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FINAL REPORT

EASTERN SHORE OF VIRGINIA NATIONAL WILDLIFE REFUGE SMALL FIREARMS RANGE ASSESSMENT

Regional Study ID: **5N32**

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Submitted by:

Sumalee Hoskin
Cindy Kane

For:

Karen Mayne
Virginia Field Office Supervisor

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ABSTRACT

The Eastern Shore of Virginia National Wildlife Refuge (Refuge) is located on the southern-most tip of the Delmarva Peninsula in Northampton County, Virginia. It consists of a variety of habitats including maritime forest, grasslands, fresh and brackish ponds, tidal salt marsh, and beach. The Refuge is considered "one of the most important avian funnels along the east coast" (Bright and Sagan, 1987); it provides outstanding foraging and sheltering habitat for migrating avian species and productive nursery grounds for fish. In 2001, the Refuge purchased 375 acres of salt marsh down range of the Northampton County small firearms range. The firing range, a two acre in-holding within the Refuge, was formerly owned by the Department of Defense and is presumed to have been active since the 1930s. In this study, we investigated contaminant levels in soils and sediments in the marsh down range of the firing range and along the Virginia Inside Passage to assess whether contaminants are present at levels that would pose an ecological threat. Samples were also collected from the marsh for lead shot or bullet density determination to assess whether lead ingestion would pose a threat to birds or other biota. Lead shot or bullets were not found in any sediment samples. Only one sample, from the marsh, exceeded the lead Effects Range Low (ERL) level, but it was below the Effects Range Median (ERM) and Probable Effect Levels (PEL). Arsenic was above the ERL level in seven of the eight marsh samples but did not approach either ERM or PEL levels. Nickel was above the ERL level in two of the eight marsh samples, but was below the ERM and PEL values. Five organic compounds - acenaphthene, anthracene, dieldrin, DDE, and total PCBs - were detected above their ERL levels. Only two of those analytes, dieldrin and DDE, were above their ERM levels. Of the two samples in which dieldrin was above the ERL, only one was above the PEL. The DDE level was above the ERM level in one marsh sample. This study indicates the soil and sediment pose no threat to wildlife from lead or other contaminants levels and there is no risk of lead poisoning to wildlife via ingestion. The few cases in which contaminant levels were elevated are localized and do not pose a widespread threat to biota. The ERL is a conservative level and although some levels were higher than the ERL, the risk those levels pose to wildlife is negligible.

PREFACE

This report summarizes soil and sediment contaminant results collected in the marsh down range of the small firing range and the Virginia Inside Passage located on the Eastern Shore NWR, Northampton County, Virginia. Questions, comments, suggestions, and data requests related to this report are encouraged. Written inquiries should refer to Regional Study ID: 5N32 and be directed to:

Sumalee Hoskin
U.S. Fish and Wildlife Service
6669 Short Lane
Gloucester, VA 23061
sumalee_hoskin@fws.gov

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Eastern Shore of Virginia Refuge staff provided us access to the boat ramp and a boat for sample collection. Many thanks to Robert Carpenter for his help operating the boat.

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ERL	Effects Range-Low
ERM	Effects Range-Median
PEL	Probable Effects Level

I. INTRODUCTION

A. Background and Justification

The Eastern Shore of Virginia National Wildlife Refuge is located at the southern tip of the Delmarva Peninsula in Northampton County, Virginia. It was established to: 1) conserve, manage and enhance the habitat for use by migratory birds, endangered and threatened species, and other species of fish and wildlife; 2) encourage natural diversity of habitat and associated fish and wildlife species; 3) fulfill the international treaty obligations of the United States relating to fish and wildlife; and 4) provide fish and wildlife-oriented recreation and education. The tidal marsh community is composed predominantly of *Spartina patens, Spartina alterniflora,* and *Scirpus spp*., benthic invertebrates, which provide a rich food source for foraging avian species, and small mammals. The tidal marsh supports a diversity of finfishes and provides nursery habitat. Richard and Castagna (1970) recorded seventy species of fish during their survey from the seaside of the Eastern Shore of Virginia. Cowan and Birdsong (1985) sampled larval and juvenile fish along the seaside bays of Virginia's Eastern Shore. They collected 19 fish species in their larval survey, primarily anchovies (*Engraulidae*) and silversides (*Atherinidae*) and 28 species in their juvenile survey, primarily drums (*Sciaenidae).* They described the area as follows, ". . . This study demonstrates the importance of Virginia's seaside estuaries as nursery areas for juvenile sciaenides, as well as for other fishes." A diversity of migratory bird species, including, but not limited to rails, raptors, herons, egrets, shorebirds, waterfowl, and neotropical migrants utilize this habitat (U.S. Fish and Wildlife Service 2004). In the fall of 1997, a volunteer banded 805 raptors and 4,626 songbirds of 83 species over the course of 65 days of work. At Kiptopeke State Park, three miles north of the Refuge, 60,000 raptor sightings were counted between August 23, 1997 and November 30, 1997; of these 363 were bald eagles (*Haliaeetus leucocephalus*, federally listed threatened). Bright and Sagan (1987) described the area as follows: ". . . the Eastern Shore constitutes one of the most important avian 'funnels' along the east coast of North America. Migratory birds streaming south from northern nesting areas tend to concentrate first on Cape May, New Jersey then leap Delaware Bay, only to be constricted again between the Atlantic and the Chesapeake Bay on the Delmarva Peninsula, and finally at the peninsula's tip, Virginia's Eastern Shore." In general, the Refuge and vicinity provide outstanding foraging and sheltering habitat for migrating avian species and a productive fish nursery habitat.

