DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE
REGION # 8

ENVIRONMENTAL CONTAMINANTS PROGRAM
ON-REFUGE INVESTIGATIONS SUB-ACTIVITY

Heavy Metal and Polyhalogenated Aromatic Hydrocarbon Contaminants in Marine Birds on the Farallon National Wildlife Refuge

FINAL REPORT
Project ID: FFS# 8N04, DEC ID#2009.80002

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September 2013

Preface

We investigated environmental contaminant concentrations in marine bird populations nesting on the Farallon National Wildlife Refuge (Refuge). The Refuge is comprised of a group of small islands located off the California coast and supports the largest breeding population of marine birds south of Alaska. Environmental contaminants may be posing a risk to wildlife on the Refuge. Previous investigations documented contaminant concentrations in eggs at or above toxicity thresholds known to cause adverse effects on hatchability. The primary objective of this investigation was to assess heavy metal (e.g., mercury, lead) and organic (e.g., DDT, PCBs) contaminant concentrations in wildlife tissue. These contaminants are a concern in California's coastal waters due to their persistent nature in the environment and bioaccumulative properties. Additionally, these can act as potent neurotoxins, immunotoxins, endocrine disruptors and carcinogens. Exposure can cause acute effects to individuals, but impaired reproductive success is the most sensitive endpoint. Assessing the effects of contaminant exposure on breeding bird populations will lead to a better understanding of the factors driving population declines and help to identify remediation and/or management strategies to minimize contaminant impacts.

This study entailed two distinct components: 1) an investigation into the impacts of historic lead contamination on the Refuge, and 2) an assessment of more widespread global contaminants in bird eggs and the local food web. One of the goals of this investigation was to present the results of these two components as separate peer-reviewed journal articles. To facilitate our goal, this final report is organized as two draft manuscripts (one for each component) that will be submitted for publication. Each draft manuscript has been written in the format required by the intended journal of submission.

Acknowledgments

This investigation would not have been possible without the support and assistance of Gerry McChesney, Farallon National Wildlife Refuge Manager, or Russ Bradley and Pete Warzybok of Point Blue Conservation Science's Farallon Program. Zach Coffman, Refuge Specialist, also assisted with fieldwork, sample preservation and transport. Fieldwork for this project would not have been possible without the efforts of the volunteer captains of the Farallon Patrol, or Captain Mick Menigoz of the F/V Superfish. Special thanks is extended to Dr. Bob Taylor of the Trace Elemental Research Laboratory for his assistance in feather sample washing, and metals and isotope analysis. We also thank Bruce Nierwienski and Ken Crabb with the U.S. Fish and Wildlife Service's Analytical Control Facility for their assistance in sample analysis and data management. Final thanks go to Dan Welsh and Janet Whitlock for providing oversight and review during all aspects of this investigation.

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ABSTRACT

The Farallon Islands are located 28 miles west of San Francisco, California. This area of the Pacific Ocean hosts a diverse marine ecosystem, and the islands support the largest breeding population of seabirds in the contiguous United States. Many species of seabirds have been experiencing declines in reproductive performance over the past several decades. We investigated historic lead contamination on Southeast Farallon Island and the impact it may be having on nesting seabird populations. We sampled breast feathers from Cassin's auklet (*Ptychoramphus aleuticus*) and western gull (*Larus occidentalis*) chicks from areas on the Island with and without known lead contamination in the soil. Additionally, a corresponding soil sample was taken from each Cassin's auklet nest box. Lead concentrations in feathers from both species taken from contaminated areas are significantly higher than those from non-contaminated areas. Moreover, we found a strong relationship between lead in soil and lead in feathers from each nest. Data generated during this study confirm that chicks nesting in areas of Southeast Farallon Island with elevated concentrations of lead in the soil are at increased risk to the adverse impacts of lead exposure. However, it remains difficult to discern these impacts from other more dramatic stressors such as reduced food availability and changes in oceanic conditions. Our study concludes that while seabirds nesting on Southeast Farallon Island may be impacted by historic lead contamination, these effects are likely minor compared to the adverse impacts that would occur should any large-scale remedial action take place.

Keywords: Lead, Cassin's auklets, western gulls, seabirds, feathers, soil

INTRODUCTION

Farallon National Wildlife Refuge

The Farallon Islands are located off the coast of Central California, approximately 28 miles west of San Francisco Bay and 20 miles south of Point Reyes. These islands are positioned within the California Current System, along the eastern edge of the Pacific Ocean basin. This region experiences seasonal upwelling of cold, nutrient rich water. Despite a relatively small area, these highly productive waters allow the islands to support a diverse marine ecosystem with vast populations of seabirds and marine mammals. During the 1800's wildlife populations were decimated by seal hunting and egg harvesting, prompting Theodore Roosevelt to protect North and Middle Farallon Island. In 1969 protection was expanded to encompass all the Farallon Islands and Noon Day Rock, becoming the Farallon National Wildlife Refuge (Refuge). Since creation of the Refuge northern elephant seals (*Mirounga angustirostrus*), northern fur seals (*Callorhincus ursinus*) and rhinoceros auklets (*Cerorhinca monocerata*), previously extirpated from the region, have begun breeding on the islands again. The Refuge also supports the largest breeding population of seabirds in the contiguous United States that is comprised of over 200,000 individuals from 12 species, including the largest breeding colonies of western gulls (*Larus occidentalis*), ashy storm-petrels (*Oceanodroma homochroa*) and Brandt's cormorants (*Phalacrocorax penicillatus*) in the world.

Lead Impacts to Birds

Lead contamination occurs through a variety of pathways, including application of lead-based paint, leaded gasoline emissions, hunting with lead shot pellets and lead fishing tackle. Exposure to lead can result in mortality, as well as a number of sub-lethal effects including immunosuppression, compromised organ function and reduced growth (ATSDR, 2007). The primary pathway of wildlife exposure is through dietary uptake, and birds often inadvertently ingest lead-containing particles stuck on food, or feed on carcasses shot with lead pellets. Ingestion can have lethal effects in adult birds, but sub-lethal effects on juveniles are the most sensitive endpoints of lead toxicity (De Francisco et al., 2003). Nestlings exposed to lead experience neurotoxic behavioral effects and impaired growth that can result in mortality (Burger and Gochfeld, 1993; Burger and Gochfeld, 1995). Laysan albatross (*Phoebastria immutabilis*) chicks from the Midway Atoll, an area with extensive lead contamination, exhibited a condition called droop-wing syndrome where birds cannot fully retract their wings and are unable to fully fledge (Sileo and Fefer, 1987). Droop-wing syndrome was caused by lead exposure via ingestion of paint chips falling from man-made structures (Sileo et al., 1990).

Historic Lead Contamination on Southeast Farallon Island

The Farallon Islands have a long history of human occupation. Over 150 years of use by the Lighthouse Service, US Coast Guard and US Navy left behind various man-made structures including barracks, a lighthouse, radio towers, pipelines and a variety of other supporting infrastructure components. Many of these structures have been removed but contamination from past use remains a concern on the Refuge. In September 2007, the United States Coast Guard conducted a contaminants survey on the Refuge and found elevated levels of lead in the soil around existing buildings, as well as sites where buildings were removed (EERG, 2007; EERG 2009). The historic Navy Barracks, former lighthouse keeper's quarters, and an old carpentry shop are among the areas most heavily contaminated with lead (EERG, 2009). Remediating lead contaminated soil is highly invasive and will undoubtedly impact nesting habitat on the Refuge. In order to determine what actions are needed Refuge managers must weigh the impacts of cleanup activities against the benefit to wildlife resulting from removal of lead contaminated soil. However, prior to this investigation lead exposure in seabirds nesting on the Refuge had not been assessed.

Study Objective

The primary objective of this study was to further investigate historic lead contamination by characterizing lead uptake by birds fledging at different locations on the Island. We were seeking to determine whether or not areas with higher documented concentrations of lead in the soil would result in increased lead uptake by chicks nesting in those areas. Additionally, we compared fledging success between an area of the Refuge with elevated concentrations of lead in the soil and an area of the Refuge that was relatively clean in an effort to assess lead impacts to seabird reproductive performance. This assessment was considered the first step in determining if further cleanup actions are warranted.

We chose to analyze lead concentrations in feather samples taken from seabird chicks nesting on Southeast Farallon Island. Feathers serve as useful indicators of lead exposure because they reflect blood concentrations during the active growth period (Burger, 1993). This makes them a valuable resource when assessing spatial or temporal trends in contaminants (Burger and Gochfeld, 2004). Feather sampling also offers the advantage of being relatively non-invasive, as samples can be collected quickly, minimizing handling time and stress placed on the bird. Storage and processing requirements of feather samples in the field is also minimal compared to other tissue matrices, which is a positive attribute when faced with the logistical challenges of conducting a study on a remote island.

MATERIALS AND METHODS

Sample Collection

Feather sampling took place on Southeast Farallon Island (37.7249°N, 123.030°W) during the 2009 to 2011 seabird breeding seasons (April – August). We collected breast feathers from Cassin's auklet (*Ptychoramphus aleuticus*) chicks nesting in artificial nest boxes. These nest boxes are part of the Point Blue Conservation Science seabird monitoring program and are placed throughout the Island. Nest boxes are constructed of plywood and are approximately eight inches deep × 14 inches wide × six inches high (see Photos 1 and 2). To mimic natural nesting conditions, the boxes are fitted with a narrow entrance tunnel and are typically filled with approximately one inch of top soil taken from the area immediately surrounding the box. By sampling chicks in artificial nest boxes only, we avoided collapsing or damaging natural nest dens and crevices. Feather samples were taken from chicks from four areas of the Island that have historic lead contamination: Power House, PRBO House, Coast Guard House, and Carpentry Shop (Figure 1). Additionally, an area that has never had any structures on it, thus no historic contamination, was also sampled (Corm Blind Hill). Feather samples were also collected from western gull chicks at the same locations except for the PRBO House, with the only difference being that western gull feathers were taken from chicks nesting in natural nests. Western gulls nest above ground, thus we were able to collect feathers from chicks in natural nests without the risk of damaging nesting habitat. Sampling these two species gave us the opportunity to compare lead uptake between birds nesting in an enclosed space (Cassin's auklet) versus out in the open (western gull). We limited our feather collection to contour feathers (i.e., no down), and sampled chicks that were near fledging. This was done in an effort to assess only post-hatching lead exposure. Two pinches of feathers were taken from each bird, and immediately placed in sterile Whirl-Paks®.

In addition to feather samples, we collected soil samples during the 2010 and 2011 breeding seasons. We collected soil from each Cassin's auklet nest box in which a feather sample was taken. Only top soil was sampled as chick would be exposed to the top soil while in the nest. We also avoided collecting any large plant material that appeared to be brought into the nest by the parent. Approximately four ounces of soil were collected from each nest, placed in a chemically cleaned I-Chem® glass jar, and kept frozen until chemical analysis.

Reproductive Monitoring

Reproductive data for this study were obtained from Cassin's auklets nesting in artificial nest boxes. Monitoring reproductive performance of Cassin's auklets is part of the routine activities associated with the Point Blue Conservation Science seabird monitoring program, and we were able to utilize annual data going back to 1997. Data prior to 1997 were not used because either not enough birds nested in artificial nest boxes, or data were not collected in a consistent fashion. Because chicks would have been exposed to lead post-hatching, we chose fledging success as the most appropriate metric of reproductive success. We limited our fledging comparison to two sites, one representing heavily contaminated areas (Carpentry Shop) and one representing non-contaminated areas (Corm Blind Hill). Because nest boxes are typically filled with soil from the surrounding area, birds nesting in these boxes served as an appropriate proxy for naturally nesting birds. Annual fledging success for each area is presented as a percentage using the following equation:

$$\textit{Fledging }\%_{(Area\ X)} = \#\ \textit{Chicks Fledged}_{(Area\ X)} / \#\ \textit{Chicks Hatched}_{(Area\ X)}$$

Lead Analysis

Lead analysis was conducted by the Trace Elemental Research Laboratory in College Town, Texas. Prior to chemical analysis, feather samples were cleaned to remove any soil or debris that could potentially contaminate the sample. Feathers were rinsed with deionized (DI) water, mechanically scrubbed, and placed in a Branson 1510 (Branson Ultrasonics, Danbury, Connecticut, USA) ultrasonic DI bath for two minutes. Following the ultrasonic bath, residual moisture was removed by freeze drying and samples were digested in their entirety with nitric and hydrochloric acid. In preparation for analysis, soil samples were freeze dried and homogenized into a fine powder. Approximately 0.5 g of the homogenate were digested using 10 mL of a 1:4 ratio (by volume) mixture of hydrochloric and nitric acids. Soil samples were homogenized using an alumina mortar and pestle then digested in nitric and hydrochloric acid in a CPI ModBlock digester (CPI International, Santa Rosa, California, USA). Quantitative analysis of all samples was done using a Perkins Elmer DRC 2 (Perkins Elmer, Santa Clara, California, USA) with inductively coupled plasma-mass spectrometer (ICP-MS).

Data Analysis

Reported lead concentrations are on a microgram per gram (µg/g) dry weight basis. Data were log-transformed prior to analysis and the Levene's test was used to ensure the data met the assumptions of parametric testing. To determine among site differences in lead concentrations we used analysis of variance (ANOVA) with $\alpha = 0.05$, and post-hoc differences were determined using the Unequal N HSD test with $\alpha = 0.05$. Western gull data failed to pass tests for normality despite log-transformation; therefore, we tested among site differences using the non-parametric Kruskal-Wallis ANOVA. Post-hoc comparisons of western gull data were carried out by individually paired Mann-Whitney U tests. To examine the relationship between lead concentrations in Cassin's auklet nest soil and feather samples we used linear regression on log-transformed data. Differences in fledging success between sites were determined using ANOVA, with both year and site as categorical variables. All analyses were conducted using STATISTICA analytical software (Version 11, StatSoft Inc., 1994).

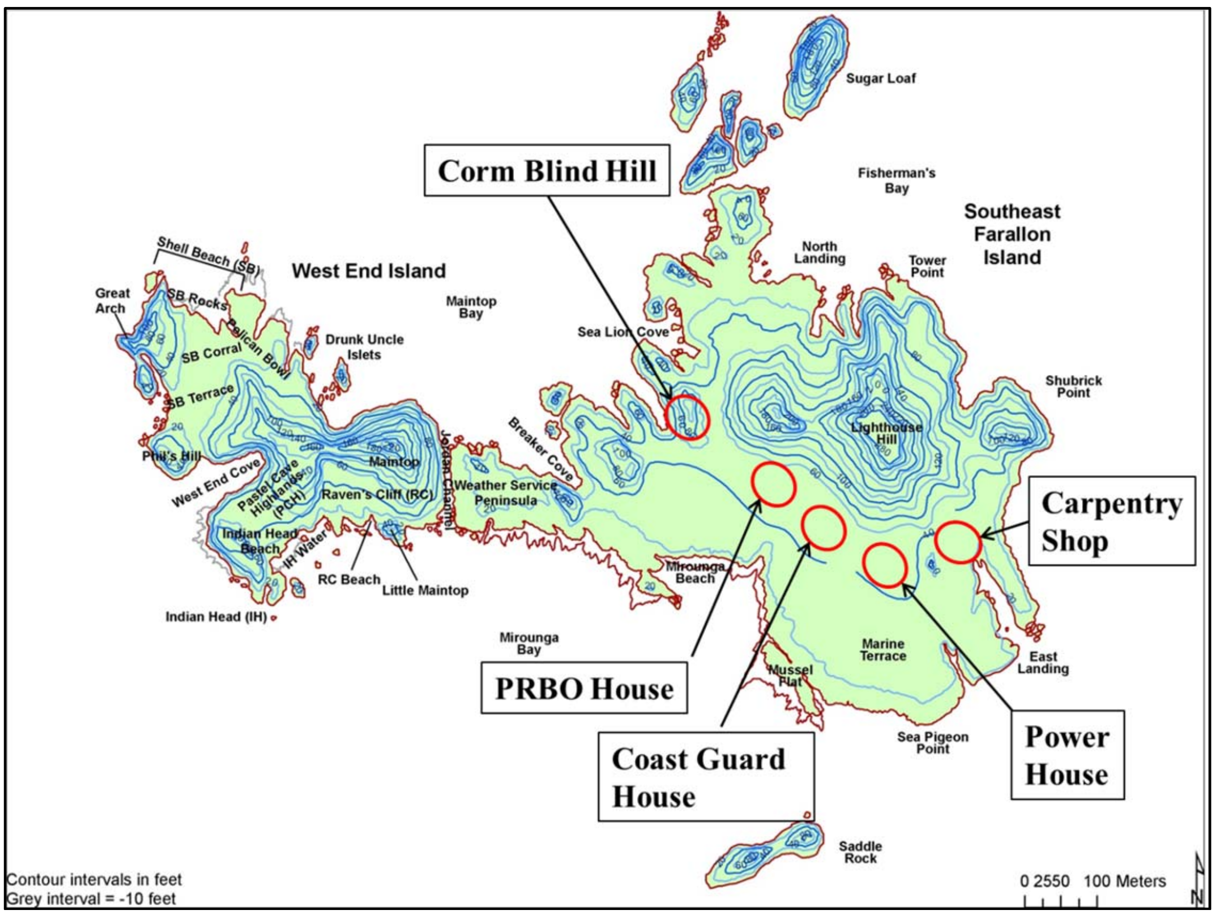

Figure 1. *Approximate locations of feather and soil sampling sites on Southeast Farallon Island: 2009-2011.*

Photograph 1. *Cassin's auklet artificial nest boxes on Southeast Farallon Island. Note the small entrance tunnels fitted to each box to mimic natural nesting conditions. The large white covers are to prevent the boxes from overheating, and the large rocks are to prevent predators from entering the boxes.*

Photograph 2. *Cassin's auklet chick taken from an artificial nest box.*

RESULTS

Western gull feathers

A total of 115 feather samples were collected from western gull chicks. Lead concentrations in western gull feathers varied significantly among sites (Kruskal Wallis ANOVA: $\chi^2 = 46.47$, $P < 0.001$), and were lowest in feathers from Corm Blind Hill, followed by the Power House, Coast Guard House, and Carpentry Shop (Table 1; see Appendix A for complete results). Post-hoc tests indicated that all sites significantly differed from each other ($P < 0.01$) except for the Carpentry Shop and Coast Guard House, which were statistically similar. Complete results are presented in Appendix A.

Table 1. *Lead concentrations in western gull chick feathers from Southeast Farallon Island. Means with similar letters are statistically similar.*

	Feathers		
Location	**N =**	**Geometric Mean**	**Range**
Carpentry Shop	28	6.91 [a]	1.78 - 42.6
Coast Guard House	31	4.56 [a]	0.36 - 33.5
Corm Blind Hill	25	0.44 [b]	0.14 - 1.85
Power House	31	1.91 [c]	0.45 - 10.5

Results are presented on a µg/g (ppm) dry weight basis.

Cassin's auklet feathers

A total of 86 feather samples were collected from Cassin's auklet chicks. Lead concentrations varied significantly among sites (ANOVA: $F_{4, 81} = 21.27$, $P < 0.01$), and were lowest in feathers from Corm Blind Hill followed by the Power House, Coast Guard House, PRBO House, and finally the Carpentry Shop (Table 2; see Appendix A for complete results). Post-hoc tests indicate that no site was significantly different from all other sites, but three groups emerged with the Carpentry Shop and PRBO House in the highest group, and Corm Blind Hill and the Power House in the lowest group.

Cassin's auklet nest box soil

We took 73 soil samples from Cassin's auklet nests. Each soil sample corresponded with a feather sample from the chick inhabiting the nest. Lead concentrations in soil samples significantly varied among sites (ANOVA: $F_{4, 68} = 57.38$, $P < 0.001$) and followed a trend similar to those observed in Cassin's auklet feather samples. Concentrations were lowest in samples from Corm Blind Hill and increased in the following order: Power House, PRBO House, Coast Guard House, and Carpentry Shop (Table 2; see Appendix A for complete results). Pair-wise post-hoc testing indicated that the Carpentry Shop was significantly higher than all other sites and Corm Blind Hill was significantly lower than all sites except for the Power House.

Table 2. *Lead concentrations in Cassin's auklet chick feathers and corresponding nest soil. Means with the same letter are statistically similar.*

	Feathers			Soil		
Location	**N =**	**Geometric Mean**	**Range**	**N =**	**Geometric Mean**	**Range**
Carpentry Shop	25	3.82 [a]	0.56 - 52.7	20	1301 [a]	479 - 5280
PRBO House	11	1.23 [a, b]	0.24 - 38.0	11	299 [b]	129 - 651
Coast Guard House	21	1.03 [b]	0.24 - 5.01	18	327 [b]	104 - 1090
Power House	6	0.39 [b, c]	0.14 - 0.64	6	148 [b, c]	123 - 227
Corm Blind Hill	23	0.27 [c]	0.06 - 2.97	18	70 [c]	33 - 219

Results are presented on a µg/g (ppm) dry weight basis.

In addition to determining among site differences in lead concentrations in soil samples, we also examined the relationship between lead in the soil of an individual nest, and lead in the feathers of the chick found in that nest. When all nests were considered together, we found a significant positive relationship between lead concentration in the soil and lead concentration in chick feathers ($P < 0.001$, $R^2 = 0.62$; Figure 2).

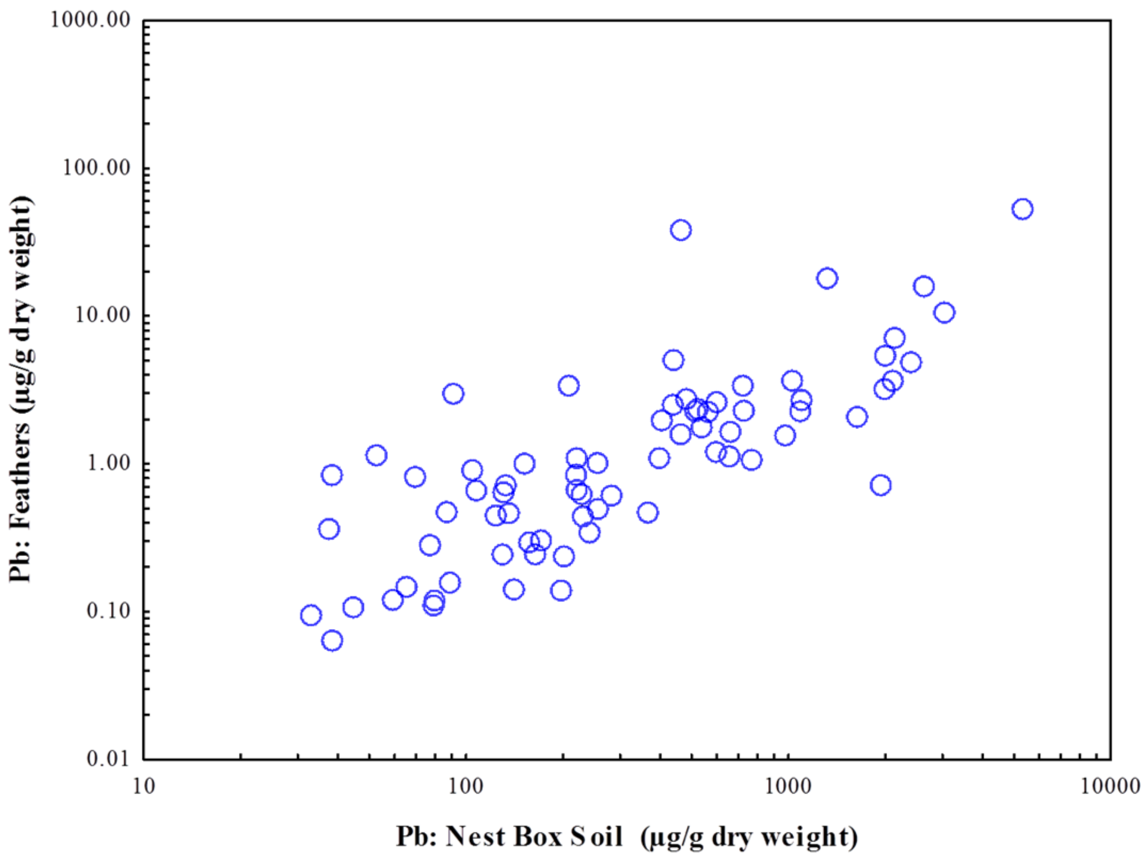

Figure 2. *Comparison of lead concentrations in Cassin's auklet nest soil to chick feathers. A significant positive relationship was found ($P < 0.01$, $R^2 = 0.62$).*

Table 3. *Cassin's auklet fledging data from Southeast Farallon Island.*

Year	Corm Blind Hill Fledging Success (% fledged)	Carpentry Shop Fledging Success (% fledged)
1997	71.4%	50.0%
1998	93.8%	78.6%
1999	93.8%	71.4%
2000	94.1%	58.3%
2001	86.7%	36.4%
2002	81.8%	100.0%
2003	91.7%	83.3%
2004	93.3%	80.0%
2006	0.0%	0.0%
2007	50.0%	54.5%
2008	80.0%	76.9%
2009	86.7%	92.3%
2010	76.9%	84.6%
2011	92.9%	58.3%
ALL YEARS	78.1%	66.0%

Fledging Success

We compared fledging success between Cassin's auklets nesting in artificial nest boxes from the Carpentry Shop and Corm Blind Hill from 1997 to 2011. Fledging success significantly differed among years and between sites (ANOVA, Year: $P < 0.001$; Site: $P = 0.03$) with Corm Blind Hill having higher fledging than the Carpentry Shop. Fledging at Corm Blind Hill was consistently higher than the Carpentry Shop from 1997 to 2004; however, this pattern ceased following 2006 (Figure 3).

