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Notes: This is a complete set of comments by Luczkovich and Sprague, another version faxed earlier, but missing some names from Table 1. If you have comments or questions, please contact me at the address listed above.

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Comments on the US Navy Draft Environmental Impact Statement (US Navy 2005)
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Potential Impacts of the US Navy's Proposed Undersea Warfare Training Range on Fishes

The US Navy has proposed a 1,713 km^2 sonar training range off NC, where sonar equipment will be used to detect simulated enemy submarines. We will review impacts on fishes that may be expected to occur in the proposed area, which includes live bottom reef areas. It is anticipated that the Navy's mid-range sonars (1–13 kHz) will influence the behavior and spawning activities of fishes, especially sciaenids (drums and croakers), serranids (groupers), carangids (jacks) and scombrids (mackerels and tunas). Sounds will be broadcast at levels > 200 dB re 1 µPa, in short pings, but fairly often (a 1 s ping every 25 s for as long as 6 hours each day on 161 exercise-days/year). Many fishes can hear sounds in the range of 1-4 kHz, especially fishes like the silver perch (*Bairdiella chrysoura*). The sound levels proposed exceed that produced by fishes themselves (silver perch make sounds ~135 dB, Sprague and Luczkovich 2004). Thus, Navy sonars may interfere with spawning choruses of sciaenids or cause fish to avoid the sonar area. Silver perch reactions to bottlenose dolphins suggest they will respond to sonar by shutting down spawning choruses (Luczkovich et al. 2000). The Navy should do more research on the species of fishes found in the proposed area and potential impacts on the acoustic environment, especially on fishes.

Introduction

The US Navy has proposed a training area for surface ships, aircraft, and submarine crews to detect enemy diesel-electric submarines in shallow water (US Navy 2005). One site being considered (Alternative A) is an area comprising 1,713 km^2 (600 mi^2) of the Atlantic Ocean in Onslow Bay, 47 miles from NC coast. Approximately 161 training events/year will be occurring in the proposed area. The US Navy plans on using mid-frequency (1-13 kHz) active sonars to locate unmanned submarine targets. We have been asked by the members of the NC Coastal Federation to review the US Navy's draft environmental impact statement (DEIS, US Navy 2005) on the sonar range and their proposed use of the coastal areas from the standpoint of effects on fishes. One of us (JJL) spoke at the public meeting held by the US Navy in Morehead City in Dec 2005, giving the US Navy an oral version of these comments. On 28 Jan 2005, one of us (JJL) gave an oral presentation of these comments at the 20th Annual Meeting of Tidewater chapter of the American Fisheries Society in Atlantic Beach, NC. This paper will provide our

written comments to the US Navy. We will also ask a few questions that we have about the draft environmental impact statement from the US Navy (US Navy 2005). We will consider the possible impacts to fishes and fisheries in the proposed sonar range.

What are potential impacts of the sonar range activities and loud sounds on fishes?

The US Navy is proposing to use various types and sound levels of sonars, and in various scenarios. To briefly summarize, the US Navy will broadcast sonar sounds at up to 235 dB re 1 µPa @ 1 m at mid-frequencies (1000 Hz – 13,000 Hz or 1 – 13 kHz). The frequency spectrum the sonars is not given in great detail (and no spectrographs of the sounds to be broadcast were included in the DEIS, so the exact frequency- and time-domain sound profile is unknown), but the sonars will be used 161 times/year in various configurations on different ships, aircraft and on active sonobuoys. The duty cycle of the sonar will be relatively short, with acoustic "pings" emitted at these sound pressure levels for 1-2 s at intervals of 25 s for six hours per day (US Navy 2005, pg 4.3-27). The sonar could be operated for 67% of the time, or about 4 hours/day, while it is being used in active search mode. The reader is referred to the details given in the DEIS (US Navy 2005) for further characterization of the sound sources levels and frequencies to be used. These sound levels will attenuate as the sound propagates from the sonar sound source, but will still be significantly above background ocean sound levels likely to occur at the site (55 – 120 dB re 1 µPa, see Luczkovich et al 1999a,b for background levels at inlet locations on Pamlico Sound). The US Navy modeled the attenuation of sonar sound source levels out to 1000 m and determined that it would drop by 55 dB from the sound source at this distance (US Navy 2005, Figure 4.3-10), or approximately 180 dB re 1 re 1 µPa). This received sound level is significantly greater than the levels of sound produced by the fishes themselves (e.g. silver perch *Bairdiella chrysoura*, a member of the drumfish family Sciaenidae, produces sounds of 128-135 dB, Sprague and Luczkovich 2004). The sounds produced by this fish are at the low end of the frequency range proposed by the Navy for sonar use (1000 Hz), so there will be some possible masking effects. Masking occurs when one sound (in this case the sonar) is louder than a second sound of importance to the receiver (in this case another fish drumming or calling). Some of these fish can also hear the sounds in the low end of the Navy sonar frequency range (Ramcharitar et al. 2004), so their ability to hear sounds may be affected as well. Sciaenid fishes with similar to the silver perch, with similar hearing and sound-producing capabilities, occur at the proposed sonar site. The depths of water in the proposed sonar range off NC are 36-402 m (120 – 1,319 ft), so these sounds could reach fishes at the bottom or throughout the water column at levels in excess background sounds as well as their own sounds.

