Monitoring the Health of Avian Scavengers on the Pacific Coast

FY2011 Interim Report to the US Fish & Wildlife Service Avian Health and Disease Program

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Common ravens and turkey vultures feeding on a harbor seal carcass along the coast north of Bandon, Oregon. Dan Varland photo.

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EXECUTIVE SUMMARY

In 2011 we initiated a multi-year research program to monitor the health of three species of avian scavengers, bald eagle, turkey vulture, and common raven, through tissue sampling on coastal beaches in Oregon and Washington. The objectives of the study are to: 1) screen for the presence of avian disease (viruses, bacteria and parasites) in avian scavengers feeding in the coastal marine environment; 2) document lead and organochlorine (OC) contaminants concentrations in marine mammal carcasses and the avian scavenger community feeding in the marine environment; 3) determine whether there is a relationship between contaminant concentrations and disease agents in avian scavengers; and 4) use the avian scavengers as surrogate species to estimate potential risks to re-introduced California condors from exposure to contaminants from consuming marine mammals.

Our trapping effort for avian scavengers extended from February 2012 to June 2012. In February and March, we used a bow net as our principal trap. Relatively few avian scavengers visited our trap set and trapping success was low during this time period. In April we began using a net launcher for trapping. Because of initial success with a net launcher, we used this trap exclusively until our sampling objectives for 2012 were met in June.

We trapped 7 turkey vultures, 5 bald eagles and 2 common ravens according to our Avian Scavenger Sample Acquisition Protocol (hereafter Protocol) which included sampling adult-aged birds and, for turkey vultures, sampling during the period of summer residency. We captured several other birds not strictly within the parameters of the Protocol, including an additional three turkey vultures (two juveniles and an adult captured in winter), and one bald eagle (a juvenile). We ran a full set of lab tests on all individuals captured to Protocol, and a subset of all tests (n = 3) or a complete set of tests (n =1) on the other birds. In addition to the live-captured birds, under our Protocol we obtained 3 common ravens for tissue sampling and analysis after they were shot by personnel of the APHIS Wildlife Services Predator Control Program at western snowy plover nesting areas on the Oregon coast. Working in cooperation with the Marine Mammal Stranding Network, we obtained marine mammal tissue samples (blubber) from 3 California sea lions and 3 harbor seals on the Washington and Oregon coasts.

We found few OCs at measureable levels in the avian scavengers we sampled. We tested for DDT and its principle metabolites DDD and DDE. Among avian scavengers captured to Protocol, we found DDT and DDD concentrations were below or near minimum detection levels. Mean DDE concentration were higher. For bald eagles (n = 5) captured to Protocol, mean DDE was 1.1 ppm and was 0.23 ppm for turkey vultures (n = 7) and common ravens (n =2) in this group. Mean total PCB concentration was 0.72 ppm for bald eagles (n = 5) captured to protocol and was 0.17 ppm and 0.30 for turkey vultures (n =7) and common ravens (n = 2) captured in this group respectively. We found most OCs below detection levels in analyses of liver samples from common raven carcasses. As with live birds measured for OCs, we detected measurable levels of total PCBs and DDE.

While we found most OC pesticides also fell below detection limits in the harbor seals and California sea lions sampled, there were measurable concentrations of some important OCs in some individuals. As with birds, DDE and total PCBs were measurable in all six marine mammals sampled. That said, individual total chlordane, total DDT and total PCB concentrations in marine mammals in our study were well below mean concentrations found from research reported on carcasses of these species in southern California where large amounts of organic pollutants reside in ocean sediments.

We analyzed blood samples in avian scavengers for heavy metals. Detectable levels of lead, mercury and selenium were found in all avian scavengers captured. Among individuals captured to Protocol, mean blood lead level for bald eagles (n = 5) was 0.03 ppm, 0.09 ppm for turkey vultures (n = 7) and 0.05 ppm for common ravens (n = 2); these lead levels fall well below those classified as "subclinical poisoning" in Falconiformes. Our analysis of bone tissue for heavy metals from common raven carcasses only showed lead above the lower limit of detection (0.001 ppm) and only in one of three ravens sampled (17 ppm, dry weight). Mean blood mercury (methylmercury) concentrations were 3.99 ppm in bald eagles (n = 5) captured to Protocol, which was substantially higher than the concentration of mercury in turkey vultures and common ravens in this group. Mercury concentration in bald eagles in our study was higher than mean concentrations reported for adult bald eagles in the region by others. Selenium concentrations were well above minimum detection levels for all avian scavengers; generally considered to protect against mercury poisoning in vertebrates, selenium may have ameliorated the effect of mercury in eagles in our study. We found detectable levels of methylmercury, the only heavy metal potentially stored in quantity in fat (blubber) tissue, in all marine mammals we tested. Methylmercury levels were relatively low: California sea lion concentration mean was 0.08 ppm range = 0.02 - 0.19, n = 3) while the harbor seal mean was 0.02 ppm (range = 0.01 - 0.04, n = 3).

Except for healed scars or occasional feather damage, we found no symptoms of disease or any other health concerns on any of the birds during physical evaluation. Serum biochemistry results were largely within International Species Information System (ISIS) reference ranges and, thus, appear to reflect major organ function. ISIS, www2.isis.org, is a fee-based information exchange where zoos and research institutions can post their medical records and laboratory results from captive or wild animals. Acquisition of more samples will enable more sophisticated statistics and refinement of reference ranges.

Fecal analyses were positive in three individuals sampled: Sarcocystis-like ova were identified in two bald eagles and low numbers of ascarid ova were found in one turkey vulture. Tracheal bacteriology revealed light growth of several species of bacteria, with turkey vultures having notably higher numbers of isolates (n = 7) compared to eagles (n = 3). We did not sample raven trachea. Turkey vultures also demonstrated the greatest number of bacterial isolates from cloacal swabs: 9 followed by 6 for eagles and 3 for ravens.

Positive serology test results indicate exposure to the pathogen in question but not necessarily active infection or disease. As such, serology is a good tool for broad monitoring of the presence

of potential pathogens in a bird's environment. Serology can also be more sensitive than PCR testing when a bird is infected but not shedding the organism.

One eagle and two turkey vultures captured to Protocol were positive for PMV-1, as demonstrated by high HI titers. These birds had likely cleared a prior infection since no symptoms consistent with paramyxovirus were seen.

One vulture and one raven captured to Protocol tested positive for *Chlamydophila spp.* exposure. Neither one demonstrated disease symptoms (e.g., weakness or decreased pectoral muscle mass). The turkey vulture exposed to *Chlamydophila* had a total white blood cell count of 25 k/ul; this was within the range of all turkey vultures in this study. Moreover, this value was within the ISIS reference range for clinically normal turkey vultures. No anemia or leukocytosis was demonstrated in either individual; these are common symptoms of active chlamydiosis. Both birds had negative blood and cloacal swab PCR test results for *Chlamydophila spp.* All birds captured to Protocol were free of *Coxiella burnetti.*

One bald eagle captured to Protocol tested positive for avian tuberculosis (infection with *Mycobacterium spp.*). This individual did not demonstrate a leukocytosis (elevated white blood count) as one would expect with advanced disease. The fact that only one bird tested positive is promising. Determination of the species of *Mycobacterium* is possible with DNA sequencing and could be useful for determining the probable source of the infection.

All birds captured to Protocol were negative for avian influenza (by PCR of throat and cloacal swabs and by AGID serology). All 5 bald eagles and 4 of 7 turkey vultures captured to Protocol tested positive for exposure to adenovirus.

Salmonella cultures from cloacal swabs were negative for all birds captured to Protocol. Three bald eagles captured to Protocol tested positive for exposure to *Mycoplasma gallisepticum* (plate agglutination serology). Upon further testing using HI methodology, all three of these birds were considered negative (titers of 1:20, reference range of positive if >1:64). All samples were negative on plate agglutination for *M. synoviae*. All avian scavengers captured to protocol were found to be free of protozoan blood parasites by both PCR testing and microscopic evaluation of stained blood smears.

Our small sample sizes to date limit our ability to analyze our data statistically and to compare our findings with other studies. Thus conclusions on the health of avian scavengers in the coastal environment and an estimate of potential risks to re-introduced California condors in this environment are not yet possible. We project that achieving our overall sampling goals will require field work FY 2012 – FY 2014. Together with the samples already acquired, our overall sample size goal is 76 avian scavengers and 48 marine mammals for analyses in Washington and Oregon.

INTRODUCTION

Avian scavengers occupy key positions at the apex of food chains. As such they are vulnerable to disease and contaminants exposure. Disease and contaminants pose substantial threats to avian health, productivity, recruitment and survival, but the extent of risk to wild populations along the Pacific Northwest coast is unclear. Effort has been made to remove pollutants from the environment (Henny and Elliot 2007), yet contaminant threats persist, especially in higher trophic birds and mammals (e.g., Ross et al. 1996). Small populations are particularly at risk from disease, contaminants and the effects of climate change (e.g., California condor *Gymnogyps californianus*; Walters et al. 2010).

At present, there is growing interest in re-introducing the critically endangered California condor to the Pacific Northwest (J. D'Elia, USFWS, pers. comm.). It is probable that contaminant and disease exposure in bald eagles (*Haliaeetus leucocephalus*), common ravens (*Corvus corax*), and turkey vultures (*Cathartes aura*) could be predictive of exposure in any re-introduced California condor population. Condors are particularly susceptible to contaminated food because they are social feeders, meaning that a single contaminated meal can poison many individuals. Contaminants of primary concern for California condors feeding on beached marine mammals are organochlorines (OCs: DDE and PCBs) and lead.

Recent assessment of contaminant levels in pinnipeds found very high levels of DDT and polychlorinated biphenyls (PCBs) in harbor seals (*Phoca vitulina)* and California sea lions (*Zalophus californianus*) in the Southern California Bight (Blasius and Goodmanlowe 2008). Because sea lions are migratory, they act as vectors for transporting these contaminants up the Pacific coastline. Further, necropsies to date by the Northwest Region Marine Mammal Stranding Network have revealed that gunshot wounds are a relatively common cause of death in sea lions and harbor seals on Oregon and Washington coasts (D. Duffield, pers. comm.). These two species constitute 70-80% of the stranded marine mammal carcasses found on the coastal beaches of northern Oregon to central Washington (D. Duffield and D. Lambourn, pers. comm.), often contain lead due to gunshot wounds, and likely constitute the bulk of the marine mammal carcasses that avian scavengers feed on along the coasts in both states.

In 2011 we initiated multi-year research to monitor the health of avian scavengers through tissue sampling on coastal beaches in Oregon and Washington. The objectives of our study are to:

1) Screen for the presence of avian disease (viruses, bacteria and parasites) in avian scavengers feeding in the coastal marine environment;

2) Document lead and OC contaminants (primarily DDE and PCBs) concentrations in tissues of both marine mammal carcasses and the avian scavenger community feeding in the marine environment, including bald eagles, turkey vultures and common ravens;

3) Determine whether there is a relationship between contaminant concentrations and disease agents in avian scavengers and;

4) Use eagles, vultures, and ravens as surrogate species to estimate potential risks to California condors from exposure to lead and organochlorine (OC) contaminants from consuming marine mammals.

With field work beginning in 2012, we sampled bald eagles, turkey vultures and common ravens for infectious and parasitic diseases and for contaminants. The research also includes collecting tissue samples for contaminants analyses from the carcasses of washed up California sea lions and harbor seals, regular food resources for these avian scavengers along the coast. Our sample size goals are ambitious, and will take several years to attain (Table 1).

Herein we report our findings from the first year of tissue sampling of avian scavengers and marine mammals on the Oregon and Washington coasts. FY2011 funding from USFWS AHD was based on a research proposal we submitted July 2011. In Study Area and Methods sections, we identify modifications we made to study area and our methodology from the original grant proposal. These changes were made to facilitate successful accomplishment of the overall objectives of the study.

STUDY AREA

The study area includes the outer coastal beaches in Washington and Oregon. We focus sampling on areas where: logistics of field work are facilitated by drivable beaches, the Marine Mammal Stranding Network responders are active (they report carcasses and take tissue samples for the study), there are known quantities of avian scavengers for sampling, and where access to properties is provided by landowners and/or land managers.

Our original proposal for funding in FY2011 identified our study area as the Washington coast north and south of Grays Harbor, Washington (Figure 1). With approval from the USFWS AHD Regional Coordinator, we expanded our study area to other sites along the Washington and Oregon coasts (Figure 2). This was done to help reach our sample size goals and to obtain samples that were more representative of a broader geographic area: coastal Oregon and Washington.

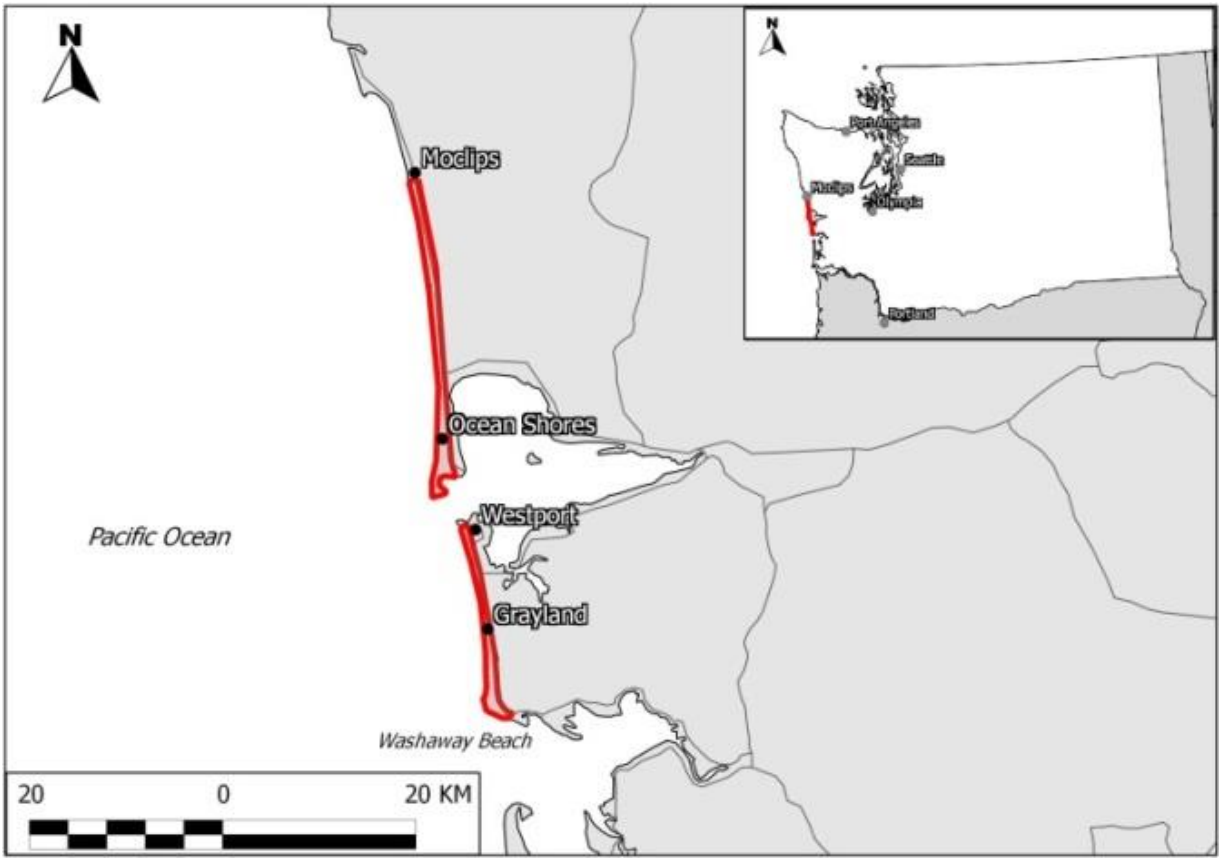

Figure 1. Extent of study area and sampling sites identified in our original FY 2011 proposal were restricted to the north-central Washington Coast, and included the beaches (in red) in the vicinity of Ocean Shores and Grayland, WA.