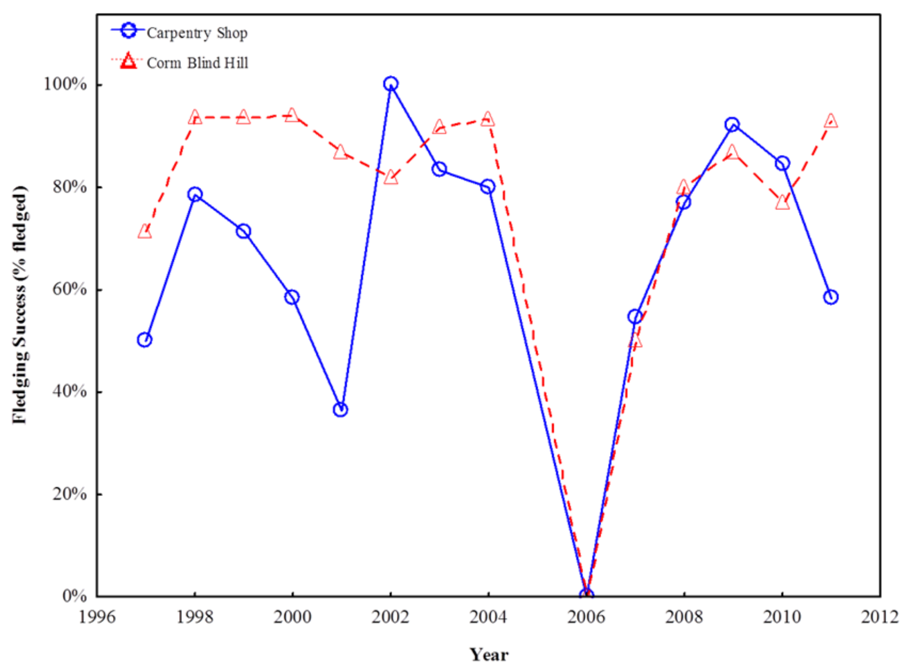

Figure 3. *Cassin's auklet fledging success data for two sites on Southeast Farallon Island: 1997 – 2011. Fledging success was generated from artificial nest boxes and is expressed as the percentage of hatched chicks that successfully fledge from the nest.*

DISCUSSION

The primary objective of this investigation was to assess whether documented lead contamination on Southeast Farallon Island was making its way into nesting seabirds and potentially affecting fledging success. The purpose of this objective was to provide information as to whether cleanup of the documented contamination might be necessary. Our results clearly indicate that birds nesting in heavily contaminated areas are taking up a greater amount of lead. Moreover, the strong relationship we found between lead in nest box soil and lead in feathers indicates that the primary exposure route is likely through ingestion of lead-containing soil particles. Lead concentrations in both western gull and Cassin's auklet feathers show similar trends to data from a 2009 report generated for the US Coast Guard (ERRG, 2009). This report found that lead concentrations in soil samples were highest at the Carpentry Shop, with the highest concentration in excess of 11,000 mg/kg followed by the PRBO House, Power House then Coast Guard House.

Lead concentrations in feathers found during this investigation exceeded toxicity benchmarks. Golden et al (2003) found that black-crowned night heron (*Nycticorax nycticorax*) chicks dosed with enough dietary lead to impair both whole-body and culmen growth rates had a corresponding mean feather concentration of 2.85 µg/g. Cassin's auklet feather concentrations from the Carpentry Shop exceeded this value, as did western gull feathers from the Carpentry Shop and Coast Guard House. Additionally, a lab-based dosing study found that a feather concentration of 4.79 µg/g in herring gull (*Larus argentatus*) chicks was associated with impaired thermoregulation and decreased survival (Burger and Gochfeld 1994). Western gull feathers from the Coast Guard House were near this benchmark (4.56 µg/g) and exceeded it at the Carpentry Shop (6.91 µg/g).

To further put data generated during this investigation into context, we compared our results to data from the Midway Atoll National Wildlife Refuge, an island that also has a history of lead contamination from the use of lead based paint and lead-containing building materials. While outbreaks of overt lead poisoning events (e.g., droop-wing syndrome) are not routinely observed on Southeast Farallon Island, western gull chicks suffering from droop-wing syndrome have been observed in the past (R. Bradley, pers.comm.). Lead concentrations in some individual feather samples approached values seen on Midway Atoll. Burger and Gochfeld (2000) documented a mean lead concentration of 31.9 µg/g in Laysan albatross (*Diomedea immutabilis*) chicks exhibiting droop-wing syndrome. These chicks were nesting in areas that had not undergone lead abatement procedures. While mean lead concentrations in feathers from both western gull and Cassin's auklet feathers from Southeast Farallon Island were well below that of the droop-winged chicks, some individual samples were near, or above, that concentration.

Soil concentrations found in Cassin's auklet nest boxes also indicate that chicks in some areas of the Island may be at risk of adverse impacts from lead exposure. In 2009 an ecological risk assessment was conducted at Midway Atoll National Wildlife Refuge to determine soil cleanup goals that would be protective of Laysan albatross chicks (Taylor et al., 2009). The risk assessment suggested that a soil concentration of < 100 mg/kg would result in lead concentrations in blood below a 10 ug/dL no observable effect concentration (NOEC). The 10 ug/dL NOEC-based threshold was determined by Franson (1996) as a benchmark for hematological responses in avian species associated with anemia. Cassin's auklet nest box soil concentrations on Southeast Farallon Island exceeded the Midway NWR cleanup goal at all the sites sampled, except for nests from Corm Blind Hill. This is not all that surprising given that Corm Blind Hill was the only area sampled that never had any structures.

While feather and soil data generated during this investigation appear to indicate that birds nesting on Southeast Farallon Island are at risk from lead exposure, fledging data do not clearly show decreased reproductive performance resulting from lead contamination. We compared Cassin's auklet fledging success from the most heavily contaminated site (Carpentry Shop) to the least contaminated site (Corm Blind Hill). Data from 1997 to 2004 appear to indicate higher fledging success at Corm Blind Hill, but in 2006, Cassin's auklets experienced near total reproductive failure. This failure was attributed to altered oceanic conditions that did not produce sustained periods of upwelling and led to a reduction in the availability of krill, the primary food source of Cassin's auklets (Warzybok et al., 2006). Fledging success began to increase following the 2006 failure event, but the difference between Corm Blind Hill and the Carpentry Shop were not observed. The Cassin's auklet population on Southeast Farallon Island experienced high mortality during a strong 1997/98 El Nino event (Warzybok and Bradley, 2011). Following this event the population rebounded and increased from 1998 to 2004. We looked at historical data from the National Oceanic and Atmospheric Administration's Climate Prediction Center (www.cpc.ncep.noaa.gov) and found that the years following the 1997/98 El Nino experienced consistently cooler than normal sea surface temperatures from June of 1998 to April of 2001. In general, cooler sea surface temperatures are correlated with greater oceanic productivity and higher reproductive success in seabirds (Warzybok and Bradley, 2011). Oceanic productivity is a strong driver of seabird reproduction on Southeast Farallon Island and it is possible that the subtle effects of lead exposure on reproduction only become evident during times of optimal oceanic conditions. When conditions are not optimal, the impacts of lead exposure may be overshadowed by other more dramatic stressors.

The Cassin's auklet data we presented must also be viewed with caution given this investigation relied entirely on birds in artificial nest boxes. We chose to strictly focus on these birds in an effort to minimize impacts to natural nesting habitat; however, there is a good chance that chicks in natural dens may be exposed to lower levels of lead. As mentioned previously, artificial nest boxes are typically filled with top soil from the surrounding area (surface to six inches below ground level), which is the same depths tested during the 2007 soil characterization study done on behalf of the US Coast Guard. It is unknown how soil concentrations of lead in natural nests compares to what we have observed in nest boxes, but it is possible that some of the deeper burrows would have much lower concentrations of lead in the soil since the source of lead contamination is from historic, above-ground building materials. Additionally, many of the naturally nesting birds are likely in areas not considered to have elevated levels of lead in the soil. Most of the soil testing done on the Island was focused on the flat areas on the southern region of the Island. A large portion of the Island is made up of steep or rocky habitat, providing nesting habitat for Cassin's auklets in areas that were never suitable for building upon. Birds nesting in these areas likely have a much lower risk of lead exposure compared to the birds we sampled. The relationship between lead in natural versus artificial nesting soil should be addressed in any future efforts to assess lead impacts to nesting seabirds.

CONCLUSIONS

The objective of this study was to determine if historic lead contamination was being taken up by seabirds nesting on the Refuge. Our data indicate that this is taking place is areas with existing or historic structures, but the degree to which lead is impairing juvenile bird survival remains unclear. The impacts of lead exposure can be subtle, and judging success by whether or not a chick fledges may not be the most sensitive endpoint. Exposure to lead in the nest can potentially impair motor function and coordination, eventually leading to death if a newly-fledged juvenile is unable to effectively forage for food. Moreover, we recognize that it is difficult to discern the effects of lead on reproduction from other more dramatic stressors, such as decreased food availability and altered oceanic conditions. Overt lead toxicity is rarely seen on the Island, but sub-lethal effects on seabird reproduction are likely occurring in the areas with elevated lead concentrations in the soil. However, we conclude that the physical impacts resulting from any type of remediation to remove and replace the contaminated soil could place greater stress on seabird populations when compared to leaving the soil in place.

MANAGEMENT ACTIONS

- We do not recommend any large-scale soil clean-up efforts. It is likely that the destruction of nesting habitat resulting from such an effort would cause greater adverse population level impacts than the impacts from lead already in the soil.

- We recommend that during the non-nesting season, soil inside artificial nest boxes in areas with a high degree of lead contamination (i.e., Carpentry Shop, Coast Guard House, PRBO House) be removed and replaced with soil from areas on the Refuge with a lower degree of contamination. The EERG (2009) soil sampling effort included samples from 3-30 feet from existing buildings. Upon review of the results we did not conclude that lead concentrations dramatically decreased in a "step-wise" fashion away from the buildings. We therefore also recommend that, when possible, replacement soil for artificial nest boxes come from areas of the Refuge that have never been built upon (e.g., North Landing).

- To further characterize the impacts of existing lead contamination on the Refuge, we recommend additional monitoring of nesting seabirds. Future monitoring efforts should include the analysis of lead concentrations in blood of seabird chicks. Assessment of lead in blood will allow a more direct comparison to established toxicity benchmarks.

- We recommend sampling soil from natural Cassin's auklet nests, if sampling can be done with minimal damage to the habitat. Samples from natural nests will provide additional information on lead exposure to all species of seabirds nesting in natural dens and crevices.

- In addition to further tissue analysis (i.e., blood), we recommend that any future lead investigations include the assessment of additional species nesting on the Refuge. Due to resource limitations this investigation could only examine two species, but many species nesting on the Refuge could be adversely impacted by historic lead contamination and should be addressed.

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Title: Contaminants in Seabird Eggs and Food Web Components from the Gulf of the Farallones, California.

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ABSTRACT

The Farallon Islands are located 28 miles west of San Francisco and support the largest colony of breeding seabirds in the contiguous United States; however, reproductive performance in many seabird species has been declining over the past several decades. Mercury remains one of the most pervasive contaminants along California's coast due to historic mining and atmospheric deposition. To investigate mercury bioaccumulation in seabirds, we analyzed eggs from three species nesting on Southeast Farallon Island: Cassin's auklet (*Ptychoramphus aleuticus*), rhinoceros auklet (*Cerorhinca monocerata*) and pigeon guillemot (*Cepphus columba*). In addition to eggs, we analyzed a variety of fish and invertebrates that are food items for seabirds. To assess trophic position and feeding location, egg and diet samples also underwent carbon and nitrogen stable isotope analysis. Results indicate that both pigeon guillemot and rhinoceros auklet eggs have mercury concentrations that exceed the lowest observed adverse effects level of 0.50 μg/g (fresh wet weight) for impaired avian egg hatchability, suggesting that seabirds breeding on Southeast Farallon Island are being exposed to levels of mercury that could be contributing to observed population declines. Further, isotopic analysis indicates that mercury bioaccumulation in seabirds is impacted by both trophic position and feeding location.

Keywords: Contaminants, seabirds, mercury, DDT, PCB, PBDE, stable isotope, bioaccumulation.

INTRODUCTION

Gulf of the Farallones and Farallon Islands

The Gulf of the Farallones (Gulf) is located off the coast of central California. This region is within the California Current System and experiences upwelling of cold, nutrient rich water which in turn supports an abundance of marine life. Within the Gulf are the Farallon Islands, a cluster of small islands and sea stacks lying 28 miles west of San Francisco. Despite a relatively small area, these islands are home to vast populations of seabirds and marine mammals. During the 1800's wildlife populations were decimated by seal hunting and egg harvesting, prompting federal protection of the northern islands in 1909. In 1969 protection was expanded to all the Farallon Islands and Noon Day Rock, becoming the Farallon National Wildlife Refuge (Refuge). A variety of species previously extirpated began to return to the region following establishment of the Refuge, and it now supports the largest breeding population of seabirds in the contiguous United States. This population is comprised of over 200,000 individuals from 12 species, including the largest breeding colonies of western gulls (*Larus occidentalis*), ashy storm-petrels (*Oceanodroma homochroa*) and Brandt's cormorants (*Phalacrocorax penicillatus*) in the world.

Since 1971 Point Blue Conservation Science has been contracted by the U.S. Fish and Wildlife Service (Service) to monitor population sizes and reproductive performance of seabirds on Southeast Farallon Island. PRBO has documented decreased reproductive success in many species when compared to long-term mean productivity metrics (Warzybok and Bradley, 2011). Some species, including western gull and Brandt's cormorant, have even experienced seasons of near complete reproductive failure. Decreased food availability resulting from changes in oceanic conditions and unusual weather patterns have been recognized as contributors to population declines on Southeast Farallon Island (Sydeman et al., 1998; Sydeman et al., 2001; Warzybok and Bradley, 2011). However, anthropogenic impacts, such as environmental contaminants, may also be affecting seabird reproduction.

Contaminant Concerns

The environmental impact of anthropogenic contaminants is a significant issue along California's coast. Many of these contaminants are persistent in the environment, and have a high degree of bioaccumulative potential and toxicity. Effects on wildlife include neurotoxicity, immunotoxicity, endocrine disruption, reproductive and developmental impairment and carcinogenicity. Mercury is one the most pervasive contaminants in aquatic systems due to atmospheric deposition from fossil fuel combustion and waste disposal. In addition to atmospheric inputs, historic mining in the Coast and Sierra Nevada Ranges has led to extensive mercury contamination in California waterways. In response, 72 California waterbodies are listed on the Clean Water Act 303 (d) list of impaired waterbodies. Methylmercury is the most toxic form of mercury and readily bioaccumulates in animal tissue. Conversion of inorganic mercury to methylmercury occurs in anoxic sediments via sulfate reducing bacteria, effectively linking methylmercury production to aquatic environments. As a result, aquatic systems are at increased risk from widespread mercury contamination, and many of California's lakes and reservoirs currently have fish consumption advisories in an effort to protect human health (OEHHA, 2013). Like humans, the primary exposure pathway in wildlife is through diet, leading to biomagnification of methylmercury in higher trophic level organisms such as birds, marine mammals and humans. In aquatic birds, mercury toxicity has the greatest effect on reproductive performance via reduced breeding effort, altered breeding behavior and reduced egg hatchability (Wolfe et al., 1998; Scheuhammer et al., 2007).

Contaminant studies have been conducted on the Refuge in the past. Sydeman and Jarman (1998) found elevated mercury concentrations in eggs collected randomly from Southeast Farallon Island. They documented a mean mercury concentration of 0.83 ppm (wet weight) in pigeon guillemot (*Cepphus columba*) eggs. This value exceeds the lowest observed adverse effects level (LOAEL, 0.50 ppm wet weight) for impacts on avian egg hatchability (Heinz, 1979). Brandt's cormorant and rhinoceros auklet (*Cororhinca monocerata*) eggs had a mean mercury concentration below the LOAEL; however, individual eggs had concentrations exceeding the LOAEL. Randomly collected eggs indicate that birds on the Refuge are at risk for mercury exposure. Mercury concentrations documented in pigeon guillemot eggs are particularly significant in light of population studies indicating a decline in this species.

Organochlorine (OC) pesticides have a history of widespread use in the U.S. and around the world. Some of the most commonly used OC pesticides are dichlorodiphenyltrichloroethane (DDT), cyclodienes (aldrin, dieldrin) and hexachlorocyclohexanes (HCH). OC pesticides are persistent and bioaccumulative contaminants that have acute and chronic toxicological effects on wildlife including neurotoxicity, carcinogenicity and endocrine disruption. These impacts led to a ban on OC pesticides in the United States during the 1970's, but they are still widely used in other countries as a means of vector control. Before the ban on OC pesticides, elevated concentrations were documented and linked to egg shell thinning of common murre (*Uria aalge*) and ashy storm-petrels on the Farallon Islands (Gress et al., 1971; Coulter and Risebrough, 1973). Although concentrations decreased over the next two decades (Jarman et al., 1996), OC pesticides are extremely persistent in the environment and still warrant concern.

Polychlorinated biphenyls (PCBs) are organochlorine compounds with a legacy of contamination in California (Ohlendorf et al., 1988; Pyle et al., 1999; She et al., 2008). PCBs are synthetic chemicals once used in a variety of applications including insulation in electrical transformers, plasticizers and hydraulic fluids. PCBs were heavily used from the 1920's until 1979, when the U.S. Environmental Protection Agency banned PCB production, distribution and use. The stable properties that make PCBs suitable for commercial and industrial use also make them extremely persistent in the environment. PCBs are lipophilic compounds that accumulate in fatty tissue, leading to bioaccumulation in organisms foraging at higher trophic levels. The toxic effects of PCB exposure can range from carcinogenicity and endocrine disruption to impaired reproduction and fetal development. Making PCB toxicity more complex, 209 different congeners exist and toxicity varies widely among congeners; therefore, effects depend on congener-specific concentrations that accumulate in tissue (Rice et al., 2003).

Jarman et al. (1996) documented PCB concentrations in common murre, rhinoceros auklet, Brandt's cormorant and pigeon guillemot eggs collected randomly from Southeast Farallon Island. PCB concentrations of common murre and Brandt's cormorant eggs approached known effects thresholds for negative impacts on reproduction (Yamashita et al.,1993), suggesting that birds nesting on the Refuge may be exposed to PCB contamination at concentrations leading to adverse effects.

Polybrominated diphenyl ethers (PBDEs) are a class of chemicals similar in structure to PCBs and are used as flame retardants in a wide variety of consumer products. Like PCBs, PBDEs are lipophilic and accumulate in fatty tissue leading to bioaccumulation and biomagnification in the environment. PBDEs elicit similar toxicological effects as PCBs (Hooper and McDonald, 2000), which led the California legislature to pass a ban on the two most toxic forms of PBDEs in 2003 (SFEI, 2006). Concern regarding PBDE exposure is relatively new when compared to other persistent contaminants; however, recent findings have documented elevated PBDE concentrations in humans and wildlife (Gauthier et al., 2008; Oros et al., 2005; She et al., 2007). The toxic effects of PBDEs on fish and wildlife are poorly understood; however, investigations indicate increasing concentrations in fish, bird eggs and marine mammals (Brown et al., 2006; She et al., 2008). The highest concentrations yet measured in tissue were observed in San Francisco Bay. Due to the recent emergence of PBDEs, previous investigations assessing contaminants on the Refuge did not examine PBDE residues in bird eggs.

Stable Isotope Analysis

The majority of contaminants of concern share the potential to bioaccumulate within individual organisms and biomagnify in higher trophic levels. Thus, understanding the dynamics of food webs becomes integral in understanding contaminant exposure, particularly to higher trophic level animals such as seabirds. The use of stable isotopes has been recognized as one of the most valuable means of assessing food web dynamics (McIntyre and Beauchamp, 2007), and has been used extensively in contaminant studies investigating marine bird species (Jarman et al., 1996; Jarman et al., 1997; Braune et al., 2002).

Carbon and nitrogen stable isotopes are among the most useful in assessing marine food web dynamics. Stable-carbon ratios ($^{13}C/^{12}C$) are often used as an indicator of pelagic/offshore versus benthic/inshore food sources in marine environments (France, 1995). Because pelagic carbon is typically depleted of the heavier carbon isotope, the isotopic ratio is generally higher (i.e., enriched) in inshore/benthic marine food webs compared to offshore/pelagic food webs. Stable-nitrogen ratios ($^{15}N/^{14}N$) serve as useful indicators of trophic position. The lighter nitrogen isotope (^{14}N) is preferentially used up during normal bodily function due to its lower molecular weight. This results in enrichment of nitrogen isotopic ratios as trophic level increases (Kelly, 2000; Vander Zanden and Rasmussen, 2001). By using carbon and nitrogen stable isotope rations, we can assess the relationship between food source and trophic position with contaminant concentration.

Study Objectives
The main objective of this project was to identify the risk posed by widespread anthropogenic contaminants to Service trust resources on the Farallon National Wildlife Refuge. In carrying out this objective we did the following:

1. Assess heavy metal (primarily mercury) concentrations in eggs relative to reproductive effect thresholds.

2. Assess PCB concentrations using congener-specific analytical techniques that could facilitate a dioxin toxic equivalence (TEQ) type approach to PCB toxicity.

3. Determine the extent of PBDE exposure to breeding bird populations on the Refuge.

4. Use stable isotope composition to determine the impact of food-web dynamics on mercury bioaccumulation.

5. Assess long-term temporal trends by comparing current contaminant concentrations to previous studies on the Farallon National Wildlife Refuge.

MATERIALS AND METHODS

Sample Collection and Processing
All samples were collected from Southeast Farallon Island (37.7249°N, 123.030°W). Cassin's auklets, rhinoceros auklets and pigeon guillemots eggs were collected by hand during the 2009 to 2011 seabird nesting seasons (April – August) from both natural and artificial nests. Following collection, eggs were processed within 24 hours when possible. The contents were removed by cutting a small hole in the blunt end of the egg. If the egg was in the later stages of development, it was bisected along the longitudinal axis to allow removal of the embryo. Embryos were examined for overt abnormalities and proper position within the egg. Contents were placed in chemically cleaned and certified I-Chem® amber glass jars and immediately frozen at -20 °C in preparation for chemical analysis. Dissection tools were rinsed with 5% hydrochloric acid, pesticide-grade hexane and deionized water between samples to prevent cross contamination.

Components of the local food web were collected for mercury and stable isotope analysis during the 2011 breeding season. A variety of fish and squid samples were collected by netting provisioning rhinoceros auklets as they returned to their dens. A complete list of species collected using this method is presented in Table 2. Additionally, two species of krill (*Euphausia pacifica* and *Thysanoessa spinifera*) were collected via pelagic plankton trawls. Following collection, fish and squid samples were individually weighed, measured and placed in 4 oz. Whirl-Paks®. Invertebrate samples were separated by species and stored as composite samples. All samples were immediately frozen at -20 °C in preparation for chemical analysis.

Organics Analysis
Egg samples were analyzed for a suite of organic contaminants by the Geochemical and Environmental Research Group laboratory in College Station, Texas. Organic analysis included congener-specific PCB and PBDE analyses, as well as an OC scan which included DDT and all DDT metabolites. Egg samples were analyzed according to the NOAA Status and Trends Method (MacLeod et al., 1985) with minor revisions determined by Wade et al. (1988). Prior to quantitative analysis samples were homogenized using a Teckmar Tissumizer (Teledyne Tekmar, Mason, Ohio, USA) and extracted using methylene chloride and Na_2SO_4. Tissue extracts were purified using silica/alumina column chromatography followed by final cleanup via high-performance liquid chromatography. Final quantitative determination was done via capillary gas chromatography with electron capture detection using a Varian 3500 Gas Chromotagraph (Agilent Technologies, Inc., Santa Clara, California, USA).