We have divided our comments into a few possible impacts that should be considered by the US Navy and various regulatory agencies (NC Fisheries Commission, NC Division of Marine Fisheries, US National Marine Fisheries Service and NOAA). There are a few major impacts that must be considered:

1) *Direct mortality* – sounds if loud enough and at low frequency could cause a loss of equilibrium and death in fishes. Little work has been done on fishes exposed to the levels of sound the US Navy is proposing to use, so the direct impacts are not well known.

2) *Hearing loss* – damage to sensory hairs in ears of fishes similar to what occurs in seismic surveys using air guns (see McCauley et al 2003, Popper, et al. 2005). While previous studies focused on the affect of impulsive sounds, more work should be done on this topic.

3) *Behavioral avoidance* - active mid-frequency sonars could cause fishes to leave the area. Such behavioral avoidance been observed to occur with bottlenose dolphins hunting for silver perch (Luczkovich et al 2000), and is likely to occur with the mid-frequency sonars (1-13 kHz), which are in the same frequency range of dolphin signature whistles (4000-6000 Hz) to which the silver perch responded during playback experiments. Avoidance could lead to reduced fish catches. A previous study examined the effect of avoidance caused by sound from gun seismic surveys, which are louder (250 dB re 1 re 1 μPa) and have lower frequency content than sonars, and found a decline in catch rates of cod and haddock (Engas et al. 1996).

4) *Dredging impacts* – a long trench will be dredged for a trunk line for the hydrophone array, which will disrupt benthic processes and affect essential fish habitat in live bottom areas on the continental shelf. A related comment by Mike Street (NC Division of Marine Fisheries) made at the public meeting in Morehead City, NC and his written comments (just forwarded to us today) suggests that the areas of live bottom reef have not been adequately surveyed in the proposed area. Additionally, Dr. Robert George, of the George Institute of Biodiversity and Sustainability and a former professor of marine biology from University of North Carolina Wilmington, has worked extensively in this area and has expressed his concerns to us over the possible impacts on this deep water reef ecosystem. He will be submitting comments to your office on this ecosystem as well.

5) *Expendable equipment impacts* - Pollution from discarded batteries, XBTs, sonobuoys, etc., will be left behind in the environment, slowing releasing toxic metals. These waste products should be minimized during operations and a clean up plan should be instituted as well, as they may have a long-term impact on the marine environment and exhibit bioaccumulation in the food web, contaminating fishes caught in the area.

Behavioral Avoidance

While all of these impacts noted above are important, and some are addressed directly in the US navy's DEIS, impact (3), the issue of behavioral avoidance of fishes in the area of the sonar range is of greatest concern to us, and this was given little or no attention in the DEIS. We will confine the remainder of our comments to this impact, as we are most familiar with the literature and impacts on the bioacoustics of fishes.

We have worked extensively on marine acoustics surveys. We have completed passive acoustic surveys in Pamlico Sound and on remote coral reefs to monitor fishes in the drum and croaker family (Sciaenidae) as well as other species of fishes and invertebrates (Luczkovich et al 1999a, 1999b, 2000; Luczkovich and Sprague 2002,

2003; Sprague et al 2000, Sprague and Luczkovich 2001, 2004). Based on our experience in these bioacoustic surveys, we have become aware that fishes are also quite sensitive to variations in the marine acoustic environment, many of them producing sounds and receiving sounds produced by other fishes, invertebrates, and mammals.