On December 26, 2001, the U.S. Fish and Wildlife Service (Service), Eastern Shore of Virginia National Wildlife Refuge (Refuge) purchased 375 acres of salt marsh down range of the Northampton County small firearms range. The firing range, a two acre in-holding within the Refuge, was formerly owned by the Department of Defense and is presumed to have been active since the 1930s. The original berm is estimated to have been six feet high. It is unknown when the berm was erected. In the early 1990s, the berm was raised to approximately 15 feet high and 40 feet thick. Storm water from the firearms range drains by a 12 inch culvert into a 400 foot long ditch and into a county, private, and Refuge-owned tidal marsh. In December 1997, Roy F. Weston, Inc. (Weston), under contract to the U.S. Environmental Protection Agency (EPA), conducted preliminary contaminant sampling at this former military base. Sample locations included one sample from the firing range, one from the ditch draining the range, and one from a reference area. Weston (1998) reported a p,p'-DDE level an (organochlorine pesticide) of 0.014 parts per million, mg/kg), which exceeded the screening values established by Long and Morgan (1990) for adverse effects to biota. Heavy metals such as antimony, copper, and lead were also detected in the berm at levels exceeding the screening values of Long and Morgan (1990) for adverse biological effects. An investigation of environmental contaminant levels in soils and sediments in the tidal marsh was not undertaken in the preliminary sampling conducted by Weston. This represented a significant data gap in an evaluation of threats to biotic resources. Given the original height of the berm, and the variety of firearms that may have been used in the early years of the range's existence, there may have been lead ammunition fallout in the marsh beyond the berm. Explosive devices have not been used, and range use has been limited to firearms.

B. Firing Ranges

For many years, the Service has been concerned about the effects to wildlife from spent lead pellets. Both lethal and sublethal effects to wildlife from lead pellets and dissolved lead are well documented (Stansley and Roscoe 1996; Kendall et al. 1996; Pain 1992; and Ma 1989). Under normal aerobic conditions in the aquatic environment, oxidized lead will release from lead pellets into water and sediments, where it becomes available to benthic organisms, as well as other wildlife (Jorgensen and Willems 1987). Available lead can cause toxic effects in plants and invertebrates living in contaminated media (Eisler 1988). Effects to the immune system, migration retardation, and lead-induced starvation are among the documented effects to wildlife. For waterfowl, lead poisoning through the ingestion of spent shot is a well recognized mortality factor (Sanderson 2002; Sanderson and Bellrose 1986). In addition to direct ingestion of spent shot, predatory animals may ingest shot while preying on exposed or poisoned animals or carcasses. In a four year study conducted by Rocke et al. (1997), mortality from lead poisoning in mallards using freshwater marshes subjected to hunting was documented at significantly higher rates than non-hunted habitats. As little as one #4 lead shot can cause mortality to some duck species (Pain and Rattner 1988). Spent lead shot can accumulate in soils and sediments as a result of firing range activities. Spent shot densities at shooting ranges can exceed those shot densities documented in hunted areas by several orders of magnitude (Roscoe et. al. 1989). Typically, the composition of lead ammunition is comprised of more than lead. The seven following elements are found in most lead ammunitions: arsenic, antimony, bismuth, cadmium, copper, silver and tin (Koons and Grant 2002). Therefore, when lead ammunitions decompose, these elements are introduced into the environment.

C. Organochlorine Pesticides

The effects of organochlorine pesticides, in particular DDT, the parent compound of DDE, in the environment are well documented. Blus (1995) presents comprehensive coverage of the persistence, bioaccumulative properties, and toxicity to both aquatic and terrestrial wildlife. The DDE concentration (0.014 mg/kg) Weston (1998) reported from the ditch sediment was above the Effects Range-Low (0.002 mg/kg) screening value, and approached the Effects Range-Median (0.027 mg/kg) value, for adverse effects to benthic biota (Long and Morgan 1990; Long et al. 1995, respectively). The Effects Range-Low (ERL) and Effects Range-Median (ERM) are screening values originally presented by Long and Morgan (1990) in which the lower 10 percentile and median percentile chemical concentrations were identified with adverse biological effects, such as mortality, reduced growth, inhibited reproduction, mutagenicity and teratogenity.

