NAES-TR-00-02
May 2000

TECHNICAL REPORT

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FWS photo by Ted Swem

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This report may be cited as follows:

Ambrose, R.E., A. Matz, T. Swem, and P. Bente. 2000. Environmental contaminants in American and arctic peregrine falcon eggs in Alaska, 1979-95. Ecological Services Fairbanks, AK, U.S. Fish and Wildlife Service, Technical Report NAES-TR-00-02. 67 pp.

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Executive Summary

Since 1979, the U.S. Fish and Wildlife Service has monitored environmental contaminants in American peregrine falcon (*Falco peregrinus anatum*) and arctic peregrine falcon (*F. p. tundrius)* eggs in interior and arctic Alaska. Monitoring goals were collection and analysis of a minimum of 10 eggs from each subspecies every five years. The results of the 1984 program were reported by Ambrose et al. (1988a); this paper reports on 1988-95 analyses and compares data across the entire time span (eggs from 89 *F. p. anatum* and 68 *F. p. tundrius* nests from interior and northern Alaska collected between 1979 and 1995). In most cases a single egg was removed from each nest. More than one egg was collected from 23 nests, and contaminant values for those eggs were averaged for the nest. The majority of eggs analyzed were addled and collected during visits to band nestlings, but fresh eggs were collected during incubation in 1984, 1989, and 1995. Multiple eggs were taken from five females at intervals of two to four years. Four females with known wintering locations (via satellite tracking) were sampled, as were 33 eggs from known or estimated-age females.

Organochlorine (OC) contaminants were measured from 1979-95, and data were adjusted for moisture loss associated with development. Metals and trace elements (metals) were measured from 1988-95. We performed statistical analyses (hypothesis testing) for analytes that were consistently detected and consistently measured over the study period (1979-95 for OCs; 1988-95 for metals). These included p,p'-DDE, dieldrin, heptachlor epoxide, oxychlordane, and total PCBs; and copper, iron, magnesium, mercury, and zinc. Summary statistics were generated for other analytes depending upon the percent detections (geometric mean, range, and percent detection). We used general linear models to test OC and metal concentrations for changes in contaminant concentrations over time, differences between the American and arctic subspecies, differences between fresh and addled eggs, differences between eggs from successful and unsuccessful nests, and the relationship of eggshell thickness with DDE. There were significant declines over time for all OCs, although the trend was weaker for total PCBs than for other OCs. Copper, iron, and zinc significantly declined over time; magnesium and mercury did not. Because there were significant changes over time, a time factor was incorporated into subsequent analyses. Dieldrin was significantly greater and p,p'-DDE was significantly lower in *F. p. tundrius* compared to *F. p. anatum* over the entire study period; no other contaminants were significantly different between subspecies, although *F. p. anatum* had generally greater concentrations overall. Because of these differences, and because the subspecies are managed separately, we separated subsequent analyses by subspecies.

There were no significant differences in OC concentrations between fresh and addled eggs, for either subspecies. For *F. p. anatum*, iron and zinc were significantly greater, and magnesium was significantly lower, in fresh eggs compared to addled. There were no differences in metal concentrations between fresh and addled eggs for *F. p. tundrius*. For *F. p. anatum*, dieldrin, oxychlordane, and total PCBs were significantly greater in eggs from unsuccessful nests compared to successful nests, as were copper, iron, and mercury. There were no differences in eggs between unsuccessful and successful nests for *F. p. tundrius*.

There were no significant differences in eggshell thickness between subspecies, between fresh and addled eggs, or between eggs from successful compared to unsuccessful nests. There was no significant increase in eggshell thickness over time, although thickness appeared to increase slightly. Eggshell thickness was significantly negatively correlated with p,p'-DDE concentrations. Mean eggshell thicknesses from 1991-95 were 12.0 and 10.6% thinner (*F. p. anatum* and *F. p. tundrius*, respectively) than pre-DDT era peregrine eggs.

Analytes that weren’t consistently measured or consistently detected over the study period (1979-95 for OCs, 1988-95 for metals), but that were found in >50% of the samples in which they were analyzed, included beta-BHC, p,p’-DDD, p,p’-DDT, HCB, mirex, trans-nonachlor, manganese, selenium, strontium, and tin. Concentrations of these and the ten analytes used for hypothesis testing were compared to several published thresholds for reproductive effects, and the only contaminant exceeding these thresholds at any time was mercury. Additionally, the percent of mercury concentrations exceeding effect thresholds increased over time.

Although both OC and contaminant concentrations have decreased over time, evidence for cumulative and single-contaminant reproductive effects were found. Further, mercury remains a contaminant of continuing concern due to increasing concentrations and toxic reproductive effects. Contaminant monitoring remains a necessary management tool because peregrine falcons are still recovering from near extinction caused largely by environmental contaminants, and because they are top predators that remain vulnerable to persistent and bioaccumulative compounds.

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Acknowledgments

We thank the many individuals who assisted with surveys for peregrine falcons in Interior and Northern Alaska between 1979 and 1995. Particular help on this contaminants project was provided by M. Britten, B. Dittrick, C. Donaldson, J. Fadely, C. Henny, J. Hughes, R. Hunter, F. Mauer, R. Mesta, K. Mueller, K. Riddle, R. Ritchie, E. Snyder-Conn, and J. Wright. We thank J. Buck, C. Henny, P. Johnson, K. Mueller, and P. Sousa for reviewing the manuscript.

Introduction

Three subspecies of peregrine falcons occur in Alaska. The Peale's peregrine falcon (*Falco peregrinus pealei*) inhabits the coastal areas of southeast, south-central and southwest Alaska. The American peregrine falcon (*F. p. anatum)* breeds in interior Alaska south of the Brooks Range, and peregrine falcons breeding north of the Brooks Range and on the Seward Peninsula are considered arctic peregrine falcons (*F. p. tundrius*) (White 1968). Both *F. p. tundrius* and *F. p. anatum* in Alaska are highly migratory and winter from the southern United States south to Argentina (Ambrose and Riddle 1988; Britten 1998; S. Ambrose and T. Swem, unpub. data). Population declines of peregrine falcons at several locations including Alaska have been correlated with DDE concentrations in their eggs, eggshell thinning, and hatching failure (Hickey and Anderson 1968, Ratcliffe 1970, Cade et al. 1971, Peakall et al. 1975). American and arctic peregrine falcons in interior and northern Alaska declined in the 1960s, stabilized in the mid-1970s, began to increase in the late 1970s, and have stabilized or continue to increase (Ambrose et al. 1988b; Ambrose and Swem, unpubl. data). In 1966, Cade et al. (1968) documented DDE and the parent compound DDT in eggs and tissues of young and adult peregrine falcons from interior Alaska. Peakall et al. (1975) reported that DDE residues in peregrine falcons from Alaska between 1969 and 1975 were greater than critical reproductive thresholds. Ambrose et al. (1988a) noted declines in contaminant concentrations and increased eggshell thickness in peregrine eggs compared to the earlier studies. Because peregrines are top predators that were affected by and are vulnerable to the effects of environmental contaminants, peregrine eggs have been monitored for DDE and other persistent contaminants.

Organochlorine (OC) contaminants, including pesticides and polychlorinated biphenyls (PCBs), are lipophilic, persistent in the environment, and bioaccumulate and biomagnify (Hoffman et al. 1995). Toxic effects on birds include acute and chronic neurotoxicity, reproductive effects through endocrine disruption, including eggshell thinning, and embryotoxicity. With some exceptions (Loganathan and Kannan 1994), concentrations of OCs in biota are generally declining due to numerous prohibitions on their use and production (Schmitt and Bunck 1995). However, due to their toxicity, persistence, and continued use in some areas, OC compounds remain contaminants of concern.

Metals and trace elements (metals) generally have fewer toxic effects in avian species compared to persistent OCs, with important exceptions. Non-physiologically regulated metals such as lead and mercury tend to be of greater toxicity than those that function as trace elements, such as iron and zinc, although excessive trace or essential elements can be toxic. Mercury, which is a potent neurotoxin, becomes bioavailable with the addition of organic molecules through bacterial transformation and other processes (Eisler 1987, Thompson 1996). Organo-mercury (methyl-mercury) is persistent, bioaccumulative, and can biomagnify, so toxic effects of this compound tend to manifest at high trophic levels, similar to persistent OCs. Anthropogenic sources of metals are, in general, declining in the Arctic (AMAP 1998) but local or regional contamination from mining, incineration, or other industrial processes can result in release or mobilization of metals with subsequent effects on local or regional populations (e.g., Blus et al. 1991). Mercury concentrations in northern biota are not decreasing and may be increasing (e.g., Lockhart et al. 1995). Because of its toxicity, bioavailability, and increasing concentrations, mercury remains a persistent contaminant of concern.

The current report summarizes data from peregrine eggs collected from 1988-95 in Alaska and compares these data to earlier collections summarized in Ambrose et al. (1988a), as both data sets together comprise a continuous monitoring program for peregrine falcons in Alaska. Our objectives were: (1) to determine concentrations of organochlorine (OC) contaminants and metals and trace elements (metals) in eggs from American and arctic peregrine falcons breeding in Alaska; (2) to assess trends (across time and between subspecies) of contaminant concentrations in eggs; and (3) to examine effects of these contaminant concentrations on breeding success. We also provide recommendations for future contaminant monitoring in peregrine falcon populations.

Methods

Egg collection procedures were similar to those described by Ambrose et al. (1988a). Unhatched, addled eggs were collected when nests were visited to count and band nestlings (no eggs were collected in 1981, 1985, and 1992). Fresh eggs were collected in 1984, 1989 and 1995 during occupancy surveys when adults were incubating. Successful nests had $\geq$ 1 nestling, usually between 7 and 28 days old, at the latter nest visit, and unsuccessful nests had no chicks present. Whole eggs were wrapped in foil, cushioned for transport, and refrigerated as much as possible prior to removal of contents. Contents were removed by scoring the eggshell at the equator and placing contents in a chemically-clean jar (I-Chem or equivalent).

Eggshell thickness (shell plus membranes) was reported as an average of three measurements taken on the equator of each egg with a micrometer graduated in units of 0.01 mm. Eggshell thickness measurements came only from shells of whole eggs, collected either as fresh or addled eggs; no measurements of eggshell fragments were included. If membranes were missing, we added 0.069 mm (Court et al. 1990). To assess percent of shell thinning, we compared thickness to a pre-1947 thickness of 0.360 ± 0.007 mm (95% C.L.) for 53 peregrine eggs from arctic and subarctic Alaska (Anderson and Hickey 1972).

Analytical Chemistry

Organochlorines were measured from 1979-95. Metals were measured from 1988-95. Analytes measured and limits of detection (LODs) are summarized in Appendix A. Total PCBs were calculated as an Aroclor sum, and mercury was measured as elemental mercury. Eggs collected prior to 1988 were analyzed at Patuxent Wildlife Research Center. Eggs collected in 1988-95 were analyzed at Texas A & M University, except for eggs collected in 1989 and 1991 which were analyzed at Mississippi State University. Detailed analytical methods are available from the Patuxent Analytical Control Facility (PACF), Patuxent Wildlife Research Center, U.S. Fish and Wildlife Service, Laurel, MD. Quality assurance and quality control (QA/QC) procedures followed PACF contractual standards. For eggs collected after 1993, additional QA/QC was provided by U.S. Fish and Wildlife Service, Northern Alaska Ecological Services Environmental Contaminants biologists (E. Synder-Conn and K. Mueller). Acceptance criteria were spike recoveries of 80-120%, Standard Reference Material value within $\pm$ 3 SD of the certified value, relative percent difference of duplicate samples within $\pm$ 20%, and analysis of matrix blanks. Additionally, 10% of positive samples were confirmed by Gas Chromatography/Mass Spectrometry. Analytes that failed to meet QA/QC acceptance criteria were excluded from data summaries and analysis.

Data Analysis

We used a variety of statistical tests, depending upon the hypothesis tested. We used multivariate tests whenever supported by the data, since they reduce the increased experiment-wise error rate associated with numerous univariate tests, and may also discern patterns not evident in univariate data (Weis and Muir 1997, Sparks et al. 1999). When possible, we used parametric statistical tests, primarily general linear models. General linear models are a broad family of tests used for univariate and multivariate Analysis of Variance (ANOVA), Analysis of Covariance (ANCOVA), and multiple regression, among others (SPSS 1998). Non-parametric tests were used when: 1) contaminants data from any group had > 50 % of data less than the LOD; and 2) log-transformation did not correct non-normality or unequal variance. All statistical analyses were done with SYSTAT 8.0 (SPSS 1998); unless otherwise stated, $\alpha = 0.05$.

We adjusted OC contaminant values for changes in moisture content (Stickel et al. 1973); adjusted residues are reported as mg/kg adjusted wet weight (ww). Metals are reported in mg/kg dry weight (dw) and were not adjusted. Data were not corrected for percent recoveries.

We accounted for different detection limits, and differences in lists of measured analytes, over the study period. It is not appropriate to combine data generated with differing detection limits except when all data are above the highest detection limit, because non-detects at a high detection limit may have been quantifiable with a lower detection limit. Therefore, we tested hypotheses on only those analytes that were consistently detected (90% of all data above the LOD) and consistently measured throughout the entire study period. Non-detections for these analytes only were substituted with ½ the LOD for analysis purposes, since a small number of such substitutions is unlikely to affect estimation of summary statistics (Gibbons 1994). Organochlorines that were consistently detected and measured (1979-95) included p,p'-DDE, dieldrin, heptachlor epoxide, oxychlordane, and total PCBs. Metals that were consistently detected and consistently measured (1988-95) included copper (Cu), iron (Fe), magnesium (Mg), mercury (Hg), and zinc (Zn). Peakall et al. (1990) listed several contaminants likely to be of toxicological concern. Contaminants that we used to test hypotheses included those listed in Peakall et al. (1990) (p,p'-DDE, PCBs, dieldrin, heptachlor epoxide, oychlordane, and mercury), with the exception of hexachlorobenzene, which was not consistently measured throughout the entire study period.

For analytes that were not consistently detected and measured from 1979-95, summary statistics were calculated for 1988-95 only, since earlier years were presented in Ambrose et al. (1988a). Analytes with > 50% above the highest detection limit for each subspecies were summarized with geometric means (with non-detects substituted at ½ the detection limit), ranges, and percent detections. Analytes with < 50% of data above the detection limit were summarized with percent detections. Since detection limits varied even from 1988-95, we calculated percent detections for OC pesticides using the nominal OC detection limit for the majority of samples from 1988-95 (0.01 mg/kg ww, Appendix A). For metals, we used the highest of the variable detection limits for each analyte (Appendix A).

Although eggs were collected from 1979-95 (excluding 1981, 1985, and 1992), there were very low sample sizes in some years. Data were therefore grouped prior to data analysis, into year groups representing the early 1980's, late 1980's, and early 1990's (Table 1). Additionally, although multiple eggs collected from the same clutch were subjected to individual chemical analyses, their contaminant concentrations could not be considered independent and were therefore averaged for use in statistical analyses. Also, we corroborated that intra-clutch variation was less than inter-clutch variation by comparing the median intra-clutch range to a bootstrapped set of 500 randomly selected inter-clutch ranges generated for each of the statistically analyzed OCs and mercury. If the intra-clutch ranges were less than 75% of the inter-clutch ranges (i.e., corresponding to the 25th or lower percentile), we were satisfied that intra-clutch ranges were substantially less than inter-clutch ranges and that averaging of residue data from multiple eggs in one clutch was justified.

Table 1. Years in which peregrine eggs were collected in Alaska, and year group for data analysis. Organochlorines were measured in all years; metals were measured from 1988-95. Samples were single eggs from one nest, or, if more than one egg was collected, average contaminant concentrations for all eggs in a nest. Sample sizes are in parentheses.

Subspecies Year of collection (n)	Year group for data analysis (n)
American peregrine falcon (*F. p. anatum*)	
1979 (1), 1980 (2), 1982 (6), 1983 (6), 1984 (16)	1979-84 (31)
1986 (1), 1987 (1), 1988 (5), 1989 (15), 1990 (4)	1986-90 (26)
1991 (11), 1993 (7), 1994 (3), 1995 (11)	1991-95 (32)
Arctic peregrine falcon (*F. p. tundrius*)	
1979 (4), 1980 (1), 1982 (3), 1983 (2), 1984 (9)	1979-84 (19)
1988 (5), 1989 (19), 1990 (5)	1986-90 (29)
1991 (7), 1993 (4), 1994 (1), 1995 (8)	1991-95 (20)

Specific hypotheses and statistical tests are summarized below. Analyses were performed in the order listed so that significant results from broad questions could be incorporated into subsequent specific analyses. We analyzed OCs and metals separately.

To test whether contaminant concentrations changed over time, and whether contaminant concentrations differed between the *F. p. anatum* and *F. p. tundrius* subspecies, we used a multivariate general linear model (analogous to two-way multivariate ANOVA design) with year group and subspecies as the main factors and contaminant concentrations as the response variables. If the overall multivariate model showed significant differences among year groups in contaminant concentrations, Bonferroni-adjusted post-hoc comparisons were performed on those analytes with significant ($p < 0.05$) univariate F-statistics to determine which year groups were significantly different from each other. Post-hoc testing on significant analytes was not required for the subspecies factor, since there were only two levels (*F. p. anatum* and *F. p. tundrius*). Significant differences among the year groups resulted in incorporation of a time factor in subsequent analysis. Significant differences among subspecies resulted in separation of subsequent analyses by subspecies.

We compared contaminant concentrations between fresh (collected at incubation) and addled (collected at banding) eggs using multivariate general linear models (analogous to two-way multivariate ANOVA design) with year group and status (addled or fresh) as factors and contaminant concentrations as response variables. Fresh eggs were collected in 1984, 1989, and 1995, so this analysis was limited to those years.

We evaluated whether contaminant concentrations in eggs were related to breeding success with two methods. First, we statistically compared contaminant concentrations among successful ($\geq$ 1 chick at banding) and unsuccessful (0 chicks at banding) nests, using general linear models (analogous to two-way multivariate ANOVA design) with year group and nest success as factors and contaminant concentrations as response variables. We used breeding success, rather than number of nestlings, because in some years a fresh egg was collected from some nests, introducing potential and unknown bias into analyses involving numbers of eggs or nestlings. We also compared geometric mean contaminant concentrations to published effect thresholds for each subspecies and each year group and calculated the percent of eggs exceeding the thresholds.

We explored the relationships between eggshell thickness, contaminant concentrations, and time, using a general linear model (analogous to a multivariate ANCOVA design) with year group as a factor, log-transformed p,p'-DDE concentrations as a covariate, and eggshell thickness as the response variable. We also used general linear models (analogous to a t-test design) to compare eggshell thickness between subspecies, between addled and fresh eggs within subspecies, and between successful and unsuccessful nests within subspecies.

We had data from banded females with known ages (coded leg bands applied as nestlings, or age at banding estimated to be after second year), previous egg collections, or known wintering areas (satellite tags), and evaluated whether contaminant concentrations in eggs were related to these factors. Because variance in contaminant concentrations increased with age and was not corrected using a log-transform, we used non-parametric Spearman rank correlations to test if female age (yr) was correlated with contaminant concentrations. We also tabulated data for eggs collected from the same female over time, with gaps of two to four years between collections. Eggs from four 1994 satellite-tagged female American peregrine falcons breeding along the Yukon River in Alaska (Britten 1998) were collected in 1995. Egg contaminants data were examined for patterns relative to migration routes and wintering areas in conjunction with a larger study (Britten 1998). Habitats were assigned to wintering locations (average latitude and longitude of satellite locations) using World Wildlife Fund's ecoregion identification (World Wildlife Fund 1998).

Results

Summary statistics (geometric mean, range, and percent detections) for analytes that were not statistically analyzed are presented in Appendix B (analytes with > 90% of samples above the detection limit), Appendix C (analytes with > 50% but less than 90% of samples above the detection limit) and Appendix D (analytes with < 50% of samples above the detection limit). Sample sizes for each year group and subspecies are presented in Table 1. Residue levels of OCs and metals in individual eggs are presented in Appendix E.

Mirex and selenium were detected in 100% of samples during 1988-95. Beta-BHC, p,p’-DDD, p,p’-DDT, HCB, Mirex, trans-nonachlor, mangenese, selenium, strontium, and tin were detected in greater than 50% of samples for both subspecies (Appendix C). Alpha-BHC, gamma-BHC, alpha-chlordane, gamma-chlordane, o,p’-DDD, o,p’-DDE, o,p’-DDT, endosulfan II, endrin, aluminum, barium, beryllium, boron, cadmium, chromium, lead, molybdenum, nickel, and vanadium were detected in fewer than 50% of samples for both subspecies (Appendix D). Aldrin, delta-BHC, heptachlor, antimony, arsenic, cobalt, silver, and thallium were not detected in any sample.