Fishes use the marine acoustic environment for detecting predators and finding prey and attracting mates, so they must also be considered as species that will be impacted by the US Navy's anthropogenic noises, both from ships and sonars. A preliminary list of species occurring along the continental shelf in NC waters in the live bottom reef areas nears the proposed area are shown in Table 1. Note that there are many other species not shown in this list based on SCUBA surveys that are likely to occur in the proposed sonar range. This might include surface pelagic species (like billfish, marlins, sailfish, mackerels, and tunas) and deep-sea macrouids (grenadiers) that are also sound producers and that serve as food sources for beaked whales (Mann and Jarvis 2004). The US Navy's DEIS is deficient in considering the acoustic impacts on these fishes, especially on their behavioral responses. ***To our knowledge, no behavioral or physiological response data have been measured for any of these marine fish species exposed to acoustic levels (received source levels) that will occur in the area proposed by the US Navy. No sound production surveys have been done to locate naturally sound producing fishes. No baseline studies on fish species diversity or abundance has been done, nor any food web studies.*** Since whales and dolphins hunt for fishes using active and passive sonar themselves, the sources of sound produced by fishes is an important characteristic of these marine mammal's habitats that has not been considered. How will the Navy's sonar use affect fish sound production levels and how will this affect whales hunting for food? What will be the ecosystem-wide impacts on fishes and whales, which play an important part of the food web in that area and use acoustic means for prey detection and avoidance? These questions do not have answers currently and are ignored in the US Navy's DEIS.

We suspect that there will be significant acoustic impacts on fishes if the US Navy begins sonar operations in the proposed area off NC. There may be physiological impacts to long-term exposure to loud anthropogenic sounds, as has been documented by MacCauley et al. (2003) and Popper et al (2005). The US Navy's DEIS says that these effects will not be biologically significant, but this is debatable, because no studies have been done on these fishes, some of which are sound-producers and hearing specialists. We expect behavioral avoidance responses to occur (Luczkovich et al 2000), for these responses to be large and for there to be a decline in catches from nearby fisheries, as has been observed in other studies where acoustics sources have been used for long periods (Engas et al 1996). The US Navy provides no studies to show that there will not be avoidance effects, except for a few studies on salmonids, species which do not occur in the area. Be aware that these types of impacts will be likely to occur if the US Navy chooses other alternative sites of Virginia and Florida, as some of the same species occur. So, the US Navy's DEIS is not sufficient with regards to behavioral avoidance effects on fishes likely to occur in the proposed sonar area.

Conclusion

The US Navy's DEIS is inadequate in that it ignores potential impacts on fishes and fisheries likely to occur in the proposed range. It ignores or attributes minimal impacts to behavioral avoidance by fishes, which is a major omission, in our opinion. This avoidance response will have major effects on whales and dolphins and fish species at the top of the food web. Since humans fish for species that may be affected, including tunas, billfish, mackerels, grunts, porgies, groupers and sea bass, those fisheries will be affected by these behavioral avoidance and physiological effects. This may translate into a loss of income or fishing opportunities for commercial and recreational fishers.

Table 1. Fishes that are sound-producers and that are likely to occur in the proposed sonar range (Taken from a list of species observed during visual SCUBA surveys at nearby sites, see http://core.ecu.edu/biol/nortons/NCFishes)

Family and Common Names	**Scientific names**
Porgies	Sparidae
Pinfish	*Lagodon rhomboides*
Spottail pinfish	*Diplodus holbrooki*
Sheepshead	*Archosargus probatocephalus*
Red porgy	*Pagrus pagrus*
Knobbed porgy	*Calamus nodosus*
Damselfishes	Pomacentridae
Beaugregory -	*Stegastes dorsopunicans*
Dusky damselfish	*Stegastes leucostictus*
Bicolor damselfish	*Stegastes partitus*
Cocoa damselfish	*Stegastes variabilis*
Drumfishes	Sciaenidae
High-hat	*Equetus acuminatus*
Cubbyu	*Equetus umbrosus*
Banded drum	*Larimus faciatus*
Grunts	Haemulidae
White grunt	*Haemulon plumieri*
Toadfishes	Batracoididae
Oyster toadfish	*Opsanus tau*
Seabass and Groupers	Serranidae
Bank sea bass	*Centropristis ocyurus*
Black sea bass	*Centropristis striata*
Speckled hind	*Epinephelus drummondhayi*
Gag	*Mycteroperca microlepis*
Scamp	*Myteroperca phenax*
Wrasses	Labridae
Spotfin hogfish	*Bodianus pulchellus*
Spanish hogfish	*Bodianus rufus*
Jacks	Carangidae
Bar jack	*Caranx ruber*
Crevalle jack	*Caranx hippos*
Greater amberjack	*Seriola dumerili*