D. Study Objectives

The objectives of this study are to evaluate the levels of lead and other inorganic and organic contaminants in sediments down range of the small firearms range and determine whether such levels represent a risk to the biota on or near the Eastern Shore of Virginia National Wildlife Refuge.

II. METHODS

A. Sampling Collection

Sample sites were located in the marsh ranging from approximately 120 to 280 meters beyond the small firearms range and at four locations along the Virginia Inside Passage; approximately 400 meters beyond the firearms range (Figure 1). Sample locations were recorded using a Garmin76 global positioning system. Eight samples were collected from the marsh for bullet density determination. Following Vyas et al. (2000), one square foot density sample plots were taken at an ecologically relevant depth of three inches and placed in separate plastic bags. The samples were wet sieved through USA Standard #5, #8, #10, and #12 sieves to collect lead shot or bullets. Lead shot and bullets were then counted.

Eight sediment samples were collected from the marsh beyond the small firearms range and four were collected from the Virginia Inside Passage near the boat ramp, to the southwest of the firing range. Samples for chemical analysis were collected from the top three inches of the sediment using a chemically cleaned stainless steel trowel, placed in a pre-cleaned glass jar, and placed on ice.

B. Contaminant Analysis

Samples were analyzed for inorganics: aluminum (Al), arsenic (As), boron (B), barium (Ba), beryllium (Be), calcium (Ca), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), potassium (K), magnesium (Mg), manganese (Mn), molybdenum (Mo), sodium (Na), nickel (Ni), lead (Pb), selenium (Se), strontium (Sr), vanadium (V), zinc (Zn), and phosphorus (P). Samples were also analyzed for total organic carbon (TOC), grain size, organochlorines, polychlorinated biphenyls (PCBs), and aromatic hydrocarbons. The Trace Element Research Laboratory (TERL) at the Texas A&M Research Foundation (College Station, TX) performed the inorganic analysis. The Service's Patuxent Analytical Control Facility (PACF) contract laboratory, Geochemical and Environmental Research Group (GERG) at Texas A&M University, College Station, Texas, performed the organic analysis. Inorganics were analyzed using inductively coupled plasma optical emission spectroscopy (ICP), atomic fluorescence spectroscopy (AFS), inductively coupled plasma-mass spectroscopy (ICP-MS), or cold-vapor atomic absorption spectroscopy (CVAAS), depending on the analyte. Organics were analyzed using a capillary gas chromatography (CGC) with a flame ionization detector for pesticides and PCBs, and a mass spectrometer detector for aromatic hydrocarbons. The Service requested the laboratory remove all visible lead shot or bullets prior to analysis.

The required number of procedural blanks, standard reference samples, duplicates, and spiked recovery samples were run. Quality assurance and quality control (QA/QC) procedures followed PACF standards. The inorganic duplicates were run on sample 08020201, and spiked recovery was run on sample 08070206. The QA/QCs for organics were run on sample number 08020201. The blank had measurable concentrations of fourteen analytes, deemed insignificant.

Contaminant concentrations were reported by the laboratory as milligrams per kilogram (mg/kg), wet weight and dry weight. For analyte results and limits of detection (mg/kg, dry weight (dw) for metals and dry weight (dw) for organics), see Appendix A.

C. Evaluation of Chemical Analysis

Laboratory results were compared to the National Oceanographic and Atmospheric Administration's Screening Quick Reference Table (SQuiRT; Buchman 1999) benchmarks for ecological effects. The benchmarks are derived from a database compiled from numerous ecological studies. ERL is the lower end of the range at which biological affects might be evidenced in sensitive organisms. The ERL is set at the level in which 10 percent of studies observed effects. ERL is considered a conservative screening level. In general, levels that fall below the ERL are not considered to be of environmental concern. The ERM for a substance is the level in which 50 percent of the database reported adverse effects, values above which adverse effects frequently occur. Concentrations that exceed the ERLs and ERMs have a higher potential for adverse effects. An additional benchmark used for ecological risk screening is the Probable Effects Levels (PEL). The PEL is based on similar data as the ERL and ERM values but is derived using a different calculation. It is the level above which adverse ecological effects are expected. The PEL is the geometric mean of the 50 percent of impacted, toxic samples, and the 85 percent of the non-impacted samples. Because the PEL is derived differently than the ERM and ERL, the three values do not necessarily rank in descending order. These benchmark values were derived based on a rigorous review of published literature and are used by EPA's Biological Technical Assistance Group (BTAG) when assessing ecological risk at Superfund sites.

Results are evaluated for analytes detected at or above the ERL at one or more sample locations. Analytes for which greater than 50 percent of the results were above the detection limit are summarized by percent detected, range, and geometric mean. Results below the limit of detection are substituted at one half the detection limit for calculation of the geometric mean. Analytes for which greater than or equal to 50 percent of the results were below detection are reported as percent detected. All results are reported in dry weight (mg/kg).