Figure 2. Expanded study area in 2012 includes (from the north, in black) beaches in the vicinity of: Ocean Shores, Grayland, and Long Beach in Washington, and Seaside, Newport, Charleston-Bandon, and Gold Beach in Oregon.

METHODS

We made changes in methods that deviated from those described in our FY2011 proposal (Table 2). We adopted these as field work proceeded during February 2012 with the intent of increasing capture success without compromising study objectives.

Trapping Avian Scavengers. We targeted bald eagles, turkey vultures and common ravens for trapping and tissue sampling (see Avian Scavenger Acquisition Protocol below). Our trapping effort extended from February - June 2012. In February and March we used several types of traps. We targeted bald eagles and common ravens with one, sometimes two, carcass-baited bow nets (Appendix 1). For eagles, on a few occasions, we also used a noose carpet set adjacent to a carcass and covered with sand, a noosed fish carcass, or a harnessed rock dove carcass (Bloom et al 2007). We deployed one or more of these traps at the same time a bow net was set. Beginning in April, we used a net launcher (Appendix 1) exclusively for trapping bald eagles, turkey vultures and ravens.

Observation Rate of Avian Scavengers at Baited Trap Sites. We recorded the number of hours spent with a trap set and the number of avian scavengers, by species, observed feeding at a bait carcass during those hours. We counted all birds we saw scavenging at our sets except gulls, which fed frequently. We calculated an observation rate for avian scavenger feeding: the total number of avian scavengers observed feeding per 10 hours of trapping. Because individuals were not marked for individual identification (e.g., with leg bands or wing tags), we were unable to obtain precise counts of the number of individuals feeding at a carcass during the course of a trapping period. Our counts underestimate scavenger abundance at bait sites. Nevertheless, they provide an index to scavenger abundance and a means to compare scavenger feeding rates between bow net and net launcher trap sets (see *Trapping Success* in *Results and Discussion*).

Avian Scavenger Sample Acquisition Protocol. We factored age and season of occurrence into our sample acquisition protocol (hereafter, the Protocol), as follows:

Age. Because of the potential for differences in contaminant levels by age class (e.g., Anthony et al. 1993, Evars et al. 2005, Harmata 2011, Pagel et al. 2012) and budget limitations precluding sampling by age class, we targeted mature individuals for tissue sampling. To this end, we sought to sample birds at the minimum age at which individuals were indistinguishable by appearance from fully mature individuals. We classified these individuals as adults. Adult age was reached at $\geq$ 4 years old for bald eagles (attainment of fully white head and tail; McCollough 1989), $\geq$ 2 years old for turkey vultures (attainment of bright ivory bill; Pyle 2008) and $\geq$ 1 years old for common ravens (attainment of black primary and secondary feathers; B Bedrosian, pers. comm).

Season. We sought to sample bald eagles and common ravens irrespective of season. For turkey vultures, we sought to sample between May 8 and August 31 to minimize the likelihood of capturing migrants (for timing of migration and summer residency in turkey vultures in Washington and Oregon, see Wahl et al. 2005 and Marshall et al. 2006).

Sex. We sexed bald eagles using bill depth and hallux measurements (Bortolotti 1984) and common ravens using foot pad length and mass (Bedrosian et al. 2008). Dead ravens were sexed during tissue sampling by examination of reproductive organs. Because it is not possible to differentiate gender using external morphology (Pyle 2008), we were unable to sex the turkey vultures we captured.

Marking Avian Scavengers. We marked all captured birds for individual identification (Appendix 2). Each bald eagle was banded with two bands: a U.S. Geological Survey (USGS) rivet-on band on one leg and an Acraft® green two-letter coded rivet-on band, also known as a Visual Identification Band (VID), on the other leg. Each common raven was banded with four bands: a USGS steel butt-end band and three color bands. Raven color bands were wraparound plastic, colored yellow, orange, green or gray. To prevent removal of these wraparounds, we sealed the plastic by melting the end with a soldering iron. We fitted each raven with two color bands on one leg and a USGS band and one color band on the other leg. We marked turkey vultures with a wraparound wing marker secured through the patagium with a pop-rivet (Varland et al. 2007); our markers were red, coded with white two-letter combinations.

Acquisition of Common Raven Carcasses for the Study. We obtained ravens for tissue sampling and analysis after they were collected by personnel of the USDA-Animal Plant and Health Inspection Service (APHIS) Wildlife Services Predator Control Program at western snowy plover (*Charadrius nivosus nivosus*) nesting areas on the Oregon coast. The ravens were shot by rifle with non-lead ammunition in February and March prior to the commencement of plover nesting. Each raven shot was fitted with a temporary numbered tag attached to one leg with wire, then wrapped in two plastic bags and frozen to -20 $C^0 \leq 3$ hours after acquisition. Carcasses remained frozen until thawing for tissue extraction by S. Ford. Tissues were shipped for analysis to the Diagnostic Center for Population and Animal Health, Michigan State University.

Avian Scavenger Sampling Protocols. Following capture, we maintained a consistent pattern of data collection procedures with only minor adjustments. Our sequence was as follows: morphometric and body mass measurements; collection of feather samples; collection of a throat swab, tracheal swabs, cloacal swabs, and a feces sample; venipuncture; marking; photo documentation; and release.

We collected tracheal swab samples by carefully passing a thin dacron-tipped sterile swab through the open glottis and into the trachea, then touching the tracheal mucosa. Care was taken not to contaminate the tracheal swab by touching oral mucosa. Throat swabs were passed through the open beak to the back of the oropharynx (throat) and gently rubbed rostrally along the dorsal midline of the palate and choana to its forward extent. Cloacal swabs were larger cotton-tipped sterile swabs that were gently passed through the vent into the coprodeum-- the innermost chamber of the cloaca. In both cases, the swabs were placed into sterile receptacles with media appropriate for the test being performed. In all, 2 tracheal swabs, 1 throat swab, and 3 cloacal swabs were collected from each subject.

We collected blood by venipuncture of the basilic vein of the wing (ventral side of the humeroulnar joint). Birds were placed in dorsal recumbency with one wing extended. A butterfly needle (23G for eagles, 25G for other species) with extension was inserted into the vein and 2 Vacutainers (7.5 cc in lithium heparin and 2.2 cc in EDTA) were used to collect blood. In

addition, we collected blood in 2 lithium heparin microhematocrit tubes and made blood smears on 4 glass coverslips (22 mm x 22 mm). Total volume desired was 9.7 cc and a maximum of 10 mls/kg body weight was allowed (Samour 2006). Following venipuncture, we applied direct pressure to the venipuncture site using gauze sponges until hemostasis was achieved.

We collected feces as freshly voided samples from the holding crate or freshly fallen on clean sand, towels, or table. If this was not available, we performed cloacal lavage to obtain a wash sample. This procedure involved passing a 14G ball-tip cannula into the coprodeum and infusing 12 cc of sterile water to expel feces through the vent into a collecting 10 x 10 cm gauze sponge. In many cases, feces could also be withdrawn into the syringe and these were then applied to the gauze sponge. Fecal samples or lavage sponges were placed into a sterile plastic sample bag.

We kept all samples in a cooler on ice or in a refrigerator until processing and shipment. For tests requiring serum or plasma, samples were separated at the end the day's field work and $\leq$ 6 hours after collection. Serum and plasma samples were separated using centrifugation for 10 minutes and then pipetted into the various other collection containers for submission to laboratories. We packaged samples with cold packs and sent them as soon as possible via same-day or overnight courier to the respective laboratories. In most cases, less than 36 hours elapsed between collection and arrival at the laboratory. A list of sample types, laboratories where samples were sent, and the analyses they performed is provided in Appendices 4 and 5.

Detailed laboratory analysis protocols are beyond the scope of this report but can be procured for use in scientific manuscripts later. A combination of methodologies was used to increase detection sensitivity as much as possible. These methods are summarized below.

Polymerase chain reaction (PCR) uses specific genetic primers to amplify or "copy" a specific segment of genomic material from an organism. Once amplified, the material can be combined with a radioactive or fluorescent marker and then fractionated using an electrically charged agarose gel plate. Imaging is then used to record the relative density of detected strips of genetic material. It is a very sensitive methodology but has limitations when a disease organism's pathobiology does not produce consistent shedding of the organism into blood or secretions that can be readily sampled. Good examples of this include *Chlamydophila psittaci* and *Mycobacterium avium*, both of which can be difficult to detect in blood or feces, particularly in birds that are infected but clinically healthy.

In these cases, various serological tests, which detect the presence of antibodies or antigens in blood serum or plasma, may be a good adjunctive methodology. There are a few limitations to this type of testing. First, high antibody titers do not necessarily indicate the presence of disease; e.g., they may indicate that the immune system was exposed to a pathogen and mounted an immune response. A successful response and elimination of the organism may have occurred and, therefore, no disease is present. Second, some serological tests can render false positive or negative results due to cross-reactivity with other substances in the sample or use of intermediate antibodies that are specific to a given species of host animal. To avoid this, we selected

serological tests that were less dependent upon species-specific antibodies. The trade-off is less specificity or sensitivity.

PCR was performed by Veterinary Molecular Diagnostics Laboratory to screen whole blood for the presence of hemoparasites and *Chlamydophila psittaci* and to screen cloacal swabs for the presence of *Mycobacterium spp*., avian paramyxovirus 1 (APMV-1), *C. psittaci,* and *Sarcocystis spp*. PCR testing was also employed by Colorado State University Veterinary Diagnostic Laboratory to screen whole blood, tracheal swabs, and cloacal swabs for the presence of *Coxiella burnetti*. The Washington State University Washington Animal Disease Diagnostic Laboratory-Avian Health and Food Safety Lab in Puyallup, WA (WADDL) in Puyallup, WA screened tracheal swabs for the presence of *Mycoplasma spp.* using a PCR methodology.

Plate agglutination (PA) was performed by WADDL to screen serum for antibodies to *Mycoplasma gallisepticum* (MG) and *M. synoviae* (MS). For this screening, precise quantities of serum and antigen are warmed to room temperature and mixed on a glass plate. After 2 minutes, a positive reaction is seen as clumping of antigen. Positive samples are then retested using a hemagglutination inhibition (HI) protocol (see below) to rule out false positives, which may occur if closely related species of *Mycoplasma* are present. Quality assurance is achieved through use of positive and negative control sera in parallel separate tests (Warren et al 2011).

Agar gel immunodiffusion (AGID) testing was performed by WADDL to screen for antibodies to adenovirus and avian influenza. In summary, wells are cut into a disk of agarose gel: one in the center for known antigen and several others in a circle around this that are dosed with either positive control or test serum. Antigen diffuses out from the central well as antibodies diffuse out from the test serum wells and positive controls. Samples that contain antibodies to the test antigen form a line of precipitate where the sample and antigen meet.

Hemagglutination inhibition (HI) testing was conducted by WADDL to screen serum for antibodies to APMV-1. The test uses dilutions of test serum incubated with an APMV-1 solution and red blood cells. Serum containing antibodies to APMV-1 will interfere with red blood cell agglutination that normally occurs in the presence of the virus. A titer is reported as the reciprocal of the highest dilution in which hemagglutination is not visible.

Immunofluorescent antibody (IFA) testing was conducted by University of Miami Department of Comparative Pathology (UMDCP) to screen for antibodies to *Chlamydophila psittaci*. Serial dilutions of test serum are incubated with a *Chlamydia*-infected cell substrate. This substrate is then washed and incubated with fluorescent-labeled antibodies that are reactive to psittacine immunoglobulins. Test substrates are then examined with a fluorescent microscope and results reported as titers. This test has been successfully used with serum from several species of birds, including eagles. However, there is a potential for non-specific reactions or false negatives since the test relies upon antibodies with reactivity for psittacine immunoglobulins.

Aerobic cultures of tracheal and cloacal swabs, including Salmonella cultures of cloacal swabs, were performed at WADDL; isolates were identified. Samples of isolates were placed in sealed

plastic tubes and archived at -80°C. We plan to re-culture selected organisms in the future, then perform antimicrobial sensitivity testing as a means to identify the likelihood of avian scavenger exposure to antimicrobial-resistant bacteria due to contamination of the environment with antimicrobial drugs.

Justification for General Health Screening Tests. Our main goal in this study has been to provide a snapshot of the average fitness of birds in the coastal avian scavenger community. The fitness of the population is, in part, a sum of the fitness of its individuals, so general health screening tests were seen as one way to assess this. General health screens also allow more complete interpretation of specific pathogen tests (e.g., helps determine whether a positive serological result reflects exposure or active disease).

Serum biochemistry results measure the levels of enzymes, proteins, and elements to provide data on the function of key organ systems, damage to specific tissues, and some indication of physiological and nutritional state (e.g., protein and calcium levels may increase in birds preparing to ovulate). Hematology results measure white and red blood cell numbers, relative volume of the erythron mass, and, by assessment of cell morphology, can provide useful information on the reactivity of the immune system or the presence of hemoparasites.

