immediately following sonar testing, even though in 15 years of research this phenomenon had never been observed. One of these was a distressed whale calf that breached 230 times and pectoral slapped 658 times in front of Dr. Marsha Green's research team in a four-hour period before the sun set on his distress. In addition, a pod of dolphins was observed by naturalists familiar with normal dolphin behavior huddling unusually close to the shore near the surface and vocalizing excessively while the sound was on.

California - Since the testing in California began in 1997, sonar exposed whales immediately began to strand in increased numbers. In addition, there was a report of

uncharacteristically aggressive behavior. More recently, *The Malibu Times* reported in January, 1999, that more than 150 gray whales were found dead due to starvation along their migratory route where testing took place in 1998. On October 3 1999, three pilot whales beached of on U.S. Virgin Islands St. Croix, St. John, and St. Thomas, coincident with Navy maneuvers

Australia - The Australian government has questioned a connection between observed US Navy and NATO maneuvering and strandings off their shores.

The Bahamas - Most recently in March 2000, about a dozen beaked whales stranded on various beaches, a rare occurrence as they are not typically schooling animals – a 1998 report in *Nature* found that only four beaked whale strandings had occurred since 1963. National Marine Fisheries spokesperson reported that two of these whales had eyes that were bleeding, "suggesting acute shock trauma." (*S.F. Chronicle* March 22, 2000.)

Without exception the Navy maintains that these strandings are only "anecdotal," that there is no connection to their testing and thus refuse to consider them worthy of being pursued.

Want more information?

There are quite a number of organizations and websites with information on SURTASS LFA and ATOC, from the informative and action oriented – to the sentimental and hysterical. Some helpful information can be excavated from the following:

The Natural Resources Defense Council has information under the Marine Mammal link at their website http://www.nrdc.org.

The Ocean Mammal Institute has helpful information at http://www.oceanmammalinst.com.

A diverse listing can be found at http://www.angelfire.com/ca/fishattorney/lfaslinks.html

Information about SURTASS LFA from its proponents can be found at http://www.trwiuss.com/pmw182.

Information about the Acoustic Thermography of Oceanic Climates (ATOC) can be found at http://atoc.ucsd.edu.

For a glowing Environmental Impact Statement sponsored by the Navy, you can visit their site at http://www.surtass-lfa-eis.com. This site has an executive summary of the 400 page EIS full of hard scientific phrases such as "conservative assumptions," "risk continuum" and "…it has been postulated." Typically the EIS evaluation of animal evasive response is based on equivalent assumptions of human behavior and perceptions.

About the Author:

Michael Stocker is an acoustician and technologist. He is currently writing "Hear Where We Are: Reawakening the Sensuality of Sound Perception," a book exploring how sound affects our sense of placement and how we humans and other animals use sound to connect with our surroundings.