III. RESULTS

A. Quality Assurance/Quality Control

The inorganic blank had measurable, but insignificant concentrations of iron and magnesium. The variability of copper in the duplicate sample was slightly high and the recovery of manganese from the spiked sediment was slightly high. Both results were deemed insignificant to the interpretation of the data. The inorganic QA/QC data was reviewed by John Moore of PACF. The organic duplicates and spiked recovery results were within acceptable ranges with 15 exceptions; six duplicates were high and nine spike recoveries were low. Those results should have no effect on data interpretation; the data passed the PACF QA/QC review. The organic review was conducted by Brenda Montgomery of PACF.

Table 1 presents the results of lead pellet counts and arsenic, nickel and lead levels. Table 2 presents results of Total Organic Carbon analysis and the grain size. Table 3 presents the organic chemical analysis. For raw data, see Appendix A.

B. Inorganics

Lead shot and bullets were not found in any of the density samples. Table 1 shows the results of the lead bullet count and the metals levels in which at least one sample was above the ERL. Lead was detected in 100 percent of the samples. Total lead concentrations ranged from 0.82 to 57.7 mg/kg, with a mean of 19.42 mg/kg. One sample location (08070207) was above (57.7 mg/kg) the ERL screening level of 46.7 mg/kg, but well below the PEL (112.2 mg/kg) and the ERM (218 mg/kg) levels at which adverse ecological effects would be expected. The samples from the Virginia Inside Passage did not have lead levels above the ERL, although lead was detected.

Arsenic was detected in 100 percent of the samples. Total arsenic concentrations ranged from 1.76 to 23.8 mg/kg (Table 1), with a mean of 11.31 mg/kg. Seven of the 12 samples were above the ERL value of 8.2 mg/kg. All of the elevated samples were from the marsh. The only marsh sample that was not above the ERL was 08070204; arsenic at that site was 7.38 mg/kg. No sites approached the ERM (70 mg/kg) or the PEL (41.6 mg/kg) values. The Virginia Inside Passage samples did not have arsenic levels above the ERL, although arsenic was detected.

Nickel was detected at 100 percent of the sample locations. Nickel concentrations ranged from 1.48 to 27.2 mg/kg (Table 1), with a mean of 11.71 mg/kg. Marsh sample sites 08070203 and 08070205 were above the ERL value of 20.9 mg/kg, 26.3 mg/kg and 27.2 mg/kg, respectively. Nickel levels at both sites were well below the PEL (42.8 mg/kg) and the ERM (51.6 mg/kg). The Virginia Inside Passage samples did not have nickel levels above the ERL, although nickel was detected.

Table 2 presents the TOC and grain size analysis results. TOC ranged from 0.1 to 13.4 %, with an average of 5.87 %. On average, grain size consisted of 30.2 % clay (1.8 % – 52.8 %), 42.7 % sand (7.9 % - 97.8 %), and 27.1 % silt (0.4 % - 54.2 %).

C. Organics

Five compounds - acenaphthene, anthracene, dieldrin, DDE, and total PCBs - were detected at levels above their ERL values (Table 3). Only two of those analytes, dieldrin and DDE, were above their ERM levels. Of the four samples in which dieldrin was above the ERL – 08070202, 08070206, 08070207, and 08070208- only one was above the PEL, 08070202.

Aromatic hydrocarbons

Acenaphthene, anthracene, and dieldrin were not detected above the detection limit in greater than 50 percent of the samples therefore, summary statistics were not calculated. Acenaphthene was detected in 42 percent (5) of the samples, one from the Virginia Inside Passage and four from the marsh. The only site in which acenaphthene was detected above the ERL of 0.016 mg/kg was marsh sample site 08070202 (0.019 mg/kg), the ERM (0.5 mg/kg) and the PEL (0.0889 mg/kg) were not exceeded. Anthracene was detected in 42 percent (5) of the samples, two from the waterway and three from the marsh. The only site in which anthracene was detected above the ERL (0.0853 mg/kg) was from the Virginia Inside Passage, site 08020204, at 0.103 mg/kg, but the ERM (1.1 mg/kg) and the PEL (0.245 mg/kg) were not exceeded.

Organochlorine pesticides

Dieldrin was detected in 33 percent (4) of the samples at levels above the ERL (0.00002 mg/kg), all from the marsh. All of the sites in which dieldrin was detected were above the ERL value. Sites in which dieldrin was detected were: 08070202 (0.0045 mg/kg), 08070206 (0.0042 mg/kg), 08070207 (0.0141 mg/kg), and 08070208 (0.0031 mg/kg). Sample 08070207 was above the ERM (0.008 mg/kg) and two samples, 08070202, and 08070207, were above the PEL (0.0043 mg/kg).