Use of average clutch values when multiple eggs from one clutch were measured was justified because intra-clutch variation was much lower than inter-clutch variation. Median intra-clutch ranges were all lower than the 25th percentile of inter-clutch ranges. Specifically, intra-clutch ranges for p,p’-DDE, dieldrin, heptachlor epoxide, oxychlordane, total PCBs (n=23), and mercury (n=13) fell below the 11th, 12th, 8th, 7th, 17th, and 25th percentiles, respectively, of 500 inter-clutch ranges randomly generated for each contaminant.

Time and Subspecies Differences

There were significant differences among year groups for all OC contaminants (Table 2), and decreasing concentrations over time were indicated by either 1986-90 or 1991-95 year groups, or both, being significantly lower than 1979-84 (Fig. 1a-e). The exception was total PCBs, where, in spite of a significant univariate F-statistic, no year group was significantly different from any other (Fig. 1e). There were also significant differences between subspecies (Table 2). Dieldrin concentrations were significantly greater and p,p’-DDE concentrations were significantly less in *F. p. tundrius* eggs compared to *F. p. anatum* (Fig. 1a, b). Heptachlor epoxide, oxychlordane, and total PCBs were not significantly different between subspecies (Table 2).

Copper, iron, and zinc were significantly lower in 1991-95 compared to 1988-90 (Table 3, Fig. 2a, b, e). Mercury and magnesium were not significantly different between year groups (Table 3), although mercury may be increasing, at least in *F. p. anatum* (Fig. 2d). There were no significant differences between subspecies in metals (Table 3, Fig. 2a-e).

Table 2. Results of two-way multivariate ANOVA that tested whether organochlorine contaminant concentrations in peregrine eggs from Alaska changed over time and whether they differed between the American (*Falco peregrinus anatum*) and arctic (*F. p. tundrius*) subspecies. Differences among year groups or subspecies were indicated by significant multivariate statistics ($P < 0.05$); significant response variables (i.e., those contributing to the significant factor differences) were indicated by significant univariate statistics ($P < 0.05$) and are noted with an asterisk.

Factor (Levels)[1]	Multivariate Statistics	Response Variables	Univariate Statistics
Year Group	Wilke's $\lambda = 0.482$	p,p'-DDE *	$F_{2, 150} = 40.385$, $P < 0.001$
(1979-84,	$F_{10, 292} = 12.838$	dieldrin *	$F_{2, 150} = 16.645$, $P < 0.001$
1988-90,	$P < 0.001$	heptachlor epoxide *	$F_{2, 150} = 36.639$, $P < 0.001$
1991-95)		oxychlordane *	$F_{2, 150} = 24.182$, $P < 0.001$
		total PCBs *	$F_{2, 150} = 5.448$, $P = 0.005$
Subspecies	Wilke's $\lambda = 0.859$	p,p'-DDE *	$F_{1, 150} = 5.120$, $P = 0.025$
(*F. p.*	$F_{5, 146} = 4.788$	dieldrin *	$F_{1, 150} = 8.566$, $P = 0.004$
anatum,	$P < 0.001$	heptachlor epoxide	$F_{1, 150} = 0.054$, $P = 0.817$
F. p.		oxychlordane	$F_{1, 150} = 0.028$, $P = 0.868$
tundrius)		total PCBs	$F_{1, 150} = 1.419$, $P = 0.235$

[1] Mean values displayed in Fig. 1.

Table 3. Results of two-way multivariate ANOVA that tested whether metal concentrations in peregrine eggs from Alaska changed over time and whether they differed between the American (*Falco peregrinus anatum*) and arctic (*F. p. tundrius*) subspecies. Differences among year groups or subspecies were indicated by significant multivariate statistics ($P < 0.05$); significant response variables (i.e., those contributing to the significant factor differences) were indicated by significant univariate statistics ($P < 0.05$) and are noted with an asterisk.

Factor (Levels)[1]	Multivariate Statistics	Response Variables	Univariate Statistics
Year Group	Wilke's $\lambda = 0.724$	copper *	$F_{1, 89} = 11.383$, $P = 0.001$
(1988-90,	$F_{5, 85} = 6.476$	iron *	$F_{1, 89} = 22.825$, $P < 0.001$
1991-95)	$P < 0.001$	magnesium	$F_{1, 89} = 0.909$, $P = 0.343$
		mercury	$F_{1, 89} = 0.319$, $P = 0.573$
		zinc *	$F_{1, 89} = 24.995$, $P < 0.001$
Subspecies	Wilke's $\lambda = 0.920$	copper	n/a [2]
(*F. p.*	$F_{5, 85} = 1.478$	iron	n/a
anatum,	$P = 0.205$	magnesium	n/a
F. p.		mercury	n/a
tundrius)		zinc	n/a

[1] Mean values displayed in Fig. 2.

[2] n/a = not applicable due to non-significant multivariate statistic.

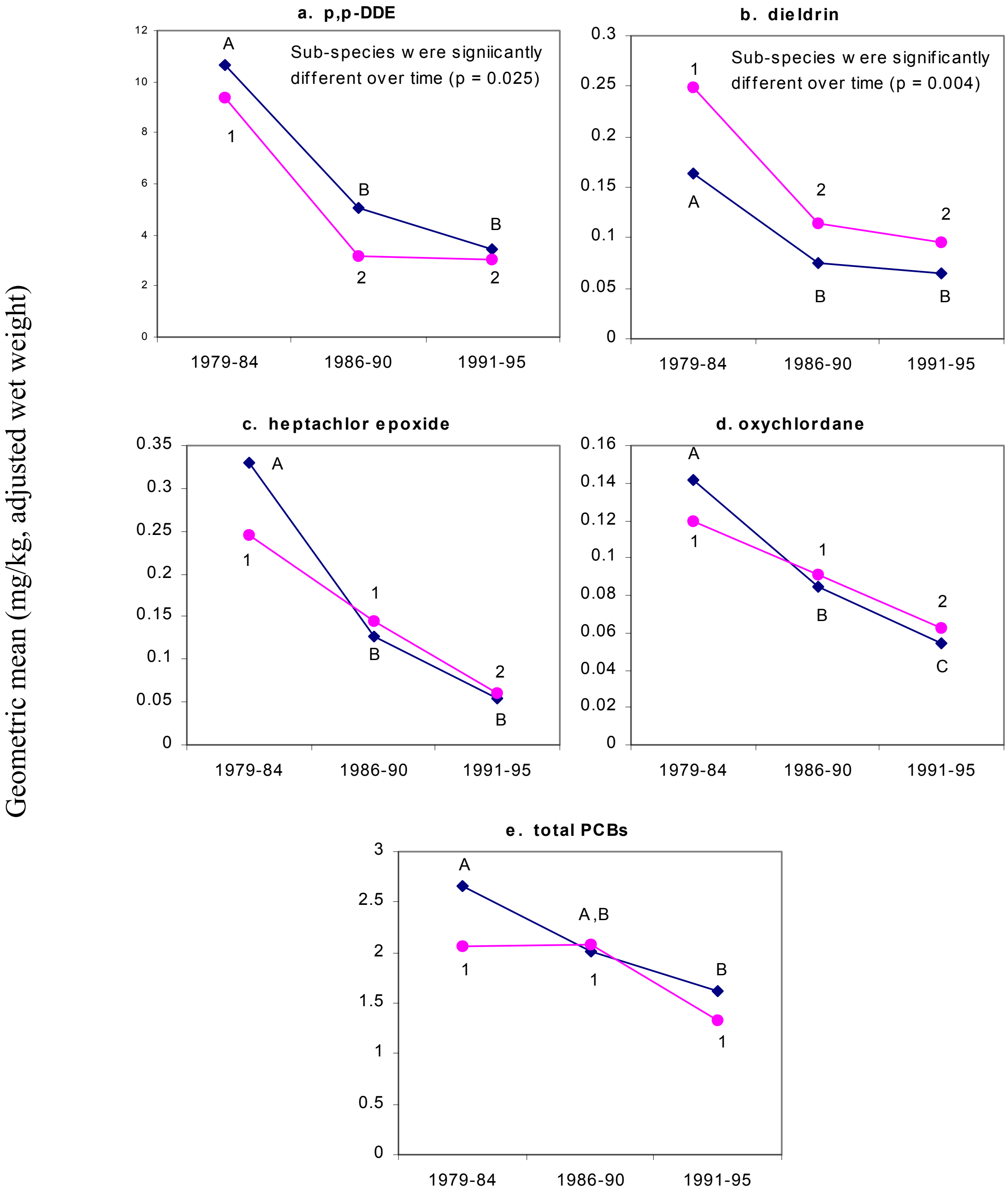

Figure 1. Mean organochlorine contaminant concentrations in peregrine eggs from Alaska over three time periods. Subspecies are denoted by separate lines (◆ = American, *F. p. anatum*, ● = arctic, *F. p. tundrius*). There were significant differences between subspecies for p,p'-DDE (P = 0.025) and dieldrin (P = 0.004) across all time periods, and significant differences among time periods are indicated by letters (A, B, C) for the American subspecies and numbers (1, 2) for the arctic subspecies (two-way MANOVA with time and subspecies factors).

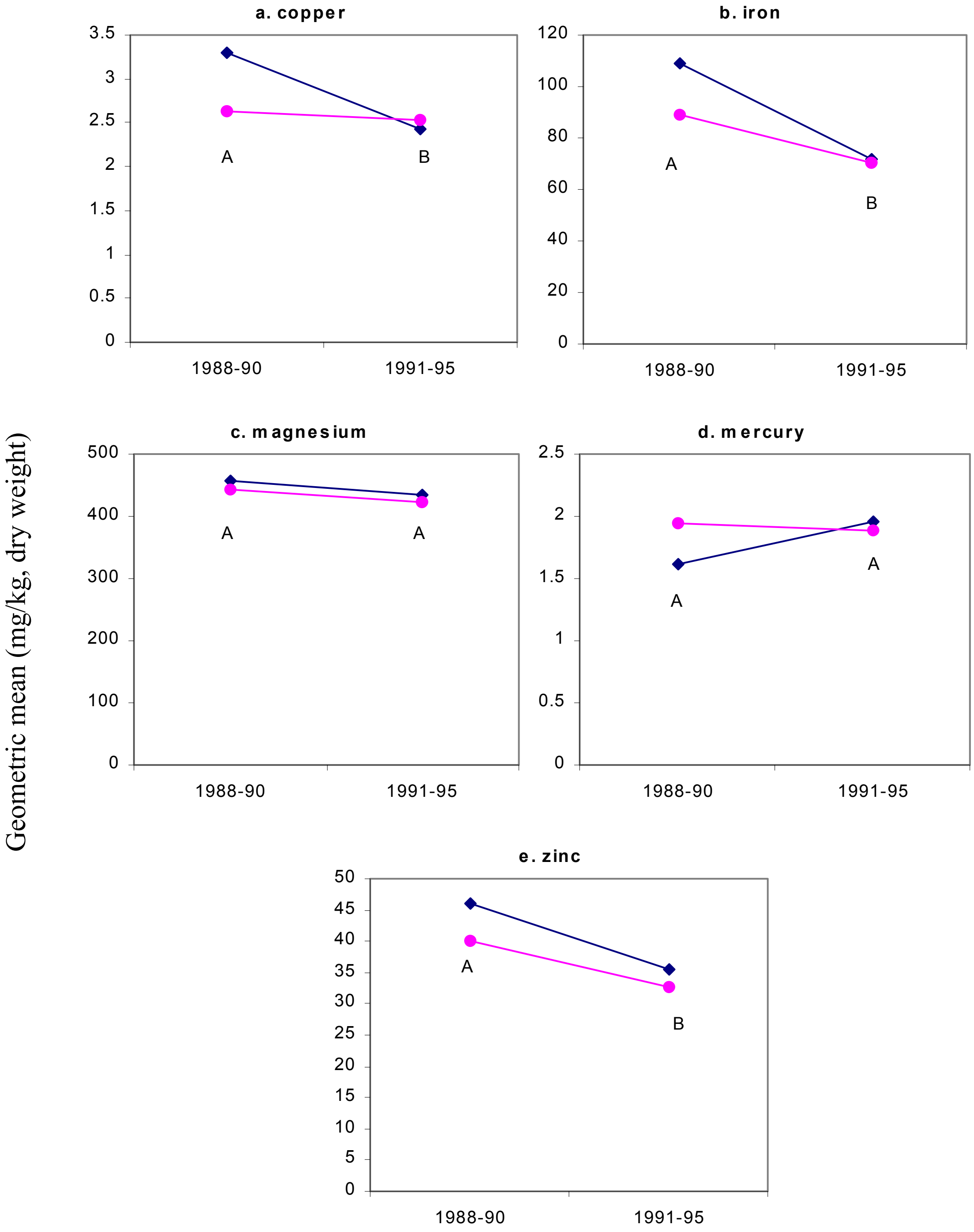

Figure 2. Mean metal and trace element concentrations in peregrine eggs from Alaska over two time periods. Subspecies are denoted by separate lines (◆ = *F. p. anatum*, ● = *F. p. tundrius*). There were no significant differences between subspecies across all time periods; for both subspecies combined, different letters (A, B) indicate significant differences between time periods (two-way MANOVA with time and subspecies factors).

Addled and Fresh Eggs

Analyses of addled and fresh eggs were performed separately on each subspecies, with year as a factor to account for decreasing concentrations over time. There were significant decreases in OC concentrations among the years tested (1984, 1989, and 1995) for both subspecies (Table 4, Fig. 3a-e), as expected from the previous analysis (Table 2), but no significant differences between addled (*F. p. anatum* n=20, *F. p. tundrius* n=12) and fresh (*F. p. anatum* n=22, *F. p. tundrius* n=24) eggs for either subspecies (Table 4).

There were no significant differences in metals between years (1989 and 1995) for either subspecies (Table 5), although the more powerful (larger sample size) previous analysis indicated decreases over time for some metals (Table 3). For *F. p. anatum,* iron and zinc were significantly greater and magnesium was significantly lower in fresh (n=12) eggs compared to addled (n=14), but there were no significant differences in copper and mercury (Table 5, Fig. 4a-e). There were no significant differences in metal concentrations between fresh (n=16) and addled (n=11) eggs for *F. p. tundrius* (Table 5, Fig. 4a-e).

Table 4. Results of two-way multivariate ANOVAs that tested whether organochlorine contaminant concentrations differed between fresh (collected prior to expected hatch date) and addled (collected after expected hatch date) peregrine eggs from Alaska. Differences among years or status were indicated by significant multivariate statistics ($P < 0.05$); significant response variables (i.e., those contributing to the significant factor differences) were indicated by significant univariate statistics (P < = 0.05) and are noted with an asterisk.

Factor (Levels)[1]	Multivariate Statistics	Response Variables	Univariate Statistics
	American subspecies (*Falco peregrinus anatum*)		
Year	Wilke's $\lambda = 0.331$	p,p'-DDE *	$F_{2, 38} = 17.379$, $P < 0.001$
(1984,	$F_{10, 124} = 9.158$	dieldrin *	$F_{2, 38} = 3.866$, $P = 0.030$
1989,	$P < 0.001$	heptachlor epoxide *	$F_{2, 38} = 14.283$, $P < 0.001$
1995)		oxychlordane *	$F_{2, 38} = 5.411$, $P = 0.009$
		total PCBs	$F_{2, 38} = 1.712$, $P = 0.194$
Status	Wilke's $\lambda = 0.890$	p,p'-DDE	n/a [2]
(Addled,	$F_{5, 34} = 0.844$	dieldrin	n/a
Fresh)	$P = 0.528$	heptachlor epoxide	n/a
		oxychlordane	n/a
		total PCBs	n/a
	Arctic subspecies (*F. p. tundrius*)		
Year	Wilke's $\lambda = 0.208$	p,p'-DDE *	$F_{2, 32} = 24.178$, $P < 0.001$
(1984,	$F_{10, 56} = 6.666$	dieldrin *	$F_{2, 32} = 5.711$, $P = 0.008$
1989,	$P < 0.001$	heptachlor epoxide *	$F_{2, 32} = 5.633$, $P = 0.008$
1995)		oxychlordane *	$F_{2, 32} = 10.599$, $P < 0.001$
		total PCBs	$F_{2, 32} = 3.054$, $P = 0.061$
Status	Wilke's $\lambda = 0.913$	p,p'-DDE	n/a [2]
(Addled,	$F_{5, 59} = 1.128$	dieldrin	n/a
Fresh)	$P = 0.356$	heptachlor epoxide	n/a
		oxychlordane	n/a
		total PCBs	n/a

[1] Mean values displayed in Fig. 3.

[2] n/a = not applicable due to non-significant multivariate statistic.

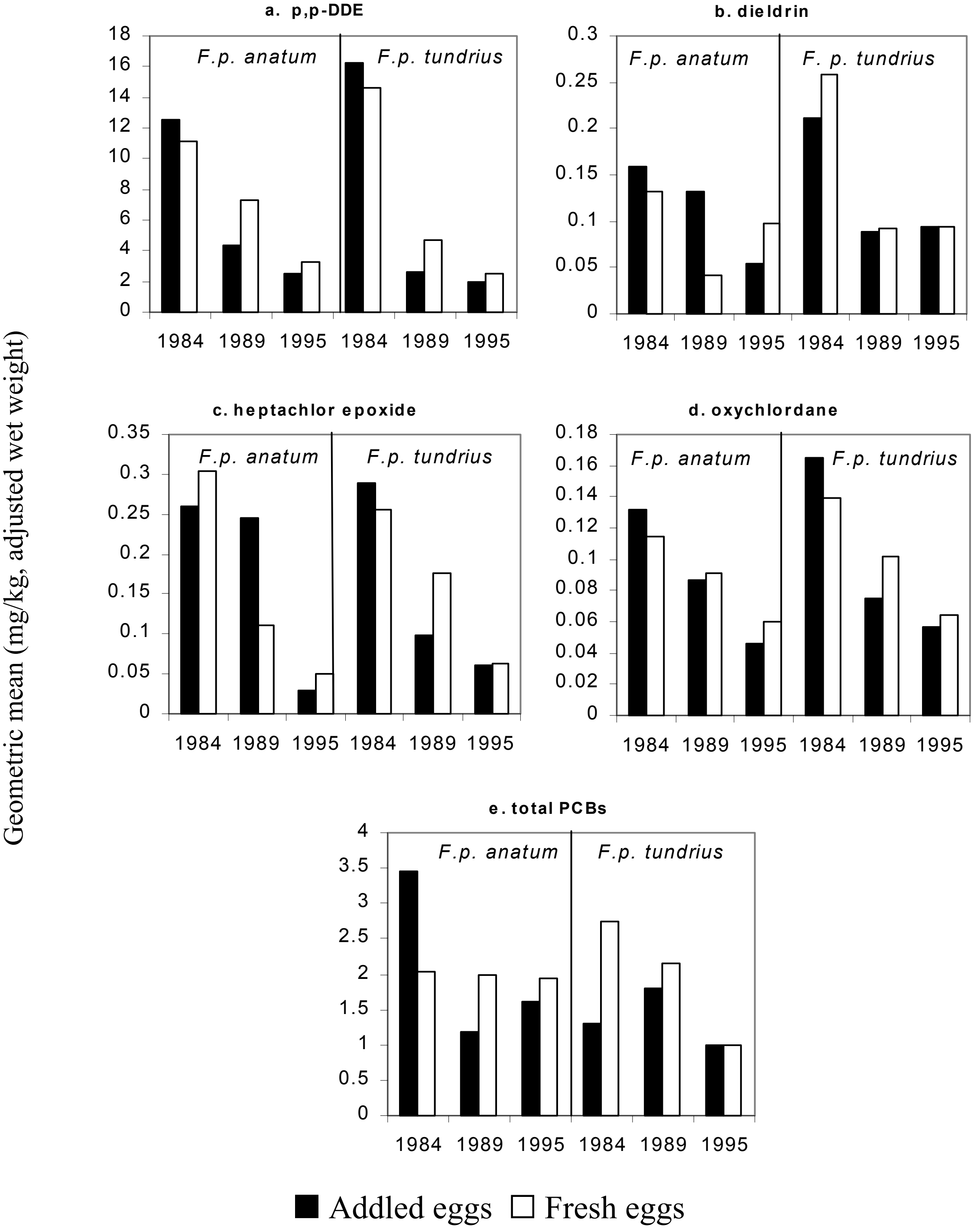

Figure 3. Mean organochlorine (OC) contaminant concentrations in addled and fresh American (*F. p. anatum*) and arctic (*F. p. tundrius*) peregrine falcon eggs from Alaska, collected in 1984, 1989, and 1995. There were no significant differences between addled and fresh eggs (two-way MANOVA with time and egg status factors).