Aerobic culture of fecal, trachea, or throat swabs is used in certain situations in veterinary medicine to monitor the health of individuals or a contained population. Culture allows the detection of unusual or pathogenic bacteria and allows monitoring of their antimicrobial resistance, both of which can reflect the immune status and well-being of individuals as well as the soundness of management practices (e.g., inappropriate use of antimicrobials). In application to a free-living population, cultures will allow: 1) a general survey of the species of bacteria individuals are carrying, both pathogenic and nonpathogenic, 2) inferences as to relative health of individuals if typically pathogenic species of bacteria are present, 3) detection of antimicrobial resistance patterns which could reflect contamination of the food chain with antimicrobials. An inventory of current common flora and their antimicrobial patterns could be useful for comparison in future health assessment studies or for investigation of antimicrobial contamination of the environment or food chain.

Justification for Specific Pathogen Testing. During our development of this study, we conducted a literature review and assembled a list of potential disease organisms. Some organisms (e.g., West Nile Virus) were eliminated from the list for the following reasons: 1) sensitive antemortem tests were unavailable or impractical for the scope of our study, and 2) the organism was considered highly unlikely to be present or to be a serious disease concern for the species in our study and region. In some cases, it was unclear whether a disease organism could be of significance to the species, age classes, or region of our study. In these cases, particularly where outside advisors expressed an interest in knowing the status of the organism (e.g., *Coxiella spp.*, *Sarcocystis spp.*, and adenovirus), testing was performed.

Paramyxovirus-1 (PMV-1) is a single-stranded RNA, enveloped virus that has been reported to cause disease in a variety of bird species including bearded vultures. The organism may be zoonotic and can be highly contagious to other birds (a disease known as "Exotic Newcastle Disease") including poultry and so it is highly monitored. Pathogenicity varies widely with the viral strain and host species and mortality can be high (Leighton et. al. 2007). Antibodies to PMV-1 are reported to have been detected in North American vultures. Clinically ill birds exhibit a variety of serious symptoms including neurological impairment, diarrhea, oculonasal discharge, and depression. One case in a captive bearded vulture in Israel resulted in death with severe lesions of the liver and intestines (Lublin et. al. 2001).

Adenoviruses are nonenveloped double-stranded DNA viruses that have been isolated or reflected serologically in falcons and hawks in the United States and Europe (Froelich 2002, Oaks, 2005, Van Wettere 2005, and Tomaszewski 2007). In some cases, the virus has been known to cause lethal disease, although generally host-adapted strains are nonpathogenic. Lesions include necrotic hepatitis and splenitis. Much remains to be known about the circulation and significance of the virus in free-living raptors.

Avian influenza A viruses are enveloped RNA viruses that circulate widely in free-living birds in North America. Waterfowl are particularly well-known hosts that frequently do not exhibit disease. Avian predators and scavengers, particularly in areas rich in waterfowl, have considerable likelihood for exposure. Much is unknown about the possible role of land birds, including Falconiformes and Passeriformes, as reservoirs of the influenza viruses. One study found that among a variety or raptors and vultures, bald eagles may have a higher prevalence of seroconversion (development of antibodies indicative of exposure) to influenza A viruses (Redig 2012). Because of this and other unknowns for the prevalence of influenza A viruses circulating in our study species and region, we decided to include this organism in our specific pathogen testing slate.

Mycoplasmas are intracellular bacterial pathogens with a broad avian host range, mild zoonotic potential, and which pose significant risk to poultry (Lierz et al. 2008a). Mycoplasmas have an affinity for mucous membranes of the respiratory and genital tracts; close-contact is generally thought to be required for transmission (Lierz and Schmidt 2011). Their role as pathogens in birds of prey is unclear although they have been isolated or detected by PCR in several species of raptors and vultures: some showed clinical signs of disease but many did not (Lierz et al. 2008a, 2008b, 2008c, 2011, Loria et al. 2008). Serology has been used in birds of prey to detect exposure to mycoplasmas but does not necessarily denote current infection. Until recently, culture of mycoplasmas was the only method of detecting infection. Culturing mycoplasmas poses several challenges that limit practicality and sensitivity. Although PCR tests have been developed for general and specific identification of mycoplasmas in raptors, serological testing can still be useful for broad screening of exposure. For this reason, and because of limited access to *Mycoplasma* PCR testing, serology was selected for screening for mycoplasmas in our test subjects.

Hematozoa (blood parasites, aka "avian malaria") are known to infect free-living birds of prey in North America, including *Haemoproteus spp., Plasmodium spp.,* and *Leucocytozoan spp* (Remple 2004). Many hematozoa are not primary pathogens but because they increase in number during periods of stress or disease, they can be important indicators of individual fitness. Some species, such as *Plasmodium spp.,* are more frequently found to cause significant disease. Detection of hematozoa is primarily by visualization of the organisms in stained blood smears. However, PCR analysis offers a more sensitive degree of detection. Because of a generous offer from the Veterinary Molecular Diagnostics Laboratory (Milford, OH) to perform PCR analysis at no charge, we elected to analyze samples using both microscopic and PCR modalities. This PCR utilizes primers for a portion of DNA conserved across all three of the above-named genera of avian malarial organisms.

Mycobacteria are acid-fast, highly persistent bacteria that reside naturally in a variety of substrates. Clinical manifestation is referred to as "avian tuberculosis," a granulomatous, chronic wasting disease affecting multiple organ systems but especially the gastrointestinal tract and liver. Species isolated from free-living birds have included various members of the *Mycobacterium avium* complex or *M. genavense* (Tell 2004). Mycobacterial infection has been documented in captive and free-living raptors worldwide including bald eagles and certain species of vultures (Tell et al. 2004, Heatley et al. 2007, Skoric et al. 2010, Oaks et al. 2004). Mycobacteria species that are isolated from birds have some zoonotic potential. Scavengers are undoubtedly exposed to mycobacterial organisms when feeding on carcasses and probably have a natural resistance to infection. Thus we elected to test for mycobacteria to measure exposure and assess individual fitness.

Chlamydophila psittaci is an intracellular bacterial pathogen of a wide range of bird species including poultry, causing "chlamydiosis." It has some zoonotic potential, resulting in "ornithosis" (from wild bird strains) or "psittacosis/parrot fever" (from parrot strains) in humans. Infected birds may mount an appropriate immune response and clear the infection. In many cases, if a bird survives acute stages, the bacteria live on within cells of the liver or other organs and may occasionally be shed in oral, ocular, and respiratory secretions and in feces (Phalen 2006). Birds that are clinically affected demonstrate anemia, wasting, weakness, and death. This could provide an opportunity for infection of avian scavengers (Andersen and Franson 2007). Relative to our study, the disease has been found in free-ranging bald eagles and corvids in North America (Andersen 2007). The organism has been detected in raptors and vultures beyond North America (Gangoso et al. 2009, Ortega et al. 2012). Gangoso et al. suggested a relationship between immunocompetence and infection with *Chlamydophila* in wild Egyptian vulture nestlings.

Coxiella burnetti is an intracellular gram-negative bacterium that has been reported in a variety of birds, arthropods, and mammals including Pacific harbor seals, harbor porpoises, and Steller sea lions (Lapointe et al. 1999, Kersh et al. 2012). The organism is zoonotic (causing the disease known as "Q fever"), typically entering humans via inhalation of airborne particles derived from

infected animals, which are typically sheep or goats. In birds, *Coxiella* do not usually cause clinical illness but may persist in the spleen or kidneys, thereby serving as a potential reservoir and source of infection (Riemann 1977). In a serological survey of free-living raptors, Riemann found high antibody titers in vultures, golden eagles (*Aquila chrysaetos*), and red-tailed hawks (*Buteo jamaicensis*). *C. burnetti* detection was included in this study because the birds in our study population frequently feed upon marine mammal carcasses and because of the lack of data regarding the life cycle of this organism in marine mammals.

Sarcocystis spp. are protozoan parasites that cause cysts in the brain, heart, and skeletal muscle of intermediate hosts. Infection has been documented in a variety of birds including bald eagles (Olson et al. 2007). There are many species recognized that also utilize raptors as their definitive host and generally demonstrate no ill effects (Greiner 2008). However, in states of disease, the most likely route of infection to birds of prey has been considered the consumption of oocysts from the definitive host for *S. falcatula*, the North American opossum (*Didelphis virginiana*). Crows and magpies have been found to be definitive hosts for *S. ovalis*, a species that infects moose (*Alces alces*) (Gjerde and Dahlgren 2010). A survey of our study subjects may reveal a life cycle relationship for sarcocyst species between marine mammals and avian scavengers.

Salmonella are Gram-negative rod-shaped bacteria that typically inhabit the large intestine of carrier animals (Daoust 2007). Salmonella are classified by one of almost 2,500 serotypes. Within each serotype may be found multiple strains. Salmonella have been isolated from a variety of raptors in free-living and captive situations on all continents (Daoust 2007). Some serotypes are host-specific but many are not. There has been some suggestion that wildlife (including raptors and marine mammals) serve as a reservoir for pathogenic Salmonella that affect humans or food animals (Smith 2002). Because of this, defining the serotype and strain of *Salmonella* can shed light on the role that avian scavengers play in dissemination of salmonellae (Reche 2003). In our study, it may also be possible to elucidate a potential pathway for Salmonella dissemination from marine mammals to avian scavengers.

Tissue-sampling Marine Mammal Carcasses.

We targeted California sea lions and harbor seals for marine mammal tissue sampling. Samples were collected for our study by the Marine Mammal Stranding Network (MMSN) or their designees according to the protocol established by the Yurok Tribe (Appendix 3) for their ongoing research on contaminants in avian scavengers in northwest California (Yurok Tribe 2010). Samples were double-wrapped in aluminum foil, placed in a plastic bag and frozen to -20 C° < 8 hours after acquisition and until shipment. Tissues were shipped for analysis to the Institute of Integrated Research for Materials, Environments, and Society (IIRMES) at California State University, Long Beach.

RESULTS AND DISCUSSION

Trapping Success. We trapped 1-12 hours per day on 37 days between February and June 2012, for a total of 226 hours of trapping. During February and March, relatively few avian scavengers visited our bait or were trapped. The observation rate for avian scavengers feeding on carcasses while at a bow net set was 1.5 individuals per 10 hours of observation (Table 3). Although we camouflaged the trap with beach debris or grass, we believe scavengers were suspicious of the set and reluctant to feed on our bait. Moreover, our bow net was often rendered inoperable as blowing sand accumulated on the trigger mechanism and net framing. Because we checked on the status of our trap at infrequent intervals to avoid allowing target birds to see us at the trap set, we were often unaware of the problem. February – March 2012 were exceptionally rainy and windy on the Washington coast (see Cliff Mass blog), having a negative effect on trapping success. We did not collect sufficient data on weather conditions during trapping such that we could quantify the effect of weather conditions on avian scavenger observation rates or capture rate at trap sties. We spent 114 hours trapping during this time, capturing two bald eagles and one turkey vulture, each with a bow net (Appendix 1). Our capture rate with a bow net set was 0.3 individuals captured per 10 hours trapping (Table 3). No birds were captured with other types of traps we deployed on occasion during February and March.

In April we began trapping with a net launcher. Because trapping success improved right away, we used this trap exclusively until our sampling goals were met in June. Hidden in a wooden box covered with driftwood, a net launcher offers more concealment than does the bow net (Appendix 1). Moreover, the cover also protects the net and electronics from the negative effects of rain and sand. We trapped for 112 hours with a net launcher; our observation rate for avian scavengers feeding on carcasses while at net launcher sets was three times greater than the bow net rate (4.5 per 10 hrs of trapping vs. 1.5; Table 3). Moreover, our trapping success was more than four times greater using the net launcher (1.5 per 10 hrs of trapping vs. 0.3; Table 3).

Also contributing to our trapping success with the net launcher was its ability to safely capture more than one bird at a time. On May 11 we captured four turkey vultures at once and on June 4 we captured two turkey vultures and a raven at once. Given the relatively narrow sweep of the bow net arc when triggered (Appendix 1), we found that attempting to capture more than one bird at a time risked injury to target birds. Trapping success was substantially better with the net launcher than with the bow net. Given this success, as field work progresses we intend to use the net launcher as our primary, perhaps exclusive, method for capturing avian scavengers for sampling in an ocean beach environment.

Avian Scavengers Captured. We trapped 14 individuals according to the Avian Scavenger Sample Acquisition Protocol: 7 turkey vultures, 5 bald eagles and 2 common ravens (Table 4, Figure 3). An additional 3 common ravens were shot at snowy plover nest sites on the Oregon coast (Figure 3) according to the Avian Scavenger Sample Acquisition Protocol. Three turkey vultures and a bald eagle were captured outside the parameters of the Protocol (Table 5).

Marine Mammals Tissue Sampled. We obtained tissue samples, two 7.5 cm x 7.5 cm squares of blubber per specimen, according to the sampling protocol described in Appendix 3. Samples were collected from 3 California sea lions and 3 harbor seals on the Washington and Oregon coasts (Table 6, Figure 3), 5 by Marine Mammal Stranding Network personnel (Dyanna Lambourn, Jim Rice, Deb Duffield) and one by Dan Varland with authorization from the Marine Mammal Stranding Network's Jan Hodder.

Contaminants. We collected feather samples for heavy metal analysis from 21 avian scavengers, 18 from captured birds and 3 from raven carcasses. We archived the feather samples and will analyze them for heavy metals later in the study period. We analyzed for OC pesticides from blood plasma and for heavy metals from whole blood. The results of these analyses are reported below.

Organochlorine Pesticides. We found few OCs at measureable levels in the avian scavengers we sampled (Tables 7 and 8). We tested for dichlorodiphenyltrichloroethane (DDT) and its principle metabolites, p,p'-DDD (DDD) and p,p'-DDE (DDE), because these have been related to adverse environmental effects (Bluss 2011). Among birds we captured according to the Avian Scavenger Sample Acquisition Protocol (hereafter, to Protocol) we found DDT and DDD concentrations were below or near minimum detection levels (Table 7). However, mean DDE concentration for bald eagles sampled to protocol was 1.1 ppm and was 0.23 ppm for turkey vultures and common ravens (Table 7). Mean total PCBs was 0.72 ppm for Bald Eagles sampled to protocol and was substantially lower for turkey vultures and common ravens in this group (Table 7). We found most OCs below detection levels in analyses of liver samples from common raven carcasses (Table 9).