Specific comments on the DEIS (US Navy 2005):

Page 12 in PDF, S-9 in document
Why was it assumed that there were no behavioral effects on fishes? There are clear examples of fishes that are affected by sound production in the range 1 kHz to 10 Khz, which is the range anticipated to be used by the Navy in the USWTR. Silver Perch, *Bairdiella chrysoura*, mating choruses are affected by playbacks of bottlenose dolphin sounds in 4-6 kHz range, at 145 dB re 1 micro Pa.. See: Luczkovich et al. 2000. Bioacoustics 11: 323-334. Navy sonars, which will be louder than this level, could produce a similar "acoustical avoidance" effect in other fishes at the USWTR.

Page 14 in PDF, S-11 in document
Sound producing and hearing specialist fishes that occur in the study area A (see Table 1 in this paper; these include various porgies (Sparidae), damselfish (Pomacentridae), grunts (Haemulidea), snappers (Lutjanidae), groupers (Serranidae), jacks (Carangidae), drumfish (Sciaenidae), and herrings (Clupeidae) that will be affected by sounds from the active sonars at sound pressure levels > 190 dB re 1 micro Pa received EL, because they may experience behavioral disturbance, reduced mating, increased predation and harassment.

Page 15 in PDF, S-12 in document
Right whales occur in NC waters as well as off VA. Why were these not considered in Site A? Later in Section Subchapter 3.3.2.4., I see that they were considered, and it was stated that they "may occur" at Site A, but this was not mentioned here in the Executive Summary.

Page 18 in PDF, S-15 in document
What about the acoustic effects on essential fish habitat? Sound production by drums and croakers and groupers are associated with spawning, which means such areas are by definition Essential Fish Habitats. Has the Navy considered the impact of sound on fish spawning activities in the USWTR?

Page 191 in PDF, 3.3-4 in document
The US Navy should have cited our paper here: Luczkovich et al. 2000. Sounds of sex and death in the sea: bottlenose dolphin whistles suppress mating choruses of silver perch. Bioacoustics 11: 323-334. Mid-frequency sonars (which are similar to bottlenose dolphins and their signature whistle playbacks, 4-6 kHz at 145 dB re 1 microPa) can affect silver perch behavior, causing their spawning chorus to become diminished by 9 dB. We termed this "acoustical avoidance" of the silver perch, due to bottlenose dolphins that were hunting for prey. Silver perch are a significant part of the dolphin's diet.

Page 327 in PDF, 4.3-34 in document
What is the frequency of the DICASS sonobuoys? Source levels are high at 201 dB. I am not sure why this is considered "not problematic". Apparently, this is not classified information, as is the case for MK30 and Mk39 targets.

Page 342 in PDF, 4.3-45 in document
Banded drum are a sound-producing species of fish, like other sciaenids. Humpback whales are likely to have found them because of their sound production, as was the case with our silver perch being hunted by bottlenose dolphins (Luczkovich et al 2000). It seems likely that "acoustical interference" may occur with humpback whales and banded drum. The mating behavior of these fish may be affected by whale and Navy sonars as well. There is no justification in the literature for assuming that the whales only feed in shallow water, outside the USWTR.

Page 372 in PDF, 4.3-75 in document
Our study published recently (Sprague and Luczkovich, 2004 JASA 116(5):3186-3191) states that the source level for a calling silver perch is 128-135 dB re 1 µPa; this sound from a helicopter could interfere with or mask the silver perch and other Sciaenidae mating calls (red drums, banded drum) and interfere with whale foraging for these fishes near the surface. However, it is unlikely that this would be an issue at the depths of the USWTR site A, due to the attenuation of sound in water

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Page 374 in PDF, 4.3-77 in document
No consideration has been given here to the sublethal behavioral responses of fishes to mid-frequency sonars. Fish in the Sciaenidae are likely to avoid the sonars and USWTR, causing diminished mating choruses from the males (Luczkovich et al . 2000); females may be unable to locate their chorusing males, resulting in lowered production of offspring. Further, whales and dolphins may be affected as they appear to hunt and locate soniferous fishes such as drums (Sciaenidae) using low-frequency passive acoustic methods (listening for prey fish). Acoustically mediated predator-prey and mating interactions are likely to be affected by Navy sonars.

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