Table 5. Results of two-way multivariate ANOVAs that tested whether metal and trace element contaminant concentrations differed between fresh (collected prior to expected hatch date) and addled (collected after expected hatch date) peregrine eggs from Alaska. Differences among years or status were indicated by significant multivariate statistics ($P < 0.05$); significant response variables (i.e., those contributing to the significant factor differences) were indicated by significant univariate statistics ($P < 0.05$) and are noted with an asterisk.

Factor (Levels)[1]	Multivariate Statistics	Response Variables	Univariate Statistics
	American subspecies (*Falco peregrinus anatum*)		
Year (1989, 1995)	Wilke's $\lambda = 0.692$	copper	n/a [2]
	$F_{5, 19} = 1.688$	iron	n/a
	$P = 0.186$	magnesium	n/a
		mercury	n/a
		zinc	n/a
Status (Addled, Fresh)	Wilke's $\lambda = 0.428$	copper	$F_{1, 23} = 0.452$, $P = 0.508$
	$F_{5, 19} = 5.070$	iron *	$F_{1, 23} = 5.722$, $P = 0.025$
	$P = 0.004$	magnesium *	$F_{1, 23} = 6.573$, $P = 0.017$
		mercury	$F_{1, 23} = 0.165$, $P = 0.688$
		zinc *	$F_{1, 23} = 4.924$, $P = 0.037$
	Arctic subspecies (*F. p. tundrius*)		
Year (1989, 1995)	Wilke's $\lambda = 0.799$	copper	n/a
	$F_{5, 20} = 1.007$	iron	n/a
	$P = 0.439$	magnesium	n/a
		mercury	n/a
		zinc	n/a
Status (Addled, Fresh)	Wilke's $\lambda = 0.758$	copper	n/a
	$F_{5, 20} = 1.274$	iron	n/a
	$P = 0.314$	magnesium	n/a
		mercury	n/a
		zinc	n/a

[1] Mean values displayed in Fig. 4.

[2] n/a = not applicable due to non-significant multivariate statistic.

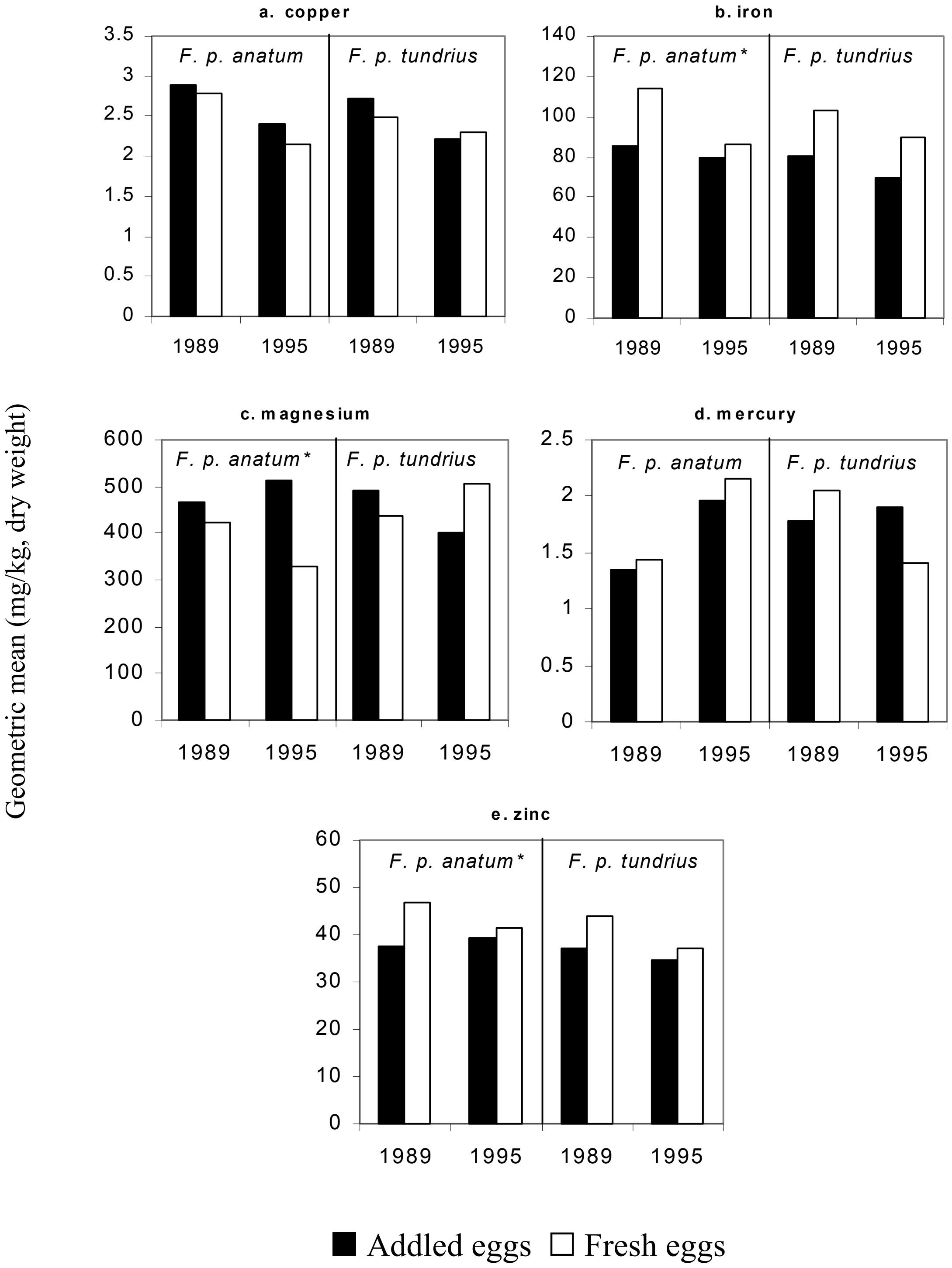

Figure 4. Mean metal and trace element concentrations in addled and fresh American (*F. p. anatum*) and arctic (*F. p. tundrius*) peregrine falcon eggs from Alaska, collected in 1984, 1989, and 1995. An asterisk following the subspecies label indicates significant differences between addled and fresh eggs (two-way MANOVA with time and egg status factors).

Effects on Breeding Success

Analyses on the effects of contaminants on breeding success were performed separately on each subspecies, with year group as a factor to account for decreasing concentrations over time. There were significant differences in OC concentrations among year groups (Table 6) for both subspecies, as expected (Table 2). In *F. p. anatum*, dieldrin, oxychlordane, and total PCB concentrations were significantly greater in unsuccessful nests (n=24) compared to successful (n=63), while p,p'-DDE and heptachlor epoxide were not significantly different (Fig. 5a-e). There were no significant differences in OC concentrations in *F. p. tundrius* eggs from successful (n=40) and unsuccessful (n=28) nests (Table 6, Fig. 5a-e).

There were significant differences in iron and zinc for both subspecies, and in copper concentrations for *F. p. anatum*, among year groups (Table 7), as expected (Table 3). In *F. p. anatum*, copper, iron, and mercury concentrations were significantly greater in unsuccessful (n=13) nests compared to successful (n=38), while magnesium and zinc were not significantly different (Fig. 6a-e). There were no significant differences in metal concentrations in *F. p. tundrius* eggs from successful (n=24) and unsuccessful (n=17) nests (Table 7, Fig. 6a-e).

Geometric mean p,p'-DDE concentrations for both subspecies were below the 15-20 mg/kg threshold associated with 20% eggshell thinning specified by Peakall et al. (1990) for all time periods. This threshold was not exceeded by individual *F. p. anatum* or *F. p. tundrius* eggs in 1991-95. Critical dieldrin levels in peregrine eggs range from 1- 4 mg/kg (Peakall et al. 1990), which was greater than geometric mean dieldrin concentrations for all time periods, and there were no exceedances during 1991-95. Geometric mean heptachlor epoxide concentrations never exceeded 1.5 mg/kg, a level considered to be critical for producing adverse reproductive effects in peregrines by Peakall et al. (1990) based on Henny et al.'s (1983) assessment of American kestrels (*Falco sparverius*), and there were no exceedances of this threshold value in 1991-95.

Thresholds for total PCBs are somewhat problematic because PCB toxicity and effects are congener-specific. Peakall et al. (1990) suggested 40 mg/kg total PCBs for peregrines, and other laboratory studies on a variety of birds suggest different total PCB thresholds (1 to 105 mg/kg, depending upon species and effect measured; Hoffman et al. 1996). PCB congeners were not measured for this study, but mean and individual concentrations of total PCBs in all time periods did not exceed the 40 mg/kg threshold identified by Peakall et al. (1990), although there were some exceedences for lower threshold values.

Mercury threshold concentrations were given as between 0.5 and 1.0 mg/kg wet weight for peregrines (Peakall et al. 1990), other raptors (Wiemeyer et al. 1993, Bowerman et al. 1995), and birds in general (Thompson 1996). We calculated mean wet weight concentrations using percent moisture from each egg to compare to these thresholds. Mean mercury concentrations (mg/kg ww) were 0.328 and 0.391 (1988-90), and 0.526 and 0.389 (1991 - 95) for *F. p. anatum* and *F. p. tundrius*, respectively. The number (%) of eggs exceeding the 0.5 mg/kg threshold were 3/22 (13%) and 2/23 (9%) in 1988-90, and 10/33 (30%) and 6/20 (30%) in 1991-95, for *F. p. anatum* and *F. p. tundrius*, respectively.

There were no exceedences for analytes that were not statistically analyzed. The highest concentrations of HCB (Appendix C) did not exceed Peakall et al.'s (1990) toxic threshold estimate of 4 mg/kg in eggs. The highest concentrations of beta-BHC in this study (Appendix C) were < 5.5

mg/kg, the concentration found in an egg from an apparently successful American kestrel nest (Henny et al. 1983). Gamma-BHC (lindane) was detected in only one sample (Appendix D). Mirex was detected in 100% of eggs measured from 1988-95, but at concentrations below those associated with reproductive effects in chickens (255-450 mg/kg ww) (Wiemeyer 1996). Selenium was measured only in 1991 and 1993-95, but was detected in 100% of eggs from those years. However, geometric mean selenium concentrations (range), after conversion to wet weight using percent moisture from each egg for comparison with published thresholds, were 0.480 (0.159 - 0.941) mg/kg ww for *F. p. anatum* and 0.415 (0.243 - 0.612) mg/kg ww for *F. p. tundrius*. These were below the general avian embryotoxic threshold suggested by Heinz (1996) of 3 mg/kg ww in eggs.

Table 6. Results of two-way multivariate ANOVAs that tested whether organochlorine contaminant concentrations differed between peregrine eggs from successful ($\geq$ 1 chick at banding) and unsuccessful (0 chicks at banding) nests in Alaska. Differences among year groups or nest success were indicated by significant multivariate statistics ($P < 0.05$); significant response variables (i.e., those contributing to the significant factor differences) were indicated by significant univariate statistics ($P < 0.05$) and are noted with an asterisk.

Factor (Levels)[1]	Multivariate Statistics	Response Variables	Univariate Statistics
		American subspecies (*Falco peregrinus anatum*)	
Year Group (1979-84, 1988-90, 1991-95)	Wilke's $\lambda = 0.490$ $F_{10, 158} = 6.771$ $P < 0.001$	p,p'-DDE *	$F_{2, 83} = 40.385$, $P < 0.001$
		dieldrin *	$F_{2, 83} = 16.645$, $P < 0.001$
		heptachlor epoxide *	$F_{2, 83} = 36.639$, $P < 0.001$
		oxychlordane *	$F_{2, 83} = 24.182$, $P < 0.001$
		total PCBs	$F_{2, 83} = 5.448$, $P = 0.053$
Nest Success (Yes, No)	Wilke's $\lambda = 0.812$ $F_{5, 79} = 3.659$ $P = 0.005$	p,p'-DDE	$F_{1, 83} = 5.120$, $P = 0.801$
		dieldrin *	$F_{1, 83} = 8.566$, $P = 0.003$
		heptachlor epoxide	$F_{1, 83} = 0.054$, $P = 0.814$
		oxychlordane *	$F_{1, 83} = 0.028$, $P = 0.046$
		total PCBs *	$F_{1, 83} = 1.419$, $P = 0.012$
		Arctic subspecies (*F. p. tundrius*)	
Year Group (1979-84, 1988-90, 1991-95)	Wilke's $\lambda = 0.371$ $F_{10, 120} = 7.697$ $P < 0.001$	p,p'-DDE *	$F_{2, 64} = 17.878$, $P < 0.001$
		dieldrin *	$F_{2, 64} = 7.920$, $P = 0.001$
		heptachlor epoxide *	$F_{2, 64} = 15.310$, $P < 0.001$
		oxychlordane *	$F_{2, 64} = 8.695$, $P < 0.001$
		total PCBs *	$F_{2, 64} = 4.312$, $P = 0.018$
Nest Success (Yes, No)	Wilke's $\lambda = 0.861$ $F_{5, 60} = 1.930$ $P = 0.103$	p,p'-DDE	n/a [2]
		dieldrin	n/a
		heptachlor epoxide	n/a
		oxychlordane	n/a
		total PCBs	n/a

[1] Mean values displayed in Fig. 5.

[2] n/a = not applicable due to non-significant multivariate statistic.

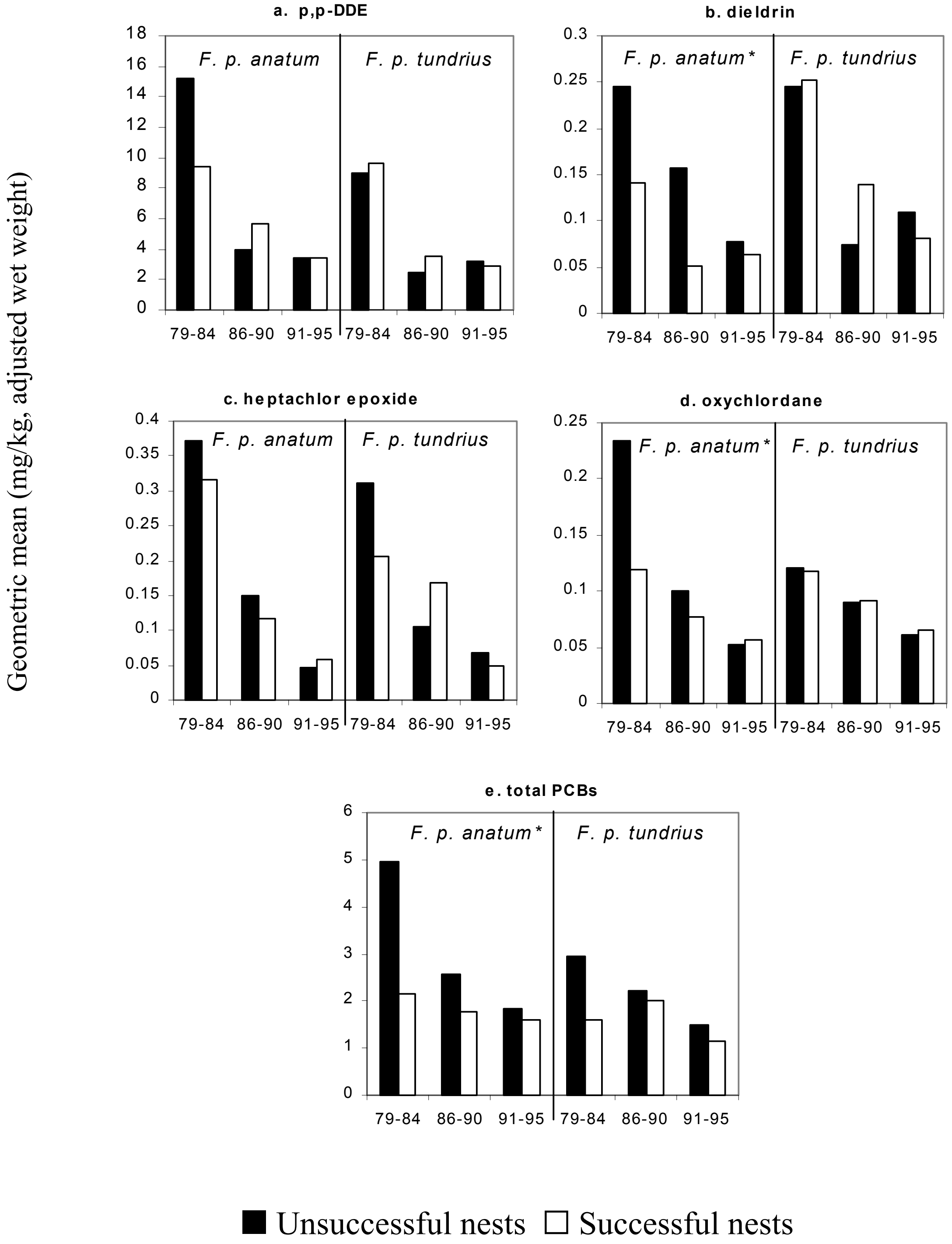

Figure 5. Mean organochlorine (OC) concentrations in American (*F. p. anatum*) and arctic (*F. p. tundrius*) peregrine falcon eggs from successful (≥ 1 chick at banding) and unsuccessful (0 chicks at banding) nests in Alaska, over three time periods. An asterisk following the subspecies label indicates significant differences between eggs from successful and unsuccessful nests (two-way MANOVA with time and success as factors).

Table 7. Results of two-way multivariate ANOVAs that tested whether metal and trace element concentrations differed between peregrine eggs from successful (≥ 1 chick at banding) and unsuccessful (0 chicks at banding) nests in Alaska. Differences between year groups or nest success were indicated by significant multivariate statistics ($P < 0.05$); significant response variables (i.e., those contributing to the significant factor differences) were indicated by significant univariate statistics ($P < 0.05$) and are noted with an asterisk.

Factor (Levels)[1]	Multivariate Statistics	Response Variables	Univariate Statistics
		American subspecies (*Falco peregrinus anatum*)	
Year Group (1988-90, 1991-95)	Wilke's $\lambda = 0.563$ $F_{5,44} = 6.841$ $P < 0.001$	copper *	$F_{1,48} = 18.502$, $P < 0.001$
		iron *	$F_{1,48} = 18.646$, $P < 0.001$
		magnesium	$F_{1,48} = 0.754$, $P = 0.389$
		mercury	$F_{1,48} = 2.130$, $P = 0.151$
		zinc *	$F_{1,48} = 20.448$, $P < 0.001$
Nest Success (Yes, No)	Wilke's $\lambda = 0.689$ $F_{5,44} = 3.963$ $P = 0.005$	copper *	$F_{1,48} = 10.349$, $P = 0.002$
		iron *	$F_{1,48} = 5.932$, $P = 0.019$
		magnesium	$F_{1,48} = 0.179$, $P = 0.674$
		mercury *	$F_{1,48} = 6.498$, $P = 0.014$
		zinc	$F_{1,48} = 2.732$, $P = 0.105$
		Arctic subspecies (*F. p. tundrius*)	
Year Group (1988-90, 1991-95)	Wilke's $\lambda = 0.717$ $F_{5,34} = 2.685$ $P = 0.038$	copper	$F_{1,38} = 0.696$, $P = 0.409$
		iron *	$F_{1,38} = 7.234$, $P = 0.011$
		magnesium	$F_{1,38} = 0.252$, $P = 0.618$
		mercury	$F_{1,38} = 0.299$, $P = 0.588$
		zinc *	$F_{1,38} = 11.798$, $P = 0.001$
Nest Success (Yes, No)	Wilke's $\lambda = 0.920$ $F_{5,34} = 0.592$ $P = 0.706$	copper	n/a [2]
		iron	n/a
		magnesium	n/a
		mercury	n/a
		zinc	n/a

[1] Mean values displayed in Fig. 6.

[2] n/a = not applicable due to non-significant multivariate statistic.