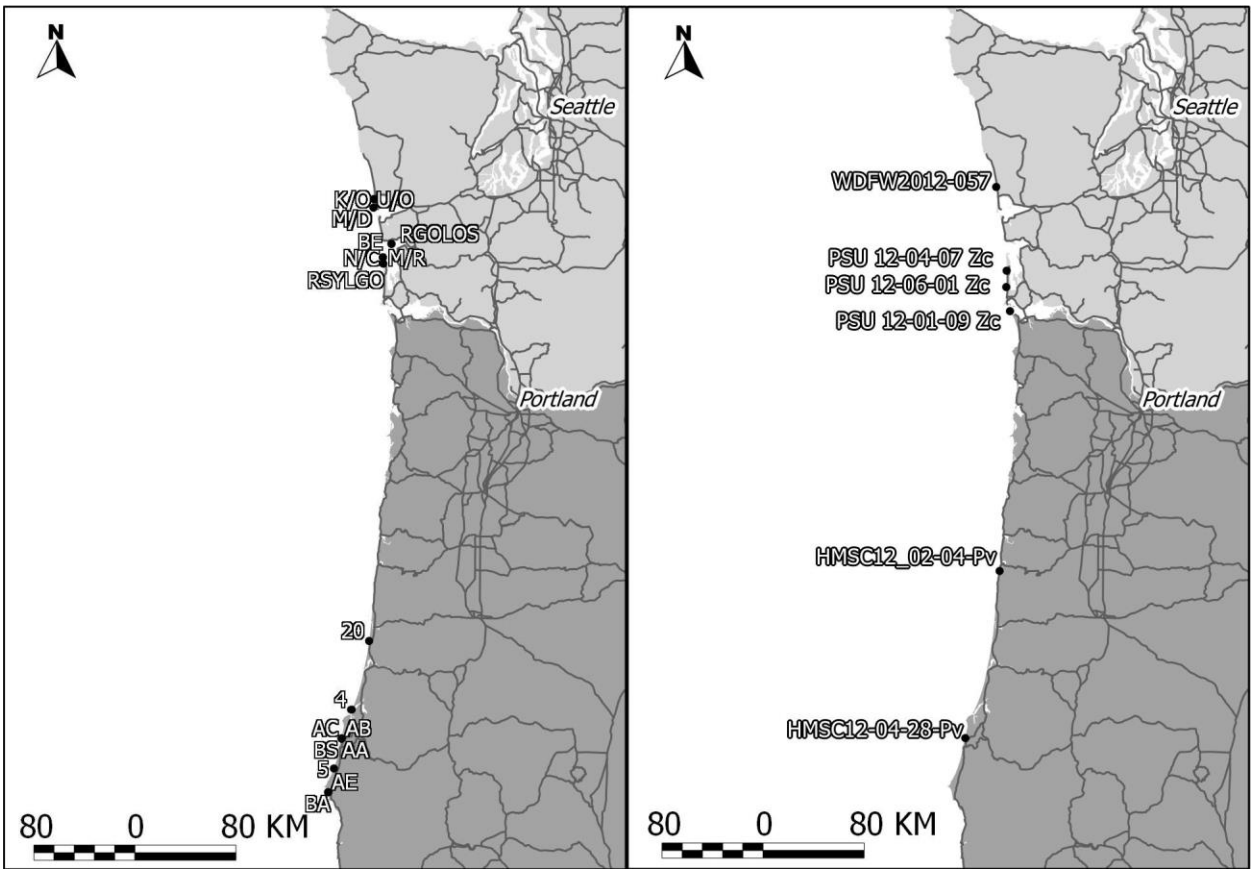

Figure 3. Locations where avian scavengers (left) and marine mammals (right) were tissue-sampled to protocol in Washington and Oregon in 2012. Animal locations are symbolized using avian scavenger auxiliary marker codes (Table 4) and marine mammal Field ID Numbers (Table 5). For information on mammals and birds sampled see Tables 4 and 5.

As with live birds measured for OCs, we detected measurable levels of total PCBs and DDE (Table 9).

As with most OCs we tested for in avian scavengers, we found most of these pesticides fell below detection limits in the harbor seals and California sea lions sampled (Tables 10 and 11). Given the large number of contaminants not detected or detected only in some of the individuals tested, we elected not to calculate statistical means from the data by species. Nevertheless, we found measurable concentrations of some important OCs in some individuals (Tables10 and 11). As with birds, DDE and total PCBs were measurable in all six marine mammals sampled (Tables 10 and 11). One individual, California sea lion PSU 12-01-09 Zc, had substantially higher concentrations of DDE and total PCBs than any other marine mammal tested. Chlordane compounds were also highest in this individual, which was sampled in Oregon at the mouth of the Columbia River (Figure 3). Total PCBs were higher in California sea lions tested than in harbor seals (Table 11).

Individual total chlordane, total DDT and total PCB concentrations in marine mammals in our study were well below mean concentrations from carcasses of these species in southern

California in proximity to where large amounts of organic pollutants were discharged into the Pacific Ocean in the decades passed (Blasius and Goodmanlowe 2008). For example, mean concentration of total DDT for five adult male California sea lions in southern California was 2,266.91 ppm, while the highest concentration in the three adult male sea lions in our study was 5.7 ppm. In the same southern California study, mean total PCB concentration in California sea lions was 86.55 ppm, greatly exceeding our highest concentration for an individual sea lion at 2.30 ppm (Table 11) and the 17 ppm concentration minimum considered potentially toxic in marine mammals (Zwiernick et al. 2011). Gunderson et al. (2012) report mean total DDT levels from marine mammal carcasses sampled from coastal northwest Oregon and southwest Washington higher than the levels we report for individuals in our study, but lower than those reported from the southern California study: California sea lion, mean = 11.92 ppm (range = 1.83-40.08 ppm, n = 8); harbor seal, mean = 7.38 ppm (range = 2.41-16.45 ppm, n = 8). Mean total PCB concentrations in California sea lions and harbor seals reported by Gunderson et al. 2012 were higher than total PCB concentrations we measured for individuals, but were lower than those for the same species reported by Blasius and Goodmanlowe 2008.

Heavy Metals. We analyzed blood samples in avian scavengers for arsenic, cadmium, lead, mercury, selenium, and thallium. Cadmium and thallium levels fell below detection levels for most individuals tested and arsenic levels were also very low (Table 12). Detectable levels of lead, mercury and selenium were found in all avian scavengers captured (all individuals: Table 12; mean levels, individuals sampled to Protocol, Table 7). Among individuals captured and sampled to Protocol, mean blood lead level for bald eagles was 0.03 ppm, was 0.09 ppm for turkey vultures and was 0.05 ppm for common ravens respectively (Table 7). These lead levels fall well below those classified as "subclinical poisoning" in Falconiformes (0.2 - 0.5 ppm; see Table 16.1 in Franson and Paine 2011). Anthony et al. (1993) reported mean blood lead levels for adult bald eagles from the Columbia River estuary in 1984-1986 within the range of subclinical poisoning (mean= 0.43 ppm, range = 0.05 - 1.00, n = 3). We sampled only one individual, turkey vulture BO captured in Washington (Figure 3), with a blood lead level consistent with "severe clinical poisoning" (1.34 ppm, Table 12; severe clinical poisoning is > 1 ppm, Table 16.1 in Franson and Paine 2011). This bird did not demonstrate any clinical signs of lead intoxication and did not demonstrate anemia, altered red blood cell morphology, or any other abnormalities of hematology of serum chemistry analyses. Further, specific disease screening for this individual was negative except for a positive PMV-1 titer. The apparent resistance of this turkey vulture to the detriments of lead intoxication is consistent with the observations of other researchers (Carpenter 2003). Captured February 14, 2012, this individual may have been an early spring migrant (Wahl et al. 2005). Thus contaminant levels in this turkey vulture may not reflect lead-contaminated food resources in the local environment. Our analysis of bone tissue for heavy metals from common raven carcasses only showed lead at detectable levels, and only in one of three ravens a sampled (17 ppm, dry weight, Table 9).

Like lead, mercury has documented effects on avian health and reproduction (e.g., Shore et al. 2011, Scheuhammer et al. 2012); levels as low as 5.0 ppm can cause nervous system dysfunction

(Eisler 1987). Mercury in avian blood is primarily methyl-mercury (Evers et al. 2005). Blood is the best tissue for evaluating short-term dietary intake (Evars et al. 2005) and for monitoring mercury in individuals because it occurs together with methylmercury in the liver in a 1:1 ratio (Henny and Elliot 2007). In our study, mean blood mercury concentrations were 3.99 ppm in bald eagles captured to Protocol; this concentration was substantially higher than was the concentration of mercury in the turkey vultures (0.94 ppm; n = 7) and common ravens (2.28 ppm; n = 2) we captured to Protocol (Table 7). Moreover, mercury concentrations in Bald Eagles in our study were higher than mean concentrations reported for adult bald eagles in the region by Wiemeyer et al. 1989: Oregon residents = 2.3 ppm, range = 1.1-4.8 ppm, n = 7; Oregon and northern California wintering = 2.3 ppm, range = 1.1-5.4 ppm, n = 13; Montana migrants = 2.0 ppm, range = 0.8-4.5 ppm, n = 3.

Anthony et al. (1993) reported blood mercury concentration in adult bald eagles from 1984 to 1986 in the Columbia River estuary was 3.07 ppm (range = 1.30-4.10, n = 3). More recently, a 2006-2008 study in Montana reported blood mercury concentrations by season for bald eagles (age classes combined): autumn 0.877 ppm (n = 23); winter = 0.728 ppm (n = 46); and spring = 0.514 ppm (n = 19) (Harmata 2011). In our study, only one bald eagle, M/R, had a mercury level > 5.0 ppm (Table 12). Effects of methylmercury poisoning range from hard to discern to obvious (e.g., difficulty flying, walking or standing: Wolfe et al. 1998); none of the bald eagles we captured and sampled showed signs of mercury poisoning.

Selenium concentrations were well above minimum detection levels for all avian scavengers in our study (Table 7, birds sampled to protocol; Table 12, all individuals). Selenium is generally considered to protect against methylmercury poisoning in vertebrates (for review, see Scheuhammer et al. 2012). Selenium may ameliorate the effect of mercury for avian scavengers in our study.

We analyzed our marine mammal tissue samples for heavy metals. Herein, we report only on mercury, which is actually stored in adipose tissue (blubber) as methylmercury. Only this heavy metal has the potential for sequestration in quantity in adipose tissue (Zed Mason, pers. comm., Institute for Integrated Research for Materials, Environments and Society, California State University, Long Beach). While we found detectable levels of methylmercury in all marine mammals tested, the levels were relatively low: California sea lion concentration mean = 0.08 ppm (range = 0.02 - 0.19 ppm, n = 3), harbor seal mean = 0.02 ppm (range = 0.01 - 0.04 ppm, n = 3).

Avian Scavengers: General Health Screening. Except for healed scars or occasional feather damage, we found no symptoms of disease or any other health concerns on any of the birds during physical evaluation. Results from general health screening tests are summarized in Tables 13 - 18. Reference values for clinically healthy individuals of these species (not necessarily free-living or from the same study region) are also provided in these tables. These reference ranges were extracted from the International Species Information System (ISIS, www2.isis.org), which

is a fee-based information exchange where zoos and research institutions can post their medical records and laboratory results from captive or wild animals. The values used here as reference ranges are from birds that were free of obvious symptoms of disease but their exact medical status was unknown. Acquisition of more samples will enable more sophisticated statistics and refinement and customization of reference ranges for these species in free-living conditions.

While our sample sizes are small and need to be increased, some initial interesting observations can be made. Hematology results demonstrate a mild leukocytosis (increased total white cell count) in turkey vultures as compared with bald eagles and common ravens (Tables 13-15). This may be a normal status for turkey vultures since the differential cell analysis indicates normal distributions of cell types. Common ravens in our study demonstrated a mild absolute lymphopenia (decrease in lymphocytes). Lymphocytes can be particularly difficult cells to differentiate. Consequently there can be wide variations in sample interpretation. The ISIS reference range standard deviation is very high, possibly due to the variety of samplers and laboratories used to generate the reference data. Although our sample size is still quite small (n = 2), our standard deviation and range is relatively small. We are hopeful that amassing more hematology data using a consistent sampling, submission, and analysis protocol will help us to build a more context-specific and reliable reference interval for free-living ravens and the other species in our study. Morphology of blood cells was normal in all samples and no hemoparasites were microscopically identified. Turkey vulture BO, with a blood lead level consistent with "severe clinical poisoning" (1.34 ppm) showed no clinical symptoms or hematological disturbances (anemia and polychromasia of red blood cells) that would be typical for lead intoxication.

Serum biochemistry results were largely within ISIS reference ranges and, thus, appear to reflect major organ function. A few minor exceptions include elevated amylase and glucose in ravens and elevated amylase in bald eagles. Serum glucose levels are highly variable in birds and will elevate with acute stress (Fudge 2000). Amylase is an enzyme whose elevation may reflect pathology of the liver, pancreas, or small intestine (Fudge 2000). There is some variability seen between laboratory chemistry analysis protocols. The meaning of increased amylase in this case remains unexplained. Unfortunately, the most reliable diagnostic for analysis of these organs is via endoscopic or surgical biopsy, which is beyond the scope of this study. Perhaps a further analysis of the literature or networking with researchers holding unpublished data will reveal that these values are relatively common for free-living eagles and ravens.

Fecal analyses were positive in three individuals sampled: Sarcocystis-like ova were identified in two bald eagles and low numbers of ascarid ova in one turkey vulture. Interestingly, specific pathogen testing for sarcocystis from cloacal swabs did not produce positives. This could be explained by the lack of specificity of the microscopic exam (e.g., sarcocystis ova seen may be from a prey host instead of from the bird being sampled) or too much specificity of the PCR primers being utilized for the test.

Tracheal bacteriology revealed light growth of several species of bacteria (Table 19). Turkey vultures had notably higher numbers of isolates (n = 7) compared to eagles (n = 3). Cloacal bacteriology results are summarized in Table 20. Turkey vultures also demonstrated the greatest number of cloacal isolates (n = 9) followed by eagles (n = 6), then ravens (n = 3).

Avian Scavengers: Specific Pathogen Testing. Specific pathogen test results are summarized in Table 21. Positive serology results indicate exposure to the pathogen in question but not necessarily active infection or disease. As such, serology is a good tool for broad monitoring of the presence of potential pathogens in the bird's environment. Serology can also be more sensitive than PCR when a bird is infected but not shedding the organism.