DDE was detected in 75 percent (9) of the samples, ranging from 0.000144 - 0.0055 mg/kg with a mean of 0.00061 mg/kg. Two sites, 08070205 (0.0055 mg/kg) and 08070207 (0.0022 mg/kg), were above the ERL (0.0227 mg/kg). One site, 08070205, was above the ERM (0.027 mg/kg), but below the PEL (0.374 mg/kg). Two sites where DDE was detected were from the waterway and seven from the marsh. Both samples that were above the ERL were collected from the marsh.

Polychlorinated biphenyls

PCBs were detected in 100 percent of the samples, ranging from 0.0037 mg/kg - 0.147 mg/kg with a mean of 0.034 mg/kg. All of the marsh samples were above the ERL (0.0227 mg/kg), but did not exceed the ERM (0.18 mg/kg) or the PEL (0.189 mg/kg), although two samples approached those values [(08070208 (0.147 mg/kg) and 08070202 (0.126 mg/kg)].

IV. DISCUSSION

A. Inorganics

The results of this study do not provide evidence that lead is present at levels in the Refuge marsh or the Virginia Inside Passage that would cause widespread adverse, ecological effects. The berm in the firearms range and the ditch were not sampled because Northampton County did not grant the Service permission to access County land. Without sampling the berm, the County land behind the berm, and the drainage ditch, we cannot determine if a lead gradient exists from the firing range out to the marsh. The highest lead levels from this study were along the tree line at sites 08070207 (57.7 mg/kg) and 08070202 (44.2 mg/kg), which could indicate the beginning of a gradient. Weston (1998) reported a lead level of 9900 mg/kg in the berm and 49.2 mg/kg in the drainage ditch that leads to the marsh. These levels support the idea of a lead gradient from the firing range to the marsh. It is unclear whether the lead levels are from a recent release, such as the drainage ditch, or from a historical release, before the berm was raised. The Weston study also reported lead concentrations of 9.2 mg/kg and 13.8 mg/kg from sediment samples taken at two marsh sites southwest of this study's sampling area. The lead level from the Weston reference sample was 39.8 mg/kg, below the ERL. The samples analyzed by Weston indicated low levels of lead in the sediment in areas outside of the influence of the firing range, which could be due to some unknown previous activities. Ecological risk from lead in the marsh ecosystem is minimal because only one sample was above the ERL value and it was well below the PEL value. Lead pellets or bullets were not found in the samples and the risk to birds (waterfowl, wading birds and birds of the marsh habitat) therefore is considered negligible for the area sampled.

All of the arsenic levels in the 1998 Weston study were below the ERL value of 8.2 mg/kg. The Weston (1998) study reported a reference level of 2.2 mg/kg, a berm level of 3.8 mg/kg, and a drainage ditch level of 1.1 mg/kg. In addition, the sediment samples Weston collected to the southwest of this study's sampling area had arsenic levels of 0.8 mg/kg and 6.0 mg/kg. In contrast, this study detected arsenic at all sites, seven of which were above the ERL, and all seven were from the marsh. There appeared to be localized elevated levels, specifically sites 08070201 (21.1 mg/kg), 08070206 (23.8 mg/kg), and 08070207(21.1 mg/kg), which could affect the invertebrate population in the surrounding area. However, these problems are local and would not effect the entire invertebrate population in the marsh. Arsenic does not biomagnify up the food chain (Eisler 1988) so the elevated levels would not be detrimental to any organisms, such as birds, that may rely on the invertebrates as a food source. Also, arsenic is less bioavaliable to plants in fine soils that are high in clay and organic matter because it is less mobile since it is not in the soil solution (NRCC 1978). The clay content in the marsh samples ranged from 33-55 percent and the silt content in these samples ranged from 28-54 percent, making it likely that the marsh plants are not taking up the arsenic and transferring it to higher trophic levels that graze on the plants. The levels do not indicate an obvious migration pathway from the range to the marsh (Figure 2). Although arsenic is one of the seven constituents that comprise lead ammunitions, the relatively low levels in the berm and drainage ditch from the range coupled with the lack of a migratory signal indicate the firing range is not the primary source of arsenic. The arsenic levels could be from naturally occurring levels or past practices, such as pesticide use. The arsenic levels found in the marsh are within the range of background levels from three active military bases in Virginia. Background levels from these bases ranged from 1.8 – 9.7 mg/kg, 0.63 – 4.1 mg/kg, and 0.42 – 25.4 mg/kg at Dahlgren, Cheatham Annex, and Quantico, respectively. A new study would be required to determine the source of arsenic or whether these levels are truly indicative of background levels. However, since none of the elevated arsenic levels from the marsh were above the PEL or the ERM, they do not pose a considerable ecological threat.