Reported concentrations of organic contaminants in eggs are in nanograms/gram (ng/g) on a fresh wet weight (fww) basis. Since eggs were not collected when freshly laid, the wet weight at time of collection was converted to a back-calculated fresh wet weight to account for the desiccation of eggs between the time of laying and time of collection. This conversion was done following the methods of Hoyt (1979) and Stickle et al. (1973) using the equation below:

$$\textit{Fresh Wet Weight} = K_w\,(\textit{Egg Length} \times \textit{Egg Breadth}^2)$$

($K_w = 0.548$ as determined in Hoyt 1979)

Metals Analysis
Egg, fish and invertebrate samples were analyzed for total mercury by the Trace Elemental Research Laboratory (TERL) in College Station, Texas. Prior to analysis all samples were freeze dried and homogenized using a Retsch ZM200 Ultra Centrifugal Mill (Retsch, Inc., Newtown, Connecticut, USA) with titanium rotor and ring sieve. Mercury determination was then done via combustion/trapping atomic absorption spectroscopy following U.S. Environmental Protection Agency method 7473 (USEPA, 2007). Final quantitative analysis on egg samples was done using a Nippon MA-3000 Mercury Analyzer (Nippon Insturments, College Station, Texas, USA), while fish and invertebrate determination was done with a Milestone DMA-80 Direct Mercury Analyzer (Milestone, Inc., Monroe, Connecticut, USA).

In addition to mercury, egg samples were also analyzed for a suit of additional metals (complete list of included metals is presented in Appendix B) by the TERL. Following the homogenization procedure outlined above, 0.2 grams of the homogenate was digested in a mix of nitric and hydrochloric acid. Digest solutions were run without further dilution for several metals (Al, B, P, S, V) on a SPECTRO CirOS (SPECTRO Analytical Instruments Inc., Mahwah, New Jersey, USA) inductively coupled plasma – optical emission spectrometer (ICP-OES) equipped with an axial torch. The remaining metals were analyzed using a Perkins Elmer DRC 2 (Perkins Elmer, Santa Clara, California, USA) inductively coupled plasma-mass spectrometer (ICP-MS). Concentrations are presented in micrograms/gram (µg/g) on a dry weight basis.

Stable Isotope Analysis

Stable isotope analysis was conducted by the Stable Isotope Geosciences Facility at Texas A&M University in College Station, Texas. Stable isotopic values of carbon and nitrogen were determined for egg, fish and invertebrate samples using a Finnegan MAT 252 Isotope Ratio Mass Spectrometer (Thermo Electron Corp., Pittsburg, Pennsylvania, USA) with ConFlo III interface and CosTech ECS 4010 elemental analyzer. Carbon and nitrogen stable isotope data are expressed using the δ notation and the following formula:

$$\delta X = [(R_{sample} / R_{standard}) - 1] \times 1000$$

When expressing stable isotope data in this format *X* is either ^{15}N or ^{13}C and *R* is the corresponding ratio of $^{15}N/^{14}N$ or $^{13}C/^{12}C$. The $R_{standard}$ values were determined using atmospheric N_2 for nitrogen and Pee Dee Belemnite (Cretaceous marine fossil) for carbon.

Quality Assurance

Quality assurance measures were conducted to ensure the accuracy of all data produced for this investigation. Measures included the analysis of two different certified reference materials during metals analysis: dogfish liver tissue (DOLT-4; National Research Council of Canada, Ottawa, Canada) and mussel tissue (SRM 2976; National Institute of Standards and Technology, Maryland, USA), as well as Lake Michigan fish tissue (SRM 1947; National Institute of Standards and Technology, Maryland, USA) during organics analysis. All analyses also included the use of method blanks, duplicate samples, and matrix spiked samples.

Data Analysis

Prior to statistical analysis, total mercury data were log-transformed to meet the assumptions of parametric testing, and normality of the data was confirmed using the Levene's test. One of the objectives of this project was to assess contaminant concentrations in the context of long-term trends. To accomplish this, we compared our data to past data using single sample t-tests with $\alpha = 0.05$. Differences in Total DDT, Total PCB, Total PBDE, Total mercury and stable isotope ratios in eggs and diet components among species were tested using analysis of variance (ANOVA) with $\alpha = 0.05$, and post-hoc comparisons were done using the Tukey Unequal N HSD test with $\alpha = 0.05$. We examined the relationship between stable isotope values and total mercury concentrations using linear regression. All analyses were conducted using STATISTICA analytical software (Version 11, StatSoft Inc., 1994).

RESULTS

Eggs: Organic Compounds

PCBs were detected in all eggs analyzed. Total PCB concentrations differed significantly among species (ANOVA: $F_{2, 83} = 44.89$, $P < 0.01$), and was lowest in Cassin's auklet followed by pigeon guillemot then rhinoceros auklet (Table1). Post-hoc testing indicated that each species was significantly different from each other species. Eggs were analyzed for PCBs on a congener-specific basis to facilitate dioxin TEQ analysis. However, total PCB results did not merit applying this approach as total concentrations were far below levels of concern. Complete total PCB data for all eggs are available in Appendix B.

PBDEs were detected in 10 of 32 Cassin's auklet eggs, 17 of 30 rhinoceros auklet eggs, and 12 of 24 pigeon guillemot eggs. In order to calculate mean concentrations we substituted one half of the detection limit for non-detect samples. Total PBDE concentrations differed significantly among species (ANOVA: $F_{2, 83} = 10.16$, $P < 0.01$; Table 1), but post-hoc testing indicated that only Cassin's auklet was statistically different. In addition to total PBDE analysis, we conducted a congener-specific PBDE analysis. However, as with the PCB analysis, total PBDE results did not merit further congener-specific analysis. Complete total PBDE results are presented in Appendix B.

Total DDT was detected in all eggs analyzed and concentrations differed significantly among species (ANOVA: $F_{2, 83} = 18.18$, $P < 0.01$; Table 1). Post-hoc testing indicated that only pigeon guillemot was statistically different. Complete results for total DDT analysis are presented in Appendix B.

Table 1. *Summary of organic contaminants in avian eggs collected from Southeast Farallon Island: 2009-2011.*

	Cassin's Auklet			Rhinoceros Auklet			Pigeon Guillemot		
	# Detects (N=32)	Geometric Mean (SD)	Range	# Detects (N=30)	Geometric Mean (SD)	Range	# Detects (N=24)	Geometric Mean (SD)	Range
Σ PCB	32	112 (47)	55 - 287	30	289 (156)	126 - 779	24	169 (49)	111 - 303
Σ PBDE*	10	11 (11)	13 - 62	17	19 (10)	13 - 51	12	18 (7)	10 - 47
Σ DDT	32	222 (91)	119 - 553	30	272 (226)	89 - 858	24	130 (33)	85 - 216
*All concentrations on a ng/g (ppb) fresh wet weight basis; * ½ DL used for NON-DETECTS*									

Eggs: Metals

All eggs collected during this investigation underwent analysis for a suite of metals, but we are limiting our discussion to mercury since the other metals were either not detected in any eggs, or were detected at concentrations far below levels of concern. A complete list of metals included in our analysis, as well as full results, are available in Appendix B.

Total mercury was detected in all eggs analyzed and differed significantly among species (ANOVA: $F_{2, 83} = 186.94$, $P < 0.01$). Concentrations of total mercury were lowest in Cassin's auklet, followed by rhinoceros auklet then pigeon guillemot (Table 2). Post-hoc testing indicated that all species were significantly different from each other.

Table 2. *Summary of total mercury in avian eggs collected from Southeast Farallon Island: 2009-2011.*

	Cassin's Auklet			Rhinoceros Auklet			Pigeon Guillemot		
	# Detects (N=32)	Geometric Mean (SD)	Range	# Detects (N=30)	Geometric Mean (SD)	Range	# Detects (N=24)	Geometric Mean (SD)	Range
Σ Mercury	32	99 (36)	57 - 189	30	334 (174)	148 - 817	24	706 (364)	434 - 1497
All concentrations on a ng/g (ppb) fresh wet weight basis									

Marine Bird Diet Components: Mercury

Total mercury was detected in all diet component samples we analyzed, and varied significantly among species (ANOVA: $F_{11, 76} = 34.37$, $P < 0.01$; Table 3). Post-hoc testing indicated that Euphausid krill had the lowest concentrations, while Myctophid fish (i.e., lantern fish) had the highest concentration. The remaining ten species fell into three intermediate categories (Figure 1). Total mercury concentrations are summarized in Table 3 and complete results are available in Appendix B.

Table 3. *Stable isotope and total mercury data for invertebrate, fish and avian egg samples collected from Southeast Farallon Island: 2011. Stable isotope data are presented as arithmetic means ± SD, total mercury data are presented as geometric means ± SD. Note: avian egg mercury data presented in this table are from 2011 eggs only and are presented as dry weight concentrations to allow comparison to diet samples.*

Species	N =	$\delta^{15}N$ (‰)	$\delta^{13}C$ (‰)	Total Hg (µg/g dw)
Invertebrates				
Euphausia pacifica (EUP)	5	9.40 ± 0.62	-19.92 ± 1.66	0.010 ± 0.010
Thysanoessa spinifera (TYS)	4	10.58 ± 0.30	-19.30 ± 1.36	0.035 ± 0.012
Fish				
Lingcod (LING)	10	11.64 ± 0.15	-19.36 ± 0.75	0.024 ± 0.007
Rockfish spp. (ROCK)	10	13.49 ± 0.59	-22.13 ± 0.73	0.034 ± 0.014
Pacific saury (PSA)	10	12.44 ± 0.61	-21.44 ± 0.27	0.035 ± 0.010
Greenling (GRN)	4	12.08 ± 0.53	-21.58 ± 0.68	0.037 ± 0.002
Sablefish (SBL)	9	11.70 ± 0.76	-19.26 ± 1.22	0.047 ± 0.007
Squid (SQD)	10	12.72 ± 0.45	-18.19 ± 0.75	0.061 ± 0.013
Pacific herring (PHER)	7	12.47 ± 0.30	-19.5 ± 0.37	0.065 ± 0.008
Chinook salmon (CHN)	4	12.63 ± 0.54	-19.76 ± 1.69	0.087 ± 0.037
Northern anchovy (NAN	10	13.42 ± 0.50	-18.16 ± 0.74	0.103 ± 0.033
Myctophid spp. (MYCT)	5	13.48 ± 0.83	-21.52 ± 1.32	0.248 ± 0.109
Birds				
Cassin's auklet (CAAU)	10	12.43 ± 0.88	-21.6 ± 0.69	0.348 ± 0.118
Rhinoceros auklet (RHAU)	9	13.97 ± 0.44	-22.6 ± 0.65	0.907 ± 0.0.214
Pigeon guillemot (PIGU)	8	15.04 ± 0.31	-21.56 ± 0.44	2.749 ± 0.487

Food Web Stable Isotopes

We analyzed bird egg and diet component samples for stable isotope composition. While organic and mercury data already presented in this report summarized eggs collected from 2009 to 2011, we were only able to analyze eggs for stable isotope composition during the 2011 field season. Values of $\delta^{15}N$ in the food web varied significantly among species (ANOVA: $F_{11, 76} = 38.41$, $P < 0.01$) with ratios ranging from 9.40‰ (Euphausid krill) to 15.04‰ (pigeon guillemots; Table 3). Post-hoc tests indicated that the fifteen species fell into six groups with a high degree of overlap between groups, and only pigeon guillemots were significantly different from all other species (Figure 2). Values of $\delta^{15}N$ are summarized in Table 2, and complete results are presented in Appendix B.

Values of $\delta^{13}C$ in the food web varied significantly among species (ANOVA: $F_{14, 100} = 23.73$, $P < 0.01$) and ranged from -22.60 ‰ in rhinoceros auklet eggs to -18.16 ‰ in northern anchovy (Table 3). Post-hoc testing indicated that the fifteen species analyzed fall into three significantly different groups with only myctophid, euphausid and Chinook salmon samples overlapping into multiple groups (Figure 3). We have summarized $\delta^{13}C$ values in Table 3, and complete results can be found in Appendix B

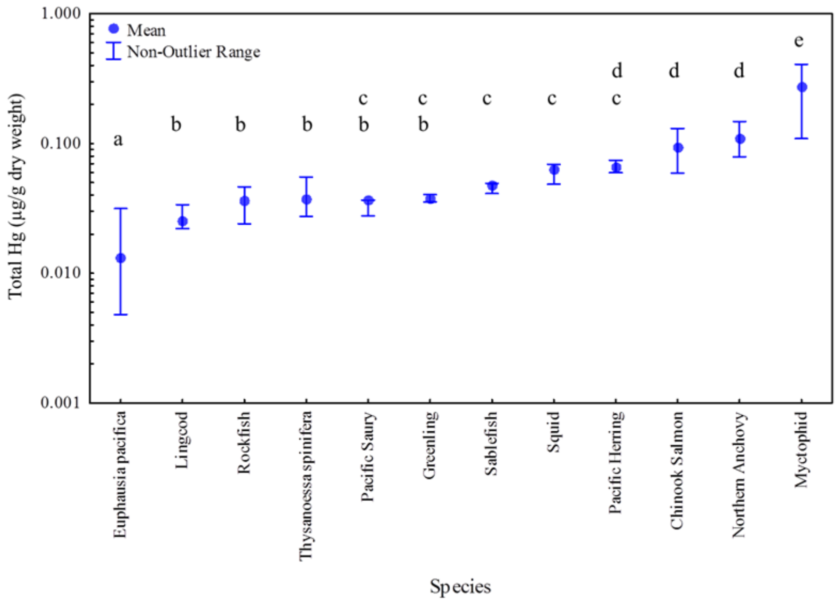

Figure 1. *Total mercury concentrations of various marine bird diet components. Results are presented in µg/g (parts per million) on a dry weight basis. Species with a similar letter are not significantly different (α = 0.05). Statistical testing was conducted on log-transformed mercury data, but raw values are presented in this figure (with logarithmic axis) for clarity.*

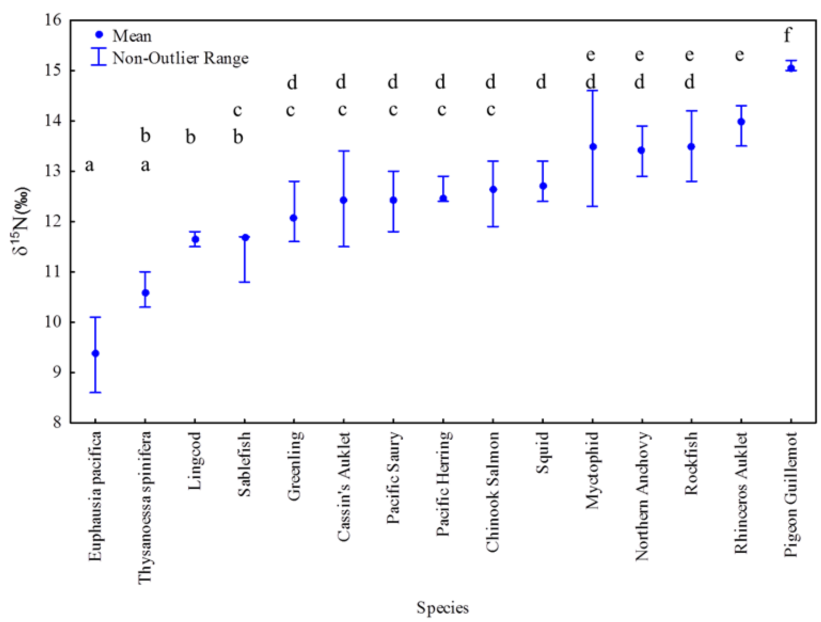

Figure 2. *Nitrogen stable isotope composition of various food web component from the Gulf of the Farallones. Results are expressed as $\delta^{15}N$ in parts per thousand (‰). Species with a similar letter are not significantly different (α = 0.05).*

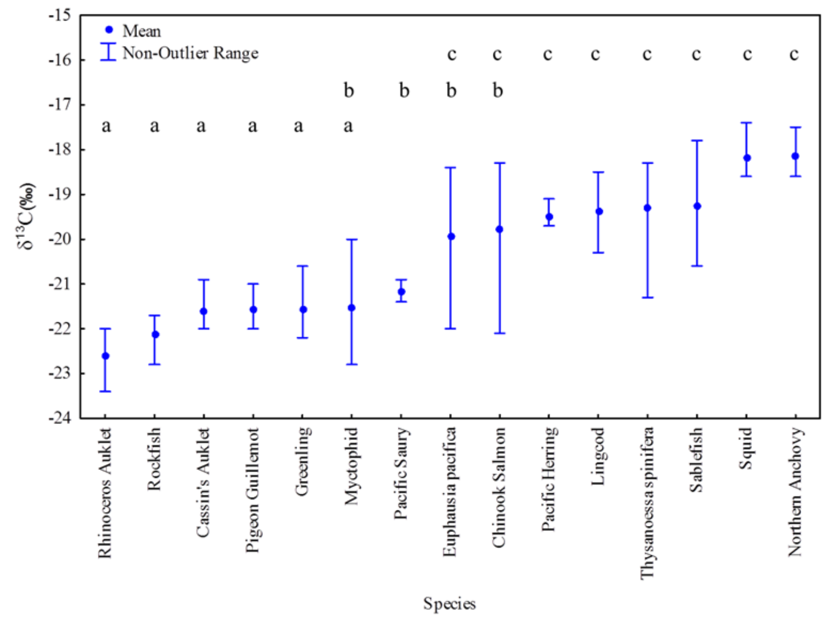

Figure 3. *Carbon stable isotope composition of various food web components from the Gulf of the Farallones. Results are expressed as $\delta^{13}C$ in parts per thousand (‰). Species with a similar letter are not significantly different ($\alpha = 0.05$).*

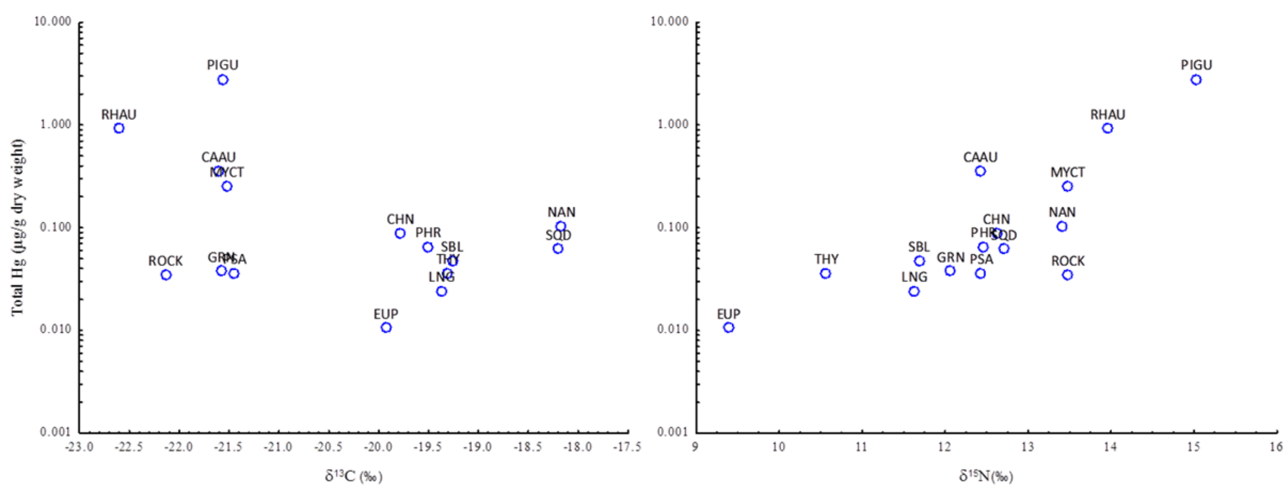

Figure 4. *Scatterplots of mean total mercury concentrations vs. mean stable isotope values for different components of the Gulf of the Farallones food-web. There is no relationship between $\delta^{13}C$ and total mercury, but we did find a significant positive relationship between $\delta^{15}N$ and total mercury ($r2 = 0.62$, $P < 0.01$). Analysis was conducted on log-transformed mercury data, but raw data are presented here (using logarithmic axis) for clarity.*

Mercury-Stable Isotope Relationship

When comparing total mercury concentrations in carbon and nitrogen stable isotope composition, we did not find a significant relationship between total mercury and $\delta^{13}C$ (Figure 4), but we did find a significant positive relationship between total mercury and $\delta^{15}N$ ($r^2 = 0.64$, $P < 0.01$; Figure 4). Due to resource limitations, avian eggs included in this analysis were from the 2011 breeding season only.

Long Term Temporal Trends

To assess long term temporal trends we compared our results to data generated by Jarman et al. (1996) and Sydeman and Jarman (1998) in the early 1990's. These two studies analyzed contaminants in avian eggs from Southeast Farallon Island, and included two of the same species that we sampled: rhinoceros auklet and pigeon guillemot. Concentrations from these studies are presented in the literature on a dry weight basis, but we presented our data on a fresh wet weight basis to allow us to compare results to established toxicity thresholds. In order to compare our data to the older data we chose to convert the dry weight concentrations to wet weight. In doing so, we back-calculated fresh wet weight concentrations assuming 80% moisture content of a freshly laid egg. We chose to use 80% as this was found to be the average moisture content of freshly laid eggs from 32 different species (Ar and Rahn, 1980).

Both pigeon guillemot and rhinoceros auklet eggs exhibited similar trends in total mercury, total PCBs and total DDT concentrations. Total mercury did not significantly differ between the 1990's eggs and current eggs. Total PCB concentrations were significantly higher in current eggs from both species, and total DDT concentrations were significantly lower in current eggs from both species (Table 4).

Table 4. *Temporal comparison of mercury, PCB and DDT concentrations in rhinoceros auklet and pigeon guillemot eggs collected from Southeast Farallon Island. Concentrations are presented as geometric means in ng/g (ppb) on a fresh wet weight basis. Differences were considered significant if p ≤ 0.05.*

		2009-2011 Eggs	1993 Eggs	Significant Difference
Rhinoceros auklet	Total Mercury (ng/g fww ± SD)	334	320*	No
	Total PCB (ng/g fww ± SD)	289	240**	Yes ($t_{(29)}$= 2.97, p < 0.01)
	Total DDT (ng/g fww ± SD)	272	380**	Yes ($t_{(29)}$= -2.82, p < 0.01)
Pigeon guillemot	Total Mercury (ng/g fww ± SD)	706	700*	No
	Total PCB (ng/g fww ± SD)	169	116**	Yes ($t_{(23)}$= 5.92, p < 0.01)
	Total DDT (ng/g fww ± SD)	130	180**	Yes ($t_{(23)}$= -6.76, p < 0.01)

*Data presented as geometric means; *Results from Sydeman and Jarman, 1998; **Results from Jarman et al., 1996*

DISCUSSION

Investigations documenting organic contaminants in Farallon Island seabird eggs were being conducted as far back as the 1970s. These studies found elevated levels of DDE and PCBs in both ashy storm petrel and common murre eggs (Gress et al., 1971; Coulter et al., 1973), and data from the 1990s indicated a 15-20 fold decrease in these contaminants (Jarman et al., 1996). Our data show that total DDT has decreased even more since that time. This trend is not surprising given the ban on DDT use in the United States. Decreases have been documented in other areas as well. Vander Pol et al. (2012) found total DDT concentrations in brown pelican (*Pelecanus occidentalis*) eggs from the Gulf of California had an average concentration of 489 ng/g (fww), and Zeeman et al. (2010) documented a mean total DDT concentration of 532 ng/g (fww) in brown pelican eggs collected from West Anacapa Island, California. Both of these studies sampled eggs from the Southern California Bight, an area that experienced a high degree of organochlorine contamination due to manufacturing discharge from the 1950s to 1970s (Mac Gregor, 1974). Data produced by Zeeman et al. (2010) and Vander Pol et al. (2012) indicate a near 17 fold decrease in DDT concentrations when compared to pre-ban levels.

Total DDT concentration in our study were also well below toxicity benchmarks that impair reproductive performance. Blus (1982) found that a total DDT concentration of 1,000 ng/g (fww) corresponded to 5-10% shell thinning in brown pelican eggs, and an egg concentration of 5,000 ng/g corresponded with 18% thinning (the degree to which egg shell thinning is considered to impair hatchability). More recent data, also from brown pelican eggs, indicate a concentration of 2,600 – 3,000 ng/g (fww) total DDT resulted in reduced nesting success, and 3,700 ng/g resulted in total reproductive failure (Blus, 1996). These toxicity benchmarks are not only orders of magnitude higher that any concentrations in our study, but they are also benchmarks associated with brown pelicans, which are considered the most sensitive species to DDT. Given these circumstances, DDT concentrations in seabird eggs from the Farallon Islands should be considered a relatively low level of concern as it appears they are not at levels high enough to impact reproduction.