One eagle and two turkey vultures captured to Protocol were positive for PMV-1, as demonstrated by high HI titers. These birds had likely cleared a prior infection since no symptoms consistent with paramyxovirus were seen. One reference notes that in experimentally infected cormorants, titers were predicted to decline to an undetectable state at 126 days post infection (Leighton et. al. 2007). No similar experimental evidence is available for our study species but if similar serologic responses occur in bald eagles or turkey vultures, then we could suspect that our 3 positive birds were infected within about 4 months of capture. Although HI titers provide accurate information about exposure to PMV-1, they do not tell us which strain of virus or whether the exposure was to Newcastle Disease Virus. The fact that these birds encountered PMV-1 virus is interesting and in future studies it may be possible with more customization of the HI test to determine if infection had been with a Newcastle Disease strain of virus (Leighton et. al. 2007).

One vulture and one raven captured to Protocol tested positive for *Chlamydophila spp.* exposure. Neither one demonstrated disease symptoms (e.g., weakness or decreased pectoral muscle mass). The turkey vulture exposed to *Chlamydophila* had a total white blood cell count of 25 k/ul; this was within the range of all turkey vultures in this study. Moreover, this value was within the ISIS reference range for clinically normal turkey vultures. No anemia or lymphocytosis was demonstrated in either individual; these are common symptoms of active chlamydiosis. Both birds had negative blood and cloacal swab PCR results for *Chlamydophila spp.*

All birds captured to Protocol were free of *Coxiella burnetti* (Table 21); the role that avian scavengers may play as a reservoir or disseminator of this organism is poorly understood, Results to date indicate that bald eagles, common ravens, and turkey vultures do not play a significant role in the cycle of *C. burnetti* in coastal Washington and Oregon.

One bald eagle captured to Protocol tested positive for avian tuberculosis (infection with *Mycobacterium spp.*). This organism is reported in the literature in free-living bald eagles (Heatley 2007). This individual did not demonstrate a leukocytosis (elevated white blood count) as one would expect with advanced disease. The fact that only one bird tested positive is promising. Determination of the species of *Mycobacterium* is possible with DNA sequencing and

could be useful for determining the probable source of the infection. Banking of frozen fecal swabs is suggested as a means to allow this in the future.

All birds captured to Protocol were negative for avian influenza (by PCR of throat and cloacal swabs and by AGID serology). All 5 bald eagles and 4 of 7 turkey vultures captured to Protocol tested positive for exposure to adenovirus (adenoviral AGID serology) (Table 21); all ravens, one live-sampled and 3 from carcasses, tested negative for this virus (Table 21). Furthermore, APMV-1 PCR test results were negative in all ravens.

Salmonella cultures from cloacal swabs were negative for all birds captured to Protocol (Table 21). Three bald eagles captured to Protocol tested positive for exposure to *Mycoplasma gallisepticum* (plate agglutination serology). Upon further testing using HI methodology, all three of these birds were considered negative (titers of 1:20, reference range of positive if >1:64). All samples were negative on plate agglutination for *M. synoviae*.

All avian scavengers captured to protocol were found to be free of protozoan blood parasites by both PCR and microscopic evaluation of stained blood smears.

CONCLUSIONS

We have accomplished a great deal in the first 12 months of this multi-year study monitoring the health of avian scavengers on the coastal beaches of Washington and Oregon. From September 2011 through September 2012, we: secured state and federal permits for our research; developed strong partnerships with many organizations, including the Marine Mammal Stranding Network; established protocols for acquiring and tissue sampling avian scavengers and marine mammals; identified and established business relationships with 5 laboratories where our tissue samples are analyzed; captured and tissue-sampled 17 avian scavengers and 6 marine mammals to Protocol; and filed this report for FY2011. Our small sample sizes to date limit our ability to analyze our data statistically and to compare our findings with other studies. Thus conclusions on the health of avian scavengers in the coastal environment and an estimate of potential risks to re-introduced California condors in this environment are not yet possible. We project that achieving our overall sampling goals will require field work FY2012 – FY 2014. Together with the samples already acquired, our overall sample size goal is 76 avian scavengers and 48 marine mammals for analyses in Washington and Oregon.

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Table 1. Sample size goals for a multi-year study of contaminants and disease in avian scavengers and marine mammals on Oregon and Washington coastal beaches. Number of avian scavengers targeted for sampling is based on factors including relative abundance of scavengers and ease of trapping.

	FY2011	FY2012	FY2013	FY2014	TOTAL
Marine Mammals					
CA Sea Lion	3	9	10	10	32
Harbor Seal	3	5	4	4	16
Total Carcasses	**6**	**14**	**14**	**14**	**48**[a]
Avian Scavengers					
Turkey Vultures	5	5	10	10	30[b]
Bald Eagles	5	5	5	5	20[c]
Common Ravens	5	5	8	8	26[d]
Total Scavengers	**15**	**15**	**23**	**23**	**76**

[a] 24 samples from OR and 24 from WA; [b] 20 samples from OR and 10 from WA; [c] all samples from WA; [d] 16 samples from OR, 10 from WA.

Table 2. Changes in Methods to the health of avian scavenger study made after the FY2011 proposal was submitted in July 2011, as field work commenced in February 2012.

Topic	**Method presented in FY2011 grant proposal before initiation of field work**	**Method applied following initiation of field work**
Trapping of avian scavengers	While feeding only on California sea lion or harbor seal carcasses sampled as part of the study.	While feeding on any marine mammal or any other food item our research team might use as bait (e.g., salmon or pigeon carcasses).
Avian Scavenger tissue sampling	From live birds only.	From Common Ravens shot as part of APHIS predator control program at Snowy Plover nest sites in OR or WA.

Table 3. Comparison of trapping for avian scavengers on the Washington and Oregon coasts with a bow net versus a net launcher.

	Bow net	Net Launcher
Months of trap use	February – March	April - June
Total hours trapping	114	112
Avian scavengers observed feeding per 10 hours trapping[a]	1.5	4.5
Capture rate per 10 hours of trap effort	0.3	1.5
Total captures[b]	3	15

[a] All avian scavengers except gulls. [b] bald eagles, common ravens, turkey vultures only.

Table 4. Avian scavengers tissue-sampled in Oregon and Washington according to the Avian Scavenger Sample Acquisition Protocol. See Methods for a description of the protocol. For capture locations, see Figure 3.

Species	Auxiliary Marker Code	Acuisition Date	How obtained	Capture Location by GPS: UTM-X	Capture Location by GPS: UTM-Y	Acquisition location	Age (years)	Sex
Bald Eagle	K/O	6/11/2012	Live-captured	410863	5208441	0.4 mi N of N boundary (Damon Rd) of Ocean Shores, WA	≥ 4	M
Bald Eagle	U/O	6/9/2012	Live-captured	410863	5208441	0.4 mi N of N boundary (Damon Rd) of Ocean Shores, WA	≥ 4	F
Bald Eagle	M/D	3/18/2012	Live-captured	410660	5201653	3.8 mi S of the N boundary of Ocean Shores, WA	≥ 4	M
Bald Eagle	M/R	4/12/2012	Live-captured	418116	5162290	8.1 mi N of Ocean Park, WA	≥ 4	M
Bald Eagle	N/C	4/27/2012	Live-captured	418116	5162290	8.1 mi N of Ocean Park, WA	≥ 4	M
Turkey Vulture	BE	5/29/2012	Live-captured	424942	5172989	Tokeland, WA	≥ 2	U
Turkey Vulture	AA	5/11/2012	Live-captured	385945	4781894	4.5 mi N of Bandon, OR	≥ 2	U
Turkey Vulture	AB	5/11/2012	Live-captured	385945	4781894	4.5 mi N of Bandon, OR	≥ 2	U
Turkey Vulture	AC	5/11/2012	Live-captured	385945	4781894	4.5 mi N of Bandon, OR	≥ 2	U
Turkey Vulture	BS	5/11/2012	Live-captured	385945	4781894	4.5 mi N of Bandon, OR	≥ 2	U
Turkey Vulture	AE	5/23/2012	Live-captured	375276	4739366	3.0 mi N of Port Orford, OR	≥ 2	U
Turkey Vulture	BA	5/23/2012	Live-captured	375276	4739366	3.0 mi N of Port Orford, OR	≥ 2	U
Common Raven	RSYLGO	5/1/2012	Live-captured	418492	5157282	5.0 mi N of Ocean Park, WA	≥ 1	U
Common Raven	RGOLOS	6/4/2012	Live-captured	424942	5172989	Tokeland, WA	≥ 1	M
Common Raven	20	3/19/2012	Shot	407222	4859116	6.9 mi S of Florence, OR; Siltcoos Recreation Area	≥ 1	M
Common Raven	4	3/9/2012	Shot	393441	4804753	Coos Bay, OR; North Spit	≥ 1	M
Common Raven	5	3/9/2012	Shot	379843	4758146	9.7 mi S of Bandon, OR; New River Area of Critical Environmental Concern	≥ 1	F

Table 5. Avian scavengers trapped outside the parameters of the Avian Scavenger Sample Acquisition Protocol.

Species	Auxiliary Marker Code	Capture location	Capture Location by GPS: UTM-X	Capture Location by GPS: UTM-Y	Capture Date	Meets sampling protocol	Acquisition	Age (years)	Age classification	Sex
Turkey Vulture	BO	3.0 mii N of Ocean City, WA	410425	5218503	2/14/2012	N[a]	Live-captured	≥ 2	Adult	U
Turkey Vulture	AH	Tokeland, WA	424942	5172989	6/4/2012	N[b]	Live-captured	1	Juvenile	U
Turkey Vulture	BC	Tokeland, WA	424942	5172989	6/4/2012	N[b]	Live-captured	1	Juvenile	U
Bald Eagle	M/Y	3.8 mi S of the N boundary of Ocean Shores, WA	410660	5201653	3/19/2012	N[b]	Live-captured	2	Juvenile	M

[a] Captured in winter, outside summer residency period.

[b] Juvenile.

Table 6. Beached harbor seal and California sea lion carcasses tissue-sampled for heavy metals and organochlorines on the Washington and Oregon coasts, 2012. For carcass locations, see Figure 3.

Species	Age	Sex	Field ID Number	Date of Collection	Carcass location	Sample location by GPS: UTM-X	Sample location by GPS: UTM-Y	Collector
Harbor Seal	Adult	Female	WDFW2012-057	5/22/2012	0.4 mi W of Copalis Beach, WA	410385	5218226	Dyanna Lambourn
Harbor Seal	Adult	Male	HMSC12_02-04-Pv	2/6/2012	3.0 mi S of Waldport, OR	413118	4914202	Jim Rice
Harbor Seal	Adult	Female	HMSC12-04-28-Pv	5/11/2012	4.5 mi N of Bandon, OR	385945	4781894	Dan Varland
CA Sea Lion	Adult	Male	PSU 12-04-07 Zc	4/9/2012	1.8 mi N of Ocean Park, WA	418665	5151924	Deborah Duffield
CA Sea Lion	Adult	Male	PSU 12-06-01 Zc	6/3/2012	6.1 mi S of Ocean Park, WA	418399	5138994	Deborah Duffield
CA Sea Lion	Adult	Male	PSU 12-01-09 Zc	1/13/2012	South jetty, Columbia River, OR	421330	5119928	Deborah Duffield

Table 7. Mean organochlorine pesticide and heavy metal levels from blood samples of bald eagles, common ravens and turkey vultures captured according to the Avian Scavenger Sample Acquisition Protocol on the Washington and Oregon coasts, 2012.

Parameter[a]	Bald Eagle	Common Raven	Turkey Vulture
Organochlorine Pesticides[a]	Mean (range) SD Sample Size	Mean (range) SD Sample Size	Mean (range) SD Sample Size
4,4'-DDD (ppm)	$\bar{x}$ = 0.03 (0.01 - 0.09) δ = 0.03 n = 5	$\bar{x}$ < 0.00 (< 0.00 - 0.01) δ < 0.00 n = 2	N.D.[b]
4,4'-DDE (ppm)	$\bar{x}$ = 1.12 (0.42 - 2.17) δ = 0.71 n = 5	$\bar{x}$ = 0.23 (0.22 - 0.24) δ = 0.02 n = 2	$\bar{x}$ = 0.23 (0.01 - 0.63) δ = 0.24 n = 7
4,4'-DDT (ppm)	N.D.[b]	N.D.[b]	N.D.[b]
Total PCBs (ppm)	$\bar{x}$ = 0.72 (0.44 - 1.26) δ = 0.33 n = 5	$\bar{x}$ = 0.30 (0.19 - 0.41) δ = 0.16 n = 2	$\bar{x}$ = 0.17 (<0.00 - 0.43) δ = 0.17[c] n = 7
Heavy metals[a]			
lead (ppm)	$\bar{x}$ =0.03 (0.02 - 0.04) δ = 0.01 n = 5	$\bar{x}$ = 0.05 (0.05 - 0.05) δ < 0.00 n = 2	$\bar{x}$ = 0.09 (0.02 - 0.33) δ = 0.11 n = 7
mercury (ppm; wet weight)	$\bar{x}$ = 3.99 (1.90 - 6.09) δ = 1.59 n = 5	$\bar{x}$ = 2.28 (0.87 - 3.69) δ = 1.99 n = 2	$\bar{x}$ = 0.94 (0.18 - 1.42) δ = 0.45 n = 7[c]
selenium (ppm)	$\bar{x}$ = 4.26 (2.54 - 6.32) δ = 1.81 n = 5	$\bar{x}$ = 6.96 (1.84 - 12.08) δ = 7.24 n = 2	$\bar{x}$ = 0.72 (0.30 - 1.21) δ = 0.31 n = 7

[a] Pesticide levels measured from plasma. Heavy metals levels measured from whole blood.

[b] Not detected. Minimum detection level is 0.001 ppm.

[c] Detected in 5 of 7 vultures; for those two falling below the detection level, 1/2 the minimum detection level (= 0.05) used in calculations.

Table 8. Organochlorine pesticide levels from blood samples (plasma) of all bald eagles, common ravens and turkey vultures captured on the Washington and Oregon coasts, 2012. All individuals shown were captured according to the Avian Scavenger Sample Acquisition Protocol except turkey vulture with auxiliary code BO.