Although nickel was detected in all the samples, in general it was not at levels that are a concern. Nickel only exceeded the ERL value at two sites, 08070203 and 08070205. At those sites, levels were far below the PEL, the levels above which adverse effects are frequently expected. Nickel is ubiquitous in the environment and can be introduced through such anthropogenic sources as, fossil fuels, land sludge application and refineries. Background levels from Dahlgren, Cheatham Annex, and Quantico ranged from 26.7 – 34.3 mg/kg, 1.4 – 3.9 mg/kg, and 1.1 – 70.0 mg/kg, respectively. The Weston study reported nickel in the two marsh sites to the southwest of our study site; levels were reported as below 4.0 mg/kg and 16.3 mg/kg. The levels in the berm, drainage ditch, and reference sample were below 4.0 mg/kg, below 4.0 mg/kg, and 20.6 mg/kg, respectively. Based on the levels Weston reported in the berm and drainage ditch, in conjunction with the nickel levels in the marsh sample, it does not appear that the firing range is a source of nickel. Since nickel levels in the marsh and Virginia Inside Passage are below levels in which adverse effects occur, and nickel does not biomagnify, current levels are not likely to pose an ecological threat.

B. Organics

There was no discernable pattern for the levels of acenaphthene, anthracene, dieldrin, and DDE. Acenaphthene and anthracene are two polycyclic aromatic hydrocarbon (PAH) compounds. These compounds are used as insecticides, which may explain their presence in the marsh. Dieldrin is an organochlorine cyclodiene insecticide, used in the 1950s. It is lipophilic and slowly metabolized. After application there is an initial loss of the compound and the remainder will bind to the soil and slowly release. Compounds persist longer in soil that is high in clay or organic matter such as the soils in the marsh. Dieldrin is also a product from the degradation of aldrin, another insecticide. Previous use of aldrin would result in dieldrin in the environment. DDE is a metabolite of DDT, and is a persistent organochlorine. It is metabolized more slowly than dieldrin and has a longer biological half-life. Because none of the elevated levels approached the PEL value, the likelihood that the DDE levels in the marsh pose an ecological threat is small.

The Weston (1998) sampling did not report any PCBs in the berm, ditch, reference sample, or samples in adjacent marshes. The lack of PCBs in the berm or drainage ditch indicates the firing range is not a source of PCBs. Yet, all of the marsh samples in our study had PCB levels higher than the ERL. PCBs may have been introduced into the marsh from insecticide spraying over the marsh. PCBs were used in the 1950s and 1960s as an additive in insecticides, such as aldrin and dieldrin, to extend their residual life and enhance their efficiency. PCBs accumulate in fatty tissue and do not biodegrade readily, and will biomagnify. Newell and Wall (1998) studied the effects of PCBs on the fungal decomposers of saltmarsh grasses. The fungal decomposers are one of the first steps in the saltmarsh food chain. The organic mass fungal decomposers produce is used by marsh invertebrates and continues up the food chain. Newell and Wall (1998) studied the PCB levels in three marshes which they categorized as highly polluted, moderately polluted, and unpolluted. Mean PCB levels in the marsh were 53 mg/kg, 0.3 mg/kg and 5 ppb, respectively. Total PCB levels in our sample fall below the levels Newell and Wall (1988) classified as highly and moderately polluted in their study. They reported no evidence of negative impacts to the fungi in response to PCB levels. These findings suggest it is unlikely there are site specific impacts to the marsh in our study from PCB levels we detected. In addition, all of the PCB levels detected in the marsh were below the PEL.

The physical composition of sediments such as grain size and TOC differed depending on the area. Samples from the Virginia Inside Passage were predominantly sand with low levels of TOCs. Of those samples, the one with the lowest percent sand, 08070201, was still comprised of over half sand (75.9 %). Alternatively, of the marsh samples, the highest percent sand was 13.4 percent from sample 08070202. In general, marsh samples were an equal mix of silt and clay. Contaminant levels are affected by the physical composition of the substrate. Substrates that consist of course grains, like sand do not readily retain contaminants. Substrates that are high in organic carbon levels and fine grains are more likely to accumulate contaminants (Forstner 1990). Sample results reflected this trend. Only one sample from the Virginia Inside Passage, 08020204, had an elevated level of one analyte, anthracene, above the ERL. The remaining contaminants were reported from samples taken from the marsh, where silt and clay were more predominant.

V. CONCLUSION

The results of the samples collected from this study indicate there is not a threat to wildlife from lead or other contaminants leaching from the small firearms range. Lead bullets or lead shot were not found in any of the samples; therefore there is no risk of lead poisoning to birds and other biota via ingestion. Only one sample resulted in a lead level that was higher than the conservative ERL benchmark, but it was well below the PEL and does not constitute a significant ecological risk. Arsenic and nickel levels also do not pose an ecological risk. The few cases in which contaminant levels were elevated are localized and do not pose a widespread threat to biota. Levels of the organic contaminants acenaphthene, anthracene, dieldrin, and DDE were not above the ERL in most of samples and all but one site, 0807202, were below the PEL. The ERL is a conservative level and although some levels were higher than the ERL, the risk those levels pose to wildlife is negligible. At this time there is negilable risk to biota utilizing the marsh. This property will support the Refuge's mission to provide habitat for species along the Eastern Shore of Virginia.