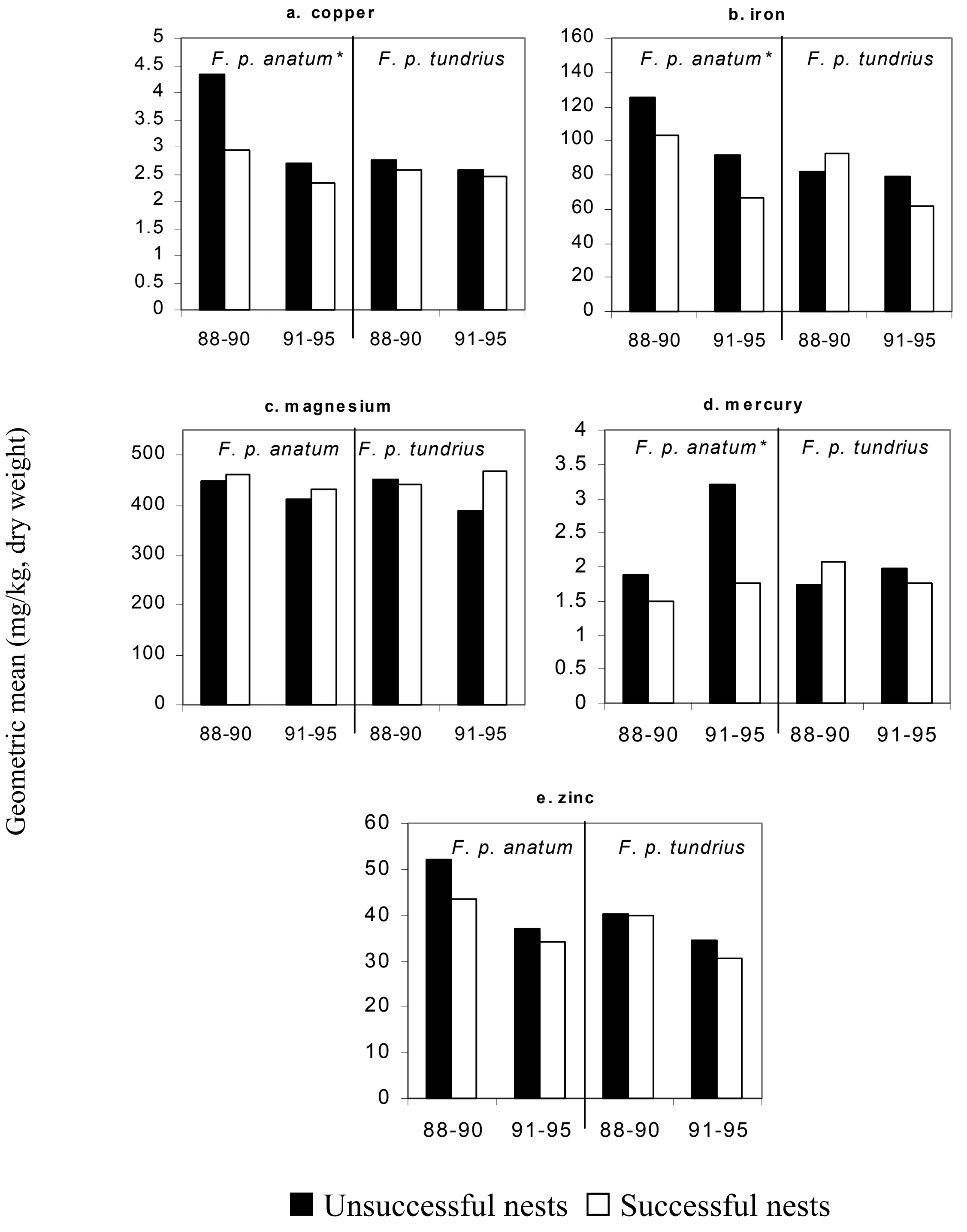

Figure 6. Mean metal and trace element concentrations in American (*F. p. anatum*) and arctic (*F. p. tundrius*) peregrine falcon eggs from successful (≥ 1 chick at banding) and unsuccessful (0 chicks at banding) nests in Alaska, over three time periods. An asterisk following the subspecies label indicates significant differences between eggs from successful and unsuccessful nests (two-way MANOVA with time and success as factors).

Eggshell Thickness

Eggshell thickness was significantly negatively correlated with p,p'-DDE in both subspecies using ANCOVA with year group as a factor and (log)p,p'-DDE as a covariate (*F. p. anatum* p,p'-DDE $F_{1,83} = 7.002$, $P = 0.010$; *F. p. tundrius* p,p'-DDE $F_{1,64} = 5.897$, $P = 0.018$) (Fig. 7a,b). Eggshell thickness was not significantly different between subspecies (ANOVA, $F_{1,153} = 0.275$, $P = 0.601$), between successful and unsuccessful nests for either subspecies (ANOVA, *F. p. anatum* $F_{1,82} = 1.153$, $P = 0.286$; *F. p. tundrius* $F_{1,66} = 3.178$, $P = 0.079$), or between fresh and addled eggs for either subspecies (ANOVA, *F. p. anatum* $F_{1,85} = 0.019$, $P = 0.892$; *F. p. tundrius* $F_{1,66} = 1.203$, $P = 0.277$).

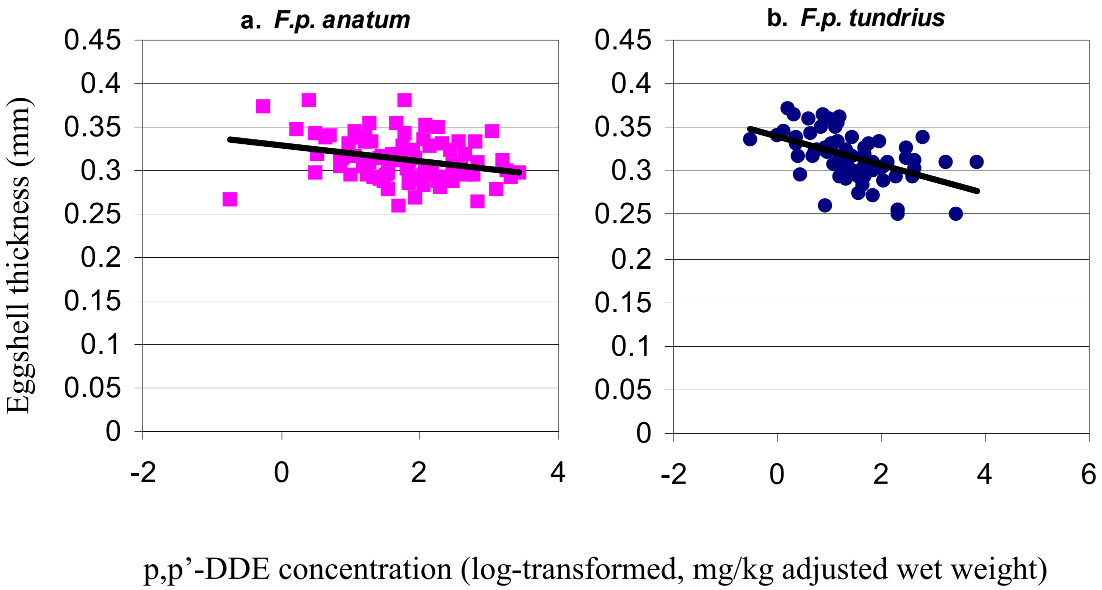

Figure 7. Relationships between eggshell thickness and p,p'-DDE in American (*F. p. anatum*) and arctic (*F. p. tundrius*) peregrine falcon eggs from Alaska, 1979-95. Significant negative correlations were noted for each subspecies (ANCOVA with year as factor and p,p'-DDE as covariate).

Eggshell thickness for both *F. p. anatum* and *F. p. tundrius* increased slightly but not significantly over time (ANCOVA with year group as factor and (log)p,p'-DDE as a covariate, *F. p. anatum* year group $F_{2,83} = 1.173$, $P = 0.315$; *F. p. tundrius* year group $F_{2,64} = 0.206$, $P = 0.814$). Based on a pre-DDT thickness of 0.360 mm for interior and northern Alaska peregrine falcon eggs (Anderson and Hickey 1972), thinning in *F. p. anatum* eggs averaged 13.1% (0.313 mm) in 1979-84 (n=31), 13.9% (0.310 mm) in 1988-90 (n=24), and 11.8% (0.317 mm) in 1991-95 (n=32). Thinning in *F. p. tundrius* eggs averaged 14.4% (0.308 mm) in 1979-84 (n=19), 12.0% (0.317 mm) in 1988-90 (n=29), and 10.6% (0.322 mm) in 1990-95 (n=20) (Fig. 8).

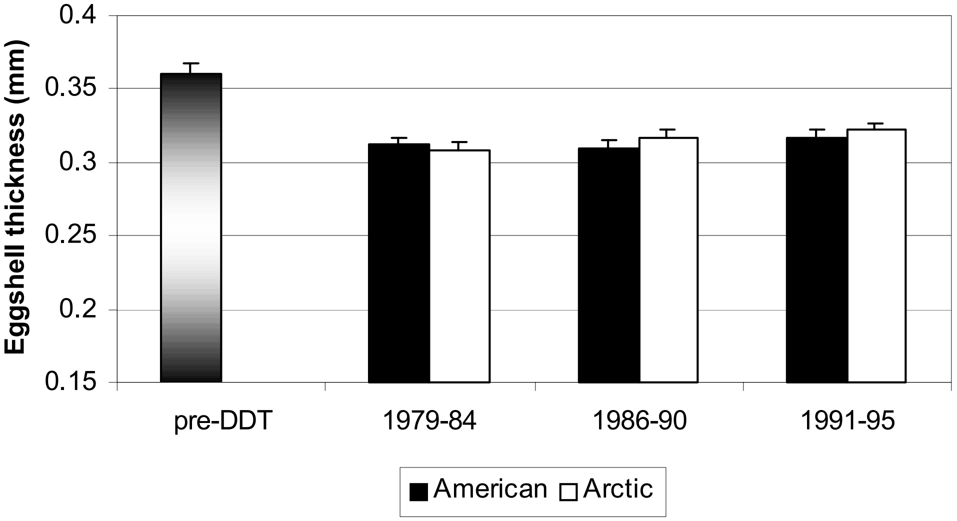

Figure 8. Mean (+ SE) eggshell thickness in American (*F. p. anatum*) and arctic (*F. p. tundrius*) peregrine eggs from Alaska, 1979-95, compared to an estimated pre-DDT era mean (shaded bar) of 0.360 (+ 95% C.I.) mm (Anderson and Hickey 1972).

Known Females

There were 24 eggs from *F. p. anatum* females of known or estimated age, and 9 from *F. p. tundrius* of known or estimated age. There was no statistically significant relationship between female age and contaminant concentrations for either subspecies (non-parametric Spearman rank correlations, all $P > 0.05$). We used a non-parametric analysis because variance was not stabilized with a log-transformation; consequently, this analysis did not account for generally declining concentrations over time or for multivariate responses.

We examined the data for eggs taken from the same females over time, although data are too few to do more than speculate. There were five females sampled twice during the study (2 to 5 years apart), with one of those sampled three times. Although contaminant concentrations varied considerably between females (two-fold in some cases), eggs sampled later in a female's life generally had lower concentrations, following the generally declining contaminant trends of this population. However, not all concentrations declined. For example, p,p'-DDE, diedrin, and heptachlor expoxide decreased in the second egg sampled in five of six comparisons, while oxychlordane and total PCBs decreased in three of six comparisons (Table 8). However, the female sampled three times had declining contaminant concentrations in her second and third eggs compared to her first, but not in her third egg compared to her second, except for total PCBs (Table 8).

Wintering locations for satellite-tagged female peregrines were southeastern Mexico (2), central El Salvador (1), and eastern Brazil (1) (Britten 1998). During the non-breeding months, falcons tended to stay in one location. The two females that wintered in southeastern Mexico were about 4.0 km apart and in the same mangrove habitat. In Central America, the wintering habitat was montane forests; and in eastern Brazil, heath forest. Differences in concentrations of the 10 analytes subjected to statistical analyses were no less in the two eggs of the two females that wintered in the same habitat compared to differences among all four females; there were no clear patterns associated with similar wintering areas. The sample size is very small, however, and more data from known-wintering area females are needed to assess exposure scenarios on the wintering grounds.

Table 8. Environmental contaminant concentrations in American (*Falco peregrinus anatum*) (Females 1-4) and arctic (*F. p. tundrius*) (Female 5) peregrine falcon eggs in Alaska, taken from the same females over time. Decrease or increase indicates whether concentrations were less or greater than concentrations in the egg sampled previously.

			Year			Decrease (↘) or increase (↗)
Female	1984	1988	1989	1990	1991	
			p,p'-DDE [1]			
1	22.330		17.011			↘
2		7.937	6.227		6.381	↘, ↗
3	9.561	8.865				↘
4	21.086		12.583			↘
5				2.870	2.096	↘
			dieldrin [1]			
1	0.240		0.027			↘
2		0.338	0.073		0.127	↘, ↗
3	0.096	0.051				↘
4	0.125		0.039			↘
5				0.312	0.193	↘
			heptachlor epoxide [1]			
1	0.215		0.206			↘
2		0.730	0.356		0.565	↘, ↗
3	0.261	.				↘
4	0.414		0.149			↘
5				0.158	0.029	↘
			oxychlordane [1]			
1	0.103		0.143			↗
2		0.230	0.105		0.125	↘, ↗
3	0.165	0.059				↘
4	0.195		0.157			↘
5				0.100	0.123	↗
			total PCBs [1]			
1	2.147		3.671			↗
2		2.689	1.860		1.318	↘ ,↘
3	1.304	2.572				↗
4	3.124		2.674			↘
5				4.992	2.228	↘
			mercury [2]			
2		1.990	1.060		1.336	↘ , ↗

[1] Adjusted for changes associated with development (Stickel et al. 1973), mg/kg wet weight

[2] mg/kg dry weight

Discussion

Contaminant Concentrations

Time Trends

With a few exceptions, contaminants of concern in eggs from peregrine falcon nesting in Alaska have substantially decreased since North American populations crashed in the 1960's. The downward trend coincides with increases in breeding populations, including those breeding in Alaska (Ambrose et al. 1988b), and with global curtailment of persistent OC use. However, individual variation in egg contaminant concentrations is noteworthy (e.g., Henny et al. 1994), resulting from variation in female body burden at laying. Individual peregrines may still be exposed to high concentrations of OC pesticides on the wintering and breeding grounds, and during migration (Henny et al. 1982, Fyfe et al. 1991, Banasch et al. 1992, Johnstone et al. 1996).

We noted that the downward trend in total PCBs is not as steep as for other OC pesticides tested (p,p'-DDE, dieldrin, heptachlor epoxide, and oxychlordane), which probably reflects relatively more widespread use and contamination. Other peregrine studies have noted that PCB concentrations have not decreased as clearly as OC pesticide concentrations in peregrine eggs (Peakall et al. 1990), if at all (Newton et al. 1989, Johnstone et al. 1996). In other biota, worldwide concentrations of PCBs have not declined to the extent other OC compounds have (Loganathan and Kannan 1994). Although the manufacture, processing, and use (except in closed systems) of PCBs was banned in the U.S. in 1979, PCBs are globally distributed and releases still occur (Eisler and Belisle 1996).

As a top predator, the peregrine remains vulnerable to persistent bioaccumulative contaminants, as indicated by the lack of a decrease or a potential increase (Fig. 2d) in mercury concentrations in eggs. Mercury concentrations have increased in the arctic environment and biota (Jensen et al. 1997), reflecting mobilization of the compound through industrial processes such as mining and waste incineration. The decreases in other metals reflect global decreases in anthropogenic emissions of these elements (AMAP 1998).

Subspecies Differences

Significant differences between subspecies occurred in only two contaminants, p,p'-DDE and dieldrin, which were greater and lower, respectively, in *F. p. anatum* compared to *F. p. tundrius* from 1979-95. These opposite patterns are surprising because concentrations of lipophilic OCs are often positively correlated. Differential exposures, caused by differences in contaminant use patterns in migrating, wintering, or breeding areas, may account for this difference. Band recoveries demonstrate that migration routes and wintering areas of the subspecies overlap, with southward migration across a broad front throughout the middle latitudes, and wintering areas from the southern United States south to Brazil and Argentina (U.S. Fish and Wildlife Service, unpubl. data). However, in Alaska, the subspecies are separated during breeding, with *F. p. anatum* nesting south of the Brooks Range and *F. p. tundrius* nesting north. While OCs do accumulate in migratory birds in wintering areas (Henny et al. 1982, Peakall et al. 1975), the subspecies' similar migration routes and wintering areas contrasted with different breeding areas suggest that differential patterns in p,p-DDE and dieldrin may be a result of exposures after arrival on the breeding grounds. Environmental residues of DDT and other OCs have been associated with human population centers and military lands south of the Brooks Range (Harding Lawson Associates 1997). Although there was also documented DDT use at Umiat in the 1950's by the Navy (Reed 1958), DDE concentrations are no greater in peregrine eggs from Colville River nests downstream from Umiat compared to upstream (two factor ANOVA with year and location on the Colville as factors and p,p'-DDE concentrations as response variable; $F_{1,26} = 0.038$, $P = 0.847$). Differential dieldrin use patterns in the breeding areas are not known.

In addition to pesticide use patterns, differences in breeding area habitats and diets may also explain differences in contaminant concentrations between subspecies. Although both subspecies consume mainly migratory avian prey, dietary studies showed that the boreal-dwelling *F. p. anatum* fed more upon waterfowl and less upon shorebirds than the tundra-dwelling *F. p. tundrius* (Cade et al. 1968, White and Cade 1971). Johnstone et al. (1996) measured OC residues in prey species for *F. p. tundrius* in northern Canada, and found waterfowl, specifically long-tailed ducks (oldsquaws) (*Clangula hyemalis*), to be among the most contaminated. The high proportion of waterfowl in the diet of *F. p. anatum* in Alaska may therefore explain generally greater OC contaminant concentrations in this subspecies. Organochlorine contaminants were measured in Alaska in 1984 in pooled whole-body samples (n = 7 to11) of 20 species of peregrine prey collected in breeding areas of *F. p. tundrius* (Colville River) and *F. p. anatum* (Tanana and Yukon rivers), including passerines (e.g., American robins *Turdus migratorius* and white-crowned sparrows *Zonotrichia leucophrys*) and shorebirds (e.g., spotted sandpipers *Actitus macularia* and American golden plover *Pluvialis dominica*) (U.S. Fish and Wildlife Service, unpubl. data). Although data were too few to analyze statistically, prey from the breeding range of *F. p. anatum* had generally greater DDE concentrations than prey from the breeding range of *F. p. tundrius* (Fig. 9a), which helps explain higher p,p'-DDE concentrations in *F. p. anatum.* However, dieldrin was detected only in shorebirds, and concentrations between the subspecies' prey were comparable, so the greater reliance upon shorebirds by *F. p. tundrius* may account for the greater dieldrin concentrations found in that subspecies (Fig. 9b).

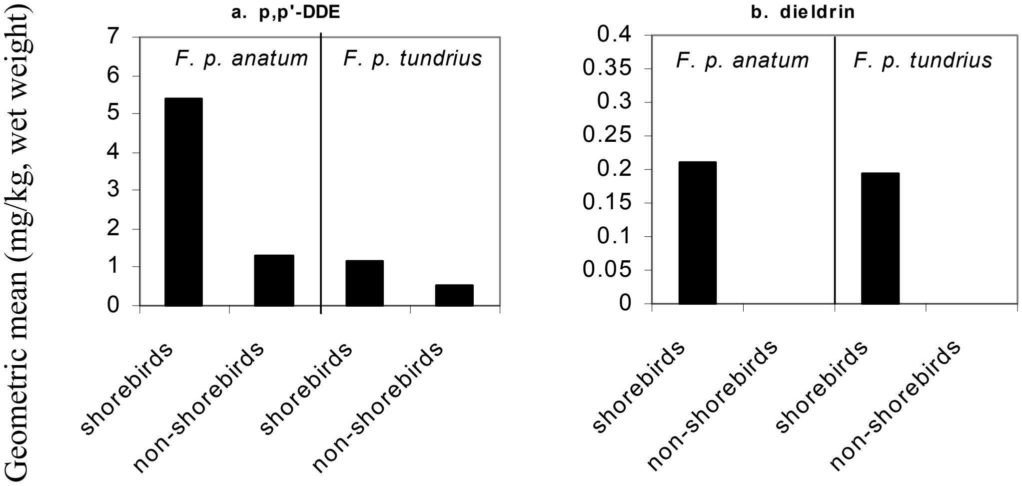

Figure 9. p,p'-DDE and dieldrin concentrations in peregrine falcon prey items collected from the breeding ranges of *Falco peregrinus anatum* (Tanana and Yukon rivers) and of *F. p. tundrius* (Colville River) in Alaska, 1984. Concentrations were measured in whole body (minus feathers, beak, feet, and digestive tract) pooled samples of 7-11 birds/species, and 4-9 species/category (shorebirds and non-shorebirds).

Effects on Breeding Success

We found greater mean concentrations of many contaminants (dieldrin, oxychlordane, total PCBs, copper, iron, and mercury) in *F. p. anatum* eggs from unsuccessful nests compared to eggs from successful nests. Although there were only two statistically significant differences between the subspecies in single contaminants (p,p'-DDE and dieldrin), *F. p. anatum* in general, and especially *F. p. anatum* eggs from unsuccessful nests, routinely had the highest contaminant concentrations (Fig. 5, Fig. 6). The cumulative effects of multiple contaminants may result in diminished success for *F. p. anatum*, therefore, and are indicated by the highly significant multivariate statistics for *F. p. anatum* in this analysis, compared to *F. p. tundrius,* which had no differences in concentrations between successful and unsuccessful nests (Table 6, 8). For all contaminants except mercury, the greatest differences between successful and unsuccessful nests occurred in earlier time periods, thus reflecting decreasing contaminant effects over time (Fig. 5b, d, and e; Fig. 6a, b). For mercury, however, the difference between unsuccessful and successful nests may be increasing with time (Fig. 6d). There were differences in some metals, but the patterns were not consistent and merit further investigation.