	Turkey Vulture	Turkey Vulture	Turkey Vulture	Turkey Vulture	Turkey Vulture	Turkey Vulture	Turkey Vulture	Turkey Vulture	Bald Eagle	Bald Eagle	Bald Eagle	Bald Eagle	Bald Eagle	Common Raven	Common Raven
Auxiliary Code	AA	AB	AC	AE	BA	BE	BS	BO	KO	MD	MR	NC	UO	RSYL60	RGOLOS
Organochlorines (ppm)[a]															
Total PCBs	0.28	0.43	0.07	N.D.	N.D.	0.05	0.31	N.D.	0.52	1.26	0.57	0.44	0.82	0.41	0.19
4,4'-DDT	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
4,4'-DDE	0.39	0.63	0.12	0.01	0.05	0.04	0.38	0.06	0.72	1.52	0.78	0.42	2.17	0.24	0.22
4,4'-DDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.09	0.03	0.02	0.01	0.02	N.D.	0.01
Aldrin	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Dieldren	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	< 0.01	0.01	0.01	0.01	0.01	< 0.01	N.D.
Endrin	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
alpha BHC	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
beta-BHC	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
delta-BHC	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
gamma-BHC	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Heptachlor	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Oxychlordane	0.01	0.01	< 0.01	N.D.	N.D.	0.002	0.006	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
H-Epoxide	N.D.	N.D.	< 0.01	N.D.	N.D.	N.D.	0.002	N.D.	< 0.01	0.007	N.D.	< 0.01	0.005	< 0.01	< 0.01
gamma-chlordane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
t-nonachlor	0.01	0.01	< 0.01	N.D.	< 0.01	< 0.01	0.01	< 0.01	0.01	0.04	0.05	0.02	0.03	0.01	0.01
alpha-Chlordane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Endosulfane I	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Endosulfane Sulfate	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

[a] N.D. = sample analyzed with less than the Minimum Detection Level; for all chemicals except PCBs, = .001 ppm; for total PCBs,= 0.05 ppm

Table 9. Organochlorine pesticide and heavy metal levels in three common ravens shot as part of the APHIS predator control program at western snowy plover nest sites on the Oregon Coast, 2012; these samples meet the Avian Scavenger Acquisition Protocol.

Common Raven ID	4	5	20
Organochlorines, from liver samples (ppm)[a]			
Total PCBs	0.08	0.14	0.95
4,4'-DDT	N.D.	N.D.	N.D.
4,4'-DDE	0.04	0.13	0.51
4,4'-DDD	< 0.01	< 0.01	0.01
Aldrin	N.D.	N.D.	N.D.
Dieldren	< 0.01	N.D	0.01
Endrin	N.D.	N.D.	0.32
alpha BHC	N.D.	N.D.	N.D.
beta-BHC	< 0.01	N.D.	0.01
delta-BHC	N.D.	N.D.	N.D.
gamma-BHC	N.D.	N.D.	N.D.
Heptachlor	N.D.	N.D.	N.D.
Oxychlordane	N.D	0.004	0.03
H-Epoxide	< 0.01	< 0.01	0.02
gamma-chlordane	N.D.	N.D.	N.D.
t-nonachlor	< 0.01	0.01	0.27
alpha-Chlordane	N.D.	N.D.	N.D.
Endosulfane I	N.D.	N.D.	N.D.
Endosulfane Sulfate	N.D.	N.D.	0.01
Heavy Metals, from bone samples (ppm)[b]			
Lead, dry weight[c]	17.3	N.D.	N.D.
Selenium[d]	N.D.	N.D.	N.D.
Cadmium[e]	N.D.	N.D.	N.D.
Arsenic[f]	N.D.	N.D.	N.D.
Aluminum[g]	N.D.	N.D.	N.D.

[a] N.D. = sample analyzed with less than the Minimum Detection Level (MDL); for all chemicals, is .001 ppm

[b] mercury not available to to limitations of extraction process

[b] ND = sample size with less than the MDL,<= 12.5 ppm

[c] ND = sample size with less than the MDL, < 100 ppm

[d] ND = sample size with less than the MDL, < 1.25 ppm

[e] ND = sample size with less than the MDL, < 25 ppm

[f] ND = sample size with less than the MDL, < 25 ppm

Table 10. Organochlorine pesticide concentrations (chlordane and DDT) taken from blubber samples of adult harbor seal and California sea lion carcasses washed up on the Washington and Oregon coasts, 2012. For Mammal locations, see Figure 3.

	Harbor Seal Female	Harbor Seal Female	Harbor Seal Male	CA Sea Lion Male	CA Sea Lion Male	CA Sea Lion Male
Field ID Number	HMSC 12-04-28-Pv	WDFW2012-057	HMSC 12-02-04-Pv	PSU 12-06-01 Zc	PSU 12-01-09 Zc	PSU 12-04-07 Zc
Wet weight [lipd; blubber sample (g)]	0.98	1.14	1.05	1.04	0.92	0.95
Concentration	ug/g lw	ug/g lw	ug/g lw	ug/g lw	ug/g lw	ug/g lw
CHLORDANE Compounds						
Heptachlor	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Heptachlor epoxide	N.D.	N.D.	N.D.	N.D.	0.03	N.D.
Oxychlordane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Chlordane-gamma	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Chlordane-alpha	N.D.	N.D.	N.D.	0.02	N.D.	N.D.
trans-Nonachlor	N.D.	0.01	0.02	0.07	0.32	0.05
cis-Nonachlor	N.D.	N.D.	N.D.	0.01	0.01	N.D.
Methoxychlor	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
TOTAL CHLORDANE	**N.D.**	**0.01**	**0.02**	**0.12**	**0.37**	**0.05**
DDT compounds						
2,4'-DDE	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
4,4'-DDE	0.11	0.22	0.39	0.92	5.56	0.51
2,4'-DDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
4,4'-DDD	N.D.	N.D.	0.03	0.04	0.12	0.05
2,4'-DDT	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
4,4'-DDT	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
TOTAL DDT	**0.11**	**0.22**	**0.41**	**0.97**	**5.67**	**0.56**

Table 11. Organochlorine pesticide concentrations (total PCBs, PCB congeners) from blubber samples taken from adult harbor seal and California sea lion carcasses washed up on the Washington and Oregon coasts, 2012. For marine mammal locations, see Figure 3.

	Harbor Seal Female	Harbor Seal Female	Harbor Seal Male	CA Sea Lion Male	CA Sea Lion Male	CA Sea Lion Male
Field ID Number	HMSC 12-04-28-Pv	WDFW2012-057	HMSC 12-02-04-Pv	PSU 12-06-01 Zc	PSU 12-01-09 Zc	PSU 12-04-07 Zc
Wet weight [lipd; blubber sample (g)]	0.98	1.14	1.05	1.04	0.92	0.95
Concentration	ug/g lw	ug/g lw	ug/g lw	ug/g lw	ug/g lw	ug/g lw
Total PCBs [a]	**0.04**	**0.24**	**0.45**	**0.84**	**2.30**	**0.41**
PCB 003	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 008	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 018	N.D.	N.D.	N.D.	0.05	N.D.	N.D.
PCB 031	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 028	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 033	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 052	N.D.	0.01	N.D.	N.D.	0.03	0.02
PCB 049	N.D.	0.00	N.D.	N.D.	0.02	0.01
PCB 044	N.D.	N.D.	N.D.	N.D.	0.01	N.D.
PCB 037	N.D.	N.D.	N.D.	N.D.	<0.00	N.D.
PCB 074	N.D.	N.D.	N.D.	N.D.	0.02	N.D.
PCB 070	N.D.	N.D.	N.D.	N.D.	0.01	N.D.
PCB 066	N.D.	N.D.	N.D.	N.D.	0.02	N.D.
PCB 095	N.D.	N.D.	N.D.	N.D.	0.01	N.D.
PCB 056 (060)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 101	N.D.	0.11	0.01	0.05	0.07	0.02
PCB 099	N.D.	0.02	0.03	0.03	0.12	0.03
PCB 119	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 097	N.D.	N.D.	N.D.	N.D.	0.032	0.014
PCB 087	N.D.	N.D.	N.D.	N.D.	0.04	N.D.
PCB 081	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 110	N.D.	N.D.	N.D.	0.02	0.02	N.D.
PCB 077	N.D.	N.D.	N.D.	0.01	0.00	N.D.
PCB 151	N.D.	N.D.	N.D.	0.03	0.02	N.D.
PCB 149	N.D.	N.D.	N.D.	0.07	0.05	0.01
PCB 123	N.D.	N.D.	N.D.	0.01	0.00	0.00
PCB 118	N.D.	N.D.	N.D.	0.03	0.11	0.02
PCB 114	N.D.	N.D.	N.D.	<0.00	0.03	<0.00
PCB 153	0.04	0.06	0.14	0.15	0.47	0.08
PCB 168 + 132	<0.00	0.02	0.03	0.04	0.12	0.02
PCB 105	N.D.	N.D.	N.D.	N.D.	0.03	N.D.
PCB 141	N.D.	N.D.	N.D.	0.03	N.D.	N.D.
PCB 138	N.D.	0.04	0.09	0.12	0.35	0.06

	Harbor Seal Female	Harbor Seal Female	Harbor Seal Male	CA Sea Lion Male	CA Sea Lion Male	CA Sea Lion Male
Field ID Number	HMSC 12-04-28-Pv	WDFW2012-057	HMSC 12-02-04-Pv	PSU 12-06-01 Zc	PSU 12-01-09 Zc	PSU 12-04-07 Zc
Wet weight [lipd; blubber sample (g)]	0.98	1.14	1.05	1.04	0.92	0.95
Concentration	ug/g lw	ug/g lw	ug/g lw	ug/g lw	ug/g lw	ug/g lw
PCB 158	N.D.	0.01	0.02	0.03	0.09	0.01
PCB 126	N.D.	N.D.	N.D.	N.D.	N.D.	19.81
PCB 187	N.D.	0.03	0.04	0.06	0.08	0.03
PCB 183	N.D.	0.01	0.01	0.03	0.05	0.04
PCB 128	N.D.	N.D.	N.D.	N.D.	0.06	N.D.
PCB 167	N.D.	N.D.	N.D.	N.D.	0.01	N.D.
PCB 174	N.D.	N.D.	N.D.	0.03	N.D.	N.D.
PCB 177	N.D.	N.D.	N.D.	N.D.	0.05	N.D.
PCB 156	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 199 (200)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 157	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 180	N.D.	0.03	0.08	0.07	0.19	0.03
PCB 169	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 170	N.D.	N.D.	N.D.	N.D.	0.09	N.D.
PCB 201	N.D.	N.D.	N.D.	N.D.	0.10	N.D.
PCB 189	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 195	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 194	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 206	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
PCB 209	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

[a] Totals from sum of PCB congeners shown below for each individual.

Table 12. Heavy metal levels from whole blood samples of all bald eagles, common ravens and turkey vultures captured on the Washington and Oregon coasts, 2012. Individuals captured according to the Avian Scavenger Sample Acquisition Protocol are shown in bold (7 turkey vultures, 5 bald eagles, and 2 common ravens).

	Turkey Vulture	**Turkey Vulture**	**Turkey Vulture**	**Turkey Vulture**	**Turkey Vulture**	**Turkey Vulture**	**Turkey Vulture**	**Turkey Vulture**	**Bald Eagle**	**Bald Eagle**	**Bald Eagle**	**Bald Eagle**	**Bald Eagle**	**Common Raven**	**Common Raven**	Turkey Vulture	Turkey Vulture	Turkey Vulture	Bald Eagle
Auxiliary Code	**AA**	**AB**	**AC**	**AE**	**BA**	**BE**	**BS**	**KO**	**MD**	**MR**	**NC**	**UO**	**RGOLOS**	**RSYLGO**	AH	BC	BO	MY	
Heavy Metal (ppm)[a]																			
arsenic	**0.01**	**0.02**	**0.01**	**N.D.**	**0.02**	**0.07**	**0.01**	**0.06**	**0.10**	**0.08**	**0.19**	**0.08**	**0.29**	**0.20**	0.05	0.16	0.02	0.17	
cadmium	**N.D.**	**0.01**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**0.01**	N.D.	N.D.	N.D.	N.D.	
lead	**0.04**	**0.04**	**0.02**	**0.08**	**0.05**	**0.33**	**0.08**	**0.02**	**0.04**	**0.02**	**0.03**	**0.03**	**0.05**	**0.05**	0.07	0.06	1.34	0.02	
mercury	**1.42**	**1.35**	**0.18**	**0.77**	**0.66**	**1.29**	**0.94**	**3.35**	**4.93**	**6.09**	**1.9**	**3.67**	**0.87**	**3.69**	1.41	1.58	1.14	3.85	
selenium	**0.96**	**1.21**	**0.59**	**0.3**	**0.53**	**0.59**	**0.88**	**2.87**	**6.32**	**6.08**	**3.47**	**2.54**	**1.84**	**12.08**	0.44	0.55	0.74	6.46	
thalium	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**N.D.**	**0.01**	**N.D.**	7.00	0.01	N.D.	N.D.	

[a] N.D. = sample analyzed with less than the Minimum Detection Level (= 0 .001 ppm)

Table 13. Hematology test results for **bald eagles** captured according to the Avian Scavenger Sample Acquisition Protocol on the Washington coast, 2012.

Parameter (units)	Results: Average (Range) / SD / n	Reference Range[1]
Total White Blood Cells (k/uL)	$\bar{x}$ = 9.66 (6.3 - 16.0) δ = 3.8442 n = 5	$\bar{x}$ = 14.34 (3.30-48.10) δ = 6.372 n = 339
Heterophils (%)	$\bar{x}$ = 63.4 (44.0 - 85.0) δ = 17.8129 n = 5	
Heterophils Absolute Count	$\bar{x}$ = 5.762 (3.960 – 8.160) δ = 1517.7681 n = 5	$\bar{x}$ = 10.07 (0.396-28.80) δ = 5.106 n = 332
Lymphocytes (%)	$\bar{x}$ = 24.2 (11.0 - 42.0) δ = 13.4796 n = 5	
Lymphocytes Absolute Count	$\bar{x}$ = 2.488 (0.690 – 4.000) δ = 1.631 n = 5	$\bar{x}$ = 2.715 (0.055-21.20) δ = 2.492 n = 333
Eosinophils (%)	$\bar{x}$ = 6.6 (1.0 - 17.0) δ = 6.5422 n = 5	
Eosinophils Absolute Count	$\bar{x}$ = 0.806 (0.100 – 2.720) δ = 1.106 n = 5	$\bar{x}$ = 1.087 (0.059-5.628) δ = 0.878 n =238
Basophils (%)	$\bar{x}$ = 1.5 (1.0 - 3.0) δ = 1.0 n = 4	
Basophils Absolute Count	$\bar{x}$ = 0.140 (0.090 - 0.210) δ = 0.0559 n = 4	$\bar{x}$ = 0.247 (0.046-1.228) δ = 0.191 n = 107
Monocytes (%)	$\bar{x}$ = 4.6 (1.0 - 8.0) δ = 2.6077 n = 5	
Monocytes Absolute Count	$\bar{x}$ = 0.492 (0.060 – 0.960) δ = 0.375 n = 5	$\bar{x}$ = 0.703 (0.075-5.134) δ = 0.696 n = 195
Packed Cell Volume (%)	$\bar{x}$ = 51.0 (44.0 - 56.0) δ = 4.6368 n = 5	$\bar{x}$ = 44.8 (19.0-70.0) δ = 7.2 n = 329
Hemoparasites	None	

[1] From the International Species Information System (ISIS), an information exchange where zoos and research institutions can post medical records and lab results from captive or wild animals. Values are from birds that were free of obvious symptoms of disease but exact medical status was unknown.