Unlike DDT, we found an increase in total PCB concentrations in both rhinoceros auklet and pigeon guillemot eggs when compared to eggs from the early 90's. This is an interesting result given PCB production was banned in the United States in 1979, and long term declines in PCBs have been documented in other studies. Blasius and Goodmanlowe (2008) found declines in PCB concentrations in California sea lion blubber from 1994 to 2006. Additionally, both the California State and National Mussel Watch Programs have documented significant, long term declines in PCBs in mussel tissue at most of their monitoring stations with no stations indicating an increase over time (Melwani et al., 2013). The long-term increase in total PCBs may have also been an artifact of different analytical techniques between the two studies. Our study calculated total PCB concentrations for each sample by summing the concentrations of 209 different PCB congeners. Jarman et al. (1996) calculated total PCB concentrations be summing only 45 different congeners. Analytical capabilities have progressed a great deal since the 1990's, and the temporal trend we observed may be a reflection of this advancement rather than an increase in PCB exposure.

Even though the manufacturing of PCBs was banned and declines in wildlife have been observed, there are still many avenues for PCB release into the environment, including mobilization of legacy contamination, improper waste disposal, or leaking electrical transformers. The risk of continued release of PCBs into the environment is likely higher in highly urbanized areas like the San Francisco Bay Area. Davis et al. (2007) indicate that PCB loading is still occurring in San Francisco Bay from a variety of sources and concentrations of PCBs in sport fish species are nearly ten times higher than thresholds of concern for human health even 25 years after the ban. Perhaps the temporal increase we observed is due to localized sources continuing to release PCBs into the environment.

Although we continued to detect PCBs in seabird eggs, levels currently found in eggs from Southeast Farallon Island are well below established concentrations that can impair avian reproductive performance. Hoffman et al. (1996) concluded that a whole-egg total PCB concentration of 5,000 ng/g (fww) was associated with reduced hatching success in chickens, which are considered the most sensitive avian species, and even higher values (8,000 to 24,000 ng/g fww) led to decreased hatching success in cormorants, terns and eagles. Further, Yamashita et al. (1993) found that total PCB concentrations near 7,000 ng/g (fww) were associated with 10% deformity and 25% mortality in double-crested cormorant (*Phalacrocorax auritus*) embryos. Current PCB concentrations in seabird eggs from Southeast Farallon Island are far below documented thresholds that can impair reproduction. Therefore, it is unlikely these seabird populations are being adversely impacted by PCB contamination. Our original study proposal included assessing PCB exposure using a dioxin toxic-equivalent (TEQ) approach to account for the wide variation in toxicity among the 209 different PCB congeners. However, we decided that this approach was not necessary given the extremely low total PCB concentrations.

Total PBDEs were detected in less than half of the eggs analyzed, and those that were above detection limits were much lower than other studies documenting PBDEs in other Pacific seabird species. Chen et al. (2012) found total PBDEs in glaucous-winged gull (*Larus glaucescens*) eggs from British Columbia, Canada ranged from 62.1 to 118 ng/g (fww). Total PBDEs in Southeast Farallon Island eggs were also much lower than concentrations found in eggs of three species of piscivorous birds from nearby San Francisco Bay: Forster's tern (*Sterna forsteri*), Caspian tern (*Hydroprogne caspia*) and California least tern (*Sterna antillarum browni*). Mean total PBDEs in these eggs ranged from 396 ng/g (fww) in California least tern to 488 ng/g in Forster's tern (Adelsbach and Maurer, 2007). Since PBDEs are a relatively new class of organic contaminants compared to some of the legacy chemicals (e.g., OC pesticides, PCBs) there are fewer documented toxicity benchmarks related to hatching success in avian eggs. Fernie et al. (2009) did conclude that eggs with PBDE concentrations ranging from 300 to 1,130 ng/g (fww) were smaller and had thinner shells when compared to control eggs containing only 3 ng/g total PBDE. Eggs from Southeast Farallon Island had much lower concentrations than even these effect levels. Data generated by Jarman et al. (1996) did not include PBDE analysis since at that time little was known about this class of chemicals. The present study addressed this information gap and current data indicate that seabirds nesting on the Farallon Islands are not at risk of PBDE exposure.

Total mercury concentrations documented in this study were within the range of other recent studies assessing mercury in piscivorous seabird eggs. Leach's storm petrel (*Oceanodroma leucorhoa*) eggs from New Brunswick, Canada averaged 1,170 ng/g (fww)(Bond and Diamond, 2009). Additionally, common murre eggs from Norton Sound in Alaska ranged from 122 – 184 ng/g (Day et al., 2012), and thick-billed murre (*Uria lomvia*) eggs from the Bering Sea and Gulf of Alaska ranged from 62 – 225 ng/g (fww). Comparison of our data to those collected from Southeast Farallon Island by Jarman et al. (1996) indicated no temporal change in total mercury concentrations in pigeon guillemot or rhinoceros auklet eggs. This lack of change may be due to continuing atmospheric inputs of mercury on a global scale. Despite a reduction in anthropogenic inputs in North America and Europe, global inputs may be increasing (Pirrone et al., 2010, Sunderland et al., 2009) with Asia now contributing over 50% of the global anthropogenic source (Streets et al., 2009, Pacyna et al., 2006). In addition to a continuing global supply of mercury, San Francisco Bay may be providing a more localized source as well. Historic mining of mercury in the Coast Range, and its subsequent use during hydraulic mining of gold in the Sierra Nevada Range during the California Gold Rush, has led to wide-spread mercury contamination in sediment thoughout the San Francisco Bay and Sacramento-San Joaquin Delta (Hornerger et al. 1999). Blouse et al. (2010) recently used geochemical characterization and isotopic analysis to verify that the mercury in these sediments was indeed from hydraulic gold mining. They also recognized the likelihood that a large extent of that mercury is still upstream trapped in stream and river beds, and Alpers et al. (2005) found that this historic mercury still resides in reservoir sediments trapped behind dams. Mercury upstream of San Francisco Bay may continue to migrate downstream, leading to continued export of mercury to areas where seabirds may be exposed. Water flowing out of San Francisco Bay can extend offshore as far as 20 kilometers and end up within the foraging area of seabirds nesting on Southeast Farallon Island (Pyle et al., 1999).

Total mercury in both Cassin's auklet and rhinoceros auklet eggs (mean = 99 and 334 ng/g respectively) were well below toxicity benchmarks known to impair avian egg hatching or chick survival. However, total mercury in pigeon guillomot eggs (mean = 706 ng/g) approached, or exceeded, these benchmarks. Fimreite (1971) documented decreased hatchability in ring-necked pheasant (*Phasianus colchicus*) eggs with total mercury concentrations between 500-1,500 ng/g (fww). Additionally, a concentration of 1,390 ng/g (fww) was associated with adverse effects in common loon (*Gavia immer*) eggs (Barr, 1986). Heinz (1979) found that 800 ng/g (fww) of total mercury in mallard duck (*Anas platyrhynchos*) eggs was associated with impaired reproductive performance. More recently, Heinz and Hoffman (2003) estimated 1,000 ng/g (fww) of total mercury in eggs as a threshold to impair embryonic development in the most sensitive avian species. Seabirds are generally less sensitive to the toxic effects of mercury than other species (Thompson, 1996) and the above mentioned benchmarks are generally considered conservative, with the low end of the range serving as the lowest observable adverse effect level (LOAEL) for mercury in avian eggs (USDOI, 1998). Comparing pigeon guillemot total mercury concentrations to these benchmarks indicate that on average this species is below toxicity thresholds, but individual eggs did exceed many of these levels. These circumstances suggest that pigeon guillemot, as well as many of the other species not assessed during this study, should continue to be monitored periodically in an effort to continue to document long-term trends on

Southeast Farallon Island. Continued monitoring of mercury in seabird eggs should be considered necessary given that global release of mercury into the environment is not decreasing and mercury in fish in the North Pacific Ocean is projected to double by the year 2050 (Sunderland et al., 2009).

The strong, positive relationship observed between total mercury and $\delta^{15}N$ in food web components is consistent with results from the 1990's. The previous study documented a biomagnification power (i.e., regression slope) of mercury in the local food web of 0.74. Our study found a mercury biomagnification power of 0.86. Directly comparing these two values must be done with caution as Jarman et al. (1996) conducted their isotopic analysis on egg albumen and two species of fish, while our analysis was done using the entire contents of the collected eggs, ten species of fish and two species of marine invertebrates. Regardless of this difference, our data confirm that mercury in Gulf of the Farallones foob web is biomagnifying as trophic level increases, and that differences in mercury bioaccumulation among seabird species nesting on Southeast Farallon Island is likely driven by differences in trophic level. Not surprising were the Cassin's auklet egg data showing they had much lower concentrations of mercury than the other two species. Cassin's auklets feed nearly exclusively on krill (Sowls et al., 1980), resulting in the occupation of a lower trophic position. This was confirmed by stable isotope composition showing Cassin's auklets with the lowest $\delta^{15}N$ values among the three seabird species sampled. More surprising was the difference in $\delta^{15}N$ values between rhinoceros auklet and pigeon guillemot. Despite both species feeding primarily on fish, $\delta^{15}N$ results indicated pigeon guillemot feed at a higher trophic level, a result that provides insight into why pigeon guillemot eggs had the highest concentrations of mercury.

The observed variation in mercury concentrations among seabirds may also be a result of different foraging habitats. Pigeon guillemots generally forage in the neritic, inshore environment and typically feed on more benthic fish species (Ewins, 1993). Rhinoceros auklets tend to feed further offshore in the mid-water zone near the continental shelf (Ainley and Boekelheide, 1990). We observed $\delta^{13}C$ ratios that reflect this difference, with rhinoceros auklets having the lowest $\delta^{13}C$ value and pigeon guillemot having the highest ($\delta^{13}C$ is generally enriched in inshore/benthic environments relative to offshore/pelagic environments). Recent studies have shown that benthic areas of the marine environment can be more active in the methylation of inorganic mercury (Chen et al., 2008, Hammerschmidt and Fitzgerald, 2006, Heyes et al., 2006). Potential increases in mercury methylation in nearshore environments, compared to offshore areas near the continental shelf, are likely being translated into the small forage fish where it results in different levels of mercury exposure in different species of seabirds.

What was also notable in our results was the high degree of variability in total mercury among the different fish species that can comprise seabird diets. We observed differences of up to an order of magnitude between species with the family Myctophidae (i.e., lantern fish) having the highest concentrations of mercury. Blum et al. (2013) recently found that microbial production of methylmercury below the surface mixed layer (50-400 m deep) is a significant contributor to mercury bioaccumulation in North Pacific food webs, a conclusion that appears to be supported by our data. Lantern fish undergo daily vertical migrations, spending the day time in deep waters

(300 – 1500 m) and migrating to the surface during the night (Eschmeyer, 1983). These fish are likely accumulating methylmercury in the deeper waters below the surface mixed layer and then migrating to shallower waters where they are fed upon by seabirds.

Overall, our data indicate that mercury exposure among piscivorous seabirds is highly variable depending on feeding strategy, or on what species of fish are available at any given time of year. Moreover, in some seabird species like pigeon guillemots, variation among individuals in diet composition has been observed, leading to potential wide-ranging intraspecific variation in mercury exposure.

CONCLUSIONS

The overall objective of this study was to characterize the risk of common anthropogenic contaminants to seabirds nesting on Southeast Farallon Island. We found that the majority of seabird eggs collected contained detectable concentrations of legacy organic contaminants (i.e., DDT and metabolites, and PCBs), as well as a newer class of contaminants not yet addressed (PBDEs). While we did detect these in eggs, the concentrations observed were well below toxicity benchmarks known to impair reproduction. We conclude that organic contaminants do not pose a risk to seabird populations nesting on Southeast Farallon Island.

We also assessed mercury levels in seabird eggs and a variety of diet components. While we did detect mercury in all samples, only pigeon guillemot eggs appeared to approach concentrations that can impair avian reproductive performance. We conclude that mercury concentrations found in Cassin's auklet and rhinoceros auklet do not pose an adverse risk to the population, but pigeon guillemot eggs were high enough to warrant continued monitoring. We also found a high degree of variability in the different species of fish that many of the seabirds nesting on Southeast Farallon Island may feed upon. Given this variability, we cannot assume that all species of piscivorous seabirds will have the same degree of mercury exposure. Current estimates by Sunderland et al. (2009) are that mercury in fish within the North Pacific Basin will double by the year 2050 given present rates of atmospheric deposition. This means that the risk of mercury exposure to seabirds will continue to increase in the Northern Pacific Ocean.

MANAGEMENT ACTIONS

- Our data indicate that mercury exposure varies widely among seabird species. We were only able to include three species of seabirds nesting on the Refuge in our study. Continued mercury monitoring is recommended, especially for species that forage in the inshore or benthic environments.

- We recommend that PCB analysis also be considered in any future egg monitoring activities given the increase observed in rhinoceros auklet and pigeon guillemot eggs. As mentioned above, inputs of PCBs may still be increasing even though manufacturing has been halted. As with mercury, we also recommend that additional species not assessed in this investigation be included as well.

- The impacts of global climate change will likely affect seabird populations by altering the timing of seasonal upwelling, or changing the migratory patterns of important forage fish species (e.g., northern anchovy). These stressors could result in increased vulnerability of seabirds on the Refuge to anthropogenic contaminants. We recommend that environmental contaminants remain an integral part of future population monitoring plans given the unknown nature of a changing climate.

- Mercury in fish from the Northern Pacific Ocean is estimated to double by 2050. We recommend that monitoring of mercury in seabird eggs on Southeast Farallon Island continue as a way to track the effect this increase may have on bird populations.

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APPENDIX A

Results of Feather and Soil Lead Analysis

Results from lead analysis of breast feathers taken from Cassin's auklet fledglings on Southeast Farallon Island from 2009-2011. Results are presented in micrograms per gram (μg/g) on a dry weight basis.

Sample ID	Species	Sample Matrix	Year	Collection Date	Location	Structure Status	Nest ID	Pb (μg/g dw)
09-CAAU-05	Cassin's auklet	Breast Feathers	2009	6/26/2009	Carpentry Shop	Historic Structure	CS 50	0.562
09-CAAU-03	Cassin's auklet	Breast Feathers	2009	6/26/2009	Carpentry Shop	Historic Structure	CS 16	3.25
09-CAAU-06	Cassin's auklet	Breast Feathers	2009	6/26/2009	Carpentry Shop	Historic Structure	CS 65	4.39
09-CAAU-40	Cassin's auklet	Breast Feathers	2009	6/26/2009	Carpentry Shop	Historic Structure	CS 05	12.1
09-CAAU-04	Cassin's auklet	Breast Feathers	2009	6/26/2009	Carpentry Shop	Historic Structure	CS 12	16.9
09-CAAU-09	Cassin's auklet	Breast Feathers	2009	6/26/2009	Coast Guard House	Historic Structure	CG 119	0.368
09-CAAU-10	Cassin's auklet	Breast Feathers	2009	6/26/2009	Coast Guard House	Historic Structure	CG 130	0.643
09-CAAU-11	Cassin's auklet	Breast Feathers	2009	6/26/2009	Coast Guard House	Historic Structure	CG 152	1.21
09-CAAU-23	Cassin's auklet	Breast Feathers	2009	6/26/2009	Corm Blind Hill	No Structure	CB 365	0.162
09-CAAU-24	Cassin's auklet	Breast Feathers	2009	6/26/2009	Corm Blind Hill	No Structure	CB 369	0.177
09-CAAU-25	Cassin's auklet	Breast Feathers	2009	6/26/2009	Corm Blind Hill	No Structure	CB 372	0.191
09-CAAU-26	Cassin's auklet	Breast Feathers	2009	6/26/2009	Corm Blind Hill	No Structure	CB 398	0.293
09-CAAU-39	Cassin's auklet	Breast Feathers	2009	6/26/2009	Corm Blind Hill	No Structure	CB 373	0.4
10-CAAU-07	Cassin's auklet	Breast Feathers	2010	6/20/2010	Carpentry Shop	Historic Structure	CS 49	1.76
10-CAAU-06	Cassin's auklet	Breast Feathers	2010	6/20/2010	Carpentry Shop	Historic Structure	CS 50	2.34
10-CAAU-05	Cassin's auklet	Breast Feathers	2010	6/20/2010	Carpentry Shop	Historic Structure	CS 09	2.73
10-CAAU-02	Cassin's auklet	Breast Feathers	2010	6/20/2010	Carpentry Shop	Historic Structure	CS 26	3.63
10-CAAU-04	Cassin's auklet	Breast Feathers	2010	6/20/2010	Carpentry Shop	Historic Structure	CS 31	3.64
10-CAAU-01	Cassin's auklet	Breast Feathers	2010	6/20/2010	Carpentry Shop	Historic Structure	CS 04	5.37
10-CAAU-03	Cassin's auklet	Breast Feathers	2010	6/20/2010	Carpentry Shop	Historic Structure	CS 15	10.50
10-CAAU-09	Cassin's auklet	Breast Feathers	2010	6/20/2010	Carpentry Shop	Historic Structure	CS 88	15.80
10-CAAU-08	Cassin's auklet	Breast Feathers	2010	6/20/2010	Carpentry Shop	Historic Structure	CS 73	17.90
10-CAAU-10	Cassin's auklet	Breast Feathers	2010	6/20/2010	Carpentry Shop	Historic Structure	CS 61	52.70
10-CAAU-14	Cassin's auklet	Breast Feathers	2010	6/20/2010	Coast Guard House	Historic Structure	CG-162	0.84
10-CAAU-20	Cassin's auklet	Breast Feathers	2010	6/20/2010	Coast Guard House	Historic Structure	CG 119	0.90
10-CAAU-17	Cassin's auklet	Breast Feathers	2010	6/20/2010	Coast Guard House	Historic Structure	CG 148	1.09
10-CAAU-19	Cassin's auklet	Breast Feathers	2010	6/20/2010	Coast Guard House	Historic Structure	CG 121	1.09
10-CAAU-13	Cassin's auklet	Breast Feathers	2010	6/20/2010	Coast Guard House	Historic Structure	CG 128	1.96
10-CAAU-22	Cassin's auklet	Breast Feathers	2010	6/20/2010	Coast Guard House	Historic Structure	CG 109	2.26
10-CAAU-16	Cassin's auklet	Breast Feathers	2010	6/20/2010	Coast Guard House	Historic Structure	CG 150	2.28
10-CAAU-21	Cassin's auklet	Breast Feathers	2010	6/20/2010	Coast Guard House	Historic Structure	CG 105	2.50
10-CAAU-23	Cassin's auklet	Breast Feathers	2010	6/20/2010	Coast Guard House	Historic Structure	CG 108	2.69
10-CAAU-15	Cassin's auklet	Breast Feathers	2010	6/20/2010	Coast Guard House	Historic Structure	CG 152	3.37
10-CAAU-18	Cassin's auklet	Breast Feathers	2010	6/20/2010	Coast Guard House	Historic Structure	CG 140	5.01
10-CAAU-35	Cassin's auklet	Breast Feathers	2010	6/20/2010	Corm Blind Hill	No Structure	CB 378	0.47
10-CAAU-34	Cassin's auklet	Breast Feathers	2010	6/20/2010	Corm Blind Hill	No Structure	CB 374	0.66
10-CAAU-36	Cassin's auklet	Breast Feathers	2010	6/20/2010	Corm Blind Hill	No Structure	CB 388	0.66
10-CAAU-32	Cassin's auklet	Breast Feathers	2010	6/20/2010	Corm Blind Hill	No Structure	CB 352	0.81
10-CAAU-33	Cassin's auklet	Breast Feathers	2010	6/20/2010	Corm Blind Hill	No Structure	CB 357	0.84
10-CAAU-38	Cassin's auklet	Breast Feathers	2010	6/20/2010	Corm Blind Hill	No Structure	CB 402	1.14
10-CAAU-37	Cassin's auklet	Breast Feathers	2010	6/20/2010	Corm Blind Hill	No Structure	CB 398	2.97
10-CAAU-12	Cassin's auklet	Breast Feathers	2010	6/20/2010	Power House	Historic Structure	PH 5	0.45
10-CAAU-11	Cassin's auklet	Breast Feathers	2010	6/20/2010	Power House	Historic Structure	PH 4	0.64

CONTINUED: Results from lead analysis of breast feathers taken from Cassin's auklet fledglings on Southeast Farallon Island from 2009-2011. Results are presented in micrograms per gram (µg/g) on a dry weight basis.

Sample ID	Species	Sample Matrix	Year	Collection Date	Location	Structure Status	Nest ID	Pb (µg/g dw)
10-CAAU-28	Cassin's auklet	Breast Feathers	2010	6/20/2010	PRBO House	Historic Structure	PRBO 349	0.61
10-CAAU-31	Cassin's auklet	Breast Feathers	2010	6/20/2010	PRBO House	Historic Structure	PRBO 344	1.00
10-CAAU-27	Cassin's auklet	Breast Feathers	2010	6/20/2010	PRBO House	Historic Structure	PRBO 350	1.01
10-CAAU-26	Cassin's auklet	Breast Feathers	2010	6/20/2010	PRBO House	Historic Structure	PRBO 21	1.12
10-CAAU-30	Cassin's auklet	Breast Feathers	2010	6/20/2010	PRBO House	Historic Structure	PRBO 346	1.58
10-CAAU-25	Cassin's auklet	Breast Feathers	2010	6/20/2010	PRBO House	Historic Structure	PRBO 18	2.24
10-CAAU-24	Cassin's auklet	Breast Feathers	2010	6/20/2010	PRBO House	Historic Structure	PRBO 14	2.61
10-CAAU-29	Cassin's auklet	Breast Feathers	2010	6/20/2010	PRBO House	Historic Structure	PRBO 347	38.00
11-CAAU-05	Cassin's auklet	Breast Feathers	2011	6/2/2011	Carpentry Shop	Historic Structure	CS 20	0.716
11-CAAU-03	Cassin's auklet	Breast Feathers	2011	6/2/2011	Carpentry Shop	Historic Structure	CS 8	1.06
11-CAAU-08	Cassin's auklet	Breast Feathers	2011	6/2/2011	Carpentry Shop	Historic Structure	CS 52	1.2
11-CAAU-01	Cassin's auklet	Breast Feathers	2011	6/2/2011	Carpentry Shop	Historic Structure	CS 4	1.55
11-CAAU-07	Cassin's auklet	Breast Feathers	2011	6/2/2011	Carpentry Shop	Historic Structure	CS 44	1.64
11-CAAU-10	Cassin's auklet	Breast Feathers	2011	6/2/2011	Carpentry Shop	Historic Structure	CS 83	2.07
11-CAAU-04	Cassin's auklet	Breast Feathers	2011	6/2/2011	Carpentry Shop	Historic Structure	CS 16	3.19
11-CAAU-02	Cassin's auklet	Breast Feathers	2011	6/2/2011	Carpentry Shop	Historic Structure	CS 7	3.37
11-CAAU-09	Cassin's auklet	Breast Feathers	2011	6/2/2011	Carpentry Shop	Historic Structure	CS 79	4.85
11-CAAU-06	Cassin's auklet	Breast Feathers	2011	6/2/2011	Carpentry Shop	Historic Structure	CS 21	7.07
11-CAAU-16	Cassin's auklet	Breast Feathers	2011	6/2/2011	Coast Guard House	Historic Structure	CG 157	0.244
11-CAAU-17	Cassin's auklet	Breast Feathers	2011	6/2/2011	Coast Guard House	Historic Structure	CG 161	0.303
11-CAAU-12	Cassin's auklet	Breast Feathers	2011	6/2/2011	Coast Guard House	Historic Structure	CG 137	0.343
11-CAAU-14	Cassin's auklet	Breast Feathers	2011	6/2/2011	Coast Guard House	Historic Structure	CG 146	0.44
11-CAAU-13	Cassin's auklet	Breast Feathers	2011	6/2/2011	Coast Guard House	Historic Structure	CG 143	0.467
11-CAAU-15	Cassin's auklet	Breast Feathers	2011	6/2/2011	Coast Guard House	Historic Structure	CG 151	0.494
11-CAAU-11	Cassin's auklet	Breast Feathers	2011	6/2/2011	Coast Guard House	Historic Structure	CG 134	2.27
11-CAAU-32	Cassin's auklet	Breast Feathers	2011	6/2/2011	Corm Blind Hill	No Structure	CB 361	0.0637
11-CAAU-31	Cassin's auklet	Breast Feathers	2011	6/2/2011	Corm Blind Hill	No Structure	CB 359	0.0945
11-CAAU-34	Cassin's auklet	Breast Feathers	2011	6/2/2011	Corm Blind Hill	No Structure	CB 369	0.107
11-CAAU-35	Cassin's auklet	Breast Feathers	2011	6/2/2011	Corm Blind Hill	No Structure	CB 371	0.11
11-CAAU-37	Cassin's auklet	Breast Feathers	2011	6/2/2011	Corm Blind Hill	No Structure	CB 382	0.119
11-CAAU-29	Cassin's auklet	Breast Feathers	2011	6/2/2011	Corm Blind Hill	No Structure	CB 352	0.12
11-CAAU-39	Cassin's auklet	Breast Feathers	2011	6/2/2011	Corm Blind Hill	No Structure	CB 384	0.139
11-CAAU-30	Cassin's auklet	Breast Feathers	2011	6/2/2011	Corm Blind Hill	No Structure	CB 353	0.147
11-CAAU-38	Cassin's auklet	Breast Feathers	2011	6/2/2011	Corm Blind Hill	No Structure	CB 383	0.157
11-CAAU-36	Cassin's auklet	Breast Feathers	2011	6/2/2011	Corm Blind Hill	No Structure	CB 373	0.281
11-CAAU-33	Cassin's auklet	Breast Feathers	2011	6/2/2011	Corm Blind Hill	No Structure	CB 368	0.362
11-CAAU-22	Cassin's auklet	Breast Feathers	2011	6/2/2011	Power House	Historic Structure	PH 3	0.141
11-CAAU-23	Cassin's auklet	Breast Feathers	2011	6/2/2011	Power House	Historic Structure	PH 5	0.294
11-CAAU-24	Cassin's auklet	Breast Feathers	2011	6/2/2011	Power House	Historic Structure	PH 6	0.463
11-CAAU-21	Cassin's auklet	Breast Feathers	2011	6/2/2011	Power House	Historic Structure	PH 2	0.621
11-CAAU-19	Cassin's auklet	Breast Feathers	2011	6/2/2011	PRBO House	Historic Structure	PRBO 344	0.236
11-CAAU-18	Cassin's auklet	Breast Feathers	2011	6/2/2011	PRBO House	Historic Structure	PRBO 342	0.243
11-CAAU-20	Cassin's auklet	Breast Feathers	2011	6/2/2011	PRBO House	Historic Structure	PRBO 345	0.715

Results from lead analysis of breast feathers taken from western gull fledglings on Southeast Farallon Island from 2009-2011. Results are presented in micrograms per gram (µg/g) on a dry weight basis.