Samples collected along the Virginia Inside Passage did not indicate an ecological threat. The Service understands the Refuge is concerned about allowing recreational fishing or crabbing in the area near the boat ramp. The Service believes contaminant levels are not a concern in regards to recreational fishing or crabbing.

VI. MANAGEMENT RECOMMENDATIONS

- The Service recommends the Refuge continue to foster relationships with Northampton County so the Refuge may help guide the management of the firing range.

- The Refuge should encourage the County to conduct routine maintenance of the berm, which includes periodic removal of contaminated soils. This will serve to reduce the level of contaminants that have the potential to migrate onto Refuge land, and it provides a measure of safety to users of the firing range by minimizing potential of bullets ricocheting off of the berm which, over time becomes saturated with shot, bullets, and fragments.

- Fostering relations between the Refuge and County may lead to the County granting permission to the Service to sample the ditch leading from the range to the marsh. If lead levels in the ditch are exceedingly high, the Service may be able to work with the County to design control structures to minimize surface runoff and leachate from the berm in order to further minimize potential of contaminants reaching the marsh.

- Contact Alex Baron (804-698-4119) of the Virginia Department of Environmental Quality (VA DEQ) if the Refuge is interested in having fish and sediments from waters surrounding the refuge tested for contaminant levels. VA DEQ will conduct testing free of charge and will conduct follow up sampling in a year if they discover elevated contaminant levels. If VA DEQ receives the request by the end of the calendar year they will include the refuge waters in the rotation for the upcoming year.

VII. REFERENCES

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Table 1. Results of the bullet count and inorganic chemical analysis of surface sediment collected from the marsh and the Virginia Inside Passage at the Eastern Shore National Wildlife Refuge, Northampton Co., Virginia, July 2002. Results in bold are above the Effects Range Low values.

Sample	Bullet/Pellet Count	Lead (mg/kg)	Arsenic (mg/kg)	Nickel (mg/kg)
08020201	0	3	3.24	4.85
08020202	0	0.815	1.76	1.48
08020203	0	2.76	2.2	2.93
08020204	0	5.41	4.85	7.33
08070201	0	15.8	**21.1**	18.3
08070202	0	44.2	**15.1**	6.92
08070203	0	20	**10.8**	**26.3**
08070204	0	13	7.38	7.45
08070205	0	20.5	**9.71**	**27.2**
08070206	0	25.3	**23.8**	11.9
08070207	0	**57.7**	**21.1**	10
08070208	0	24.6	**14.7**	15.8
ERL (mg/kg)		46.7	8.2	20.9
ERM (mg/kg)		218	70	51.6
PEL (mg/kg)		112.2	41.6	42.8

Table 2. Results of the total organic carbon and grain size analysis of surface sediment collected from the marsh and the Virginia Inside Passage at the Eastern Shore National Wildlife Refuge, Northampton Co., Virginia, July 2002.

Sample	Total Organic Carbon (mg/kg)	% sand	% silt	% clay
08020201	0.18	89.1	6.1	4.8
08020202	0.1	97.8	0.4	1.8
08020203	0.12	92.9	2	5.1
08020204	0.53	75.9	14.6	9.5
08070201	8.28	14.6	42	43.3
08070202	13.4	13.4	33.8	52.8
08070203	2.81	13.8	48.9	37.2
08070204	11.7	24.2	28.4	47.4
08070205	2.03	7.9	54.2	37.9
08070206	9.43	27.5	31.4	41.2
08070207	11.4	25.1	25.9	49
08070208	10.5	30	37.1	32.9

Table 3. Results of the organic chemical analysis of surface sediment collected from the marsh and the Virginia Inside Passage at the Eastern Shore National Wildlife Refuge, Northampton Co., Virginia, July 2002. Results in bold are above the Effects Range Low (ERL) values.

Sample	Acenaphthene (mg/kg)	Anthracene (mg/kg)	Dieldrin (mg/kg)	DDE (mg/kg)	Total PCBs (mg/kg)
08020201	<0.00409	0.00585	<0.000137	<0.000137	0.00669
08020202	<0.00372	<0.00372	<0.000125	<0.000125	0.00414
08020203	<0.00406	<0.00406	<0.000136	0.000144	0.0037
08020204	0.00787	**0.103**	<0.000148	0.000324	0.02
08070201	<0.00614	<0.00614	<0.000206	<0.000206	**0.0283**
08070202	**0.019**	<0.0176	**0.00454**	0.00169	**0.126**
08070203	0.0147	0.00997	<0.000330	0.00173	**0.0351**
08070204	<0.0154	<0.0154	<0.000513	0.00114	**0.0809**
08070205	0.0113	0.0175	<0.000301	**0.0055**	**0.0761**
08070206	<0.0137	<0.0137	**0.00418**	0.00192	**0.113**
08070207	<0.00992	<0.00992	**0.0141**	**0.0022**	**0.103**
08070208	0.0113	0.00885	**0.00314**	0.00168	**0.147**
ERL (mg/kg)	0.016	0.0853	0.00002	0.0022	0.0227
ERM (mg/kg)	0.5	1.1	0.008	0.027	0.18
PEL (mg/kg)	0.0889	0.245	0.0043	0.374	0.189

Appendix A: Analytes, concentrations, and detection limits.