Mercury concentrations were significantly greater in eggs from unsuccessful *F. p. anatum* nests, and did not decline during our study (1988-95). Further, mercury was the only contaminant of concern that exceeded published thresholds for reproductive impairment in the most recent time period (1991-95), and had increasing percentages of threshold exceedances over time. Because mercury is toxic, persistent, and increasing in biota worldwide, it will continue to be a contaminant of concern for peregrine falcons in Alaska.

While only one contaminant exceeded published effect levels or thresholds for individual contaminants, multivariate analysis associated contaminant concentrations with lowered nest success. Strict utilization of threshold values is relatively ineffective in detecting effects of multiple, sometimes correlated, toxic contaminants on productivity or other population parameters. Further, it may be impossible to derive strict thresholds or effect levels when multiple contaminants are involved. Multivariate analysis can identify cumulative contaminant effects on population parameters; thresholds are useful to identify or corroborate whether particular contaminants are of concern. Both methods should be used, whenever possible, to study effects of environmental contaminants in avian populations.

Eggshell Thickness

Following trends identified in Ambrose et al. (1988a), eggshell thickness increased slightly, though not significantly, and p,p'-DDE concentrations in eggs declined significantly over time. Further, eggshell thinning was below the critical thresholds of 17% (Peakall and Kiff 1988) or 18% (Hickey and Anderson 1968) associated with peregrine population declines. However, peregrine eggshells were still thinner by 10-12% in 1991-95 compared to pre-DDT era eggs, reflecting the continued presence of p,p'-DDE and the parent compound DDT in peregrine eggs. The significant decrease in DDE but a non-significant increase in eggshell thickness corresponds with the concept of a semi-logarithmic relationship between DDE concentrations and eggshell thickness (Henny et al. 1984).

Eggshell thickness in our study was not related to time of collection (addled or fresh) or nest success, in contrast to *F. p. tundrius* at Rankin Inlet, Northwest Territories, Canada, which had differences in thickness between addled eggs collected from 1981-85 and "storm-killed" (presumably non-addled) eggs collected in 1986, and significantly lower eggshell thickness at failed compared to successful nests from 1981-86 (Court et al. 1990). During the same time (1979-84 for Alaska, 1981-86 for Rankin Inlet), average eggshell thickness and geometric mean p,p'-DDE concentrations were similar (14% of pre-1947 thickness, and 9.3 mg/kg, adjusted ww for Alaska *F. p. tundrius*; 16% of pre-1947 thickness, and 7.59 mg/kg, ww for Rankin Inlet). However, conclusions of no difference in our study were based on a longer overall time span (1979-95), and we collected fresh eggs only after p,p'-DDE concentrations decreased significantly (Fig. 1). Because OC concentrations tend to be correlated in egg contents (Court et al. 1990), in early years with relatively high p,p'-DDE and other OC contaminant concentrations, thinner eggshells may have been found in addled eggs. The cumulative effects of the entire suite of contaminants may be important, since Court et al. (1990) found no difference in p,p'-DDE concentrations (as opposed to eggshell thickness) between addled and "storm-killed" eggs.

Known Females

We found no significant relationships between female age and contaminant concentration or eggshell thickness. Burnham et al. (1984) also found that eggshell thickness (for the first clutch in a breeding year) did not change with age of female. We did find, however, that concentrations in the eggs of the five females sampled twice in our study followed the general downward trend of the population, although with considerable individual variation. Jarman et al. (1994), using plasma, also reported considerable variation in DDT and PCB concentrations among females, but did not detect any clear time trends with respect to residues, either for individuals sampled twice or for the population as a whole for the period 1984-89 (a shorter time period than our study). Our data from females with known wintering locations, although sparse, further indicate that there is high individual variation among females. Combined with low intra-clutch variation, this suggests that the appropriate sample unit is the female or nest, rather than the egg.

Recommendations for Contaminant Monitoring

The primary cause of the decline of peregrine falcons was the use of organochlorine pesticides, and other environmental contaminants have the potential to negatively influence this species. Therefore, we recommend that population monitoring programs for this species include contaminant monitoring. Early detection and trend monitoring for harmful contaminants may help prevent drastic declines such as those witnessed in the 1950s and 1960s. The mercury trends we observed in peregrines in Alaska speak for monitoring new and emerging contaminants of concern, since peregrines as top predators remain vulnerable to persistent and bioaccumulative compounds. Organo-mercury, not total mercury, should be analyzed since toxic effects are generally associated with those bioavailable compounds. Additionally, measurement of PCB congeners rather than, or in addition to, total PCBs will delineate the toxic effects of PCBs.

Given that intra-clutch variation was much less than inter-clutch variation in this study and others (e.g., Newton et al. 1989), we recommend that contaminant monitoring programs include samples from several different females rather than whole clutches from few females. Identical methodology for eggshell thickness measurements, such as minimizing use of fragments, will standardize monitoring of this contaminant effect. Both the interval of egg collection and the number of eggs collected will depend upon specific contamination or population viability issues within populations or regions. For Alaska, a 3- to 5-year monitoring interval, which in this study showed significant decreases in contaminant concentrations, should provide cost-effective monitoring of identified contaminant threats while allowing timely assessment of new threats, such as mercury. Other regions may require more frequent monitoring. Power analysis, using estimates of variation from recent contaminant data, can suggest appropriate sample sizes.

A major issue for contaminant monitoring using avian eggs is whether to collect fresh, potentially viable eggs during incubation or to wait and collect addled eggs, usually during banding nest visits (note that the distinction between "fresh" and "addled" may be arbitrary, because at the time of collection it is unknown whether a fresh egg will fail to hatch). If there is no discernible effect on productivity, and if contaminant concentrations in fresh and addled eggs are similar, collection of fresh eggs is desirable from a monitoring viewpoint because adequate sample size can be assured, and known females or territories can be targeted. To address the concern of potential effects on productivity, we compared the number of chicks per pair (at banding) between nests where fresh eggs were taken and all other nests (including those with addled eggs) from 1984, 1989, and 1995, and found no significant difference (Table 9). To account for any bias associated with not collecting fresh eggs from nests with only one or two eggs, which may have occurred for *F. p. tundrius* in some years, we also compared percent of eggs resulting in fledglings between nests where fresh eggs were taken and all other nests, in 1984, 1989, and 1995 (for the subset of nests with clutch size data), and again found no significant difference (Table 10).

Table 9. Productivity (mean chicks per pair) of peregrine falcons from Alaska at nests with a fresh egg taken for contaminants analysis compared to productivity at nests with no fresh egg taken. There was no significant difference in productivity (Mann-Whitney U-test). Standard errors are presented for comparison purposes only. Subspecies were analyzed separately.

	Mean (SE) number of chicks at banding	U statistic P-value
American subspecies *(F. p. anatum*)		
Nests with fresh egg removed (n = 22)	2.0 (0.2)	U = 1292.0 P = 0.453
Other nests (n = 130)	1.7 (0.1)	
Arctic subspecies *(F. p. tundrius*)		
Nests with fresh egg removed (n = 24)	1.7 (0.2)	U = 1133.5 P = 0.133
Other nests (n = 116)	1.3 (0.1)	

Table 10. Average percent of eggs per nest resulting in fledglings from peregrine falcon nests with a fresh egg taken for contaminants analysis compared to nests with no fresh egg taken, from Alaska. There was no significant difference in the percent of eggs per nest resulting in fledglings (Mann-Whitney U-test). Subspecies were analyzed separately.

	Average percent of eggs resulting in fledglings	U statistic P-value
American subspecies *(F. p. anatum*)		
Nests with fresh egg removed (n = 22)	54.5	U = 169.5 P = 0.424
Other nests (n = 18)	40.3	
Arctic subspecies *(F. p. tundrius*)		
Nests with fresh egg removed (n = 24)	43.9	U = 337.5 P = 0.792
Other nests (n = 32)	41.9	

Collection of addled eggs only might result in upwardly biased contaminant estimates for a population, which can be viewed as either highly or overly protective. However, we found no differences between fresh and addled peregrine eggs in OC concentrations, similar to Court et al. (1990), comparing DDE in addled and "storm-killed" eggs, and Peakall et al. (1990) reviewing peregrine contaminants data from Canada, 1965-87. We found significantly lower iron and zinc concentrations in addled eggs, indicating that excess metals were not associated with hatch failure, and the toxicological importance of greater magnesium concentrations in addled *F. p. anatum* eggs is unknown. Magnesium, iron, and zinc are all essential elements, so they would be expected to be closely regulated in egg contents, although females can reduce toxic levels of essential elements into eggs (Eisler 1993) or eggshells (Dauwe et al. 1999). Dauwe et al. (1999), however, did not find differences in zinc and copper in passerine eggs from polluted and reference sites, "...indicating that copper and zinc concentrations are homeostatically controlled in the egg content" (Dauwe et al. 1999:445).

Since we found no decrease in productivity associated with removal of a fresh egg and found few differences in contaminant concentrations between fresh and addled eggs, we conclude that either sample type is adequate for general contaminant monitoring in peregrine falcons. Fresh eggs may be desirable since the uncertainty associated with finding and collecting fresh eggs is less than that of collecting addled eggs. However, addled egg collection may be desirable for populations where collection of even one fresh egg that might have hatched would result in unacceptably reduced productivity, and addled eggs may have greater contaminant concentrations in populations severely affected by embryotoxic contamination (Peakall et al. 1990, Henny et al. 1994). We also suggest that description of embryo development should be routinely performed on all eggs taken, regardless of the timing, to gain more accurate information about contaminant effects on egg viability.

LITERATURE CITED

AMAP. 1998. AMAP Assessment Report: Arctic Pollution Issues. Arctic Monitoring and Assessment Program (AMAP), Oslo, Norway. 859 pp.

Ambrose, R.E. and K.E. Riddle. 1988. Population dispersal, turnover, and migration of Alaska peregrines. Pages 677-684 *in*: T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White (eds). Peregrine Falcon Populations: Their Management and Recovery. Proceedings of the 1985 International Peregrine Conference. The Peregrine Fund, Inc., Boise, ID.

Ambrose, R. E., C. J. Henny, R. E. Hunter, and J. A. Crawford. 1988a. Organochlorines in Alaskan peregrine falcon eggs and their current impact on productivity. Pages 385-393 *in*: T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White (eds). Peregrine Falcon Populations: Their Management and Recovery. Proceedings of the 1985 International Peregrine Conference. The Peregrine Fund, Inc., Boise, ID.

Ambrose, R. E., R. J. Ritchie, C. M. White, P. F. Schempf, T. Swem, and R. Dittrick. 1988b. Changes in the status of peregrine falcon populations in Alaska. Pages 73-82 *in*: T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White (eds). Peregrine Falcon Populations: Their Management and Recovery. Proceedings of the 1985 International Peregrine Conference. The Peregrine Fund, Inc., Boise, ID.

Anderson, D.W. and J.J. Hickey. 1972. Eggshell changes in certain North American birds. Pages 514-540 *in*: K.H. Voous (ed.). Proc. XVth Int. Ornithol. Congr., The Hague.

Banasch, U, J. P. Goossen, A.E. Riez, C. Casler, and R.D. Barradas. 1992. Organochlorine contaminants in migrant and resident prey of peregrine falcons, *Falco peregrinus*, in Panama, Venezuela, and Mexico. Can. Field-Nat. 106:493-498.

Blus, L.J., C.J. Henny, D.J. Hoffman, and R.A. Grove. 1991. Lead toxicosis in tundra swans near a mining and smelting complex in northern Idaho. Arch. Environ. Contam. Toxicol. 21:549-555.

Bowerman, W.W., J.P. Giesy, D.A. Best and V.J. Kramer. 1995. A review of factors affecting productivity of bald eagles in the Great Lakes region: Implications for recovery. Environ. Health Perspect. 103:51-59.

Britten, M. W. 1998. Migration routes and non-breeding areas of sub-arctic and temperate latitude breeding populations of peregrine falcons. M. S. thesis, Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, CO. 114 pp.

Burnham, W.A., J.H. Enderson, and T.J. Boardman. 1984. Variation in peregrine falcon eggs. Auk 101:578-583.

Cade, T. J., C. M. White, and J. R. Haugh. 1968. Peregrines and pesticides in Alaska. Condor 70:170-178.

Cade, T. J., J. L. Lincer, C.M. White, D. G. Roseneau, and L.G. Swartz. 1971. DDE residues and eggshell changes in Alaskan falcons and hawks. Science 172:955-957.

Court, G. S., C. C. Gates, D. A. Boag, J. D. MacNeil, D. M. Bradley, A. C. Fesser, J. R. Patterson, G. B. Stenhouse, and L. W. Oliphant. 1990. A toxicological assessment of peregrine falcons, *Falco peregrinus tundrius*, breeding in the Keewatin District of the Northwest Territories, Canada. Can. Field-Nat. 104:255-272.

Dauwe, T., L. Bervoets, R. Blust, R. Pinxten, and M. Eens. 1999. Are eggshells and egg contents of great and blue tits suitable as indicators of heavy metal pollution? Belg. J. Zool. 129:439-447.

Eisler, R. 1987. Mercury hazards to fish, wildlife and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 85(1.10), Contaminant Hazard Reviews Rep. No. 10. 90 pp.

Eisler, R. 1993. Zinc hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 10, Contaminant Hazard Reviews Rep. No. 26. 106 pp.

Eisler, R. and A.A. Belisle. 1996. Planar PCB hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 31, Contaminant Hazard Reviews Rep. No. 31. 75 pp.

Fyfe, R.W., U. Banasch, V. Benavides, N.H. de Benevides, A. Luscombe, and J. Sanchez. 1991. Organochlorine residues in potential prey of peregrine falcons, *Falco peregrinus*, in Latin America. Can. Field-Nat. 104:285-292.

Gibbons, R. D. 1994. Statistical Methods for Groundwater Monitoring. John Wiley & Sons, New York, NY. 286 pp.

Harding Lawson Associates. 1997. Postwide risk assessment, Fort Wainwright, Alaska. Prepared for U.S. Army Corps of Engineers, Alaska District, Anchorage, AK.

Heinz, G.H. 1996. Selenium in birds. Pages 447-458 *in*: W.N Beyer, G.H. Heinz, and A. W. Redmon-Norwood (eds). Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations. CRC Press, Boca Raton, FL. 494 pp.

Henny, C.J., F. P. Ward, K.E. Riddle, and R.M. Prouty. 1982. Migratory peregrine falcons, *Falco peregrinus*, accumulate pesticides in Latin America during winter. Can. Field-Nat. 96:333-338.

Henny, C.J., L. J. Blus, and C.J. Stafford. 1983. Effects of heptachlor on American kestrels in the Columbia Basin, Oregon. J. Wildl. Manage. 47:1080-1087.

Henny, C.J., A. J. Krynitsky, and C. M. Bunck. 1984. Current impact of DDE on black-crowned night-herons in the intermountain west. J. Wildl. Manage. 48:1-13.

Henny, C.J., S.A. Ganusevich, F. P. Ward, and T.R. Schwartz. 1994. Organochlorine pesticides, chlorinated dioxins and furans, and PCBs in peregrine falcon *Falco peregrinus* eggs from the Kola Peninsula, Russia. Pages 739-750 *in*: B.-U. Meyburg and R.D. Chancellor (eds). Raptor Conservation Today. World Working Group on Birds of Prey and Owls, London.

Hickey, J. J. and D. W. Anderson. 1968. Chlorinated hydrocarbons and eggshell changes in raptorial and fish-eating birds. Science 162:271-273.

Hoffman, D.J., B.A. Rattner, G.A. Burton, Jr., and J. Cairns, Jr. 1995. Handbook of Ecotoxicology. CRC Press, Boca Raton, FL. 755 pp.

Hoffman, D.J., C.P. Rice, and T.J. Kubiak. 1996. PCBs and dioxins in birds. Pages 165-208 *in*: W.N Beyer, G.H. Heinz, and A. W. Redmon-Norwood (eds). Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations. CRC Press, Boca Raton, FL. 494 pp.

Jarman, W.M, S.A. Burns, W.G. Mattox, and W.S. Seegar. 1994. Organochlorine compounds in the plasma of peregrine falcons and gyrfalcons nesting in Greenland. Arctic 47:334-340.

Jensen, J., D. Adare, and R. Shearer, eds. 1997. Canadian Arctic Contaminants Assessment Report. Indian and Northern Affairs Canada. Ottawa, Canada. 460 pp.

Johnstone, R.M., G.S. Court, A.C. Fesser, D. M. Bradley, L.W. Oliphant, and J. D. MacNeil. 1996. Long-term trends and sources of organochlorine contamination in Canadian tundra peregrine falcons, *Falco peregrinus tundrius*. Environ. Pollut. 93:109-120.

Lockhart, W.L., P. Wilkinson, B.N. Billeck, R.V. Hunt, R. Wagemann, and G.J. Brunskill. 1995. Current and historical inputs of mercury to high-latitude lakes in Canada and to Hudson Bay. Water, Air, and Soil Pollut. 80:603-610.

Loganathan, B.G. and K. Kannan. 1994. Global organochlorine trends: An overview. Ambio 23:187-191.

Newton, I., J.A. Bogan, and M.B. Haas. 1989. Organchlorines and mercury in the eggs of British peregrines *Falco peregrinus*. Ibis 131:355-376.

Peakall, D. B. and L. F. Kiff. 1988. DDE contamination in Peregrines and American Kestrels and its effects on reproduction. Pages 337-350 *in*: T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White (eds). Peregrine Falcon Populations: Their Management and Recovery. Proceedings of the 1985 International Peregrine Conference. The Peregrine Fund, Inc., Boise, ID.

Peakall, D. B., T. J. Cade, C. M. White, and J. R. Haugh. 1975. Organochlorine residues in Alaskan Peregrines. Pesticide Monitor. J. 8:255-260.

Peakall, D. B., D. G. Noble, J. E. Elliott, J. D. Somers, and G. Erickson. 1990. Environmental contaminants in Canadian peregrine falcons, *Falco peregrinus*: A toxicological assessment. Can. Field-Nat. 104:244-254.

Ratcliffe, D. A. 1970. Changes attributable to pesticides in egg breakage frequency and eggshell thickness in some British birds. J. Appl. Ecol. 7:67-115.

Reed, J.C. 1958. Exploration of Naval Petroleum Reserve No. 4 and adjacent areas, northern Alaska, 1944-53. Part I, history of the exploration. Geological Survey Professional Paper 301, U.S. Dept. of the Interior. 192 pp.

Schmitt, C.J and C.M. Bunck. 1995. Persistent environmental contaminants in fish and wildlife. Pages 413-416 *in*: E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac (eds). Our

Living Resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. Dept. of the Interior, National Biological Service, Washington, DC. 530 pp.

Sparks, T.H., W.A. Scott, and R.T. Clarke. 1999. Traditional multivariate techniques: Potential for use in ecotoxicology. Environ. Toxicol. Chem. 18:128-137.

SPSS, Inc. 1998. SYSTAT 8.0 Statistics. SPSS, Inc., Chicago, IL. 1086 pp.

Stickel, L. F., S. N. Wiemeyer, and L. J. Blus. 1973. Pesticide residues in eggs of wild birds: adjustment for loss of moisture and lipid. Bull. Environ. Contam. Toxicol. 9:193-196.

Thompson, D.R. 1996. Mercury in birds and terrestrial animals. Pages 341-356 *in*: W.N Beyer, G.H. Heinz, and A. W. Redmon-Norwood (eds). Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations. CRC Press, Boca Raton, FL. 494 pp.

Weis, I.M. and D.C.G. Muir. 1997. Geographical variation of persistent organochlorine concentrations in blubber of ringed seal (*Phoca hispida*) from the Canadian Arctic: Univariate and multivariate approaches. Environ. Pollut. 96:321-333.

White, C. M. 1968. Diagnosis and relationships of the North American tundra-inhabiting Peregrine Falcons. Auk 85:179-191.

White, C.M. and T. J. Cade. 1971. Cliff-nesting raptors and ravens along the Colville River in Arctic Alaska. Living Bird 10:107-150.

Wiemeyer, S.N. 1996. Other organochlorine pesticides in birds. Pages 99-116 *in*: W.N Beyer, G.H. Heinz, and A. W. Redmon-Norwood (eds). Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations. CRC Press, Boca Raton, FL. 494 pp.

Wiemeyer, S.N, C.M. Bunck, and C.J. Stafford. 1993. Environmental contaminants in bald eagle eggs - 1980-84 - and further interpretations of relationships to productivity and shell thickness. Arch. Environ. Contam. Toxicol. 24:213-227.