Sample ID	Species	Sample Matrix	Year	Collection Date	Location	Structure Status	Nest ID	Pb (µg/g dw)
09-WEGU-04	Western gull	Breast Feathers	2009	7/29/2009	Carpentry Shop	Historic Structure	n/a	1.78
09-WEGU-03	Western gull	Breast Feathers	2009	7/29/2009	Carpentry Shop	Historic Structure	n/a	1.83
09-WEGU-05	Western gull	Breast Feathers	2009	7/29/2009	Carpentry Shop	Historic Structure	n/a	3.01
09-WEGU-06	Western gull	Breast Feathers	2009	7/29/2009	Carpentry Shop	Historic Structure	n/a	3.77
09-WEGU-07	Western gull	Breast Feathers	2009	7/29/2009	Carpentry Shop	Historic Structure	n/a	8.16
09-WEGU-10	Western gull	Breast Feathers	2009	7/29/2009	Carpentry Shop	Historic Structure	n/a	9.55
09-WEGU-09	Western gull	Breast Feathers	2009	7/29/2009	Carpentry Shop	Historic Structure	n/a	10.9
09-WEGU-08	Western gull	Breast Feathers	2009	7/29/2009	Carpentry Shop	Historic Structure	n/a	16.1
09-WEGU-02	Western gull	Breast Feathers	2009	7/29/2009	Carpentry Shop	Historic Structure	n/a	30.1
09-WEGU-01	Western gull	Breast Feathers	2009	7/29/2009	Carpentry Shop	Historic Structure	n/a	42.6
09-WEGU-28	Western gull	Breast Feathers	2009	7/29/2009	Coast Guard House	Historic Structure	n/a	0.355
09-WEGU-27	Western gull	Breast Feathers	2009	7/29/2009	Coast Guard House	Historic Structure	n/a	1.32
09-WEGU-26	Western gull	Breast Feathers	2009	7/29/2009	Coast Guard House	Historic Structure	n/a	2.03
09-WEGU-29	Western gull	Breast Feathers	2009	7/29/2009	Coast Guard House	Historic Structure	n/a	2.49
09-WEGU-30	Western gull	Breast Feathers	2009	7/29/2009	Coast Guard House	Historic Structure	n/a	10.5
09-WEGU-24	Western gull	Breast Feathers	2009	7/29/2009	Coast Guard House	Historic Structure	n/a	10.6
09-WEGU-25	Western gull	Breast Feathers	2009	7/29/2009	Coast Guard House	Historic Structure	n/a	14.3
09-WEGU-22	Western gull	Breast Feathers	2009	7/29/2009	Coast Guard House	Historic Structure	n/a	21.6
09-WEGU-23	Western gull	Breast Feathers	2009	7/29/2009	Coast Guard House	Historic Structure	n/a	31.4
09-WEGU-21	Western gull	Breast Feathers	2009	7/29/2009	Coast Guard House	Historic Structure	n/a	33.5
09-WEGU-31	Western gull	Breast Feathers	2009	7/29/2009	Corm Blind Hill	No Structure	n/a	0.142
09-WEGU-34	Western gull	Breast Feathers	2009	7/29/2009	Corm Blind Hill	No Structure	n/a	0.15
09-WEGU-38	Western gull	Breast Feathers	2009	7/29/2009	Corm Blind Hill	No Structure	n/a	0.18
09-WEGU-35	Western gull	Breast Feathers	2009	7/29/2009	Corm Blind Hill	No Structure	n/a	0.246
09-WEGU-32	Western gull	Breast Feathers	2009	7/29/2009	Corm Blind Hill	No Structure	n/a	0.26
09-WEGU-39	Western gull	Breast Feathers	2009	7/29/2009	Corm Blind Hill	No Structure	n/a	0.327
09-WEGU-36	Western gull	Breast Feathers	2009	7/29/2009	Corm Blind Hill	No Structure	n/a	0.347
09-WEGU-33	Western gull	Breast Feathers	2009	7/29/2009	Corm Blind Hill	No Structure	n/a	0.377
09-WEGU-37	Western gull	Breast Feathers	2009	7/29/2009	Corm Blind Hill	No Structure	n/a	0.41
09-WEGU-40	Western gull	Breast Feathers	2009	7/29/2009	Corm Blind Hill	No Structure	n/a	0.411
09-WEGU-20	Western gull	Breast Feathers	2009	7/29/2009	Power House	Historic Structure	n/a	0.681
09-WEGU-11	Western gull	Breast Feathers	2009	7/29/2009	Power House	Historic Structure	n/a	0.885
09-WEGU-14	Western gull	Breast Feathers	2009	7/29/2009	Power House	Historic Structure	n/a	1.84
09-WEGU-15	Western gull	Breast Feathers	2009	7/29/2009	Power House	Historic Structure	n/a	1.85
09-WEGU-12	Western gull	Breast Feathers	2009	7/29/2009	Power House	Historic Structure	n/a	1.98
09-WEGU-13	Western gull	Breast Feathers	2009	7/29/2009	Power House	Historic Structure	n/a	2.11
09-WEGU-16	Western gull	Breast Feathers	2009	7/29/2009	Power House	Historic Structure	n/a	2.67
09-WEGU-17	Western gull	Breast Feathers	2009	7/29/2009	Power House	Historic Structure	n/a	7.13
09-WEGU-19	Western gull	Breast Feathers	2009	7/29/2009	Power House	Historic Structure	n/a	7.19
09-WEGU-18	Western gull	Breast Feathers	2009	7/29/2009	Power House	Historic Structure	n/a	10.5
10WEGU-F-07	Western gull	Breast Feathers	2010	8/2/2010	Carpentry Shop	Historic Structure	n/a	1.87
10WEGU-F-09	Western gull	Breast Feathers	2010	8/2/2010	Carpentry Shop	Historic Structure	n/a	3.66
10WEGU-F-04	Western gull	Breast Feathers	2010	8/2/2010	Carpentry Shop	Historic Structure	n/a	6.30

CONTINUED: Results from lead analysis of breast feathers taken from western gull fledglings on Southeast Farallon Island from 2009-2011. Results are presented in micrograms per gram (μg/g) on a dry weight basis.

Sample ID	Species	Sample Matrix	Year	Collection Date	Location	Structure Status	Nest ID	Pb (μg/g dw)
10WEGU-F-05	Western gull	Breast Feathers	2010	8/2/2010	Carpentry Shop	Historic Structure	n/a	7.49
10WEGU-F-03	Western gull	Breast Feathers	2010	8/2/2010	Carpentry Shop	Historic Structure	n/a	8.54
10WEGU-F-02	Western gull	Breast Feathers	2010	8/2/2010	Carpentry Shop	Historic Structure	n/a	9.01
10WEGU-F-08	Western gull	Breast Feathers	2010	8/2/2010	Carpentry Shop	Historic Structure	n/a	9.23
10WEGU-F-06	Western gull	Breast Feathers	2010	8/2/2010	Carpentry Shop	Historic Structure	n/a	9.51
10WEGU-F-01	Western gull	Breast Feathers	2010	8/2/2010	Carpentry Shop	Historic Structure	n/a	13.10
10WEGU-F-26	Western gull	Breast Feathers	2010	8/2/2010	Coast Guard House	Historic Structure	n/a	1.93
10WEGU-F-23	Western gull	Breast Feathers	2010	8/2/2010	Coast Guard House	Historic Structure	n/a	2.34
10WEGU-F-29	Western gull	Breast Feathers	2010	8/2/2010	Coast Guard House	Historic Structure	n/a	2.40
10WEGU-F-30	Western gull	Breast Feathers	2010	8/2/2010	Coast Guard House	Historic Structure	n/a	3.16
10WEGU-F-27	Western gull	Breast Feathers	2010	8/2/2010	Coast Guard House	Historic Structure	n/a	4.60
10WEGU-F-22	Western gull	Breast Feathers	2010	8/2/2010	Coast Guard House	Historic Structure	n/a	5.85
10WEGU-F-25	Western gull	Breast Feathers	2010	8/2/2010	Coast Guard House	Historic Structure	n/a	6.23
10WEGU-F-28	Western gull	Breast Feathers	2010	8/2/2010	Coast Guard House	Historic Structure	n/a	6.67
10WEGU-F-21	Western gull	Breast Feathers	2010	8/2/2010	Coast Guard House	Historic Structure	n/a	19.50
10WEGU-F-24	Western gull	Breast Feathers	2010	8/2/2010	Coast Guard House	Historic Structure	n/a	20.90
10WEGU-F-36	Western gull	Breast Feathers	2010	8/2/2010	Corm Blind Hill	No Structure	n/a	0.51
10WEGU-F-35	Western gull	Breast Feathers	2010	8/2/2010	Corm Blind Hill	No Structure	n/a	0.53
10WEGU-F-33	Western gull	Breast Feathers	2010	8/2/2010	Corm Blind Hill	No Structure	n/a	0.56
10WEGU-F-34	Western gull	Breast Feathers	2010	8/2/2010	Corm Blind Hill	No Structure	n/a	0.83
10WEGU-F-37	Western gull	Breast Feathers	2010	8/2/2010	Corm Blind Hill	No Structure	n/a	0.92
10WEGU-F-32	Western gull	Breast Feathers	2010	8/2/2010	Corm Blind Hill	No Structure	n/a	1.32
10WEGU-F-31	Western gull	Breast Feathers	2010	8/2/2010	Corm Blind Hill	No Structure	n/a	1.37
10WEGU-F-38	Western gull	Breast Feathers	2010	8/2/2010	Corm Blind Hill	No Structure	n/a	0.54
10WEGU-F-40	Western gull	Breast Feathers	2010	8/2/2010	Corm Blind Hill	No Structure	n/a	0.92
10WEGU-F-39	Western gull	Breast Feathers	2010	8/2/2010	Corm Blind Hill	No Structure	n/a	1.85
10WEGU-F-16	Western gull	Breast Feathers	2010	8/2/2010	Power House	Historic Structure	n/a	1.03
10WEGU-F-20	Western gull	Breast Feathers	2010	8/2/2010	Power House	Historic Structure	n/a	1.03
10WEGU-F-17	Western gull	Breast Feathers	2010	8/2/2010	Power House	Historic Structure	n/a	1.11
10WEGU-F-19	Western gull	Breast Feathers	2010	8/2/2010	Power House	Historic Structure	n/a	1.18
10WEGU-F-18	Western gull	Breast Feathers	2010	8/2/2010	Power House	Historic Structure	n/a	1.41
10WEGU-F-10	Western gull	Breast Feathers	2010	8/2/2010	Power House	Historic Structure	n/a	2.27
10WEGU-F-15	Western gull	Breast Feathers	2010	8/2/2010	Power House	Historic Structure	n/a	3.24
10WEGU-F-11	Western gull	Breast Feathers	2010	8/2/2010	Power House	Historic Structure	n/a	3.81
10WEGU-F-12	Western gull	Breast Feathers	2010	8/2/2010	Power House	Historic Structure	n/a	3.99
10WEGU-F-14	Western gull	Breast Feathers	2010	8/2/2010	Power House	Historic Structure	n/a	4.35
10WEGU-F-13	Western gull	Breast Feathers	2010	8/2/2010	Power House	Historic Structure	n/a	4.73
11-WEGU-03	Western gull	Breast Feathers	2011	7/31/2011	Carpentry Shop	Historic Structure	n/a	3.38
11-WEGU-06	Western gull	Breast Feathers	2011	7/31/2011	Carpentry Shop	Historic Structure	n/a	3.54
11-WEGU-05	Western gull	Breast Feathers	2011	7/31/2011	Carpentry Shop	Historic Structure	n/a	4.4
11-WEGU-07	Western gull	Breast Feathers	2011	7/31/2011	Carpentry Shop	Historic Structure	n/a	4.99
11-WEGU-02	Western gull	Breast Feathers	2011	7/31/2011	Carpentry Shop	Historic Structure	n/a	5.02
11-WEGU-04	Western gull	Breast Feathers	2011	7/31/2011	Carpentry Shop	Historic Structure	n/a	5.21

CONTINUED: Results from lead analysis of breast feathers taken from western gull fledglings on Southeast Farallon Island from 2009-2011. Results are presented in micrograms per gram (µg/g) on a dry weight basis.

Sample ID	Species	Sample Matrix	Year	Collection Date	Location	Structure Status	Nest ID	Pb (µg/g dw)
11-WEGU-08	Western gull	Breast Feathers	2011	7/31/2011	Carpentry Shop	Historic Structure	n/a	11.4
11-WEGU-09	Western gull	Breast Feathers	2011	7/31/2011	Carpentry Shop	Historic Structure	n/a	12.4
11-WEGU-01	Western gull	Breast Feathers	2011	7/31/2011	Carpentry Shop	Historic Structure	n/a	18
11-WEGU-20	Western gull	Breast Feathers	2011	7/31/2011	Coast Guard House	Historic Structure	n/a	1.18
11-WEGU-17	Western gull	Breast Feathers	2011	7/31/2011	Coast Guard House	Historic Structure	n/a	1.3
11-WEGU-11	Western gull	Breast Feathers	2011	7/31/2011	Coast Guard House	Historic Structure	n/a	1.49
11-WEGU-13	Western gull	Breast Feathers	2011	7/31/2011	Coast Guard House	Historic Structure	n/a	1.63
11-WEGU-18	Western gull	Breast Feathers	2011	7/31/2011	Coast Guard House	Historic Structure	n/a	1.83
11-WEGU-12	Western gull	Breast Feathers	2011	7/31/2011	Coast Guard House	Historic Structure	n/a	3.45
11-WEGU-16	Western gull	Breast Feathers	2011	7/31/2011	Coast Guard House	Historic Structure	n/a	3.87
11-WEGU-10	Western gull	Breast Feathers	2011	7/31/2011	Coast Guard House	Historic Structure	n/a	5.02
11-WEGU-14	Western gull	Breast Feathers	2011	7/31/2011	Coast Guard House	Historic Structure	n/a	5.25
11-WEGU-15	Western gull	Breast Feathers	2011	7/31/2011	Coast Guard House	Historic Structure	n/a	8.15
11-WEGU-19	Western gull	Breast Feathers	2011	7/31/2011	Coast Guard House	Historic Structure	n/a	10.3
11-WEGU-33	Western gull	Breast Feathers	2011	7/31/2011	Corm Blind Hill	No Structure	n/a	0.243
11-WEGU-31	Western gull	Breast Feathers	2011	7/31/2011	Corm Blind Hill	No Structure	n/a	0.288
11-WEGU-34	Western gull	Breast Feathers	2011	7/31/2011	Corm Blind Hill	No Structure	n/a	0.313
11-WEGU-35	Western gull	Breast Feathers	2011	7/31/2011	Corm Blind Hill	No Structure	n/a	0.396
11-WEGU-32	Western gull	Breast Feathers	2011	7/31/2011	Corm Blind Hill	No Structure	n/a	0.417
11-WEGU-26	Western gull	Breast Feathers	2011	7/31/2011	Power House	Historic Structure	n/a	0.452
11-WEGU-23	Western gull	Breast Feathers	2011	7/31/2011	Power House	Historic Structure	n/a	0.638
11-WEGU-27	Western gull	Breast Feathers	2011	7/31/2011	Power House	Historic Structure	n/a	0.735
11-WEGU-24	Western gull	Breast Feathers	2011	7/31/2011	Power House	Historic Structure	n/a	0.785
11-WEGU-28	Western gull	Breast Feathers	2011	7/31/2011	Power House	Historic Structure	n/a	0.887
11-WEGU-25	Western gull	Breast Feathers	2011	7/31/2011	Power House	Historic Structure	n/a	0.902
11-WEGU-29	Western gull	Breast Feathers	2011	7/31/2011	Power House	Historic Structure	n/a	1.06
11-WEGU-21	Western gull	Breast Feathers	2011	7/31/2011	Power House	Historic Structure	n/a	3.01
11-WEGU-30	Western gull	Breast Feathers	2011	7/31/2011	Power House	Historic Structure	n/a	4.4
11-WEGU-22	Western gull	Breast Feathers	2011	7/31/2011	Power House	Historic Structure	n/a	5.05

Results from lead analysis of soil samples taken from Cassin's auklet nest boxes on Southeast Farallon Island from 2010-2011. Results are presented in micrograms per gram (µg/g) on a dry weight basis.

Sample ID	Collection Date	Location	Nest ID	Corresponding feather sample	Soil Pb (µg/g d.w.)	Feather Pb (µg/g d.w.)	Structure Status
10-SOIL-01	6/20/2010	Carpentry Shop	CS 04	10-CAAU-01	1980	5.37	Historic Structure
10-SOIL-02	6/20/2010	Carpentry Shop	CS 26	10-CAAU-02	2090	3.63	Historic Structure
10-SOIL-03	6/20/2010	Carpentry Shop	CS 15	10-CAAU-03	3020	10.50	Historic Structure
10-SOIL-04	6/20/2010	Carpentry Shop	CS 31	10-CAAU-04	1020	3.64	Historic Structure
10-SOIL-05	6/20/2010	Carpentry Shop	CS 09	10-CAAU-05	479	2.73	Historic Structure
10-SOIL-06	6/20/2010	Carpentry Shop	CS 50	10-CAAU-06	520	2.34	Historic Structure
10-SOIL-07	6/20/2010	Carpentry Shop	CS 49	10-CAAU-07	534	1.76	Historic Structure
10-SOIL-08	6/20/2010	Carpentry Shop	CS 73	10-CAAU-08	1310	17.90	Historic Structure
10-SOIL-09	6/20/2010	Carpentry Shop	CS 88	10-CAAU-09	2610	15.80	Historic Structure
10-SOIL-10	6/20/2010	Carpentry Shop	CS 61	10-CAAU-10	5280	52.70	Historic Structure
11-SOIL-01	7/31/2011	Carpentry Shop	CS 4	11-CAAU-01	970	1.55	Historic Structure
11-SOIL-02	7/31/2011	Carpentry Shop	CS 7	11-CAAU-02	717	3.37	Historic Structure
11-SOIL-03	7/31/2011	Carpentry Shop	CS 8	11-CAAU-03	763	1.06	Historic Structure
11-SOIL-04	7/31/2011	Carpentry Shop	CS 16	11-CAAU-04	1970	3.19	Historic Structure
11-SOIL-05	7/31/2011	Carpentry Shop	CS 20	11-CAAU-05	1920	0.716	Historic Structure
11-SOIL-06	7/31/2011	Carpentry Shop	CS 21	11-CAAU-06	2120	7.07	Historic Structure
11-SOIL-07	7/31/2011	Carpentry Shop	CS 44	11-CAAU-07	656	1.64	Historic Structure
11-SOIL-08	7/31/2011	Carpentry Shop	CS 52	11-CAAU-08	592	1.2	Historic Structure
11-SOIL-09	7/31/2011	Carpentry Shop	CS 79	11-CAAU-09	2380	4.85	Historic Structure
11-SOIL-10	7/31/2011	Carpentry Shop	CS 83	11-CAAU-10	1620	2.07	Historic Structure
10-SOIL-13	6/20/2010	Coast Guard House	CG 128	10-CAAU-13	402	1.96	Historic Structure
10-SOIL-14	6/20/2010	Coast Guard House	CG-162	10-CAAU-14	218	0.84	Historic Structure
10-SOIL-15	6/20/2010	Coast Guard House	CG 152	10-CAAU-15	207	3.37	Historic Structure
10-SOIL-16	6/20/2010	Coast Guard House	CG 150	10-CAAU-16	722	2.28	Historic Structure
10-SOIL-17	6/20/2010	Coast Guard House	CG 148	10-CAAU-17	395	1.09	Historic Structure
10-SOIL-18	6/20/2010	Coast Guard House	CG 140	10-CAAU-18	437	5.01	Historic Structure
10-SOIL-19	6/20/2010	Coast Guard House	CG 121	10-CAAU-19	219	1.09	Historic Structure
10-SOIL-20	6/20/2010	Coast Guard House	CG 119	10-CAAU-20	104	0.90	Historic Structure
10-SOIL-21	6/20/2010	Coast Guard House	CG 105	10-CAAU-21	435	2.50	Historic Structure
10-SOIL-22	6/20/2010	Coast Guard House	CG 109	10-CAAU-22	1080	2.26	Historic Structure
10-SOIL-23	6/20/2010	Coast Guard House	CG 108	10-CAAU-23	1090	2.69	Historic Structure
11-SOIL-11	7/31/2011	Coast Guard House	CG 134	11-CAAU-11	511	2.27	Historic Structure
11-SOIL-12	7/31/2011	Coast Guard House	CG 137	11-CAAU-12	240	0.343	Historic Structure
11-SOIL-13	7/31/2011	Coast Guard House	CG 143	11-CAAU-13	364	0.467	Historic Structure
11-SOIL-14	7/31/2011	Coast Guard House	CG 146	11-CAAU-14	229	0.44	Historic Structure
11-SOIL-15	7/31/2011	Coast Guard House	CG 151	11-CAAU-15	255	0.494	Historic Structure
11-SOIL-16	7/31/2011	Coast Guard House	CG 157	11-CAAU-16	163	0.244	Historic Structure
11-SOIL-17	7/31/2011	Coast Guard House	CG 161	11-CAAU-17	170	0.303	Historic Structure
10-SOIL-32	6/20/2010	Corm Blind Hill	CB 352	10-CAAU-32	69.2	0.81	No Structure
10-SOIL-33	6/20/2010	Corm Blind Hill	CB 357	10-CAAU-33	38.2	0.84	No Structure
10-SOIL-34	6/20/2010	Corm Blind Hill	CB 374	10-CAAU-34	107	0.66	No Structure
10-SOIL-35	6/20/2010	Corm Blind Hill	CB 378	10-CAAU-35	86.6	0.47	No Structure
10-SOIL-36	6/20/2010	Corm Blind Hill	CB 388	10-CAAU-36	219	0.66	No Structure

CONTINUED: Results from lead analysis of soil samples taken from Cassin's auklet nest boxes on Southeast Farallon Island from 2010-2011. Results are presented in micrograms per gram (μg/g) on a dry weight basis.