Table 14. Hematology test results for **common ravens** captured according to the Avian Scavenger Sample Acquisition Protocol on the Washington coast, 2012.

Parameter (units)	Results: Average (Range) / SD / n	Reference Range[2]
Total White Blood Cells (k/uL)	$\bar{x}$ = 6.25 (6.0 - 6.5) δ = 0.3536 n = 2	$\bar{x}$ = 7.196 (4.00-14.9) δ = 2.870 n = 14
Heterophils (%)	$\bar{x}$ = 75.0 (67.0 - 83.0) δ = 11.3137 n = 2	
Heterophils Absolute Count	$\bar{x}$ = 4705.0 (4020.0 - 5390.0) δ = 968.7363 n = 2	$\bar{x}$ = 3734 (1500-7750) δ = 3734 n = 14
Lymphocytes (%)	$\bar{x}$ = 13.0 (8.0 - 18.0) δ = 7.0711 n = 2	
Lymphocytes Absolute Count	$\bar{x}$ = 800.0 (520.0 - 1080.0) δ = 395.9798 n = 2	$\bar{x}$ = 2925 (976-6560) δ = 1545 n = 14
Eosinophils (%)	$\bar{x}$ = 3.5 (2.0 - 5.0) δ = 2.1213 n = 2	
Eosinophils Absolute Count	$\bar{x}$ = 215.0 (130.0 - 300.0) δ = 120.2082 n = 2	$\bar{x}$ = 344 (63-730) δ = 235 n = 8
Basophils (%)	$\bar{x}$ = 7.0 (4.0 - 10.0) δ = 4.2426 n = 2	
Basophils Absolute Count	$\bar{x}$ = 430.0 (260.0 - 600.0) δ = 240.4163 n = 2	$\bar{x}$ = 445 (50-780) δ = 307 n = 7
Monocytes (%)	$\bar{x}$ = 1.5 (0.0 - 3.0) n = 2	
Monocytes Absolute Count	$\bar{x}$ = 100.0 (0.0 - 200.0) n = 2	$\bar{x}$ = 277 (50-480) δ = 172 n = 6
Packed Cell Volume (%)	$\bar{x}$ = 49.0 (43.0 - 55.0) δ = 8.4853 n = 2	$\bar{x}$ = 42.6 (35.0-52.0) δ = 5.4 n = 17
Hemoparasites	None	

[2] From the International Species Information System (ISIS), an information exchange where zoos and research institutions can post medical records and lab results from captive or wild animals. Values are from birds that were free of obvious symptoms of disease but exact medical status was unknown.

Table 15. Hematology test results for **turkey vultures** captured according to the Avian Scavenger Sample Acquisition Protocol on the Washington and Oregon coasts, 2012.

Parameter (units)	Results: Average (Range) / SD / n	Reference Range[3]
Total White Blood Cells (k/uL)	$\bar{x}$ = 22.5857 (14.3 - 30.0) δ = 5.1934 n = 7	$\bar{x}$ = 17.39 (7.00-34.30) δ = 7.112 n = 26
Heterophils (%)	$\bar{x}$ = 70.0 (36.0 - 91.0) δ = 18.5293 n = 7	
Heterophils Absolute Count	$\bar{x}$ = 15.053 (10.80 – 18.63) δ = 2.598 n = 7	$\bar{x}$ = 9.182 (2.99-19.40) δ = 4.034 n = 26
Lymphocytes (%)	$\bar{x}$ = 21.5714 (4.0 - 50.0) δ = 15.0317 n = 7	
Lymphocytes Absolute Count	$\bar{x}$ = 5.471 (0.570 – 15.000) δ = 4.787 n = 7	$\bar{x}$ = 4.761 (0.675-16.70) δ = 3.927 n = 26
Eosinophils (%)	$\bar{x}$ = 6.1429 (3.0 - 11.0) δ = 2.8536 n = 7	
Eosinophils Absolute Count	$\bar{x}$ = 1.460 (0.530 – 2.750) δ = 0.874 n = 7	$\bar{x}$ = 3.166 (0.150-7.859) δ = 2.477 n = 22
Basophils (%)	$\bar{x}$ = 2.0 (1.0 - 3.0) δ = 0.7071 n = 5	
Basophils Absolute Count	$\bar{x}$ = 0.492 (0.300 – 0.700) δ = 0.143 n = 5	$\bar{x}$ = 0.491 (0.090-1.350) δ = 0.364 n = 20
Monocytes (%)	$\bar{x}$ = 3.0 (1.0 - 5.0) δ = 2.8284 n = 2	
Monocytes Absolute Count	$\bar{x}$ = 0.875 (0.250 – 1.500) δ = 0.884 n = 2	$\bar{x}$ = 0.636 (0.100-1.407) δ = 0.465 n = 16
Packed Cell Volume (%)	$\bar{x}$ = 47.8571 (43.0 - 55.0) δ = 4.5981 n = 7	$\bar{x}$ = 45.7 (38.5-55.0) δ = 4.3 n = 30
Hemoparasites	None	

[3] From the International Species Information System (ISIS), an information exchange where zoos and research institutions can post medical records and lab results from captive or wild animals. Values are from birds that were free of obvious symptoms of disease but exact medical status was unknown.

Table 16. Serum biochemistry test results for **common ravens** captured according to the Avian Scavenger Sample Acquisition Protocol on the Washington coast, 2012.

Parameter (units)	Results: Average (Range) / SD / n	Reference Range[4]
Amylase (U/L)	$\bar{x}$ = 1387.5 (1371.0 - 1404.0) δ = 23.3345 n = 2	$\bar{x}$ = 565 (1-781) δ = 321 n = 5
Aspartate Aminotransferase (U/L)	$\bar{x}$ = 444.5 (343.0 - 546.0) δ = 143.5427 n = 2	$\bar{x}$ = 260 (147-411 δ = 68 n = 21
Bile acids (umol/l)	$\bar{x}$ = 3.0 (2.0 - 4.0) δ = 1.4142 n = 2	
Blood Urea Nitrogen (mg/dl)	$\bar{x}$ = 4.25 (2.5 - 6.0) δ = 2.4749 n = 2	$\bar{x}$ = 4 (3-5) δ = 1 n = 7
Calcium (mg/dl)	$\bar{x}$ = 7.85 (7.8 - 7.9) δ = 0.0707 n = 2	$\bar{x}$ = 8.2 (7.1-9.6) δ = 0.7 n = 23
Phosphorus (mg/dl)	$\bar{x}$ = 1.6 (1.4 - 1.7) δ = 0.2121 n = 2	$\bar{x}$ = 2.3 (1.2-7.2) δ = 1.8 n = 10
Ca/Ph ratio	$\bar{x}$ = 5.1 (4.6 - 5.6) δ = 0.7071 n = 2	
Cholesterol (mg/dl)	$\bar{x}$ = 189.5 (181.0 - 198.0) δ = 12.0208 n = 2	$\bar{x}$ = 202 (118-308) δ = 49 n = 20
Creatine phosphokinase (U/L)	$\bar{x}$ = 388.5 (386.0 - 391.0) δ = 3.5355 n = 2	$\bar{x}$ = 196 (61-537) δ = 138 n = 11
Chloride (meq/l)	$\bar{x}$ = 117.5 (117.0 - 118.0) δ = 0.7071 n = 2	$\bar{x}$ = 123 (115-144) δ = 10 n = 8
Gamma Glutamyltransferase (U/L)	$\bar{x}$ = 1.5 (1.0 - 2.0) δ = 0.7071 n = 2	$\bar{x}$ = 8 (4-14) δ = 5 n = 4
Potassium (meq/l)	$\bar{x}$ = 7.1 (4.2 - 10.0) δ = 4.1012 n = 2	$\bar{x}$ = 3.2 (2.3-4.8) δ = 0.7 n = 8
Sodium (meq/l)	$\bar{x}$ = 146.5 (144.0 - 149.0) δ = 3.5355 n = 2	$\bar{x}$ = 161 (154-177) δ = 7 n = 9
Na/K ratio	$\bar{x}$ = 24.5 (14.0 - 35.0) δ = 14.8492 n = 2	

Parameter (units)	Results: Average (Range) / SD / n	Reference Range[4]
Serum Glucose (mg/dl)	$\bar{x}$ = 644.0 (504.0 - 784.0) δ = 197.9899 n = 2	$\bar{x}$ = 366 (305-439) δ = 34 n = 20
Total Protein by colorimetry (g/dl)	$\bar{x}$ = 3.8 (3.8 - 3.8) δ = 0.0 n = 2	$\bar{x}$ = 3.6 (2.5-4.3 δ = 0.5 n = 20
Globulin (g/dl)	$\bar{x}$ = 2.5 (2.4 - 2.5) δ = 0.0707 n = 2	$\bar{x}$ = 2.1 (1.6-3.2) δ = 0.5 n = 10
Triglycerides (mg/dl)	$\bar{x}$ = 80.0 (65.0 - 95.0) δ = 21.2132 n = 2	$\bar{x}$ = 103 (86-138) δ = 21 n = 5
Uric Acid (mg/dl)	$\bar{x}$ = 6.9 (6.6 - 7.2) δ = 0.4243 n = 2	$\bar{x}$ = 8.1 (1.8-18.6) δ = 4.8 n = 22

[1] From the International Species Information System (ISIS), an information exchange where zoos and research institutions can post medical records and lab results from captive or wild animals. Values are from birds that were free of obvious symptoms of disease but exact medical status was unknown.

Table 17. Serum biochemistry test results for **bald eagles** captured according to the Avian Scavenger Sample Acquisition Protocol on the Washington coast, 2012.

Parameter (units)	Results: Average (Range) / SD / n	ISIS Reference Range[5]
Amylase (U/L)	$\bar{x}$ = 1501.5 (995.0 - 2052.0) δ = 583.7582 n = 4	$\bar{x}$ = 854 (302 – 1478) δ = 347 n = 25
AST (U/L)	$\bar{x}$ = 476.5 (293.0 - 1002.0) δ = 350.3888 n = 4	$\bar{x}$ = 196 (47 – 781) δ = 347 n = 25
Bile acids (umol/l)	$\bar{x}$ = 33.8 (12.0 - 54.0) δ = 18.8392 n = 4	
Blood Urea Nitrogen (mg/dl)	$\bar{x}$ = 3.375 (2.5 - 6.0) δ = 1.75 n = 4	$\bar{x}$ = 4 (0 – 15) δ = 2 n = 67
Calcium (mg/dl)	$\bar{x}$ = 8.475 (7.8 - 9.6) δ = 0.8617 n = 4	$\bar{x}$ = 10.0 (0 – 17.0) δ = 1.5 n = 304
Phosphorus (mg/dl)	$\bar{x}$ = 2.4 (2.0 - 3.1) δ = 0.4967 n = 4	$\bar{x}$ = 3.4 (0.6 – 14.5) δ = 1.8 n = 177
Ca/Ph ratio	$\bar{x}$ = 7.2 (2.8 - 11.1) δ = 3.9837 n = 4	
Cholesterol (mg/dl)	$\bar{x}$ = 221.0 (180.0 - 289.0) δ = 50.0333 n = 4	$\bar{x}$ = 211 (0 – 330) δ = 42 n = 136
Creatinine Kinase (U/L)	$\bar{x}$ = 521.8 (432.0 - 641.0) δ = 105.006 n = 4	$\bar{x}$ = 521 (60 – 3220) δ = 457 n = 175
Chloride (meq/l)	$\bar{x}$ = 112.5 (112.0 - 113.0) δ = 0.7071 n = 2	$\bar{x}$ = 117 (93 – 148) δ = 7 n = 96
Gamma Glutamyl Transferase (U/L)	$\bar{x}$ = 5.0 (0.0 - 12.0) δ = 5.2915 n = 4	$\bar{x}$ = 5 (0 – 13) δ = 4 n = 30
Potassium (meq/l)	$\bar{x}$ = 2.9 (2.8 - 3.0) δ = 0.1414 n = 2	$\bar{x}$ = 2.5 (0.7 – 6.7) δ = 1.1 n = 144
Sodium (meq/l)	$\bar{x}$ = 146.5 (145.0 - 148.0) δ = 2.1213 n = 2	$\bar{x}$ = 152 (134 – 169) δ = 5 n = 153
Na/K ratio	$\bar{x}$ = 50.5 (49.0 - 52.0) δ = 2.1213 n = 2	

Parameter (units)	Results: Average (Range) / SD / n	ISIS Reference Range[5]
Serum Glucose (mg/dl)	$\bar{x}$ = 376.3 (318.0 - 452.0) δ = 55.9665 n = 4	$\bar{x}$ = 291 (0 – 422) δ = 44 n = 299
Total Protein (g/dl)	$\bar{x}$ = 3.6 (3.3 - 4.1) δ = 0.3403 n = 4	$\bar{x}$ = 3.6 (2.0 – 6.1) δ = 0.6 n = 305
Globulin (g/dl)	$\bar{x}$ = 2.5 (2.2 - 2.7) δ = 0.2217 n = 4	$\bar{x}$ = 2.3 (1.1 – 4.3) δ = 0.6 n = 179
Triglycerides (mg/dl)	$\bar{x}$ = 102.0 (60.0 - 161.0) δ = 47.9653 n = 4	$\bar{x}$ = 111 (47 – 332) δ = 57 n = 24
Uric Acid (mg/dl)	$\bar{x}$ = 7.8 (3.9 - 11.7) δ = 3.9441 n = 4	$\bar{x}$ = 10.1 (1.5 – 38.0) δ = 6.6 n = 335

[5] From the International Species Information System (ISIS), an information exchange where zoos and research institutions can post medical records and lab results from captive or wild animals. Values are from birds that were free of obvious symptoms of disease but exact medical status was unknown.