Available electronically upon request from:

Sumalee Hoskin
U.S. Fish and Wildlife Service
6669 Short Lane
Gloucester, VA 23061
sumalee_hoskin@fws.gov

Figure 1. Eastern Shore National Wildlife Refuge, Northampton Co., Virginia, sediment sampling locations.

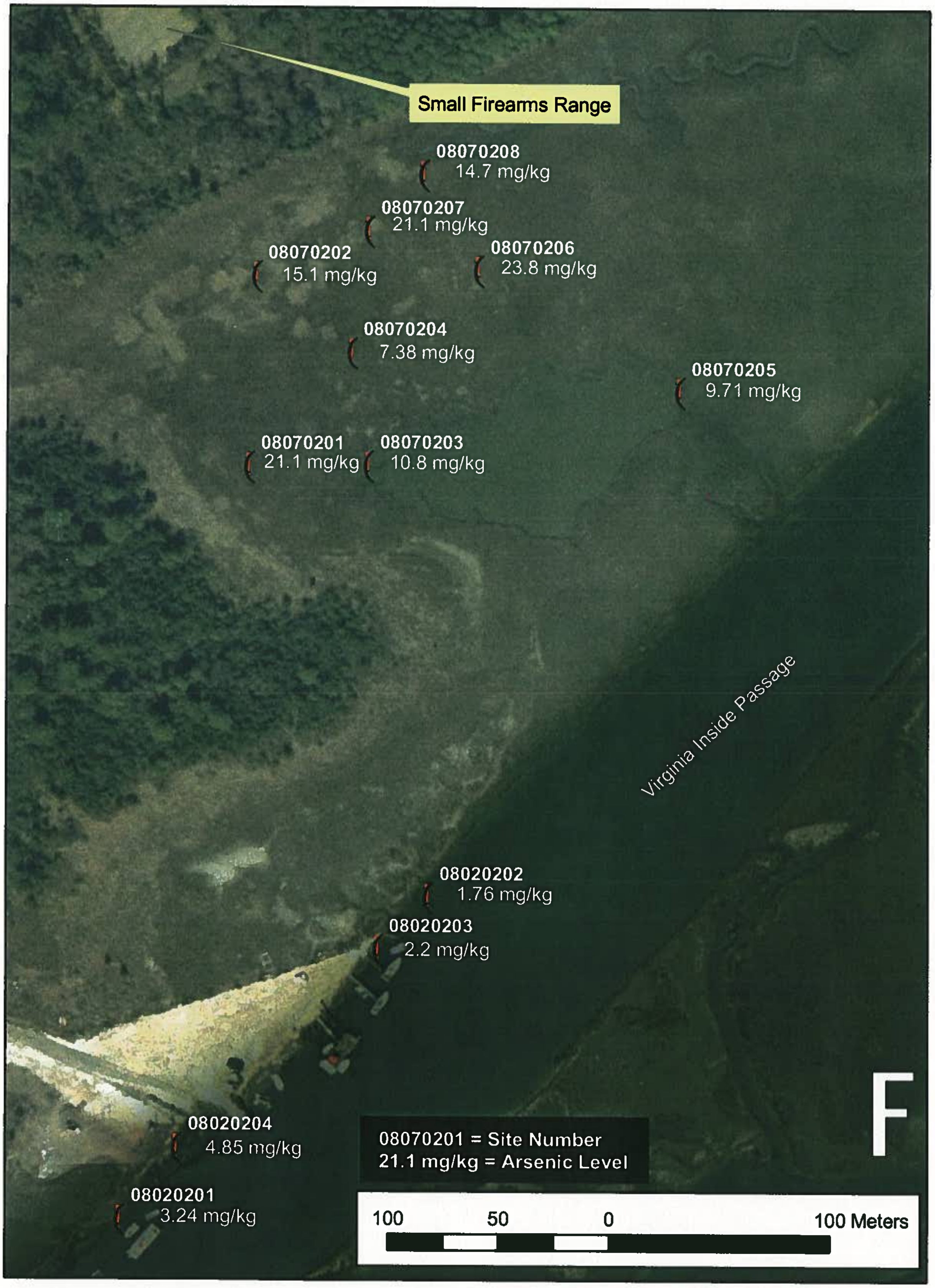

Figure 2. Arsenic levels in the saltmarsh and along the Virginia Inside Passage, July 2002.