Sample ID	Collection Date	Location	Nest ID	Corresponding feather sample	Soil Pb (μg/g d.w.)	Feather Pb (μg/g d.w.)	Structure Status
10-SOIL-37	6/20/2010	Corm Blind Hill	CB 398	10-CAAU-37	90.9	2.97	No Structure
10-SOIL-38	6/20/2010	Corm Blind Hill	CB 402	10-CAAU-38	52.5	1.14	No Structure
11-SOIL-29	7/31/2011	Corm Blind Hill	CB 352	11-CAAU-29	59	0.12	No Structure
11-SOIL-30	7/31/2011	Corm Blind Hill	CB 353	11-CAAU-30	65	0.147	No Structure
11-SOIL-31	7/31/2011	Corm Blind Hill	CB 359	11-CAAU-31	32.9	0.0945	No Structure
11-SOIL-32	7/31/2011	Corm Blind Hill	CB 361	11-CAAU-32	38.3	0.0637	No Structure
11-SOIL-33	7/31/2011	Corm Blind Hill	CB 368	11-CAAU-33	37.4	0.362	No Structure
11-SOIL-34	7/31/2011	Corm Blind Hill	CB 369	11-CAAU-34	44.5	0.107	No Structure
11-SOIL-35	7/31/2011	Corm Blind Hill	CB 371	11-CAAU-35	78.9	0.11	No Structure
11-SOIL-36	7/31/2011	Corm Blind Hill	CB 373	11-CAAU-36	76.9	0.281	No Structure
11-SOIL-37	7/31/2011	Corm Blind Hill	CB 382	11-CAAU-37	79.4	0.119	No Structure
11-SOIL-38	7/31/2011	Corm Blind Hill	CB 383	11-CAAU-38	88.6	0.157	No Structure
11-SOIL-39	7/31/2011	Corm Blind Hill	CB 384	11-CAAU-39	196	0.139	No Structure
10-SOIL-11	6/20/2010	Power House	PH 4	10-CAAU-11	130	0.64	Historic Structure
10-SOIL-12	6/20/2010	Power House	PH 5	10-CAAU-12	123	0.45	Historic Structure
11-SOIL-21	7/31/2011	Power House	PH 2	11-CAAU-21	227	0.621	Historic Structure
11-SOIL-22	7/31/2011	Power House	PH 3	11-CAAU-22	140	0.141	Historic Structure
11-SOIL-23	7/31/2011	Power House	PH 5	11-CAAU-23	156	0.294	Historic Structure
11-SOIL-24	7/31/2011	Power House	PH 6	11-CAAU-24	135	0.463	Historic Structure
10-SOIL-24	6/20/2010	PRBO House	PRBO 14	10-CAAU-24	594	2.61	Historic Structure
10-SOIL-25	6/20/2010	PRBO House	PRBO 18	10-CAAU-25	559	2.24	Historic Structure
10-SOIL-26	6/20/2010	PRBO House	PRBO 21	10-CAAU-26	651	1.12	Historic Structure
10-SOIL-27	6/20/2010	PRBO House	PRBO 350	10-CAAU-27	254	1.01	Historic Structure
10-SOIL-28	6/20/2010	PRBO House	PRBO 349	10-CAAU-28	281	0.61	Historic Structure
10-SOIL-29	6/20/2010	PRBO House	PRBO 347	10-CAAU-29	461	38.00	Historic Structure
10-SOIL-30	6/20/2010	PRBO House	PRBO 346	10-CAAU-30	460	1.58	Historic Structure
10-SOIL-31	6/20/2010	PRBO House	PRBO 344	10-CAAU-31	151	1.00	Historic Structure
11-SOIL-18	7/31/2011	PRBO House	PRBO 342	11-CAAU-18	129	0.243	Historic Structure
11-SOIL-19	7/31/2011	PRBO House	PRBO 344	11-CAAU-19	200	0.236	Historic Structure
11-SOIL-20	7/31/2011	PRBO House	PRBO 345	11-CAAU-20	132	0.715	Historic Structure

APPENDIX B

Avian Egg Organic Compound Analysis and Metals Scan Results

Food Web Stable Isotope and Mercury Results

Organic compound data for eggs collected from Southeast Farallon Island from 2009 – 2011. Results are presented in micrograms/gram (µg/g). Non-detects are indicated as italics and the result entered indicates the detection limit.

Sample ID	Species	Year	Collection Date	Egg Content Weight	Egg Content Fresh Weight	∑ PCB dw	∑ PCB fww	∑ PBDE dw	∑ PBDE fww	∑ DDT dw	∑ DDT fww
09-CAAU-02	Cassin's Auklet	2009	6/1/2009	22.82	24.95	0.26	0.07	*0.08*	*0.02*	0.85	0.23
09-CAAU-11	Cassin's Auklet	2009	6/26/2009	19.52	23.95	0.44	0.13	*0.06*	*0.02*	1.11	0.32
09-CAAU-12	Cassin's Auklet	2009	6/26/2009	22.87	30.97	0.54	0.12	0.08	0.02	1.67	0.37
09-CAAU-13	Cassin's Auklet	2009	6/26/2009	21.68	25.77	0.62	0.15	0.09	0.02	0.84	0.20
09-CAAU-15	Cassin's Auklet	2009	6/26/2009	19.77	23.69	0.49	0.14	0.06	0.02	1.20	0.34
09-CAAU-16	Cassin's Auklet	2009	6/26/2009	25.33	27.79	0.37	0.10	*0.07*	*0.02*	0.43	0.12
09-CAAU-17	Cassin's Auklet	2009	6/26/2009	20.65	22.10	0.30	0.08	*0.08*	*0.02*	0.69	0.18
09-CAAU-18	Cassin's Auklet	2009	6/26/2009	24.19	24.68	0.54	0.15	0.10	0.03	0.95	0.26
09-CAAU-42	Cassin's Auklet	2009	8/16/2009	24.2	24.57	0.21	0.06	*0.07*	*0.02*	0.62	0.18
09-CAAU-43	Cassin's Auklet	2009	8/16/2009	15.1	18.19	0.25	0.05	*0.09*	*0.02*	0.94	0.20
09-CAAU-44	Cassin's Auklet	2009	8/11/2009	18.7	23.23	0.39	0.08	*0.08*	*0.02*	0.89	0.19
09-CAAU-46	Cassin's Auklet	2009	8/11/2009	21.2	25.09	0.35	0.08	*0.07*	*0.02*	0.60	0.14
10-CAAU-11	Cassin's Auklet	2010	5/24/2010	22.27	27.54	0.92	0.20	0.10	0.02	1.17	0.26
10-CAAU-12	Cassin's Auklet	2010	5/24/2010	26.11	26.02	0.30	0.08	*0.04*	*0.01*	0.66	0.19
10-CAAU-13	Cassin's Auklet	2010	5/24/2010	22.87	24.21	0.41	0.11	*0.04*	*0.01*	0.73	0.19
10-CAAU-14	Cassin's Auklet	2010	5/24/2010	26.1	28.38	0.32	0.09	*0.04*	*0.01*	0.77	0.21
10-CAAU-15	Cassin's Auklet	2010	5/24/2010	19.89	21.06	0.34	0.09	*0.04*	*0.01*	0.65	0.18
10-CAAU-17	Cassin's Auklet	2010	6/7/2010	22.13	26.08	0.86	0.18	0.09	0.02	1.10	0.23
10-CAAU-18	Cassin's Auklet	2010	6/18/2010	19.45	22.85	0.74	0.17	0.16	0.04	1.52	0.36
10-CAAU-21	Cassin's Auklet	2010	5/27/2010	21.36	26.20	0.59	0.12	0.07	0.01	1.37	0.28
10-CAAU-31	Cassin's Auklet	2010	7/28/2010	21.01	26.83	0.53	0.14	0.05	0.01	1.44	0.39
10-CAAU-33	Cassin's Auklet	2010	7/28/2010	18.04		1.17	0.29	0.25	0.06	2.26	0.55
11-CAAU-20	Cassin's Auklet	2011	7/19/2011	24.71	29.93	0.74	0.14	*0.11*	*0.02*	0.86	0.17
11-CAAU-21	Cassin's Auklet	2011	7/19/2011	21.68	26.13	0.47	0.11	*0.09*	*0.02*	0.78	0.19
11-CAAU-26	Cassin's Auklet	2011	6/7/2011	17.61	25.16	0.50	0.11	*0.08*	*0.02*	0.98	0.21
11-CAAU-27	Cassin's Auklet	2011	6/8/2011	15.39	23.55	0.63	0.13	*0.08*	*0.02*	1.26	0.25
11-CAAU-30	Cassin's Auklet	2011	6/8/2011	19.13	23.28	0.41	0.10	*0.12*	*0.03*	0.75	0.18
11-CAAU-33	Cassin's Auklet	2011	6/8/2011	26.67	27.37	0.33	0.08	*0.09*	*0.02*	0.59	0.15
11-CAAU-35	Cassin's Auklet	2011	5/13/2011	21.25	24.26	0.42	0.10	*0.07*	*0.02*	0.88	0.21
11-CAAU-37	Cassin's Auklet	2011	5/13/2011	20.8	24.81	0.55	0.14	*0.07*	*0.02*	0.76	0.19
11-CAAU-40	Cassin's Auklet	2011	5/11/2011	21.7	27.54	0.69	0.16	*0.08*	*0.02*	1.31	0.31
11-CAAU-42	Cassin's Auklet	2011	7/19/2011	22.58	25.62	0.38	0.08	*0.09*	*0.02*	0.63	0.13
09-PIGU-33	Pigeon Guillemot	2009	7/1/2009	38.2	45.45	0.61	0.14	*0.08*	*0.02*	0.44	0.10
09-PIGU-34	Pigeon Guillemot	2009	7/21/2009	31.5	44.10	0.81	0.20	0.06	0.02	0.58	0.14
09-PIGU-35	Pigeon Guillemot	2009	7/21/2009	42.8	48.50	0.56	0.14	*0.08*	*0.02*	0.61	0.15
09-PIGU-37	Pigeon Guillemot	2009	7/1/2009	31.6	40.78	0.59	0.12	*0.06*	*0.01*	0.42	0.08
09-PIGU-38	Pigeon Guillemot	2009	8/11/2009	40.9	45.83	0.95	0.23	0.08	0.02	0.88	0.22
09-PIGU-39	Pigeon Guillemot	2009	8/11/2009	40.1	47.32	0.88	0.19	*0.09*	*0.02*	0.87	0.19
09-PIGU-40	Pigeon Guillemot	2009	8/11/2009	44.6	46.49	0.95	0.22	*0.09*	*0.02*	0.56	0.13
09-PIGU-41	Pigeon Guillemot	2009	8/11/2009	47	48.97	0.80	0.20	0.07	0.02	0.70	0.17
10-PIGU-01	Pigeon Guillemot	2010	5/27/2010	44.19	45.32	0.54	0.14	*0.05*	*0.01*	0.63	0.16
10-PIGU-02	Pigeon Guillemot	2010	5/27/2010	49.32	50.63	0.49	0.12	0.05	0.01	0.41	0.11
10-PIGU-03	Pigeon Guillemot	2010	5/27/2010	47.13	47.77	0.71	0.18	0.06	0.02	0.47	0.12
10-PIGU-04	Pigeon Guillemot	2010	5/27/2010	49.9	49.49	0.64	0.18	0.05	0.02	0.47	0.13
10-PIGU-05	Pigeon Guillemot	2010	5/27/2010	43.49	49.40	0.60	0.14	0.04	0.01	0.46	0.11
10-PIGU-25	Pigeon Guillemot	2010	7/19/2010	41.36	50.83	1.09	0.25	0.10	0.02	0.64	0.15
10-PIGU-26	Pigeon Guillemot	2010	7/19/2010	30.97	48.41	0.82	0.18	0.06	0.01	0.62	0.14
10-PIGU-27	Pigeon Guillemot	2010	7/19/2010	40.12	43.73	1.17	0.30	0.08	0.02	0.64	0.18
11-PIGU-12	Pigeon Guillemot	2011	7/24/2011	41.99	53.56	0.52	0.11	*0.09*	*0.02*	0.44	0.09
11-PIGU-13	Pigeon Guillemot	2011	7/19/2011	42.66	51.49	0.52	0.13	0.20	0.05	0.41	0.10
11-PIGU-14	Pigeon Guillemot	2011	7/19/2011	38.37	47.87	0.85	0.21	*0.08*	*0.02*	0.45	0.11
11-PIGU-15	Pigeon Guillemot	2011	7/19/2011	44.67	54.76	0.57	0.12	*0.08*	*0.02*	0.51	0.11
11-PIGU-16	Pigeon Guillemot	2011	7/19/2011	40.54	49.20	0.73	0.16	*0.09*	*0.02*	0.59	0.13
11-PIGU-17	Pigeon Guillemot	2011	7/31/2011	51.06	56.36	0.59	0.15	0.10	0.03	0.44	0.11
11-PIGU-18	Pigeon Guillemot	2011	7/31/2011	39.78	44.21	0.77	0.18	*0.10*	*0.02*	0.64	0.15
11-PIGU-19	Pigeon Guillemot	2011	7/31/2011	34.01	48.35	1.03	0.23	*0.08*	*0.02*	0.67	0.15

CONTINUED: Organic contaminant data for eggs collected from Southeast Farallon Island from 2009 – 2011. Results are presented in micrograms/gram (µg/g). Non-detects are indicated as italics and the result entered indicates the detection limit.

Sample ID	Species	Year	Collection Date	Egg Content Weight	Egg Content Fresh Weight	∑ PCB dw	∑ PCB fww	∑ PBDE dw	∑ PBDE fww	∑ DDT dw	∑ DDT fww
09-RHAU-20	Rhinoceros Auklet	2009	6/11/2009	64.59	69.65	1.68	0.48	0.07	0.02	2.73	0.79
09-RHAU-21	Rhinoceros Auklet	2009	6/26/2009	74.1	81.83	1.73	0.47	0.10	0.03	2.14	0.58
09-RHAU-22	Rhinoceros Auklet	2009	6/26/2009	59.1	73.69	2.64	0.44	0.12	0.02	4.33	0.72
09-RHAU-23	Rhinoceros Auklet	2009	6/26/2009	58.1	65.51	1.01	0.28	0.07	0.02	1.16	0.32
09-RHAU-24	Rhinoceros Auklet	2009	6/26/2009	59.7	71.82	1.90	0.49	0.09	0.02	1.95	0.51
09-RHAU-26	Rhinoceros Auklet	2009	7/21/2009	67.4	79.35	2.86	0.78	0.15	0.04	2.90	0.79
09-RHAU-27	Rhinoceros Auklet	2009	7/21/2009	48.9	59.75	1.15	0.23	*0.08*	*0.02*	1.52	0.30
09-RHAU-28	Rhinoceros Auklet	2009	7/21/2009	41	51.86	1.99	0.45	0.11	0.02	2.14	0.49
09-RHAU-29	Rhinoceros Auklet	2009	7/21/2009	55.5	66.11	1.65	0.47	0.09	0.03	1.95	0.55
09-RHAU-30	Rhinoceros Auklet	2009	7/20/2009	65.3	73.13	2.28	0.60	0.11	0.03	3.27	0.86
09-RHAU-31	Rhinoceros Auklet	2009	7/21/2009	50.6	58.34	1.14	0.30	0.08	0.02	1.89	0.50
09-RHAU-32	Rhinoceros Auklet	2009	7/21/2009	47.8	61.76	1.14	0.24	0.07	0.02	1.54	0.33
10-RHAU-06	Rhinoceros Auklet	2010	5/27/2010	67.93	77.81	0.98	0.30	*0.03*	*0.01*	0.62	0.19
10-RHAU-07	Rhinoceros Auklet	2010	5/27/2010	67.47	76.63	0.54	0.15	*0.03*	*0.01*	0.39	0.11
10-RHAU-08	Rhinoceros Auklet	2010	5/27/2010	64.38	71.02	1.08	0.30	*0.04*	*0.01*	0.55	0.15
10-RHAU-09	Rhinoceros Auklet	2010	5/27/2010	59.53	66.88	1.30	0.36	0.05	0.01	0.96	0.27
10-RHAU-10	Rhinoceros Auklet	2010	5/27/2010	72.79	77.94	0.77	0.21	*0.04*	*0.01*	0.63	0.18
10-RHAU-20	Rhinoceros Auklet	2010	6/18/2010	56.84	75.70	1.70	0.37	0.07	0.01	1.03	0.24
10-RHAU-28	Rhinoceros Auklet	2010	7/19/2010	58.53	59.79	1.39	0.41	0.06	0.02	0.81	0.24
10-RHAU-29	Rhinoceros Auklet	2010	7/19/2010	49.64	68.47	1.86	0.41	*0.04*	*0.01*	1.26	0.28
10-RHAU-30	Rhinoceros Auklet	2010	8/3/2010	51.63	58.98	1.49	0.35	0.06	0.01	0.93	0.22
11-RHAU-03	Rhinoceros Auklet	2011	6/8/2011	60.45	63.20	1.05	0.32	0.09	0.03	0.75	0.23
11-RHAU-04	Rhinoceros Auklet	2011	6/8/2011	60.01	59.33	0.68	0.18	0.19	0.05	0.77	0.21
11-RHAU-05	Rhinoceros Auklet	2011	6/8/2011	63.87	70.34	0.43	0.13	*0.07*	*0.02*	0.29	0.09
11-RHAU-06	Rhinoceros Auklet	2011	6/8/2011	53.55	65.97	0.62	0.17	*0.07*	*0.02*	0.50	0.14
11-RHAU-07	Rhinoceros Auklet	2011	7/19/2011	47.96	71.54	0.60	0.13	*0.08*	*0.02*	0.74	0.16
11-RHAU-08	Rhinoceros Auklet	2011	7/19/2011	57.97	65.57	0.60	0.15	*0.09*	*0.02*	0.44	0.11
11-RHAU-09	Rhinoceros Auklet	2011	7/19/2011	46.2	59.46	1.05	0.27	*0.06*	*0.02*	0.76	0.19
11-RHAU-10	Rhinoceros Auklet	2011	7/19/2011	57.6	63.93	0.50	0.14	0.16	0.04	0.68	0.18
11-RHAU-11	Rhinoceros Auklet	2011	7/19/2011	60.81	77.67	0.66	0.15	*0.08*	*0.02*	0.51	0.11

Metals scan data for Cassin's auklet eggs collected from Southeast Farallon Island from 2009 – 2011. Results are presented in micrograms/gram (µg/g). Non-detects are in italics and the result entered indicates the detection limit. Fresh wet weight concentrations were not calculated for non-detect results.

Sample ID	Species	Egg Content Weight (g)	Egg Content Fresh Weight (g)	Year	Collection Date	Al dw	Al fww	As dw	As fww	B dw	B fww	Ba dw	Ba fww	Be dw	Be fww	Cd dw	Cd fww	Cr dw	Cr fww	Cu dw	Cu fww	Fe dw	Fe fww
09-CAAU-02	Cassin's auklet	22.82	24.95	2009	6/1/2009	*0.48*		0.41	0.11	0.59	0.15	*0.10*		*0.05*		*0.01*		*0.48*		3.16	0.82	175.00	45.46
09-CAAU-11	Cassin's auklet	19.52	23.95	2009	6/26/2009	0.75	0.20	0.56	0.15	1.57	0.43	*0.10*		*0.05*		0.01	0.00	*0.50*		4.33	1.17	162.00	43.93
09-CAAU-12	Cassin's auklet	22.87	30.97	2009	6/26/2009	*0.50*		0.60	0.13	0.97	0.21	*0.10*		*0.05*		*0.01*		*0.50*		4.56	0.97	136.00	29.09
09-CAAU-13	Cassin's auklet	21.68	25.77	2009	6/26/2009	*0.55*		0.46	0.11	0.96	0.22	*0.11*		*0.06*		*0.01*		*0.55*		3.63	0.84	148.00	34.15
09-CAAU-15	Cassin's auklet	19.77	23.69	2009	6/26/2009	*0.51*		0.63	0.17	1.21	0.32	*0.10*		*0.05*		*0.01*		*0.51*		4.16	1.11	119.00	31.80
09-CAAU-16	Cassin's auklet	25.33	27.79	2009	6/26/2009	*0.52*		0.57	0.15	1.03	0.28	*0.10*		*0.05*		0.02	0.01	*0.52*		3.13	0.84	185.00	49.40
09-CAAU-17	Cassin's auklet	20.65	22.10	2009	6/26/2009	*0.48*		0.45	0.12	0.52	0.14	*0.10*		*0.05*		*0.01*		*0.48*		3.57	0.99	201.00	55.79
09-CAAU-18	Cassin's auklet	24.19	24.68	2009	6/26/2009	*0.46*		0.41	0.11	*0.46*		*0.09*		*0.05*		*0.01*		*0.46*		3.28	0.87	123.00	32.84
09-CAAU-42	Cassin's auklet	24.2	24.57	2009	8/16/2009	*0.50*		0.29	0.08	*0.50*		*0.10*		*0.05*		*0.01*		*0.50*		2.80	0.76	149.00	40.38
09-CAAU-43	Cassin's auklet	15.1	18.19	2009	8/16/2009	*0.49*		0.44	0.09	0.84	0.18	0.27	0.06	*0.05*		*0.01*		*0.49*		4.31	0.92	202.00	43.09
09-CAAU-44	Cassin's auklet	18.7	23.23	2009	8/11/2009	*0.48*		0.61	0.14	0.70	0.16	*0.10*		*0.05*		*0.01*		*0.48*		4.08	0.95	191.00	44.59
09-CAAU-46	Cassin's auklet	21.2	25.09	2009	8/11/2009	*0.51*		0.50	0.12	*0.51*		0.22	0.05	*0.05*		*0.01*		*0.51*		5.39	1.32	153.00	37.35
10-CAAU-11	Cassin's auklet	22.27	27.54	2010	5/24/2010	2.41	0.48	0.51	0.10	1.29	0.26	0.27	0.05	*0.05*		*0.02*		0.25	0.05	6.31	1.26	153.00	30.65
10-CAAU-12	Cassin's auklet	26.11	26.02	2010	5/24/2010	1.06	0.30	0.75	0.21	*0.99*		0.06	0.02	*0.05*		*0.02*		*0.20*		3.27	0.91	188.00	52.47
10-CAAU-13	Cassin's auklet	22.87	24.21	2010	5/24/2010	0.99	0.26	0.40	0.10	1.39	0.36	0.09	0.02	*0.05*		*0.02*		0.28	0.07	3.90	1.01	164.00	42.41
10-CAAU-14	Cassin's auklet	26.1	28.38	2010	5/24/2010	1.06	0.28	0.47	0.13	1.79	0.48	0.10	0.03	*0.05*		*0.02*		*0.20*		3.19	0.85	157.00	41.76
10-CAAU-15	Cassin's auklet	19.89	21.06	2010	5/24/2010	1.49	0.42	0.98	0.28	*1.00*		0.17	0.05	*0.05*		*0.02*		0.30	0.08	3.86	1.10	141.00	39.95
10-CAAU-17	Cassin's auklet	22.13	26.08	2010	6/7/2010	2.33	0.50	0.53	0.11	1.49	0.32	0.37	0.08	*0.05*		*0.02*		0.43	0.09	4.52	0.97	175.00	37.59
10-CAAU-18	Cassin's auklet	19.45	22.85	2010	6/18/2010	1.66	0.39	0.58	0.13	1.64	0.38	0.09	0.02	*0.05*		*0.02*		0.22	0.05	3.67	0.85	158.00	36.69
10-CAAU-21	Cassin's auklet	21.36	26.20	2010	5/27/2010	1.44	0.30	0.59	0.12	1.12	0.23	0.19	0.04	*0.05*		*0.02*		0.37	0.08	4.16	0.86	192.00	39.62
10-CAAU-31	Cassin's auklet	21.01	26.83	2010	7/28/2010	*0.98*		0.37	0.10	1.23	0.33	0.06	0.02	*0.05*		*0.02*		*0.20*		3.92	1.04	124.00	33.05
10-CAAU-33	Cassin's auklet	18.04	ND	2010	7/28/2010	1.53	0.37	0.25	0.06	1.10	0.27	0.15	0.04	*0.05*		*0.02*		*0.19*		3.98	0.98	118.00	28.91
11-CAAU-20	Cassin's auklet	24.71	29.93	2011	7/19/2011	*0.50*		0.37	0.07	*0.50*		0.30	0.06	*0.05*		*0.01*		0.11	0.02	4.80	0.94	219.00	43.02
11-CAAU-21	Cassin's auklet	21.68	26.13	2011	7/19/2011	*0.47*		0.40	0.10	*0.47*		0.13	0.03	*0.05*		*0.01*		0.11	0.03	3.26	0.80	173.00	42.48
11-CAAU-26	Cassin's auklet	17.61	25.16	2011	6/7/2011	*0.50*		0.56	0.12	*0.50*		0.10	0.02	*0.05*		*0.01*		0.06	0.01	3.66	0.82	155.00	34.58
11-CAAU-27	Cassin's auklet	15.39	23.55	2011	6/8/2011	*0.49*		0.76	0.16	*0.49*		0.21	0.04	*0.05*		*0.01*		0.07	0.02	3.99	0.84	170.00	35.68
11-CAAU-30	Cassin's auklet	19.13	23.28	2011	6/8/2011	*0.50*		0.58	0.14	*0.50*		0.04	0.01	*0.05*		*0.01*		0.12	0.03	3.22	0.78	123.00	29.91
11-CAAU-33	Cassin's auklet	26.67	27.37	2011	6/8/2011	*0.49*		0.43	0.11	*0.49*		0.10	0.03	*0.05*		*0.01*		0.08	0.02	3.63	0.94	140.00	36.16
11-CAAU-35	Cassin's auklet	21.25	24.26	2011	5/13/2011	*0.50*		0.64	0.16	*0.50*		0.02	0.01	*0.05*		*0.01*		0.06	0.02	4.10	1.02	118.00	29.26
11-CAAU-37	Cassin's auklet	20.8	24.81	2011	5/13/2011	*0.47*		0.53	0.14	*0.47*		0.04	0.01	*0.05*		*0.01*		*0.05*		3.17	0.82	183.00	47.53
11-CAAU-40	Cassin's auklet	21.7	27.54	2011	5/11/2011	*0.50*		0.68	0.16	*0.50*		0.08	0.02	*0.05*		*0.01*		*0.05*		3.93	0.92	176.00	41.21
11-CAAU-42	Cassin's auklet	22.58	25.62	2011	7/19/2011	*0.49*		0.47	0.10	*0.49*		0.34	0.07	*0.05*		*0.01*		0.18	0.04	3.94	0.82	193.00	40.10

CONTINUED: Metals scan data for Cassin's auklet eggs collected from Southeast Farallon Island from 2009 – 2011. Results are presented in micrograms/gram (µg/g). Non-detects are in italics and the result entered indicates the detection limit. Fresh wet weight concentrations were not calculated for non-detect results.