Table 18. Serum biochemistry test results for **turkey vultures** captured according to the Avian Scavenger Sample Acquisition Protocol on the Washington and Oregon coasts, 2012.

Parameter (units)	Results: Average (Range) / SD / n	Reference Range[6]
Amylase (U/L)	$\bar{x}$ = 124.7 (63.0 - 189.0) δ = 45.1099 n = 7	$\bar{x}$ = 108 (79 – 138) δ = 30 n = 3
AST (U/L)	$\bar{x}$ = 26.6 (18.0 - 33.0) δ = 6.3471 n = 7	$\bar{x}$ = 34 (12 – 138) δ = 29 n = 21
Bile acids (umol/l)	$\bar{x}$ = 14.9 (6.0 - 30.0) δ = 8.8962 n = 7	
Blood Urea Nitrogen (mg/dl)	$\bar{x}$ = 3.0 (2.5 - 6.0) δ = 1.3229 n = 7	$\bar{x}$ = 3 (2 – 4) δ = 1 n = 5
Calcium (mg/dl)	$\bar{x}$ = 8.5 (7.5 - 9.6) δ = 0.7616 n = 7	$\bar{x}$ = 9.2 (7.2 – 10.3) δ = 0.7 n = 21
Phosphorus (mg/dl)	$\bar{x}$ = 2.0 (1.5 - 2.7) δ = 0.3761 n = 7	$\bar{x}$ = 2.5 (0.8 – 10.5) δ = 2.1 n = 19
Ca/Ph ratio	$\bar{x}$ = 7.8 (3.6 - 16.2) δ = 4.6028 n = 7	
Cholesterol (mg/dl)	$\bar{x}$ = 164.7143 (123.0 - 235.0) δ = 34.0818 n = 7	$\bar{x}$ = 171 (128 – 215) δ = 22 n = 15
Creatinine Kinase (U/L)	$\bar{x}$ = 581.4 (330.0 - 1047.0) δ = 297.0224 n = 7	$\bar{x}$ = 448 (123 – 876) δ = 172 n = 15
Chloride (meq/l)	$\bar{x}$ = 109.0 (108.0 - 110.0) δ = 1.4142 n = 2	$\bar{x}$ = 116 (1.2 – 5.3) δ = 1.0 n = 17
Gamma Glutamyl Transferase (U/L)	$\bar{x}$ = 2.5714 (0.0 - 3.0) δ = 1.1339 n = 7	$\bar{x}$ = 4 (0 – 7) δ = 3 n = 5
Potassium (meq/l)	$\bar{x}$ = 4.35 (4.1 - 4.6) δ = 0.3536 n = 2	$\bar{x}$ = 3.0 (1.2 – 5.3) δ = 1.0 n = 17
Sodium (meq/l)	$\bar{x}$ = 143.5 (143.0 - 144.0) δ = 0.7071 n = 2	$\bar{x}$ = 153 (141 – 168) δ = 7 n = 18
Na/K ratio	$\bar{x}$ = 156.0 (31.0 - 306.0) δ = 143.7382 n = 4	

Parameter (units)	Results: Average (Range) / SD / n	Reference Range[6]
Serum Glucose (mg/dl)	$\bar{x}$ = 280.7 (228.0 - 351.0) δ = 40.6887 n = 7	$\bar{x}$ = 257 (182 – 318) δ = 39 n = 23
Total Protein (g/dl)	$\bar{x}$ = 3.8 (3.0 - 4.8) δ = 0.594 n = 7	$\bar{x}$ = 4.0 (2.9 – 6.0) δ = 0.6 n = 20
Globulin (g/dl)	$\bar{x}$ = 2.7 (2.1 - 3.6) δ = 0.5024 n = 7	$\bar{x}$ = 2.4 (1.7 – 2.9) δ = 0.3 n = 16
Triglycerides (mg/dl)	$\bar{x}$ = 52.6 (33.0 - 69.0) δ = 13.8667 n = 7	$\bar{x}$ = 56 (37 – 79) δ = 16 n = 6
Uric Acid (mg/dl)	$\bar{x}$ = 5.3 (2.4 - 9.8) δ = 2.3607 n = 7	$\bar{x}$ = 4.3 (1.6 – 8.1) δ = 1.8 n = 21

[6] From the International Species Information System (ISIS), an information exchange where zoos and research institutions can post medical records and lab results from captive or wild animals. Values are from birds that were free of obvious symptoms of disease but exact medical status was unknown.

Table 19. Bacterial isolates identified from tracheal swabs collected from bald eagles and turkey vultures captured according to the Avian Scavenger Sample Acquisition Protocol on the Washington and Oregon coasts, 2012.

Bird Species (n)[1]	# Isolates	Isolates from tracheal swabs
Turkey vulture (7)	7	*Brevibacterium sp., Cellulomonas sp., Corynebacterium. Enterococcus sp., E. coli (2), Microbacterium sp.*
Bald eagle (5)	3	*Pseudomonas fluorescens, Corynebacterium jerikeim, Coagulase negative Staphylococcus sp.*

[1] Tracheal samples were not collected from ravens.

Table 20. Bacterial isolates identified from cloacal swabs collected from bald eagles, turkey vultures and common ravens obtained according to the Avian Scavenger Sample Acquisition Protocol on the Washington and Oregon coasts, 2012.

Bird Species (n)	# Isolates	Isolates from cloacal swabs
Bald eagle (5)	6	*E. coli (3), Coagulase Negative Staphylococcus, Enterococcus faecalis, Proteus mirabilis*
Common raven (5)[a]	6	*Coag. Neg. Staphylococcus, Enterococcus sp. (3), E. coli (2)*
Turkey vulture (7)	7	*Corynebacterium sp., E. coli (4), Klebsiella sp., Proteus sp. (2), Vagococcus camiphilus, Unspeciated Gram-positive catalase negative isolate*

[a] sample includes 3 dead ravens.

Table 21. Results from pathogen tests for bald eagles, turkey vultures and common ravens obtained according to the Avian Scavenger Sample Acquisition Protocol on the Washington and Oregon coasts, 2012.

Pathogen/Sample/Method		Results: Positive / n			
		Bald eagle (n=5)	Live common raven (n=2)	Dead common raven[7] (n=3)	Turkey vulture (n=7)
Adenovirus	Serum AGID	5/5	0/1	n/a	4/7
	Liver/spleen swab PCR (dead ravens only)			0/3	
Avian Influenza	Throat swab PCR	5/5	0/1	0/3	0/7
	Serum AGID	0/5	0/1	n/a	0/6
Avian Paramyxovirus 1 (APMV-1)	Serum HI	1/5	1/1	n/a	2/7
	Liver/spleen swab PCR (dead ravens only)			0/3	
Chlamydophila sp.	Plasma IFA	0/3	1/2		1/7
	Whole blood PCR	0/5	0/1	0/3	0/6
	Cloacal swab PCR	0/5	0/1	0/3	0/6
	Liver/spleen swab PCR			0/3	
Coxiella burnetti	Whole blood PCR	0/5	0/2	n/a	0/7
	Tracheal swab PCR	0/5	0/2	n/a	0/7
	Cloacal swab PCR	0/5	0/2	n/a	0/7
	Liver (dead ravens only)			0/3	
	Spleen (dead ravens only)			0/3	
	Kidney (dead ravens only)			0/3	
	Lung (dead ravens only)			0/3	
	Intestine (dead ravens only)			0/3	
Hemoparasites	Microscopic visual analysis	0/5	0/2	n/a	0/7
	Brachyspira spp. (protozoan hemoparasites) PCR whole blood	0/5	0/1	n/a	0/6
Mycobacterium spp. cloacal swab PCR		1/5	0/1	0/3	0/7
Mycoplasma	*M. gallisepticum* serum PA	3/5	0/1	n/a	0/7
	M. synoviae serum HI (to verify positive PA)	0/3		n/a	
	M. synoviae serum PA	0/5	0/1	n/a	0/7
Salmonella spp. cloacal swab culture		0/3	0/1		0/6
Sarcocystis spp. cloacal swab PCR		0/5	0/1	0/3	0/7

[7] Results designated "n/a" indicate that performing this test was not possible in dead ravens.

Appendix 1. Principal traps deployed for capturing avian scavengers on coastal beaches of Oregon and Washington: bow net (above) and net launcher (below). Both traps shown here were baited with a harbor seal carcass.

Capture of juvenile male bald eagle on the Ocean Shores peninsula on March 19, 2012. This individual was fitted with Visual Identification Band M/Y.

Photos by Tom Rowley.

Capture of adult bald eagle north of Ocean Shores on June 9, 2012. This individual was fitted with Visual Identified Band U/O.

Photos by Dalene Edgar.

Appendix 2. Marking avian scavengers. For identification of individual birds, we applied wrap-around wing markers to turkey vultures and leg bands to common ravens and bald eagles.

Glenn Johnson with turkey vulture. Dan Varland photo.

Dan Varland releases common raven. Tom Rowley photo left, D Varland photo above.

Scott Ford with Bald Eagle. Dan Varland photos.

Appendix 3. Marine Mammal Tissue Sampling Protocol

Sample Collection – Standard Blubber Sample

Use a sharp knife with a plastic or metal handle (not wooden). Knives with serrated blades are acceptable.

The cut

The sample should be full-thickness, defined here as including the skin and muscle tissue with the blubber in between.

- Cut two 3 inch x 3 inch (7.5 x 7.5 cm) full-thickness squares from the ventral axillary area, with both cuts on the same side of the animal. Lift the cut pieces from the carcass using forceps.

- Double-wrap each sample separately in aluminum foil.

- Place both in one labeled ziplock storage bag, place on ice, then store in freezer as soon as possible after returning from the field.

Sample Labeling

Sample bags will have a label and include:

- collector;
- field identification number
- date and time of collection;
- location of specimen on beach, including GPS coordinates
- species, including age and sex;
- condition of carcass
- number and type of tissues sampled

Appendix 4. Sample type, tests and laboratories where tests were run for bald eagles, turkey vultures and common ravens live-captured according to the Avian Scavenger Sample Acquisition Protocol on the Washington and Oregon coasts, 2012.

#	Sample Type	Tests	Lab[8]
1	3.5 mls plasma, Li-hep Vacutainer	OCs & PCBs	DCPAH
2	0.4 mls plasma, Li-hep Microtainer	Serum biochemistry & *Chlamydophila* serology	PCL
3	0.4 mls serum Screw-top vial	Serology: PMV-1, adenovirus, *Mycoplasma*, AI	WADDL
4	0.5 mls whole blood EDTA Vacutainer	Heavy metals	DCPAH
5	0.1 mls whole blood Li-heparin (DGTT) Microtainer	Hemoparasites & *Chlamydophila* PCR	VMD
6	0.5 mls whole blood EDTA Vacutainer	*Coxiella burnetti* PCR	CSU
7	2 Li-heparinized capillary tubes	CBC	PCL
8	4 coverslip blood smears, air-dried	CBC & visual hemoparasites check	PCL
9	Tracheal Swab Blue-top wire culturette	*Mycoplasma through PCR; aerobic culture*	WADDL
10	Tracheal Swab Polyester swab	*Coxiella burnetti*____	CSU
11	Throat Swab in VTM Vial	Avian influenza PCR	WADDL
12	Cloacal Swab #1 Blue-top culturette	GI Culture (aerobic & *Salmonella*)	WADDL
13	Cloacal Swab #3 Polyester swab	*Mycobacterium, Chlamydophila,* PMV-1, & *Sarcocystis* PCR	VMD
14	Cloacal Swab #4 Polyester swab	*Coxiella burnetti* PCR	CSU
15	>1 gm feces in Whirl-Pak or Ziploc	Direct and float parasitology	PCL
16	5 whole breast feathers	Stable isotopes	OSU
17	Both 4th secondaries, distal 1 cm.	Heavy metals	OSU

[8] **Laboratory key:**

WADDL = Washington Animal Disease Diagnostic Laboratory
CSU = Colorado State University, Veterinary Diagnostic Lab, Ft Collins, CO
DCPAH = Diagnostic Center for Animal and Population Health, Lansing, MI
PCL = Phoenix Central Laboratories, Everett, WA
VMD = Veterinary Molecular Diagnostics, OH
OSU = Oregon State University

Appendix 5. Sample type, tests and laboratories where tests were run from dead common ravens obtained according to the Avian Scavenger Sample Acquisition Protocol on the Oregon coast, 2012.

#	Sample Type	Tests	Lab[9]
1	0.2 mls blood clot Li-heparin (DGTT) Microtainer	Hematozoa PCR	VMD
2	Cloacal Swab #1 Blue-top culturette	GI Culture (aerobic & *Salmonella*)	WADDL
3	Cloacal Swab #3 (Mucosal surface of **both** Duodenum & Cloaca) Polyester swab in red-top Vacutainer	*Mycobacterium* & *Sarcocystis* PCR	VMD
4	Cloacal Swab #4 Polyester swab in red-top Vacutainer	*Coxiella burnetti* PCR	CSU
5	>1 gm lower GIT contents in Whirl-Pak or Ziploc	Direct and float parasitology	PCL
6	5 whole breast feathers	Stable isotopes	OSU
7	Both 4th secondaries, distal 1 cm.	Heavy metals	OSU
8	Entire left humerus	Heavy Metals	DCPAH
9	≥ 10 g liver	OC	DCPAH
10	≥ 5 g liver	PCB	DCPAH
11	Swab of cut liver and spleen (particularly any visible lesions)	*Chlamydophila*, PMV-1, adenovirus	VMD
12	1 cm^2 in Whirl-Pak	*Coxiella PCR*	CSU
13	50% in Whirl-Pak	*Coxiella PCR*	CSU
14	1 or 2 lobes in Whirl-Pak	*Coxiella PCR*	CSU
15	1 lung in Whirl-Pak	*Coxiella PCR*	CSU
16	all in Whirl-Pak	*Coxiella PCR*	CSU

[9] **Laboratory key:**

WADDL = Washington Animal Disease Diagnostic Laboratory
CSU = Colorado State University, Veterinary Diagnostic Lab, Ft Collins, CO
DCPAH = Diagnostic Center for Animal and Population Health, Lansing, MI
PCL = Phoenix Central Laboratories, Everett, WA
VMD = Veterinary Molecular Diagnostics, OH
OSU = Oregon State University