World Wildlife Fund. 1998. Global 200 Ecoregions: A representation approach to conserving the earth's distinctive ecoregions. World Wildlife Fund, Washington, DC. 152 pp.

Appendix A. Nominal detection limits for environmental contaminants analyzed in peregrine falcon eggs from Alaska, 1979-95. Blank cells indicate that the contaminant was not analyzed or failed QA/QC for that year. Year corresponds to year(s) of collection; separate columns represent separate analytical chemistry submissions.

	Year									
Organochlorines (mg/kg, ww)	1979	1980	1982	1983	1984	1988	1989	1990	1991	1993-95
Aldrin						0.05				0.0009
alpha-BHC						0.05	0.01	0.01	0.01	0.0009
beta-BHC	0.05					0.05	0.01	0.01	0.01	0.0009
delta-BHC						0.05	0.01	0.01	0.01	0.0009
gamma-BHC						0.05	0.01	0.01	0.01	0.0009
alpha-chlordane	0.05	0.05	0.1	0.1	0.1	0.05	0.01	0.01	0.01	0.0009
gamma-chlordane						0.05	0.01	0.01	0.01	0.0009
cis-nonachlor	0.05	0.05	0.1	0.1	0.1	0.05	0.01	0.01		0.0009
p,p’-DDD	0.05	0.05	0.1	0.1	0.1	0.05	0.01	0.01	0.01	0.0009
p,p’-DDE	0.05	0.05	0.1	0.1	0.1	0.05	0.01	0.01	0.01	0.0009
p,p’-DDT	0.05	0.05	0.1	0.1	0.1	0.05	0.01	0.01	0.01	0.0009
o,p’-DDD						0.05	0.01	0.01	0.01	0.0009
o,p’-DDE						0.05	0.01	0.01	0.01	0.0009
o,p’-DDT						0.05	0.01	0.01	0.01	0.0009
Dieldrin	0.05	0.05	0.1	0.1	0.1	0.05	0.01	0.01	0.01	0.0009
Endosulfan II										0.002
Endrin	0.05	0.05	0.1	0.1	0.1	0.05	0.01	0.01	0.01	0.0009
HCB	0.05	0.05				0.05	0.01	0.01	0.01	0.0009
heptachlor						0.05				0.0009
heptachlor epoxide	0.05	0.05	0.1	0.1	0.1	0.05	0.01	0.01	0.01	0.0009
Mirex	0.05	0.05				0.05	0.01	0.01	0.01	0.0009
oxychlordane	0.05	0.05	0.1	0.1	0.1	0.05	0.01	0.01	0.01	0.0009
total PCBs	0.05	0.05	0.5	0.5	0.5	0.5	0.05	0.05	0.1	0.009
trans-nonachlor		0.05	0.1	0.1	0.1	0.05	0.01	0.01	0.01	0.0009

(Appendix A cont.)

Metals and Trace Elements (mg/kg, dw)	Year 1988	1989	1991	1993-95
Aluminum (Al)	11.4	2	5.5	5
Antimony (Sb)	11.4	3.5		
Arsenic (As)		0.3	0.56	
Barium (Ba)	5.68	0.1	1.11	1
Beryllium (Be)	0.57	0.03	0.11	0.1
Boron (B)	5.68	0.5	2.2	5
Cadmium (Cd)	0.57	0.1	0.33	0.1
Chromium (Cr)	4.96	0.9	0.55	0.5
Cobalt (Co)		0.5		
Copper (Cu)	3.38	0.4	0.56	0.5
Iron (Fe)	11.34	5	5.56	5
Magnesium (Mg)	11.34	5	5.56	5
Lead (Pb)	3.41	0.1		0.5
Manganese (Mn)	1.4	0.3	0.55	1
Mercury (Hg)	0.147	0.02	0.139	0.05
Molybdenum (Mo)	5.68	1	2.2	2
Nickel (Ni)	4.54	0.6	0.66	0.5
Silver (Ag)	5.68	4		
Selenium (Se)		0.3		0.5
Strontium (Sr)	1.14	0.3	0.28	0.5
Thallium (Tl)	22.7			
Tin (Sn)	5.68	5		
Vanadium (V)	5.68	0.3	0.28	0.5
Zinc (Zn)	2.29	1	1.11	1

Appendix B. Summary statistics for environmental contaminants detected in > 90% of peregrine falcon eggs from Alaska. Organochlorines were measured from 1979 - 95, adjusted for changes associated with development (Stickel et al. 1973), and presented in mg/kg wet weight. Metals data were measured from 1988-95, were not adjusted, and presented in mg/kg dry weight. Geometric means were calculated with data less than the lower limit of detection substituted at half the detection limit. Detection limits varied depending upon the year of sampling (Appendix A).

	Geometric mean (range) Percent of detections					
	American peregrine falcon (*F. p. anatum*)			Arctic peregrine falcon (*F. p. tundrius*)		
Analyte	1979-84 (n=31)	1988-90 (n=26)	1991-95 (n=32)	1970-84 (n=19)	1988-90 (n=29)	1991-95 (n=20)
p,p'-DDE	10.7 (4.3 - 30.7) 100	5.03 (1.69 - 17.01) 100	3.41 (0.48 - 14.12) 100	9.4 (1.5 - 46.4) 100	3.17 (0.61 - 10.31) 100	3.04 (1.23 - 13.27) 100
dieldrin	0.2 (nd[1] - 0.7) 93.5	0.08 (0.013 - 1.187) 100	0.07 (0.01 - 0.36) 100	0.3 (nd - 1.7) 94.7	0.11 (0.02 - 0.57) 100	0.10 (0.02 - 0.32) 100
heptachlor epoxide	0.3 (nd - 3.3) 96.8	0.13 (nd - 0.73) 96.2	0.05 (0.01 - 0.57) 100	0.3 (nd - 1.9) 94.7	0.15 (nd - 0.88) 100	0.06 (0.02 - 0.16) 100
oxy-chlordane	0.1 (nd - 1.0) 93.5	0.08 (0.03 - 0.33) 100	0.05 (0.02 - 0.13) 100	0.1 (0.03 - 0.3) 100	0.09 (0.04 - 0.20) 100	0.06 (0.02 - 0.14) 100
total PCBs	2.7 (0.8 - 28.0) 100	2.0 (0.7 - 15.0) 100	1.6 (0.4 - 8.5) 100	2.1 (0.6 - 6.3) 100	2.1 (0.7 - 14.8) 100	1.3 (0.6 - 6.0) 100

[1] nd = not detected.

Appendix B (cont.)

	Geometric mean (range) Percent of detections			
	American peregrine falcon (*F. p. anatum*)		Arctic peregrine falcon (*F. p. tundrius*)	
Analyte	1988-90 (n=22)	1991-95 (n=31)	1988-90 (n=23)	1991-95 (n=19)
copper	3.2	2.4	2.6	2.5
	(1.7 - 6.8)	(1.8 - 3.7)	(1.5 - 4.3)	(1.7 - 4.0)
	95.5	100	95.7	100
iron	109	72	89	70
	(67 - 207)	(36 - 174)	(42 - 140)	(28 - 163)
	100	100	100	100
magnesium [2]	457.6	434.4	443.5	424.0
	(272.9 - 688.8)	(198.3 - 884.8)	(335.0 - 601.0)	(165.9 - 601.8)
	100	100	100	100
mercury [3]	1.61	1.96	1.95	1.88
	(0.82 - 4.04)	(0.48 - 9.58)	(0.91 - 7.69)	(1.20 - 3.12)
	100	100	100	100
zinc	46	35	40	33
	(31 - 90)	(24 - 66)	(25 - 79)	(22 - 44)
	100	100	100	100

[1] nd = not detected.

[2] n = 21 for American subspecies, 1988-90

[3] n = 33 for American and 20 for Arctic subspecies, 1991 - 95

Appendix C. Summary statistics for environmental contaminants detected in > 50% but < 90% of peregrine falcon eggs from Alaska, 1988-95. Organochlorines were adjusted for changes associated with development (Stickel et al. 1973), and presented in mg/kg wet weight. Metals data were not adjusted, and presented in mg/kg dry weight. Geometric means were calculated with data less than the lower limit of detection substituted at half the detection limit.

	Geometric mean (range) Percent of detections (number detected/number analyzed)	
Analyte	American peregrine falcon (*F. p. anatum*)	Arctic peregrine falcon (*F. p. tundrius*)
beta-BHC	0.03 (nd [1] - 0.39) 81.0 (47/58)	0.03 (nd - 0.50) 81.6 (40/49)
p,p'-DDD	0.02 (nd - 0.43) 62.1 (36/58)	0.02 (nd - 2.58) 51.0 (25/49)
p,p'-DDT	0.02 (nd - 0.30) 62.1 (36/58)	0.02 (nd - 0.35) 51.0 (25/49)
HCB	0.03 (nd - 1.02) 72.4 (42/58)	0.02 (nd - 1.28) 77.6 (38/49)
Mirex	0.13 (0.02 - 0.54) 100 (58/58)	0.13 (0.03 - 0.53) 100 (49/49)
trans-nonachlor	0.02 (nd - 0.21) 84.5 (49/58)	0.03 (nd - 0.13) 93.9 (46/49)
Mangenese	0.8 (nd - 3.7) 69.8 (37/53)	0.8 (nd - 2.9) 69.0 (29/42)
Selenium	2.5 (0.8 - 4.5) 100 (37/37)	2.3 (1.6 - 2.9) 100 (32/32)
Strontium	0.7 (nd - 2.7) 73.6 (39/53)	0.9 (nd - 2.8) 88.1 (37/42)
Tin	9.2 (nd - 15.0) 85.7 (6/7)	4.7 (nd - 10.8) 50.0 (2/4)

[1] nd = Not detected at detection limit of 0.01 mg/kg wet weight for organochlorines; and 0.55, 0.3, 0.5, and 5.0 mg/kg dry weight for manganese, selenium, strontium, and tin, respectively.

Appendix D. Percent detections for analytes detected in < 50% of peregrine egg samples from Alaska, 1988-95. Detection limit for OCs was 0.01 mg/kg wet weight and metal detection limits were the highest of the variable detection limits for these years (Appendix A).

	Percent of Detections (number detected/number analyzed)	
Analyte	American subspecies *(F. p. anatum)*	Arctic subspecies *(F. p. tundrius)*
alpha-BHC	1.7 (1/58)	0.0 (0/49)
gamma-BHC	1.7 (1/58)	0.0 (0/49)
alpha-chlordane	0.0 (0/58)	4.1 (2/49)
gamma-chlordane	3.4 (2/58)	0.0 (0/49)
o,p’-DDD	13.8 (8/58)	8.2 (4/49)
o,p’-DDE	1.7 (1/58)	0.0 (0/49)
o,p’-DDT	19.0 (11/58)	16.3 (8/49)
endosulfan II	0.0 (0/21)	0.0 (0/13)
endrin	0.0 (0/58)	4.1 (2/49)
Aluminum	15.8 (6/38)	21.7(5/23)
Barium	3.8 (2/53)	4.8(2/42)
Beryllium	0.0 (0/53)	4.8(2/42)
Boron	18.9 (10/53)	26.2(11/42)
Cadmium	1.9 (1/53)	2.4(1/42)
Chromium	15.1 (8/53)	4.8(2/42)
Lead	0.0 (0/44)	2.8(1/36)
Molybdenum	1.9 (1/53)	2.4(1/42)
Nickel	13.2 (7/53)	9.5(4/42)
Vanadium	1.9 (1/53)	0.0(0/42)

Appendix E. Individual sample data for environmental contaminants measured peregrine falcon eggs from Alaska, 1979-95. Organochlorines adjusted for changes associated with development (Stickel et al. 1973), and presented in mg/kg wet weight. Metals data were not adjusted, and presented in mg/kg dry weight. Not all analytes were measured in all years, and detection limits varied depending upon the year (Appendix A). Sample ID's ending in "z" denotes an average value of multiple eggs; all other data are from individual eggs.

Sample ID	Sample Location	Subspecies	Year	% Lipid	Aldrin	alpha-BHC	beta-BHC	delta-BHC	gamma-BHC	alpha-chlordane	gamma-chlordane
79PR056AIE	PORC56.5	American [1]	1979	4.40	NA [3]	NA	ND	NA	NA	ND	NA
79SR194ZIE	SAGA194.0	Arctic [2]	1979	3.93	NA	NA	ND	NA	NA	ND	NA
79CO002AIE	COLV358.0	Arctic	1979	3.40	NA	NA	ND	NA	NA	ND	NA
79CO015AIE	COLV524.0	Arctic	1979	3.60	NA	NA	0.22	NA	NA	ND	NA
79CO014AIE	COLV540.0	Arctic	1979	3.70	NA	NA	ND	NA	NA	ND	NA
80PR001AIE	PORC48.0	American	1980	2.50	NA	NA	NA	NA	NA	ND	NA
80YR002AIE	YUKO1577.2	American	1980	4.20	NA	NA	NA	NA	NA	ND	NA
80CO069AIE	COLV563.0	Arctic	1980	3.50	NA	NA	NA	NA	NA	ND	NA
82PR001AIE	PORC143.5	American	1982	NA	NA	NA	NA	NA	NA	ND	NA
82PR002AIE	PORC10.0	American	1982	NA	NA	NA	NA	NA	NA	ND	NA
82SR003AIE	SAGA198.0	Arctic	1982	NA	NA	NA	NA	NA	NA	ND	NA
82TA005ZIE	TANA205.0	American	1982	NA	NA	NA	NA	NA	NA	ND	NA
82YR008AIE	YUKO124.0	American	1982	NA	NA	NA	NA	NA	NA	ND	NA
82YR010AIE	YUKO1103.7	American	1982	NA	NA	NA	NA	NA	NA	ND	NA
82CO012AIE	COLV265.0	Arctic	1982	NA	NA	NA	NA	NA	NA	ND	NA
82CO014AIE	COLV395.0	Arctic	1982	NA	NA	NA	NA	NA	NA	ND	NA
82YR015AIE	YUKO1542.9	American	1982	NA	NA	NA	NA	NA	NA	ND	NA
83CO001AIE	COLV409.0	Arctic	1983	4.10	NA	NA	NA	NA	NA	ND	NA
83KO002AIE	KOGO3.0	Arctic	1983	4.20	NA	NA	NA	NA	NA	ND	NA
83YR003AIE	YUKO83.0	American	1983	4.80	NA	NA	NA	NA	NA	ND	NA
83PR004AIE	PORC2.0	American	1983	3.50	NA	NA	NA	NA	NA	ND	NA
83YR005ZIE	YUKO205.5	American	1983	2.00	NA	NA	NA	NA	NA	ND	NA
83TA008ZIE	TANA221.5	American	1983	3.70	NA	NA	NA	NA	NA	ND	NA

[1] *Falco peregrinus anatum*

[2] *F. p. tundrius*

[3] ND = not detected, NA = not analyzed, QA/QC = failed quality assurance or quality control checks

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	% Lipid	Aldrin	alpha-BHC	beta-BHC	delta-BHC	gamma-BHC	alpha-chlordane	gamma-chlordane
83YR010AIE	YUKO254.0	American	1983	4.00	NA	NA	NA	NA	NA	ND	NA
83KU011AIE	KUSK438.0	American	1983	2.70	NA	NA	NA	NA	NA	ND	NA
84YR001ZIE	YUKO231.0	American	1984	4.80	NA	NA	NA	NA	NA	ND	NA
84CO003AIE	COLV566.0	Arctic	1984	5.80	NA	NA	NA	NA	NA	ND	NA
84CO004AIE	COLV525.0	Arctic	1984	4.00	NA	NA	NA	NA	NA	ND	NA
84CO005AIE	COLV386.0	Arctic	1984	5.20	NA	NA	NA	NA	NA	ND	NA
84CO007AIE	COLV546.0	Arctic	1984	2.80	NA	NA	NA	NA	NA	ND	NA
84CO008AIE	COLV6.0	Arctic	1984	5.80	NA	NA	NA	NA	NA	ND	NA
84CO009AIE	COLV465.0	Arctic	1984	3.40	NA	NA	NA	NA	NA	ND	NA
84YR011AIE	YUKO229.0	American	1984	5.00	NA	NA	NA	NA	NA	ND	NA
84SR012AIE	SAGAFRANKA	Arctic	1984	5.20	NA	NA	NA	NA	NA	ND	NA
84YR013AIE	YUKO138.0	American	1984	4.30	NA	NA	NA	NA	NA	ND	NA
84YR014AIE	YUKO95.0	American	1984	4.40	NA	NA	NA	NA	NA	ND	NA
84YR015AIE	YUKO254.0	American	1984	6.10	NA	NA	NA	NA	NA	ND	NA
84YR016AIE	YUKO205.5	American	1984	1.60	NA	NA	NA	NA	NA	ND	NA
84SR017AIE	SAGAFRANKB	Arctic	1984	4.30	NA	NA	NA	NA	NA	ND	NA
84YR018AIE	YUKO3.5	American	1984	6.30	NA	NA	NA	NA	NA	ND	NA
84YR019ZIE	YUKO90.5	American	1984	5.15	NA	NA	NA	NA	NA	ND	NA
84TA020AIE	TANA243.0	American	1984	4.50	NA	NA	NA	NA	NA	ND	NA
84TA021AIE	TANA299.0	American	1984	5.30	NA	NA	NA	NA	NA	ND	NA
84YR022ZIE	YUKO249.0	American	1984	5.00	NA	NA	NA	NA	NA	ND	NA
84YR023AIE	YUKO191.5	American	1984	5.10	NA	NA	NA	NA	NA	ND	NA
84TA025AIE	TANA205.0	American	1984	5.10	NA	NA	NA	NA	NA	0.2	NA
84YR027AIE	YUKO1103.7	American	1984	6.50	NA	NA	NA	NA	NA	ND	NA
84SR028AIE	SAGA158.0	Arctic	1984	6.20	NA	NA	NA	NA	NA	ND	NA
84BR030ZIE	BLACKRIVER	American	1984	5.10	NA	NA	NA	NA	NA	ND	NA
84YR032AIE	YUKO124.0	American	1984	5.70	NA	NA	NA	NA	NA	ND	NA
88YR001AIE	YUKO205.5	American	1988	4.31	ND	ND	ND	ND	ND	ND	ND
88TA002AIE	TANA436.0	American	1988	3.70	ND	ND	0.04	ND	ND	ND	ND
88YR003AIE	YUKO3.5	American	1988	3.85	ND	ND	0.16	ND	ND	ND	ND
88YR004AIE	YUKO138.0	American	1988	5.70	ND	ND	0.08	ND	ND	ND	ND

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	% Lipid	Aldrin	alpha-BHC	beta-BHC	delta-BHC	gamma-BHC	alpha-chlordane	gamma-chlordane
86PR013AIE	PORC	American	1986	6.70	ND	ND	0.11	ND	ND	ND	ND
87YR014AIE	MY-13	American	1987	5.84	ND	ND	0.18	ND	ND	ND	ND
88YR015AIE	MY-4	American	1988	3.80	ND	ND	0.04	ND	ND	ND	ND
88SA021ZIE	T7NR14ES28	Arctic	1988	4.64	ND	ND	0.08	ND	ND	ND	ND
88CO024AIE	COLVILLE R.	Arctic	1988	5.04	ND	ND	0.11	ND	ND	ND	ND
88CO026AIE	COLV497.0	Arctic	1988	2.86	ND	ND	ND	ND	ND	ND	ND
88CO027AIE	COLV528.0	Arctic	1988	5.13	ND	ND	0.09	ND	ND	ND	ND
89SR001AIE	SAGA203.5	Arctic	1989	4.74	NA	ND	0.03	ND	ND	ND	ND
89NS002AIE	NORT725.8	Arctic	1989	5.24	NA	ND	0.16	ND	ND	ND	ND
89SR003AIE	SAGA122.0	Arctic	1989	5.62	NA	ND	0.06	ND	ND	ND	ND
89NS004AIE	NORT767.5	Arctic	1989	4.56	NA	ND	0.04	ND	ND	ND	ND
89CO005AIE	COLV592.5	Arctic	1989	5.04	NA	ND	0.05	ND	ND	ND	ND
89YR006AIE	YUKO254.0	American	1989	3.74	NA	ND	0.39	ND	ND	ND	ND
89CO007AIE	COLV541.8	Arctic	1989	5.18	NA	ND	0.03	ND	ND	ND	ND
89NS008AIE	NORT541.8	Arctic	1989	6.10	NA	ND	0.02	ND	ND	ND	ND
89CO009AIE	COLV515.5	Arctic	1989	5.48	NA	ND	0.03	ND	ND	ND	ND
89YR010AIE	YUKO229.0	American	1989	5.70	NA	ND	0.39	ND	ND	ND	ND
89YR011AIE	YUKO95.0	American	1989	5.05	NA	ND	0.02	ND	ND	ND	ND
89TA012AIE	TANA443.0	American	1989	5.54	NA	ND	0.01	ND	ND	ND	ND
89YR013AIE	YUKO239.5	American	1989	6.08	NA	ND	0.01	ND	ND	ND	ND
89YR014AIE	YUKO191.5	American	1989	4.08	NA	ND	0.02	ND	ND	ND	ND
89CO015AIE	COLV601.0	Arctic	1989	5.48	NA	ND	0.10	ND	ND	ND	ND
89TA016AIE	TANA299.0	American	1989	5.84	NA	0.0179	0.17	ND	ND	ND	ND
89TA017AIE	TANA272.0	American	1989	7.22	NA	ND	0.02	ND	ND	ND	ND
89SR018AIE	SAGA158.0	Arctic	1989	5.48	NA	ND	0.50	ND	ND	ND	ND
89YR019AIE	YUKO243.5	American	1989	5.22	NA	ND	ND	ND	ND	ND	ND
89YR021AIE	YUKO138.0	American	1989	5.86	NA	ND	0.04	ND	ND	ND	ND
89CO022AIE	COLV334.0	Arctic	1989	5.44	NA	ND	0.04	ND	ND	ND	ND
89CO024AIE	COLV311.0	Arctic	1989	10.30	NA	ND	0.09	ND	ND	ND	ND
89CO025AIE	COLV453.0	Arctic	1989	6.20	NA	ND	0.02	ND	ND	ND	ND
89YR026AIE	YUKO1110.5	American	1989	5.58	NA	ND	0.04	ND	ND	ND	ND