Sample ID	Species	Egg Content Weight (g)	Egg Content Fresh Weight (g)	Year	Collection Date	**Hg dw**	**Hg fww**	**Mg dw**	**Mg fww**	**Mn dw**	**Mn fww**	**Mo dw**	**Mo fww**	**Ni dw**	**Ni fww**	**Pb dw**	**Pb fww**	**Se dw**	**Se fww**	**Sr dw**	**Sr fww**	**V dw**	**V fww**	**Zn dw**	**Zn fww**
09-CAAU-02	Cassin's auklet	22.82	24.95	2009	6/1/2009	0.58	0.15	368	96.05	0.81	0.21	*0.96*		0.58	0.15	*0.04*		2.50	0.65	3.29	0.85	*0.48*		59.60	15.46
09-CAAU-11	Cassin's auklet	19.52	23.95	2009	6/26/2009	0.34	0.09	344	93.73	0.96	0.26	*1.00*		*0.50*		*0.05*		2.64	0.72	2.73	0.74	*0.50*		60.90	16.55
09-CAAU-12	Cassin's auklet	22.87	30.97	2009	6/26/2009	0.50	0.11	445	95.26	0.52	0.11	*1.01*		*0.50*		*0.05*		2.79	0.60	2.68	0.57	*0.50*		57.90	12.41
09-CAAU-13	Cassin's auklet	21.68	25.77	2009	6/26/2009	0.82	0.19	443	101.79	0.34	0.08	*1.10*		*0.55*		*0.05*		3.12	0.72	3.42	0.79	*0.55*		55.00	12.70
09-CAAU-15	Cassin's auklet	19.77	23.69	2009	6/26/2009	0.49	0.13	437	116.85	0.56	0.15	*1.03*		*0.51*		*0.05*		2.66	0.71	3.39	0.90	*0.51*		57.90	15.44
09-CAAU-16	Cassin's auklet	25.33	27.79	2009	6/26/2009	0.45	0.12	384	102.99	0.73	0.19	*1.04*		*0.52*		*0.05*		2.56	0.68	3.32	0.89	*0.52*		65.90	17.59
09-CAAU-17	Cassin's auklet	20.65	22.10	2009	6/26/2009	0.38	0.11	327	90.75	0.81	0.22	*0.97*		*0.48*		*0.05*		2.12	0.59	3.97	1.10	*0.48*		60.00	16.64
09-CAAU-18	Cassin's auklet	24.19	24.68	2009	6/26/2009	0.46	0.12	374	99.99	1.40	0.37	*0.91*		*0.46*		*0.04*		2.29	0.61	2.71	0.72	*0.46*		50.30	13.43
09-CAAU-42	Cassin's auklet	24.2	24.57	2009	8/16/2009	0.46	0.12	354	95.92	0.53	0.14	*0.99*		*0.50*		*0.05*		2.13	0.58	2.77	0.75	*0.50*		62.30	16.84
09-CAAU-43	Cassin's auklet	15.1	18.19	2009	8/16/2009	0.61	0.13	575	122.88	1.30	0.28	*0.97*		*0.49*		0.06	0.01	2.78	0.59	9.96	2.13	*0.49*		63.20	13.45
09-CAAU-44	Cassin's auklet	18.7	23.23	2009	8/11/2009	0.81	0.19	627	146.48	1.22	0.28	*0.96*		*0.48*		*0.04*		2.93	0.68	5.20	1.22	*0.48*		60.30	14.08
09-CAAU-46	Cassin's auklet	21.2	25.09	2009	8/11/2009	0.68	0.17	261	63.71	1.07	0.26	*1.01*		0.63	0.15	*0.05*		2.36	0.58	4.99	1.22	*0.51*		55.10	13.44
10-CAAU-11	Cassin's auklet	22.27	27.54	2010	5/24/2010	0.29	0.06	649	130.18	2.41	0.48	0.14	0.03	0.60	0.12	0.08	0.02	2.30	0.46	7.02	1.41	*0.49*		65.40	13.10
10-CAAU-12	Cassin's auklet	26.11	26.02	2010	5/24/2010	0.54	0.15	335	93.40	1.12	0.31	0.14	0.04	*0.10*		*0.02*		1.86	0.52	3.27	0.91	*0.49*		50.10	13.95
10-CAAU-13	Cassin's auklet	22.87	24.21	2010	5/24/2010	0.40	0.10	378	98.23	1.22	0.32	0.12	0.03	*0.10*		*0.02*		2.17	0.56	2.60	0.67	*0.49*		42.10	10.86
10-CAAU-14	Cassin's auklet	26.1	28.38	2010	5/24/2010	0.35	0.09	429	114.05	1.53	0.41	0.14	0.04	0.19	0.05	*0.02*		1.52	0.40	3.53	0.94	*0.49*		52.30	13.89
10-CAAU-15	Cassin's auklet	19.89	21.06	2010	5/24/2010	0.22	0.06	291	82.44	1.79	0.51	0.10	0.03	*0.10*		0.03	0.01	1.66	0.47	4.35	1.23	*0.50*		61.20	17.38
10-CAAU-17	Cassin's auklet	22.13	26.08	2010	6/7/2010	0.38	0.08	612	131.52	1.41	0.30	0.16	0.03	0.14	0.03	0.16	0.03	2.56	0.55	7.28	1.56	*0.48*		72.50	15.53
10-CAAU-18	Cassin's auklet	19.45	22.85	2010	6/18/2010	0.36	0.08	418	97.05	1.54	0.36	0.14	0.03	*0.10*		*0.02*		2.38	0.55	4.44	1.03	*0.51*		61.10	14.22
10-CAAU-21	Cassin's auklet	21.36	26.20	2010	5/27/2010	0.37	0.08	668	137.77	1.78	0.37	0.19	0.04	0.11	0.02	*0.02*		2.42	0.50	10.60	2.18	*0.49*		68.90	14.18
10-CAAU-31	Cassin's auklet	21.01	26.83	2010	7/28/2010	0.32	0.09	403	107.29	0.62	0.16	0.23	0.06	*0.10*		*0.02*		1.74	0.46	2.96	0.79	*0.49*		45.60	12.14
10-CAAU-33	Cassin's auklet	18.04	ND	2010	7/28/2010	0.34	0.08	317	77.67	0.90	0.22	0.20	0.05	*0.10*		0.05	0.01	1.77	0.43	3.69	0.90	*0.49*		58.40	14.31
11-CAAU-20	Cassin's auklet	24.71	29.93	2011	7/19/2011	0.65	0.13	674	132.11	1.32	0.26	0.16	0.03	0.14	0.03	0.06	0.01	2.29	0.45	8.60	1.69	*0.50*		76.90	15.11
11-CAAU-21	Cassin's auklet	21.68	26.13	2011	7/19/2011	0.42	0.10	524	128.61	0.95	0.23	*0.09*		0.08	0.02	*0.05*		2.21	0.54	8.27	2.03	*0.47*		59.50	14.60
11-CAAU-26	Cassin's auklet	17.61	25.16	2011	6/7/2011	0.37	0.08	435	97.30	1.55	0.35	*0.10*		0.13	0.03	*0.05*		2.16	0.48	6.11	1.37	*0.50*		51.40	11.48
11-CAAU-27	Cassin's auklet	15.39	23.55	2011	6/8/2011	0.27	0.06	596	124.81	1.96	0.41	*0.10*		0.13	0.03	*0.05*		2.20	0.46	9.43	1.98	*0.49*		71.50	15.03
11-CAAU-30	Cassin's auklet	19.13	23.28	2011	6/8/2011	0.29	0.07	452	110.10	1.02	0.25	*0.10*		0.07	0.02	*0.05*		2.00	0.49	5.01	1.22	*0.50*		41.00	9.94
11-CAAU-33	Cassin's auklet	26.67	27.37	2011	6/8/2011	0.41	0.10	371	95.80	0.83	0.21	*0.10*		*0.05*		*0.05*		2.02	0.52	3.63	0.94	*0.49*		61.20	15.79
11-CAAU-35	Cassin's auklet	21.25	24.26	2011	5/13/2011	0.28	0.07	356	88.48	0.68	0.17	*0.10*		*0.05*		*0.05*		1.75	0.43	2.17	0.54	*0.50*		47.50	11.74
11-CAAU-37	Cassin's auklet	20.8	24.81	2011	5/13/2011	0.31	0.08	417	108.13	0.78	0.20	0.10	0.03	0.07	0.02	*0.05*		1.97	0.51	5.55	1.44	*0.47*		64.20	16.68
11-CAAU-40	Cassin's auklet	21.7	27.54	2011	5/11/2011	0.25	0.06	296	69.27	1.30	0.30	*0.10*		0.11	0.02	*0.05*		1.99	0.47	5.09	1.19	*0.50*		59.30	13.87
11-CAAU-42	Cassin's auklet	22.58	25.62	2011	7/19/2011	0.37	0.08	705	146.32	2.00	0.42	*0.10*		0.13	0.03	*0.05*		2.35	0.49	6.66	1.38	*0.49*		71.80	14.90

Metals scan data for pigeon guillemot eggs collected from Southeast Farallon Island from 2009 – 2011. Results are presented in micrograms/gram (µg/g). Non-detects are in italics and the result entered indicates the detection limit. Fresh wet weight concentrations were not calculated for non-detect results.

Sample ID	Species	Egg Content Weight (g)	Egg Content Fresh Weight (g)	Year	Collection Date	**Al dw**	**Al fww**	**As dw**	**As fww**	**B dw**	**B fww**	**Ba dw**	**Ba fww**	**Be dw**	**Be fww**	**Cd dw**	**Cd fww**	**Cr dw**	**Cr fww**	**Cu dw**	**Cu fww**	**Fe dw**	**Fe fww**
09-PIGU-33	pigeon gullimot	38.2	45.45	2009	7/1/2009	*0.47*		0.79	0.15	*0.47*		0.12	0.02	*0.05*		*0.01*		*0.47*		4.53	0.86	188.00	35.56
09-PIGU-34	pigeon gullimot	31.5	44.10	2009	7/21/2009	*0.42*		0.76	0.19	*0.42*		*0.09*		*0.04*		*0.01*		*0.42*		3.46	0.88	139.00	35.35
09-PIGU-35	pigeon gullimot	42.8	48.50	2009	7/21/2009	*0.46*		0.30	0.07	*0.46*		*0.09*		*0.05*		*0.01*		*0.46*		3.63	0.85	165.00	38.48
09-PIGU-37	pigeon gullimot	31.6	40.78	2009	7/1/2009	*0.50*		0.56	0.10	*0.50*		0.19	0.04	*0.05*		*0.01*		*0.50*		4.31	0.81	174.00	32.47
09-PIGU-38	pigeon gullimot	40.9	45.83	2009	8/11/2009	*0.47*		0.23	0.05	*0.47*		*0.09*		*0.05*		*0.01*		*0.47*		3.29	0.77	152.00	35.43
09-PIGU-39	pigeon gullimot	40.1	47.32	2009	8/11/2009	*0.50*		0.29	0.06	*0.50*		*0.10*		*0.05*		*0.01*		*0.50*		3.44	0.70	141.00	28.81
09-PIGU-40	pigeon gullimot	44.6	46.49	2009	8/11/2009	*0.46*		0.29	0.08	*0.46*		*0.09*		*0.05*		*0.01*		*0.46*		2.97	0.81	151.00	41.25
09-PIGU-41	pigeon gullimot	47	48.97	2009	8/11/2009	*0.49*		0.29	0.07	*0.49*		*0.10*		*0.05*		*0.01*		*0.49*		3.30	0.80	137.00	33.11
10-PIGU-01	pigeon gullimot	44.19	45.32	2010	5/27/2010	1.20	0.29	0.33	0.08	1.15	0.28	0.40	0.10	*0.05*		*0.02*		*0.20*		4.03	0.98	140.00	34.12
10-PIGU-02	pigeon gullimot	49.32	50.63	2010	5/27/2010	1.20	0.28	0.40	0.09	1.00	0.23	0.12	0.03	*0.05*		*0.02*		*0.19*		7.02	1.66	96.20	22.70
10-PIGU-03	pigeon gullimot	47.13	47.77	2010	5/27/2010	1.38	0.33	0.40	0.09	1.22	0.29	0.52	0.12	*0.05*		*0.02*		*0.19*		8.69	2.05	136.00	32.06
10-PIGU-04	pigeon gullimot	49.9	49.49	2010	5/27/2010	1.38	0.37	0.33	0.09	*0.95*		0.16	0.04	*0.05*		*0.02*		*0.19*		3.54	0.93	97.30	25.71
10-PIGU-05	pigeon gullimot	43.49	49.40	2010	5/27/2010	2.15	0.52	0.31	0.08	1.24	0.30	0.39	0.09	*0.05*		*0.02*		*0.20*		4.32	1.04	166.00	39.88
10-PIGU-25	pigeon gullimot	41.36	50.83	2010	7/19/2010	*0.96*		0.30	0.07	0.98	0.21	0.14	0.03	*0.05*		*0.02*		*0.19*		3.29	0.71	73.20	15.78
10-PIGU-26	pigeon gullimot	30.97	48.41	2010	7/19/2010	*0.97*		0.28	0.06	*0.97*		0.40	0.09	*0.05*		*0.02*		*0.20*		3.68	0.77	146.00	30.84
10-PIGU-27	pigeon gullimot	40.12	43.73	2010	7/19/2010	*0.97*		0.18	0.04	*0.97*		1.44	0.35	*0.05*		*0.02*		*0.19*		3.04	0.75	146.00	35.87
11-PIGU-12	pigeon gullimot	41.99	53.56	2011	7/24/2011	*0.49*		0.22	0.05	*0.49*		0.15	0.03	*0.05*		*0.01*		*0.05*		3.49	0.75	146.00	31.51
11-PIGU-13	pigeon gullimot	42.66	51.49	2011	7/19/2011	*0.48*		0.23	0.06	*0.48*		0.20	0.05	*0.05*		*0.01*		0.09	0.02	3.39	0.82	205.00	49.80
11-PIGU-14	pigeon gullimot	38.37	47.87	2011	7/19/2011	*0.48*		0.30	0.07	*0.48*		0.18	0.04	*0.05*		*0.01*		0.06	0.02	3.17	0.76	123.00	29.66
11-PIGU-15	pigeon gullimot	44.67	54.76	2011	7/19/2011	*0.49*		0.25	0.05	*0.49*		0.82	0.17	*0.05*		*0.01*		0.19	0.04	3.81	0.81	171.00	36.14
11-PIGU-16	pigeon gullimot	40.54	49.20	2011	7/19/2011	*0.48*		0.21	0.05	*0.48*		0.69	0.15	*0.05*		*0.01*		0.18	0.04	3.48	0.76	141.00	30.90
11-PIGU-17	pigeon gullimot	51.06	56.36	2011	7/31/2011	*0.49*		0.36	0.09	*0.49*		0.08	0.02	*0.05*		*0.01*		0.06	0.01	3.61	0.87	125.00	29.99
11-PIGU-18	pigeon gullimot	39.78	44.21	2011	7/31/2011	*0.50*		0.25	0.06	*0.50*		0.10	0.03	*0.05*		*0.01*		0.39	0.10	3.32	0.81	152.00	37.16
11-PIGU-19	pigeon gullimot	34.01	48.35	2011	7/31/2011	*0.48*		0.21	0.05	*0.48*		0.13	0.03	*0.05*		*0.01*		0.09	0.02	3.31	0.73	137.00	30.18

CONTINUED: Metals scan data for pigeon guillemot eggs collected from Southeast Farallon Island from 2009 – 2011. Results are presented in micrograms/gram (µg/g). Non-detects are in italics and the result entered indicates the detection limit. Fresh wet weight concentrations were not calculated for non-detect results.

Sample ID	Species	Egg Content Weight (g)	Egg Content Fresh Weight (g)	Year	Collection Date	**Hg dw**	**Hg fww**	**Mg dw**	**Mg fww**	**Mn dw**	**Mn fww**	**Mo dw**	**Mo fww**	**Ni dw**	**Ni fww**	**Pb dw**	**Pb fww**	**Se dw**	**Se fww**	**Sr dw**	**Sr fww**	**V dw**	**V fww**	**Zn dw**	**Zn fww**
09-PIGU-33	pigeon gullimot	38.2	45.45	2009	7/1/2009	7.23	1.37	776	147.10	1.99	0.38	*0.94*		*0.47*		*0.04*		3.30	0.62	37.20	7.04	*0.47*		68.50	12.94
09-PIGU-34	pigeon gullimot	31.5	44.10	2009	7/21/2009	4.30	1.09	421	107.13	1.66	0.42	*0.85*		*0.42*		*0.04*		2.54	0.65	13.10	3.33	*0.42*		59.80	15.21
09-PIGU-35	pigeon gullimot	42.8	48.50	2009	7/21/2009	3.11	0.72	491	114.73	1.68	0.39	*0.91*		*0.46*		*0.04*		2.26	0.53	7.91	1.84	*0.46*		50.20	11.74
09-PIGU-37	pigeon gullimot	31.6	40.78	2009	7/1/2009	3.50	0.65	766	143.34	2.19	0.41	*1.01*		*0.50*		*0.05*		3.72	0.70	40.60	7.58	*0.50*		84.00	15.65
09-PIGU-38	pigeon gullimot	40.9	45.83	2009	8/11/2009	2.79	0.65	399	92.80	1.29	0.30	*0.94*		*0.47*		*0.04*		2.14	0.50	8.15	1.90	*0.47*		60.00	14.01
09-PIGU-39	pigeon gullimot	40.1	47.32	2009	8/11/2009	3.68	0.75	550	112.70	1.24	0.25	*0.99*		*0.50*		*0.05*		2.40	0.49	10.70	2.19	*0.50*		54.50	11.10
09-PIGU-40	pigeon gullimot	44.6	46.49	2009	8/11/2009	2.38	0.65	446	121.84	1.84	0.50	*0.92*		*0.46*		*0.04*		1.92	0.52	7.85	2.15	*0.46*		61.70	16.88
09-PIGU-41	pigeon gullimot	47	48.97	2009	8/11/2009	5.31	1.29	457	110.37	1.43	0.35	*0.99*		*0.49*		*0.05*		2.42	0.59	6.41	1.55	*0.49*		53.30	12.86
10-PIGU-01	pigeon gullimot	44.19	45.32	2010	5/27/2010	1.79	0.44	438	107.25	1.77	0.43	0.17	0.04	0.71	0.17	*0.02*		1.80	0.44	8.05	1.96	*0.50*		57.50	14.04
10-PIGU-02	pigeon gullimot	49.32	50.63	2010	5/27/2010	4.65	1.10	470	111.05	1.95	0.46	0.13	0.03	0.36	0.08	0.22	0.05	2.50	0.59	7.04	1.66	*0.47*		48.30	11.40
10-PIGU-03	pigeon gullimot	47.13	47.77	2010	5/27/2010	1.60	0.38	476	112.46	2.11	0.50	0.17	0.04	2.02	0.48	0.16	0.04	1.88	0.44	8.66	2.04	*0.47*		56.70	13.42
10-PIGU-04	pigeon gullimot	49.9	49.49	2010	5/27/2010	2.86	0.76	423	111.92	2.82	0.75	0.17	0.04	1.75	0.46	*0.02*		2.30	0.61	7.76	2.05	*0.47*		57.70	15.23
10-PIGU-05	pigeon gullimot	43.49	49.40	2010	5/27/2010	2.64	0.63	454	109.16	3.32	0.80	0.14	0.03	0.22	0.05	0.02	0.00	2.37	0.57	11.00	2.64	*0.49*		66.80	16.02
10-PIGU-25	pigeon gullimot	41.36	50.83	2010	7/19/2010	6.95	1.50	480	103.33	0.99	0.21	0.12	0.03	*0.10*		*0.02*		2.15	0.46	26.40	5.70	*0.48*		42.50	9.19
10-PIGU-26	pigeon gullimot	30.97	48.41	2010	7/19/2010	2.06	0.44	469	99.17	1.68	0.35	0.12	0.03	0.12	0.03	*0.02*		2.12	0.45	12.20	2.58	*0.49*		60.30	12.73
10-PIGU-27	pigeon gullimot	40.12	43.73	2010	7/19/2010	2.40	0.59	352	86.51	1.52	0.37	0.15	0.04	*0.10*		*0.02*		1.91	0.47	10.10	2.49	*0.49*		55.20	13.58
11-PIGU-12	pigeon gullimot	41.99	53.56	2011	7/24/2011	3.33	0.72	554	119.16	0.71	0.15	*0.10*		0.06	0.01	*0.05*		2.36	0.51	9.91	2.14	*0.49*		48.20	10.43
11-PIGU-13	pigeon gullimot	42.66	51.49	2011	7/19/2011	1.79	0.43	433	105.23	2.29	0.56	*0.10*		*0.05*		*0.05*		1.56	0.38	7.76	1.88	*0.48*		60.10	14.58
11-PIGU-14	pigeon gullimot	38.37	47.87	2011	7/19/2011	2.87	0.69	453	109.01	1.04	0.25	*0.10*		*0.05*		*0.05*		1.99	0.48	9.45	2.28	*0.48*		46.10	11.14
11-PIGU-15	pigeon gullimot	44.67	54.76	2011	7/19/2011	2.43	0.51	628	132.96	1.93	0.41	*0.10*		0.19	0.04	*0.05*		2.05	0.43	18.60	3.93	*0.49*		68.90	14.52
11-PIGU-16	pigeon gullimot	40.54	49.20	2011	7/19/2011	2.75	0.60	594	130.19	1.28	0.28	0.10	0.02	0.13	0.03	*0.05*		1.90	0.42	14.60	3.20	*0.48*		67.00	14.67
11-PIGU-17	pigeon gullimot	51.06	56.36	2011	7/31/2011	3.11	0.75	503	120.49	1.54	0.37	*0.10*		*0.05*		*0.05*		2.15	0.52	7.97	1.91	*0.49*		55.80	13.41
11-PIGU-18	pigeon gullimot	39.78	44.21	2011	7/31/2011	3.12	0.76	538	131.37	1.87	0.46	*0.10*		0.07	0.02	*0.05*		2.21	0.54	5.72	1.40	*0.50*		63.20	15.48
11-PIGU-19	pigeon gullimot	34.01	48.35	2011	7/31/2011	2.94	0.65	431	94.97	0.68	0.15	*0.10*		0.07	0.02	*0.05*		1.86	0.41	6.35	1.40	*0.48*		60.70	13.37

Metals scan data for rhinoceros auklet eggs collected from Southeast Farallon Island from 2009 – 2011. Results are presented in micrograms/gram (µg/g). Non-detects are in italics and the result entered indicates the detection limit. Fresh wet weight concentrations were not calculated for non-detect results.

Sample ID	Species	Egg Content Weight (g)	Egg Content Fresh Weight (g)	Year	Collection Date	Al dw	Al fww	As dw	As fww	B dw	B fww	Ba dw	Ba fww	Be dw	Be fww	Cd dw	Cd fww	Cr dw	Cr fww	Cu dw	Cu fww	Fe dw	Fe fww
09-RHAU-20	rhinoceros auklet	64.59	69.65	2009	6/11/2009	*0.53*		0.43	0.12	*0.53*		*0.11*		*0.05*		*0.01*		*0.53*		3.71	1.04	116.00	32.37
09-RHAU-21	rhinoceros auklet	74.1	81.83	2009	6/26/2009	*0.51*		0.51	0.14	*0.51*		*0.10*		*0.05*		*0.01*		*0.51*		4.66	1.24	86.80	23.00
09-RHAU-22	rhinoceros auklet	59.1	73.69	2009	6/26/2009	*0.51*		1.02	0.21	*0.51*		*0.10*		*0.05*		*0.01*		*0.51*		5.04	1.02	147.00	29.67
09-RHAU-23	rhinoceros auklet	58.1	65.51	2009	6/26/2009	*0.50*		0.54	0.14	*0.50*		0.53	0.13	*0.05*		*0.01*		*0.50*		4.64	1.18	105.00	26.60
09-RHAU-24	rhinoceros auklet	59.7	71.82	2009	6/26/2009	1.51	0.36	0.55	0.13	*0.49*		0.56	0.13	*0.05*		*0.01*		0.60	0.14	6.31	1.49	114.00	26.93
09-RHAU-26	rhinoceros auklet	67.4	79.35	2009	7/21/2009	*0.46*		0.47	0.13	*0.46*		*0.09*		*0.05*		*0.01*		*0.46*		4.00	1.09	69.70	18.94
09-RHAU-27	rhinoceros auklet	48.9	59.75	2009	7/21/2009	*0.47*		0.51	0.12	*0.47*		*0.10*		*0.05*		*0.01*		*0.47*		5.41	1.22	179.00	40.27
09-RHAU-28	rhinoceros auklet	41	51.86	2009	7/21/2009	*0.53*		0.35	0.08	*0.53*		*0.11*		*0.05*		*0.01*		*0.53*		4.74	1.15	77.80	18.97
09-RHAU-29	rhinoceros auklet	55.5	66.11	2009	7/21/2009	*0.45*		0.36	0.09	*0.45*		*0.09*		*0.04*		*0.01*		*0.45*		5.08	1.30	118.00	30.22
09-RHAU-30	rhinoceros auklet	65.3	73.13	2009	7/20/2009	*0.47*		0.40	0.10	*0.47*		*0.10*		*0.05*		*0.01*		*0.47*		4.51	1.13	117.00	29.29
09-RHAU-31	rhinoceros auklet	50.6	58.34	2009	7/21/2009	*0.48*		0.35	0.09	*0.48*		*0.10*		*0.05*		*0.01*		*0.48*		4.27	1.14	106.00	28.53
09-RHAU-32	rhinoceros auklet	47.8	61.76	2009	7/21/2009	*0.45*		0.60	0.12	*0.45*		0.29		*0.04*		0.02	0.01	*0.45*		5.77	1.20	168.00	34.98
10-RHAU-06	rhinoceros auklet	67.93	77.81	2010	5/27/2010	2.09	0.57	0.57	0.16	*0.99*		0.13	0.04	*0.05*		*0.02*		*0.20*		5.58	1.53	97.60	26.63
10-RHAU-07	rhinoceros auklet	67.47	76.63	2010	5/27/2010	1.53	0.42	0.43	0.12	*1.01*		0.09	0.02	*0.05*		*0.02*		*0.20*		8.74	2.38	103.00	28.00
10-RHAU-08	rhinoceros auklet	64.38	71.02	2010	5/27/2010	1.73	0.46	0.49	0.13	*0.98*		0.10	0.03	*0.05*		*0.02*		*0.20*		4.50	1.20	127.00	33.81
10-RHAU-09	rhinoceros auklet	59.53	66.88	2010	5/27/2010	1.19	0.31	0.44	0.11	*0.98*		0.06	0.02	*0.05*		*0.02*		*0.20*		5.67	1.45	115.00	29.46
10-RHAU-10	rhinoceros auklet	72.79	77.94	2010	5/27/2010	1.38	0.36	0.44	0.11	*0.99*		0.05		*0.05*		*0.02*		*0.20*		6.17	1.62	95.50	24.94
10-RHAU-20	rhinoceros auklet	56.84	75.70	2010	6/18/2010	1.46	0.30	0.61	0.13	*0.96*		0.19	0.04	*0.05*		*0.02*		*0.19*		5.97	1.24	128.00	26.66
10-RHAU-28	rhinoceros auklet	58.53	59.79	2010	7/19/2010	0.97	0.29	0.42	0.13	*0.96*		0.05		*0.05*		*0.02*		*0.19*		4.50	1.34	95.00	28.29
10-RHAU-29	rhinoceros auklet	49.64	68.47	2010	7/19/2010	0.98	0.23	0.66	0.16	1.08	0.26	0.08	0.02	*0.05*		*0.02*		*0.20*		5.61	1.33	90.30	21.39
10-RHAU-30	rhinoceros auklet	51.63	58.98	2010	8/3/2010	1.41	0.32	0.54	0.12	*0.97*		0.15	0.03	*0.05*		*0.02*		0.35	0.08	6.02	1.36	106.00	23.81
11-RHAU-03	rhinoceros auklet	60.45	63.20	2011	6/8/2011	*0.48*		0.59	0.18	*0.48*		0.01	0.00	*0.05*		*0.01*		0.10	0.03	4.20	1.25	113.00	33.76
11-RHAU-04	rhinoceros auklet	60.01	59.33	2011	6/8/2011	*0.49*		0.49	0.13	*0.49*		0.02	0.00	*0.05*		*0.01*		0.07	0.02	4.22	1.15	108.00	29.44
11-RHAU-05	rhinoceros auklet	63.87	70.34	2011	6/8/2011	*0.49*		0.54	0.14	*0.49*		0.02	0.00	*0.05*		*0.01*		0.14	0.04	3.75	1.01	110.00	29.60
11-RHAU-06	rhinoceros auklet	53.55	65.97	2011	6/8/2011	*0.48*		0.79	0.22	*0.48*		0.01	0.00	*0.05*		*0.01*		0.05	0.01	4.27	1.17	108.00	29.63
11-RHAU-07	rhinoceros auklet	47.96	71.54	2011	7/19/2011	*0.49*		0.36	0.07	*0.49*		0.03	0.01	*0.05*		*0.01*		*0.05*		5.13	1.07	86.40	17.97
11-RHAU-08	rhinoceros auklet	57.97	65.57	2011	7/19/2011	*0.48*		0.39	0.10	*0.48*		0.04	0.01	*0.05*		*0.01*		*0.05*		4.06	1.06	124.00	32.36
11-RHAU-09	rhinoceros auklet	46.2	59.46	2011	7/19/2011	*0.48*		0.46	0.12	*0.48*		0.02	0.01	*0.05*		*0.01*		0.07	0.02	4.53	1.17	79.40	20.59
11-RHAU-10	rhinoceros auklet	57.6	63.93	2011	7/19/2011	*0.48*		0.52	0.14	*0.48*		0.05	0.01	*0.05*		*0.01*		0.11	0.03	4.51	1.24	94.50	26.13
11-RHAU-11	rhinoceros auklet	60.81	77.67	2011	7/19/2011	*0.48*		0.64	0.14	*0.48*		0.19	0.04	*0.05*		*0.01*		0.24	0.05	7.11	1.53	106.00	22.86

CONTINUED: Metals scan data for rhinoceros auklet eggs collected from Southeast Farallon Island from 2009 – 2011. Results are presented in micrograms/gram (µg/g). Non-detects are in italics and the result entered indicates the detection limit. Fresh wet weight concentrations were not calculated for non-detect results.

Sample ID	Species	Egg Content Weight (g)	Egg Content Fresh Weight (g)	Year	Collection Date	**Hg dw**	**Hg fww**	**Mg dw**	**Mg fww**	**Mn dw**	**Mn fww**	**Mo dw**	**Mo fww**	**Ni dw**	**Ni fww**	**Pb dw**	**Pb fww**	**Se dw**	**Se fww**	**Sr dw**	**Sr fww**	**V dw**	**V fww**	**Zn dw**	**Zn fww**
09-RHAU-20	rhinoceros auklet	64.59	69.65	2009	6/11/2009	1.67	0.47	311	86.81	0.51	0.14	*1.06*		*0.53*		*0.05*		1.70	0.47	1.80	0.50	*0.53*		44.30	12.33
09-RHAU-21	rhinoceros auklet	74.1	81.83	2009	6/26/2009	3.08	0.82	462	122.25	0.85	0.23	*1.02*		*0.51*		0.19	0.05	2.37	0.63	3.06	0.81	*0.51*		49.80	13.22
09-RHAU-22	rhinoceros auklet	59.1	73.69	2009	6/26/2009	3.80	0.77	751	151.58	0.60	0.12	*1.01*		*0.51*		*0.05*		2.80	0.57	6.97	1.41	*0.51*		54.90	11.07
09-RHAU-23	rhinoceros auklet	58.1	65.51	2009	6/26/2009	2.13	0.54	593	150.76	0.70	0.18	*1.00*		*0.50*		*0.05*		2.00	0.51	4.03	1.02	*0.50*		53.80	13.66
09-RHAU-24	rhinoceros auklet	59.7	71.82	2009	6/26/2009	2.00	0.47	634	149.62	0.55	0.13	*0.98*		0.94	0.22	0.14	0.03	2.05	0.48	7.08	1.67	*0.49*		54.50	12.88
09-RHAU-26	rhinoceros auklet	67.4	79.35	2009	7/21/2009	2.44	0.66	455	124.01	0.30	0.08	*0.92*		*0.46*		*0.04*		1.93	0.52	1.89	0.51	*0.46*		43.30	11.81
09-RHAU-27	rhinoceros auklet	48.9	59.75	2009	7/21/2009	2.04	0.46	643	144.86	0.55	0.12	*0.95*		*0.47*		*0.04*		2.33	0.52	6.18	1.39	*0.47*		50.90	11.46
09-RHAU-28	rhinoceros auklet	41	51.86	2009	7/21/2009	2.31	0.56	464	113.05	*0.21*		*1.05*		*0.53*		*0.05*		1.78	0.43	2.27	0.55	*0.53*		41.60	10.12
09-RHAU-29	rhinoceros auklet	55.5	66.11	2009	7/21/2009	1.20	0.31	467	119.21	0.53	0.13	*0.89*		*0.45*		*0.04*		2.20	0.56	2.97	0.76	*0.45*		52.70	13.52
09-RHAU-30	rhinoceros auklet	65.3	73.13	2009	7/20/2009	2.15	0.54	477	119.65	0.78	0.19	*0.95*		*0.47*		*0.04*		1.94	0.48	3.39	0.85	*0.47*		48.10	12.05
09-RHAU-31	rhinoceros auklet	50.6	58.34	2009	7/21/2009	1.28	0.34	366	98.01	0.55	0.15	*0.95*		*0.48*		*0.04*		1.77	0.48	1.68	0.45	*0.48*		43.60	11.71
09-RHAU-32	rhinoceros auklet	47.8	61.76	2009	7/21/2009	2.27	0.47	750	156.34	0.75	0.16	*0.89*		0.53	0.11	*0.04*		2.14	0.45	7.97	1.66	*0.45*		65.90	13.70
10-RHAU-06	rhinoceros auklet	67.93	77.81	2010	5/27/2010	0.88	0.24	448	122.23	0.76	0.21	0.11	0.03	0.17	0.05	0.02	0.01	1.60	0.44	1.92	0.52	*0.50*		46.00	12.57
10-RHAU-07	rhinoceros auklet	67.47	76.63	2010	5/27/2010	1.21	0.33	398	108.30	1.17	0.32	0.13	0.03	1.29	0.35	0.11	0.03	1.80	0.49	5.30	1.44	*0.51*		44.70	12.15
10-RHAU-08	rhinoceros auklet	64.38	71.02	2010	5/27/2010	1.08	0.29	440	116.93	0.63	0.17	0.11	0.03	0.33	0.09	0.20	0.05	1.76	0.47	2.69	0.72	*0.49*		52.40	13.96
10-RHAU-09	rhinoceros auklet	59.53	66.88	2010	5/27/2010	1.53	0.39	399	102.35	0.78	0.20	0.13	0.03	0.17	0.04	*0.02*		2.03	0.52	3.75	0.96	*0.49*		47.10	12.10
10-RHAU-10	rhinoceros auklet	72.79	77.94	2010	5/27/2010	0.81	0.21	337	88.17	0.53	0.14	*0.10*		0.13	0.03	0.02	0.00	1.48	0.39	1.64	0.43	*0.50*		39.20	10.27
10-RHAU-20	rhinoceros auklet	56.84	75.70	2010	6/18/2010	1.52	0.32	668	138.91	1.04	0.22	0.12	0.03	0.45	0.09	0.15	0.03	2.03	0.42	11.80	2.46	*0.48*		55.60	11.56
10-RHAU-28	rhinoceros auklet	58.53	59.79	2010	7/19/2010	0.59	0.18	309	91.93	0.33	0.10	*0.10*		*0.10*		*0.02*		1.41	0.42	1.96	0.58	*0.48*		42.80	12.73
10-RHAU-29	rhinoceros auklet	49.64	68.47	2010	7/19/2010	1.13	0.27	383	90.63	1.07	0.25	0.11	0.03	0.13	0.03	*0.02*		1.84	0.44	4.48	1.06	*0.49*		48.30	11.46
10-RHAU-30	rhinoceros auklet	51.63	58.98	2010	8/3/2010	1.10	0.25	670	150.58	1.14	0.26	0.11	0.02	1.44	0.32	0.08	0.02	2.07	0.47	7.39	1.66	*0.49*		53.60	12.08
11-RHAU-03	rhinoceros auklet	60.45	63.20	2011	6/8/2011	1.13	0.34	396	118.60	0.54	0.16	*0.10*		0.07	0.02	*0.05*		1.78	0.53	2.88	0.86	*0.48*		41.00	12.24
11-RHAU-04	rhinoceros auklet	60.01	59.33	2011	6/8/2011	1.17	0.32	393	107.22	0.71	0.19	*0.10*		*0.05*		*0.05*		1.87	0.51	1.59	0.43	*0.49*		39.70	10.82
11-RHAU-05	rhinoceros auklet	63.87	70.34	2011	6/8/2011	0.72	0.19	482	129.86	0.80	0.22	*0.10*		0.06	0.02	*0.05*		2.01	0.54	4.11	1.11	*0.49*		46.50	12.53
11-RHAU-06	rhinoceros auklet	53.55	65.97	2011	6/8/2011	1.21	0.33	439	120.13	0.46	0.13	*0.10*		0.07	0.02	*0.05*		1.80	0.49	2.42	0.66	*0.48*		39.10	10.71
11-RHAU-07	rhinoceros auklet	47.96	71.54	2011	7/19/2011	0.71	0.15	425	88.49	0.36	0.07	0.12	0.03	0.06	0.01	*0.05*		1.79	0.37	3.00	0.62	*0.49*		46.90	9.72
11-RHAU-08	rhinoceros auklet	57.97	65.57	2011	7/19/2011	0.74	0.19	398	103.44	0.68	0.18	*0.10*		*0.05*		*0.05*		1.75	0.46	2.78	0.72	*0.48*		47.40	12.38
11-RHAU-09	rhinoceros auklet	46.2	59.46	2011	7/19/2011	0.78	0.20	357	92.46	0.52	0.14	*0.10*		*0.05*		*0.05*		1.89	0.49	2.19	0.57	*0.48*		45.30	11.73
11-RHAU-10	rhinoceros auklet	57.6	63.93	2011	7/19/2011	0.80	0.22	328	90.99	0.49	0.13	*0.10*		*0.05*		*0.05*		1.61	0.45	2.60	0.72	*0.48*		42.60	11.80
11-RHAU-11	rhinoceros auklet	60.81	77.67	2011	7/19/2011	1.09	0.23	753	162.06	1.18	0.25	*0.10*		0.53	0.11	0.06	0.01	2.30	0.49	7.23	1.56	*0.48*		54.50	11.74

Mercury, carbon and nitrogen stable isotope data for food web component samples collected from Southeast Farallon Island in 2011. Avian samples are whole egg, fish samples are individual whole body, and invertebrate samples are composites. Mercury results are presented in micrograms/gram (µg/g) on a dry weight basis. Stable isotope results are expressed using the δ notation in parts per thousand.

Sample ID	Species	δ13C (‰)	δ15N (‰)	Total Hg (µg/g dw)
11-CAAU-20	Cassin's Auklet	-20.9	11.5	0.653
11-CAAU-21	Cassin's Auklet	-22.7	11.7	0.416
11-CAAU-26	Cassin's Auklet	-21	13.8	0.368
11-CAAU-27	Cassin's Auklet	-21.6	13.6	0.272
11-CAAU-30	Cassin's Auklet	-22.5	11.8	0.286
11-CAAU-33	Cassin's Auklet	-21.7	12.2	0.405
11-CAAU-35	Cassin's Auklet	-21.4	12.3	0.284
11-CAAU-37	Cassin's Auklet	-21.7	13.4	0.314
11-CAAU-40	Cassin's Auklet	-22	12.5	0.246
11-CAAU-42	Cassin's Auklet	-20.5	11.5	0.373
11-DIET- 67	Chinook Salmon	-18.8	13.2	0.0592
11-DIET- 68	Chinook Salmon	-19.9	12.7	0.117
11-DIET- 69	Chinook Salmon	-22.1	11.9	0.131
11-DIET- 70	Chinook Salmon	-18.3	12.7	0.0626
11-DIET- 11	Euphausia pacifica	-18.4	9.9	0.0315
11-DIET- 12	Euphausia pacifica	-19.5	9	0.011
11-DIET- 13	Euphausia pacifica	-22	9.4	0.00481
11-DIET- 14	Euphausia pacifica	-21.3	10.1	0.00681
11-DIET- 15	Euphausia pacifica	-18.4	8.6	0.0111
11-DIET- 25	Greenling	-21.7	11.6	0.0362
11-DIET- 26	Greenling	-20.6	11.8	0.0404
11-DIET- 27	Greenling	-21.8	12.8	0.0369
11-DIET- 28	Greenling	-22.2	12.1	0.0355
11-DIET- 36	Lingcod	-20.3	11.6	0.0338
11-DIET- 37	Lingcod	-20.3	11.6	0.0338
11-DIET- 38	Lingcod	-20.2	11.6	0.0297
11-DIET- 39	Lingcod	-19.3	11.9	0.0087
11-DIET- 40	Lingcod	-19.9	11.4	0.026
11-DIET- 41	Lingcod	-18.5	11.8	0.0252
11-DIET- 42	Lingcod	-18.5	11.8	0.0226
11-DIET- 43	Lingcod	-18.8	11.6	0.0221
11-DIET- 44	Lingcod	-18.7	11.5	0.0251
11-DIET- 45	Lingcod	-19.1	11.6	0.0233
11-SEFI-69	Myctophid spp.	-22.2	13.3	0.246
11-SEFI-68	Myctophid spp.	-22.4	13.8	0.282
11-DIET- 46	Myctophid spp.	-20.2	12.3	0.109
11-SEFI-75	Myctophid spp.	-22.8	13.4	0.306
11-DIET- 47	Myctophid spp.	-20	14.6	0.409
11-DIET- 01	Northern Anchovy	-17.7	13.6	0.106
11-DIET- 02	Northern Anchovy	-18.6	13	0.079
11-DIET- 03	Northern Anchovy	-18	13.9	0.148
11-DIET- 04	Northern Anchovy	-18.1	12.6	0.112
11-DIET- 05	Northern Anchovy	-17.1	13.5	0.15
11-DIET- 06	Northern Anchovy	-18.3	13.6	0.107
11-DIET- 07	Northern Anchovy	-17.5	12.9	0.0964
11-DIET- 08	Northern Anchovy	-19.5	13.6	0.0441
11-DIET- 09	Northern Anchovy	-19.1	13.2	0.0983
11-DIET- 10	Northern Anchovy	-17.7	14.3	0.14

CONTINUED: Mercury, carbon and nitrogen stable isotope data for food web component samples collected from Southeast Farallon Island in 2011. Avian samples are whole egg, fish samples are individual whole body, and invertebrate samples are composites. Mercury results are presented in micrograms/gram (µg/g) on a dry weight basis. Stable isotope results are expressed using the δ notation in parts per thousand.

Sample ID	**Species**	**δ13C (‰)**	**δ15N (‰)**	**Total Hg (µg/g dw)**
11-DIET- 29	Pacific Herring	-19.6	12.4	0.0595
11-DIET- 30	Pacific Herring	-19.4	12.4	0.0531
11-DIET- 31	Pacific Herring	-20.2	12.4	0.0601
11-DIET- 32	Pacific Herring	-19.7	12	0.0679
11-DIET- 33	Pacific Herring	-19.3	12.4	0.0731
11-DIET- 34	Pacific Herring	-19.1	12.9	0.0664
11-DIET- 35	Pacific Herring	-19.2	12.8	0.0744
11-DIET- 71	Pacific Saury	-21.2	12.8	0.0524
11-DIET- 72	Pacific Saury	-21.7	13	0.0338
11-DIET- 73	Pacific Saury	-20.9	12.7	0.031
11-DIET- 74	Pacific Saury	-21.1	11.8	0.033
11-DIET- 75	Pacific Saury	-21.2	12.3	0.0367
11-DIET- 76	Pacific Saury	-21.4	11.8	0.0278
11-DIET- 77	Pacific Saury	-20.9	12.7	0.0323
11-DIET- 78	Pacific Saury	-21.1	13	0.0317
11-DIET- 79	Pacific Saury	-21.3	11.3	0.0287
11-DIET- 80	Pacific Saury	-20.8	13	0.0553
11-PIGU-12	Pigeon Guillemot	-22.2	15.2	3.33
11-PIGU-13	Pigeon Guillemot	-22	14.4	1.79
11-PIGU-14	Pigeon Guillemot	-21.8	15	2.87
11-PIGU-15	Pigeon Guillemot	-21.2	15.5	2.43
11-PIGU-16	Pigeon Guillemot	-21.2	15	2.75
11-PIGU-17	Pigeon Guillemot	-21.3	15.2	3.11
11-PIGU-18	Pigeon Guillemot	-21	15	3.12
11-PIGU-19	Pigeon Guillemot	-21.8	15	2.94
11-RHAU-03	Rhinoceros Auklet	-22.8	13.5	1.13
11-RHAU-04	Rhinoceros Auklet	-23	14.1	1.17
11-RHAU-05	Rhinoceros Auklet	-22.4	13.8	0.724
11-RHAU-06	Rhinoceros Auklet	-23.4	13.3	1.21
11-RHAU-07	Rhinoceros Auklet	-23.1	14	0.714
11-RHAU-08	Rhinoceros Auklet	-22	14.3	0.744
11-RHAU-09	Rhinoceros Auklet	-23	13.9	0.78
11-RHAU-10	Rhinoceros Auklet	-21.3	14.8	0.796
11-RHAU-11	Rhinoceros Auklet	-22.4	14	1.09
11-DIET- 48	Rockfish spp.	-22.3	12.8	0.0702
11-DIET- 49	Rockfish spp.	-21	13.2	0.0463
11-DIET- 50	Rockfish spp.	-20.9	12.7	0.0358
11-DIET- 51	Rockfish spp.	-21.7	12.8	0.0312
11-DIET- 52	Rockfish spp.	-21.9	13.5	0.0333
11-DIET- 53	Rockfish spp.	-22.8	14.2	0.036
11-DIET- 54	Rockfish spp.	-22.7	13.7	0.0241
11-DIET- 55	Rockfish spp.	-22.8	14.1	0.0254
11-DIET- 56	Rockfish spp.	-22.4	13.7	0.0296
11-DIET- 57	Rockfish spp.	-22.8	14.2	0.0267

CONTINUED: Mercury, carbon and nitrogen stable isotope data for food web component samples collected from Southeast Farallon Island in 2011. Avian samples are whole egg, fish samples are individual whole body, and invertebrate samples are composites. Mercury results are presented in micrograms/gram (µg/g) on a dry weight basis. Stable isotope results are expressed using the δ notation in parts per thousand.

Sample ID	Species	δ13C (‰)	δ15N (‰)	Total Hg (µg/g dw)
11-DIET- 58	Sablefish	-18.3	11.4	0.0412
11-DIET- 59	Sablefish	-17.8	11.3	0.0491
11-DIET- 60	Sablefish	-18.9	11.6	0.0489
11-DIET- 61	Sablefish	-18.6	10.8	0.049
11-DIET- 62	Sablefish	-19.6	11.7	0.0427
11-DIET- 63	Sablefish	-18.9	11.2	0.0494
11-DIET- 64	Sablefish	-18.9	11.4	0.0479
11-DIET- 65	Sablefish	-20.6	13.1	0.0596
11-DIET- 66	Sablefish	-21.7	12.8	0.0362
11-DIET- 81	Squid	-17.7	13.2	0.0651
11-DIET- 82	Squid	-17.5	13	0.0646
11-DIET- 83	Squid	-17.4	13.2	0.0692
11-DIET- 84	Squid	-17.4	12.9	0.0612
11-DIET- 85	Squid	-18	11.7	0.0578
11-DIET- 86	Squid	-18.4	12.4	0.0486
11-DIET- 87	Squid	-18.6	12.6	0.0575
11-DIET- 88	Squid	-18.5	12.7	0.0555
11-DIET- 89	Squid	-18.6	13	0.0515
11-DIET- 90	Squid	-19.8	12.5	0.0932
11-DIET- 16	Thysanoessa spinifera	-21.3	11	0.0553
11-DIET- 17	Thysanoessa spinifera	-18.7	10.3	0.0291
11-DIET- 18	Thysanoessa spinifera	-18.9	10.5	0.0274
11-DIET- 19	Thysanoessa spinifera	-18.3	10.5	0.0357