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	% Lipid	Aldrin	alpha-BHC	beta-BHC	delta-BHC	gamma-BHC	alpha-chlordane	gamma-chlordane
89CO023AIE	COLV336.5	Arctic	1989	6.38	NA	ND	ND	ND	ND	ND	ND
89YR020AIE	YUKO3.5	American	1989	6.12	NA	ND	0.08	ND	ND	ND	ND
89NA027AIE	NANUOOA	Arctic	1989	4.86	NA	ND	0.06	ND	ND	ND	ND
89YR030AIE	YUKO1643.5	American	1989	6.64	NA	ND	0.01	ND	ND	ND	ND
89TA031AIE	TANA288.5	American	1989	5.92	NA	ND	0.02	ND	ND	ND	ND
89YR032AIE	YUKO198.5	American	1989	7.04	NA	ND	0.06	ND	ND	ND	ND
89CO041AIE	COLV536.0	Arctic	1989	4.02	NA	ND	0.05	ND	ND	ND	ND
89CO043AIE	COLV464.0	Arctic	1989	5.66	NA	ND	0.03	ND	ND	ND	ND
89CO044AIE	COLV482.8	Arctic	1989	4.44	NA	ND	0.01	ND	ND	ND	ND
89NS046AIE	NORT767.5	Arctic	1989	5.54	NA	ND	0.04	ND	ND	ND	ND
90CO001AIE	COLV281.8	Arctic	1990	8.20	NA	ND	0.02	ND	ND	ND	ND
90CO002ZIE	COLV533.5	Arctic	1990	3.20	NA	ND	0.05	ND	ND	0.01	ND
90CO004AIE	COLV503.9	Arctic	1990	2.38	NA	ND	0.03	ND	ND	ND	ND
90CO005AIE	COLV395.0	Arctic	1990	5.80	NA	ND	0.01	ND	ND	ND	ND
90YR006AIE	YUKO233.0	American	1990	5.94	NA	ND	0.07	ND	ND	ND	ND
90SR007ZIE	SAGA146.9	Arctic	1988	6.24	NA	ND	0.11	ND	ND	ND	ND
90TA009AIE	TANA299.0	American	1990	2.18	NA	ND	0.06	ND	ND	ND	ND
90YR010AIE	YUKO235.0	American	1990	6.54	NA	ND	0.02	ND	ND	ND	ND
90CO011AIE	COLV474.0	Arctic	1990	8.30	NA	ND	0.04	ND	ND	ND	ND
90YR015AIE	YUKO1225.2	American	1990	4.88	NA	ND	0.02	ND	ND	ND	ND
91AA015ZIE	PORC137.0	American	1991	6.93	NA	ND	0.02	NA	ND	ND	ND
91CO001AIE	COLV283.0	Arctic	1991	5.86	NA	ND	ND	NA	ND	0.03	ND
91CO002ZIE	COLV409.3	Arctic	1991	3.30	NA	ND	0.01	NA	ND	0.02	ND
91NA025AIE	ITKI	Arctic	1991	5.43	NA	ND	0.03	NA	ND	ND	ND
91NS019AIE	NORT372.0	Arctic	1991	6.67	NA	ND	0.03	NA	ND	ND	ND
91NS020ZIE	NORT306.0	Arctic	1991	6.01	NA	ND	0.01	NA	ND	ND	ND
91NS023ZIE	STUA6.4	Arctic	1991	5.00	NA	ND	0.01	NA	ND	ND	ND
91SR004AIE	SAGA101.8	Arctic	1991	7.53	NA	ND	0.30	NA	ND	ND	ND
91YR005AIE	YUKO239.0	American	1991	8.71	NA	ND	0.09	NA	ND	ND	ND
91YR006AIE	YUKO183.0	American	1991	7.49	NA	ND	0.03	NA	0.01	ND	ND
91YR007ZIE	YUKO138.0	American	1991	6.02	NA	ND	0.03	NA	ND	ND	ND

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	% Lipid	Aldrin	alpha-BHC	beta-BHC	delta-BHC	gamma-BHC	alpha-chlordane	gamma-chlordane
91YR009AIE	YUKO1225.2	American	1991	5.75	NA	ND	ND	NA	ND	ND	ND
91YR010AIE	YUKO1250.5	American	1991	6.86	NA	ND	0.05	NA	ND	ND	ND
91YR011AIE	YUKO1282.4	American	1991	5.83	NA	ND	0.04	NA	ND	ND	ND
91YR012AIE	YUKO1291.3	American	1991	5.50	NA	ND	0.02	NA	ND	ND	ND
91YR013AIE	YUKO1350.0	American	1991	6.78	NA	ND	ND	NA	ND	ND	ND
91YR014AIE	YUKO1433.0	American	1991	3.83	NA	0.01	0.07	NA	ND	ND	ND
91YR026AIE	YUKO1132.8	American	1991	10.34	NA	ND	0.06	NA	ND	ND	ND
95CO01ABIE	COLV497.0	Arctic	1995	2.87	ND	ND	0.0109	ND	0.0012	ND	ND
95CO01ACIE	COLV509.0	Arctic	1995	3.59	ND	0.0019	0.0074	ND	0.0011	ND	ND
95CO01ADIE	COLV515.0	Arctic	1995	4.77	ND	ND	0.0121	ND	0.0024	ND	ND
95CO01FAIE	COLV497.0	Arctic	1995	6.12	ND	ND	0.0107	ND	0.0015	ND	ND
95CO01FEIE	COLV551.0	Arctic	1995	1.19	ND	ND	0.0449	ND	ND	ND	ND
95CO01FFIE	KOGO	Arctic	1995	4.3	ND	ND	0.0163	ND	ND	0.0009	ND
95PR01AAIE	PORC2.0	American	1995	1.63	ND	0.0018	0.0280	ND	0.0007	0.0007	ND
95PR01ABIE	PORC80.0	American	1995	5.33	ND	ND	0.0039	ND	0.0008	ND	ND
94SR01AAIE	SAGA123.5	Arctic	1994	4.29	ND	ND	0.0090	ND	0.0010	ND	ND
93SR01ABIE	SAGA157.0	Arctic	1993	2.68	ND	0.0018	0.1319	ND	ND	ND	ND
93SR01ACIE	SAGA191.9	Arctic	1993	5.73	ND	0.0023	0.0500	ND	0.0025	ND	ND
SR01ADIEz	SAGA199.5	Arctic	1993	3.69	ND	0.0010	0.0162	ND	ND	0.0013	0.0006
95SR01AFIE	SAGA200.0	Arctic	1995	4.72	ND	0.0022	0.0230	ND	0.0010	ND	ND
93SR01AGIE	SAGA207.0	Arctic	1993	4.91	ND	0.0015	0.0483	ND	ND	0.0014	ND
95SR01AHIE	SAGA209.0	Arctic	1995	5.1	ND	0.0017	0.0095	ND	0.0011	0.0008	0.0007
93TA01AAIEz	TANA232.5	American	1993	5.48	ND	0.0016	0.0109	ND	ND	0.0008	0.0074
93TA01ACIE	TANA247.5	American	1993	4.52	ND	0.0012	0.0321	ND	0.0006	0.0014	ND
93TA01ADIE	TANA258.5	American	1993	5.31	ND	0.0016	0.0045	ND	0.0009	ND	ND
94TA01AEIE	TANA299.0	American	1994	5.9	ND	0.0017	0.0123	ND	0.0011	ND	ND
94TA01AFIE	TANA336.5	American	1994	7.04	ND	0.0016	0.0217	ND	ND	0.0006	ND
94TA01AGIE	TANA407.8	American	1994	5.1	ND	0.0013	0.0114	ND	ND	0.0010	ND
93TA01AHIE	TANA427.0	American	1993	8.2	ND	0.0016	0.0463	ND	ND	ND	ND
93TA01AIIEz	TANA460.0	American	1993	6.64	ND	0.0013	0.0377	ND	ND	0.0004	0.0103
95TA02ALIE	TANA221.5D	American	1995	6.19	ND	0.0010	0.0273	ND	ND	ND	0.0142

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	% Lipid	Aldrin	alpha-BHC	beta-BHC	delta-BHC	gamma-BHC	alpha-chlordane	gamma-chlordane
93YR01AAIE	YUKO3.5	American	1993	7.16	ND	0.0011	0.0233	ND	0.0018	ND	0.0075
93YR01ACIEz	YUKO166.0	American	1993	2.36	ND	0.0010	0.0050	ND	ND	ND	ND
95YR01AEIE	YUKO167.0	American	1995	3.77	ND	0.0014	0.0139	ND	ND	ND	ND
95YR01AHIEz	YUKO25.0	American	1995	3.45	ND	0.0009	0.0068	ND	0.0021	ND	ND
95YR01AJIE	YUKO48.5	American	1995	5.47	ND	0.0007	0.0149	ND	0.0013	ND	ND
95YR01AKIE	YUKO76.5	American	1995	5.17	ND	0.0014	0.0121	ND	ND	0.0011	ND
95YR01FFIE	YUKO117.0	American	1995	3.43	ND	0.0016	0.0287	ND	0.0446	ND	ND
95YR01FGIE	YUKO229.0	American	1995	4.15	ND	0.0008	0.0132	ND	ND	ND	ND
95YR01FLIE	YUKO208.5	American	1995	3.69	ND	0.0013	0.0401	ND	ND	ND	ND
95YR02AAIE	70 Mile R.(#305)	American	1995	6.13	ND	0.0006	0.0075	ND	ND	0.0003	ND

Sample ID	Sample Location	Subspecies	Year	cis-nonachlor	p,p’-DDD	p,p’-DDE	p,p’-DDT	o,p’-DDD	o,p’-DDE	o,p’-DDT	Dieldrin
79PR056AIE	PORC56.5	American	1979	ND	ND	4.30	ND	NA	NA	NA	0.12
79SR194ZIE	SAGA194.0	Arctic	1979	ND	0.03	14.25	0.09	NA	NA	NA	1.68
79CO002AIE	COLV358.0	Arctic	1979	ND	0.04	5.30	ND	NA	NA	NA	0.32
79CO015AIE	COLV524.0	Arctic	1979	ND	0.08	10.00	0.17	NA	NA	NA	0.40
79CO014AIE	COLV540.0	Arctic	1979	ND	0.06	12.00	ND	NA	NA	NA	0.70
80PR001AIE	PORC48.0	American	1980	ND	ND	6.20	ND	NA	NA	NA	0.25
80YR002AIE	YUKO1577.2	American	1980	ND	0.36	27.00	0.12	NA	NA	NA	0.26
80CO069AIE	COLV563.0	Arctic	1980	ND	0.07	5.20	ND	NA	NA	NA	0.32
82PR001AIE	PORC143.5	American	1982	ND	ND	6.2	ND	NA	NA	NA	ND
82PR002AIE	PORC10.0	American	1982	ND	ND	5.7	ND	NA	NA	NA	0.1
82SR003AIE	SAGA198.0	Arctic	1982	ND	ND	4.2	ND	NA	NA	NA	0.1
82TA005ZIE	TANA205.0	American	1982	0.1	ND	12.0	ND	NA	NA	NA	0.4
82YR008AIE	YUKO124.0	American	1982	ND	ND	5.0	ND	NA	NA	NA	0.1
82YR010AIE	YUKO1103.7	American	1982	ND	0.2	17.0	ND	NA	NA	NA	0.3
82CO012AIE	COLV265.0	Arctic	1982	ND	0.2	12.0	0.2	NA	NA	NA	0.3
82CO014AIE	COLV395.0	Arctic	1982	ND	ND	1.5	0.0	NA	NA	NA	0.1
82YR015AIE	YUKO1542.9	American	1982	ND	0.0	6.4	0.1	NA	NA	NA	0.2
83CO001AIE	COLV409.0	Arctic	1983	ND	ND	3.3	ND	NA	NA	NA	0.1
83KO002AIE	KOGO3.0	Arctic	1983	ND	ND	7.1	ND	NA	NA	NA	0.1

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	cis-nonachlor	p,p’-DDD	p,p’-DDE	p,p’-DDT	o,p’-DDD	o,p’-DDE	o,p’-DDT	Dieldrin
83YR003AIE	YUKO83.0	American	1983	ND	ND	8.5	ND	NA	NA	NA	0.3
83PR004AIE	PORC2.0	American	1983	ND	0.2	13.0	ND	NA	NA	NA	0.0
83YR005ZIE	YUKO205.5	American	1983	ND	ND	13.5	ND	NA	NA	NA	0.4
83TA008ZIE	TANA221.5	American	1983	ND	0.7	30.7	ND	NA	NA	NA	0.2
83YR010AIE	YUKO254.0	American	1983	ND	0.2	13.0	ND	NA	NA	NA	0.3
83KU011AIE	KUSK438.0	American	1983	ND	0.1	6.7	ND	NA	NA	NA	0.1
84YR001ZIE	YUKO231.0	American	1984	ND	0.1	10.2	ND	NA	NA	NA	0.1
84CO003AIE	COLV566.0	Arctic	1984	ND	ND	25.8	0.1	NA	NA	NA	0.4
84CO004AIE	COLV525.0	Arctic	1984	ND	ND	8.3	ND	NA	NA	NA	0.3
84CO005AIE	COLV386.0	Arctic	1984	ND	0.1	7.5	ND	NA	NA	NA	0.3
84CO007AIE	COLV546.0	Arctic	1984	ND	ND	14.2	ND	NA	NA	NA	0.6
84CO008AIE	COLV6.0	Arctic	1984	ND	ND	31.1	ND	NA	NA	NA	ND
84CO009AIE	COLV465.0	Arctic	1984	ND	ND	10.0	ND	NA	NA	NA	0.1
84YR011AIE	YUKO229.0	American	1984	ND	ND	16.4	0.2	NA	NA	NA	0.1
84SR012AIE	SAGAFRANKA	Arctic	1984	ND	ND	6.3	ND	NA	NA	NA	0.3
84YR013AIE	YUKO138.0	American	1984	ND	ND	11.4	ND	NA	NA	NA	0.1
84YR014AIE	YUKO95.0	American	1984	ND	ND	8.3	ND	NA	NA	NA	0.1
84YR015AIE	YUKO254.0	American	1984	ND	ND	21.1	ND	NA	NA	NA	0.1
84YR016AIE	YUKO205.5	American	1984	ND	ND	9.6	ND	NA	NA	NA	0.1
84SR017AIE	SAGAFRANKB	Arctic	1984	ND	ND	46.4	0.1	NA	NA	NA	0.5
84YR018AIE	YUKO3.5	American	1984	ND	ND	6.9	ND	NA	NA	NA	0.1
84YR019ZIE	YUKO90.5	American	1984	ND	ND	5.2	ND	NA	NA	NA	0.1
84TA020AIE	TANA243.0	American	1984	ND	ND	15.8	ND	NA	NA	NA	0.2
84TA021AIE	TANA299.0	American	1984	ND	ND	22.3	ND	NA	NA	NA	0.2
84YR022ZIE	YUKO249.0	American	1984	ND	ND	11.7	ND	NA	NA	NA	0.2
84YR023AIE	YUKO191.5	American	1984	ND	ND	9.8	ND	NA	NA	NA	0.2
84TA025AIE	TANA205.0	American	1984	0.1	0.1	24.1	ND	NA	NA	NA	0.7
84YR027AIE	YUKO1103.7	American	1984	ND	0.5	25.5	ND	NA	NA	NA	0.2
84SR028AIE	SAGA158.0	Arctic	1984	ND	0.1	16.2	0.2	NA	NA	NA	0.2
84BR030ZIE	BLACKRIVER	American	1984	ND	ND	7.9	ND	NA	NA	NA	0.1
84YR032AIE	YUKO124.0	American	1984	ND	ND	5.0	ND	NA	NA	NA	ND

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	cis-nonachlor	p,p’-DDD	p,p’-DDE	p,p’-DDT	o,p’-DDD	o,p’-DDE	o,p’-DDT	Dieldrin
88YR001AIE	YUKO205.5	American	1988	ND	ND	8.87	0.05	0.04	ND	ND	0.05
88TA002AIE	TANA436.0	American	1988	ND	0.43	2.36	ND	ND	ND	ND	0.05
88YR003AIE	YUKO3.5	American	1988	ND	0.14	7.68	ND	ND	ND	ND	0.04
88YR004AIE	YUKO138.0	American	1988	ND	ND	7.94	ND	ND	ND	ND	0.34
86PR013AIE	PORC	American	1986	ND	0.16	3.49	0.24	ND	ND	0.15	1.19
87YR014AIE	MY-13	American	1987	ND	ND	3.65	ND	ND	ND	ND	0.19
88YR015AIE	MY-4	American	1988	ND	ND	1.69	ND	ND	ND	ND	0.05
88SA021ZIE	T7NR14ES28	Arctic	1988	ND	0.09	5.45	0.29	ND	ND	0.18	0.38
88CO024AIE	COLVILLE R.	Arctic	1988	ND	ND	0.60	ND	ND	ND	ND	0.06
88CO026AIE	COLV497.0	Arctic	1988	ND	0.04	0.98	ND	ND	ND	ND	0.08
88CO027AIE	COLV528.0	Arctic	1988	ND	0.05	1.15	ND	ND	ND	ND	0.12
89SR001AIE	SAGA203.5	Arctic	1989	ND	0.07	5.71	0.14	ND	ND	ND	0.29
89NS002AIE	NORT725.8	Arctic	1989	ND	ND	10.31	ND	ND	ND	ND	0.05
89SR003AIE	SAGA122.0	Arctic	1989	ND	ND	6.29	0.02	ND	ND	ND	0.12
89NS004AIE	NORT767.5	Arctic	1989	ND	0.01	5.28	0.03	ND	ND	ND	0.02
89CO005AIE	COLV592.5	Arctic	1989	ND	ND	2.76	0.02	ND	ND	ND	0.11
89YR006AIE	YUKO254.0	American	1989	ND	ND	12.58	ND	ND	ND	ND	0.04
89CO007AIE	COLV541.8	Arctic	1989	ND	0.01	2.45	0.01	ND	ND	ND	0.09
89NS008AIE	NORT541.8	Arctic	1989	ND	ND	3.38	ND	ND	ND	ND	0.08
89CO009AIE	COLV515.5	Arctic	1989	ND	0.02	3.23	ND	ND	ND	ND	0.09
89YR010AIE	YUKO229.0	American	1989	ND	0.09	7.88	0.24	ND	ND	ND	0.03
89YR011AIE	YUKO95.0	American	1989	ND	0.03	5.71	0.04	ND	ND	ND	0.01
89TA012AIE	TANA443.0	American	1989	ND	0.05	4.17	0.16	ND	ND	ND	0.04
89YR013AIE	YUKO239.5	American	1989	ND	0.03	4.83	0.05	ND	ND	ND	0.05
89YR014AIE	YUKO191.5	American	1989	ND	0.02	3.30	0.04	ND	ND	ND	0.02
89CO015AIE	COLV601.0	Arctic	1989	ND	ND	5.25	ND	ND	ND	ND	0.06
89TA016AIE	TANA299.0	American	1989	ND	0.14	17.01	0.30	ND	ND	ND	0.03
89TA017AIE	TANA272.0	American	1989	ND	ND	2.04	ND	ND	ND	ND	0.02
89SR018AIE	SAGA158.0	Arctic	1989	ND	ND	7.63	ND	ND	ND	ND	0.38
89YR019AIE	YUKO243.5	American	1989	ND	ND	6.77	ND	ND	ND	ND	0.28
89YR020AIE	YUKO3.5	American	1989	ND	0.03	14.60	0.06	ND	ND	ND	0.11

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	cis-nonachlor	p,p’-DDD	p,p’-DDE	p,p’-DDT	o,p’-DDD	o,p’-DDE	o,p’-DDT	Dieldrin
89YR021AIE	YUKO138.0	American	1989	ND	0.02	6.23	0.03	ND	ND	ND	0.07
89CO022AIE	COLV334.0	Arctic	1989	ND	ND	4.72	ND	ND	ND	ND	0.06
89CO023AIE	COLV336.5	Arctic	1989	ND	0.03	3.75	0.06	ND	ND	ND	0.14
89CO024AIE	COLV311.0	Arctic	1989	ND	ND	6.38	ND	ND	ND	ND	0.12
89CO025AIE	COLV453.0	Arctic	1989	ND	0.01	3.11	0.02	ND	ND	ND	0.14
89YR026AIE	YUKO1110.5	American	1989	ND	ND	3.48	ND	ND	ND	ND	0.28
89NA027AIE	NANUOOA	Arctic	1989	ND	0.03	3.33	0.06	ND	ND	ND	0.26
89YR030AIE	YUKO1643.5	American	1989	ND	0.01	8.11	0.04	ND	ND	ND	0.03
89TA031AIE	TANA288.5	American	1989	ND	0.02	2.66	0.04	ND	ND	ND	0.83
89YR032AIE	YUKO198.5	American	1989	ND	0.31	6.84	0.08	ND	ND	ND	0.67
89CO041AIE	COLV536.0	Arctic	1989	ND	ND	2.52	0.00	ND	ND	ND	0.15
89CO043AIE	COLV464.0	Arctic	1989	ND	0.07	1.82	0.09	ND	ND	ND	0.02
89CO044AIE	COLV482.8	Arctic	1989	ND	0.03	2.56	0.11	ND	ND	ND	0.13
89NS046AIE	NORT767.5	Arctic	1989	ND	0.01	2.34	0.05	ND	ND	ND	0.03
90CO001AIE	COLV281.8	Arctic	1990	0.02	0.03	2.87	ND	ND	ND	ND	0.31
90CO002ZIE	COLV533.5	Arctic	1990	0.01	2.58	4.76	0.11	ND	ND	ND	0.21
90CO004AIE	COLV503.9	Arctic	1990	0.01	0.03	1.88	ND	ND	ND	ND	0.57
90CO005AIE	COLV395.0	Arctic	1990	ND	0.01	1.41	0.02	ND	ND	ND	0.07
90YR006AIE	YUKO233.0	American	1990	ND	0.09	4.51	ND	ND	ND	ND	0.18
90SR007ZIE	SAGA146.9	Arctic	1988	ND	0.03	3.92	ND	ND	ND	ND	0.15
90TA009AIE	TANA299.0	American	1990	ND	0.07	2.89	ND	ND	ND	ND	0.04
90YR010AIE	YUKO235.0	American	1990	ND	0.02	3.35	0.05	ND	ND	ND	0.05
90CO011AIE	COLV474.0	Arctic	1990	ND	0.01	3.34	0.02	ND	ND	ND	0.29
90YR015AIE	YUKO1225.2	American	1990	ND	0.02	3.51	0.02	ND	ND	ND	0.03
91AA015ZIE	PORC137.0	American	1991	NA	0.07	5.89	0.01	ND	ND	ND	0.14
91CO001AIE	COLV283.0	Arctic	1991	NA	0.34	2.10	ND	0.03	ND	ND	0.19
91CO002ZIE	COLV409.3	Arctic	1991	NA	0.01	2.93	0.20	ND	ND	ND	0.16
91NA025AIE	ITKI	Arctic	1991	NA	ND	3.79	0.01	ND	ND	ND	0.07
91NS019AIE	NORT372.0	Arctic	1991	NA	ND	4.21	ND	ND	ND	ND	0.05
91NS020ZIE	NORT306.0	Arctic	1991	NA	ND	3.71	ND	ND	ND	ND	0.10
91NS023ZIE	STUA6.4	Arctic	1991	NA	ND	2.06	ND	ND	ND	ND	0.02

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	cis-nonachlor	p,p'-DDD	p,p'-DDE	p,p'-DDT	o,p'-DDD	o,p'-DDE	o,p'-DDT	Dieldrin
91SR004AIE	SAGA101.8	Arctic	1991	NA	0.03	5.22	0.29	ND	ND	ND	0.32
91YR005AIE	YUKO239.0	American	1991	NA	ND	14.12	0.03	ND	0.02	ND	0.06
91YR006AIE	YUKO183.0	American	1991	NA	0.02	3.51	0.01	ND	ND	ND	0.06
91YR007ZIE	YUKO138.0	American	1991	NA	0.02	6.38	0.01	ND	ND	ND	0.13
91YR009AIE	YUKO1225.2	American	1991	NA	ND	2.93	ND	ND	ND	ND	0.03
91YR010AIE	YUKO1250.5	American	1991	NA	ND	3.40	ND	ND	ND	ND	0.02
91YR011AIE	YUKO1282.4	American	1991	NA	ND	2.73	0.01	ND	ND	ND	0.12
91YR012AIE	YUKO1291.3	American	1991	NA	ND	9.64	0.02	ND	ND	ND	0.14
91YR013AIE	YUKO1350.0	American	1991	NA	0.01	1.88	0.01	ND	ND	ND	0.04
91YR014AIE	YUKO1433.0	American	1991	NA	0.01	5.70	ND	ND	ND	ND	0.07
91YR026AIE	YUKO1132.8	American	1991	NA	0.04	7.66	0.02	ND	ND	ND	0.10
95CO01ABIE	COLV497.0	Arctic	1995	0.0031	0.0194	1.4514	ND	ND	ND	0.0054	0.0961
95CO01ACIE	COLV509.0	Arctic	1995	0.0044	0.0067	1.5547	0.0220	ND	ND	0.0048	0.1560
95CO01ADIE	COLV515.0	Arctic	1995	0.0059	0.0572	4.1639	0.3477	ND	0.0019	0.0101	0.1125
95CO01FAIE	COLV497.0	Arctic	1995	0.0034	0.0063	1.2273	0.0206	ND	0.0008	0.0061	0.1057
95CO01FEIE	COLV551.0	Arctic	1995	0.0023	0.0049	3.4989	0.0031	ND	0.0029	0.0172	0.0602
95CO01FFIE	KOGO	Arctic	1995	0.0068	0.0067	3.2360	0.0263	ND	0.0019	0.0101	0.1398
95PR01AAIE	PORC2.0	American	1995	0.0054	0.0240	4.1099	0.0107	0.0314	0.0021	0.0305	0.0957
95PR01ABIE	PORC80.0	American	1995	0.0004	0.0065	0.7721	0.0101	ND	0.0007	0.0050	0.0163
94SR01AAIE	SAGA123.5	Arctic	1994	0.0044	0.0396	2.8534	0.0052	ND	0.0009	0.0094	0.0841
93SR01ABIE	SAGA157.0	Arctic	1993	0.0069	0.0446	4.3326	0.0317	ND	0.0044	0.0108	0.1345
93SR01ACIE	SAGA191.9	Arctic	1993	0.0122	0.0193	7.6004	0.0397	0.0372	0.0057	0.0239	0.1829
SR01ADIEz	SAGA199.5	Arctic	1993	0.0298	0.0056	2.0074	0.0111	ND	0.0007	0.0054	0.0801
95SR01AFIE	SAGA200.0	Arctic	1995	0.0064	0.0131	2.6280	0.0361	0.0132	0.0023	0.0143	0.0603
93SR01AGIE	SAGA207.0	Arctic	1993	0.0059	0.0645	13.2686	ND	0.0185	0.0024	0.0214	0.0844
95SR01AHIE	SAGA209.0	Arctic	1995	0.0024	0.0119	1.3884	0.0079	0.0077	0.0008	0.0081	0.0647
93TA01AAIEz	TANA232.5	American	1993	0.0040	0.0135	3.6573	0.0252	0.0101	0.0005	0.0116	0.0575
93TA01ACIE	TANA247.5	American	1993	0.0104	0.0385	10.0453	ND	ND	0.0006	0.0089	0.1367
93TA01ADIE	TANA258.5	American	1993	0.0049	0.0123	1.2398	ND	0.0035	0.0010	0.0072	0.0354
94TA01AEIE	TANA299.0	American	1994	0.0012	0.0104	2.8650	0.0024	0.0067	ND	0.0061	0.0561
94TA01AFIE	TANA336.5	American	1994	0.0056	0.0078	4.6258	0.0231	0.0140	ND	0.0161	0.0810

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	cis-nonachlor	p,p'-DDD	p,p'-DDE	p,p'-DDT	o,p'-DDD	o,p'-DDE	o,p'-DDT	Dieldrin
94TA01AGIE	TANA407.8	American	1994	0.0111	0.0263	3.7682	0.0332	0.0118	0.0028	0.0170	0.3581
93TA01AHIE	TANA427.0	American	1993	0.0013	0.0064	1.6234	0.0285	ND	ND	0.0036	0.0494
93TA01AIIEz	TANA460.0	American	1993	0.0052	0.0422	5.4855	0.0051	0.0294	0.0014	0.0399	0.0751
95TA02ALIE	TANA221.5D	American	1995	0.0076	0.0118	5.2443	0.0488	0.0108	0.0027	0.0175	0.0635
93YR01AAIE	YUKO3.5	American	1993	0.0014	0.0062	4.7125	0.0753	0.0065	0.0017	0.0122	0.0399
93YR01ACIEz	YUKO166.0	American	1993	0.0007	0.0070	0.4822	ND	0.0012	ND	0.0020	0.0128
95YR01AEIE	YUKO167.0	American	1995	0.0065	0.0302	4.4511	0.0602	0.0076	0.0019	0.0382	0.1368
95YR01AHIEz	YUKO25.0	American	1995	0.0035	0.0065	1.6455	0.0117	0.0068	0.0009	0.0093	0.0577
95YR01AJIE	YUKO48.5	American	1995	0.0025	0.0162	1.5096	0.0950	0.0031	ND	0.0064	0.0307
95YR01AKIE	YUKO76.5	American	1995	0.0343	0.0128	3.2742	0.0178	0.0078	0.0029	0.0166	0.0744
95YR01FFIE	YUKO117.0	American	1995	0.0113	0.0261	5.8526	0.0375	0.0134	0.0028	0.0271	0.2287
95YR01FGIE	YUKO229.0	American	1995	0.0025	0.0231	2.4314	0.0143	0.0044	0.0008	0.0072	0.0417
95YR01FLIE	YUKO208.5	American	1995	0.0033	0.0094	2.3701	0.0311	0.0049	ND	0.0083	0.0961
95YR02AAIE	70 Mile R.(#305)	American	1995	0.0014	0.0088	3.0363	ND	0.0017	ND	0.0041	0.0371

Sample ID	Sample Location	Subspecies	Year	Endosulfan II	Endrin	HCB	Heptachlor	Heptachlor epoxide	Mirex	Oxychlordane	Total PCBs	trans-nonachlor
79PR056AIE	PORC56.5	American	1979	NA	ND	ND	NA	0.48	0.18	0.09	0.9	NA
79SR194ZIE	SAGA194.0	Arctic	1979	NA	ND	ND	NA	0.40	0.17	0.13	2.4	NA
79CO002AIE	COLV358.0	Arctic	1979	NA	ND	ND	NA	0.38	0.08	0.12	2.0	NA
79CO015AIE	COLV524.0	Arctic	1979	NA	ND	0.04	NA	1.90	0.22	0.28	1.7	NA
79CO014AIE	COLV540.0	Arctic	1979	NA	ND	ND	NA	0.37	0.43	0.08	1.9	NA
80PR001AIE	PORC48.0	American	1980	NA	ND	0.03	NA	0.82	0.16	0.13	2.6	0.03
80YR002AIE	YUKO1577.2	American	1980	NA	ND	0.05	NA	0.20	0.13	0.20	3.8	0.04
80CO069AIE	COLV563.0	Arctic	1980	NA	ND	0.04	NA	0.19	0.10	0.07	3.5	0.03
82PR001AIE	PORC143.5	American	1982	NA	ND	NA	NA	0.1	NA	0.1	2.1	ND
82PR002AIE	PORC10.0	American	1982	NA	ND	NA	NA	0.1	NA	0.1	8.7	ND
82SR003AIE	SAGA198.0	Arctic	1982	NA	ND	NA	NA	0.5	NA	0.1	2.6	0.1
82TA005ZIE	TANA205.0	American	1982	NA	ND	NA	NA	1.2	NA	0.5	28.0	0.3
82YR008AIE	YUKO124.0	American	1982	NA	ND	NA	NA	0.4	NA	0.1	1.6	ND

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Endosulfan II	Endrin	HCB	Heptachlor	Heptachlor epoxide	Mirex	Oxychlordane	Total PCBs	trans-nonachlor
82YR010AIE	YUKO1103.7	American	1982	NA	ND	NA	NA	0.7	NA	1.0	6.3	ND
82CO012AIE	COLV265.0	Arctic	1982	NA	ND	NA	NA	0.2	NA	0.2	1.7	ND
82CO014AIE	COLV395.0	Arctic	1982	NA	ND	NA	NA	0.0	NA	0.0	0.6	ND
82YR015AIE	YUKO1542.9	American	1982	NA	0.1	NA	NA	0.1	NA	0.1	2.6	0.0
83CO001AIE	COLV409.0	Arctic	1983	NA	ND	NA	NA	0.1	NA	0.1	1.0	ND
83KO002AIE	KOGO3.0	Arctic	1983	NA	ND	NA	NA	0.2	NA	0.1	1.5	ND
83YR003AIE	YUKO83.0	American	1983	NA	ND	NA	NA	1.5	NA	0.2	1.7	ND
83PR004AIE	PORC2.0	American	1983	NA	ND	NA	NA	0.4	NA	0.2	2.6	ND
83YR005ZIE	YUKO205.5	American	1983	NA	ND	NA	NA	0.7	NA	0.2	4.1	ND
83TA008ZIE	TANA221.5	American	1983	NA	ND	NA	NA	0.5	NA	0.3	2.7	ND
83YR010AIE	YUKO254.0	American	1983	NA	ND	NA	NA	0.2	NA	0.1	1.4	ND
83KU011AIE	KUSK438.0	American	1983	NA	ND	NA	NA	0.6	NA	0.1	0.8	ND
84YR001ZIE	YUKO231.0	American	1984	NA	ND	NA	NA	ND	NA	ND	1.9	ND
84CO003AIE	COLV566.0	Arctic	1984	NA	ND	NA	NA	0.3	NA	0.2	2.1	ND
84CO004AIE	COLV525.0	Arctic	1984	NA	ND	NA	NA	0.6	NA	0.1	2.4	ND
84CO005AIE	COLV386.0	Arctic	1984	NA	ND	NA	NA	1.2	NA	0.1	1.5	ND
84CO007AIE	COLV546.0	Arctic	1984	NA	ND	NA	NA	0.1	NA	0.2	2.2	ND
84CO008AIE	COLV6.0	Arctic	1984	NA	ND	NA	NA	ND	NA	0.1	6.3	ND
84CO009AIE	COLV465.0	Arctic	1984	NA	ND	NA	NA	0.1	NA	0.1	5.0	ND
84YR011AIE	YUKO229.0	American	1984	NA	ND	NA	NA	0.2	NA	0.1	2.1	ND
84SR012AIE	SAGAFRANKA	Arctic	1984	NA	ND	NA	NA	0.3	NA	0.1	3.3	ND
84YR013AIE	YUKO138.0	American	1984	NA	ND	NA	NA	3.3	NA	0.3	1.7	ND
84YR014AIE	YUKO95.0	American	1984	NA	ND	NA	NA	0.1	NA	0.1	1.9	ND
84YR015AIE	YUKO254.0	American	1984	NA	ND	NA	NA	0.4	NA	0.2	3.1	ND
84YR016AIE	YUKO205.5	American	1984	NA	ND	NA	NA	0.3	NA	0.2	1.3	ND
84SR017AIE	SAGAFRANKB	Arctic	1984	NA	ND	NA	NA	0.5	NA	0.2	1.9	ND
84YR018AIE	YUKO3.5	American	1984	NA	ND	NA	NA	0.4	NA	0.1	2.9	ND
84YR019ZIE	YUKO90.5	American	1984	NA	ND	NA	NA	0.1	NA	ND	1.7	ND
84TA020AIE	TANA243.0	American	1984	NA	ND	NA	NA	1.9	NA	0.2	3.3	ND
84TA021AIE	TANA299.0	American	1984	NA	ND	NA	NA	0.2	NA	0.1	2.1	ND

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Endosulfan II	Endrin	HCB	Heptachlor	Heptachlor epoxide	Mirex	Oxychlordane	Total PCBs	trans-nonachlor
84YR022ZIE	YUKO249.0	American	1984	NA	ND	NA	NA	0.1	NA	0.1	1.4	ND
84YR023AIE	YUKO191.5	American	1984	NA	ND	NA	NA	0.2	NA	0.1	5.5	ND
84TA025AIE	TANA205.0	American	1984	NA	ND	NA	NA	0.5	NA	0.4	27.3	0.3
84YR027AIE	YUKO1103.7	American	1984	NA	0.1	NA	NA	0.2	NA	0.1	2.2	ND
84SR028AIE	SAGA158.0	Arctic	1984	NA	ND	NA	NA	0.3	NA	0.2	1.3	0.0
84BR030ZIE	BLACKRIVER	American	1984	NA	ND	NA	NA	0.1	NA	0.1	1.7	ND
84YR032AIE	YUKO124.0	American	1984	NA	ND	NA	NA	0.7	NA	0.1	1.5	ND
88YR001AIE	YUKO205.5	American	1988	NA	ND	ND	ND	ND	0.18	0.06	2.6	ND
88TA002AIE	TANA436.0	American	1988	NA	ND	ND	ND	0.05	0.15	0.08	1.5	ND
88YR003AIE	YUKO3.5	American	1988	NA	ND	ND	ND	0.10	0.26	0.08	1.6	ND
88YR004AIE	YUKO138.0	American	1988	NA	ND	ND	ND	0.73	0.25	0.23	2.7	0.05
86PR013AIE	PORC	American	1986	NA	ND	0.17	ND	0.64	0.54	0.17	8.7	0.11
87YR014AIE	MY-13	American	1987	NA	ND	ND	ND	0.18	0.37	0.11	1.9	ND
88YR015AIE	MY-4	American	1988	NA	ND	0.09	ND	0.02	0.15	0.04	1.0	ND
88SA021ZIE	T7NR14ES28	Arctic	1988	NA	ND	ND	ND	0.33	0.20	0.19	4.8	0.07
88CO024AIE	COLVILLE R.	Arctic	1988	NA	ND	0.06	ND	0.05	0.07	0.08	2.4	0.05
88CO026AIE	COLV497.0	Arctic	1988	NA	ND	ND	ND	0.44	0.12	0.09	1.1	ND
88CO027AIE	COLV528.0	Arctic	1988	NA	ND	ND	ND	0.10	0.28	0.12	2.1	0.07
89SR001AIE	SAGA203.5	Arctic	1989	NA	ND	0.01	NA	0.20	0.08	0.09	0.78	0.04
89NS002AIE	NORT725.8	Arctic	1989	NA	ND	0.16	NA	0.10	0.25	0.20	6.10	0.02
89SR003AIE	SAGA122.0	Arctic	1989	NA	ND	0.02	NA	0.11	0.05	0.08	14.80	0.03
89NS004AIE	NORT767.5	Arctic	1989	NA	ND	0.02	NA	0.06	0.23	0.06	1.76	0.02
89CO005AIE	COLV592.5	Arctic	1989	NA	ND	0.01	NA	0.87	0.07	0.14	0.82	0.05
89YR006AIE	YUKO254.0	American	1989	NA	ND	0.50	NA	0.15	0.18	0.16	2.67	0.05
89CO007AIE	COLV541.8	Arctic	1989	NA	ND	0.02	NA	0.53	0.06	0.09	1.27	0.03
89NS008AIE	NORT541.8	Arctic	1989	NA	ND	0.03	NA	0.12	0.13	0.08	1.25	0.04
89CO009AIE	COLV515.5	Arctic	1989	NA	ND	0.02	NA	0.14	0.24	0.09	0.68	0.02
89YR010AIE	YUKO229.0	American	1989	NA	ND	0.02	NA	0.10	0.17	0.07	1.40	0.04
89YR011AIE	YUKO95.0	American	1989	NA	ND	0.13	NA	0.02	0.06	0.03	0.79	0.02
89TA012AIE	TANA443.0	American	1989	NA	ND	0.02	NA	0.05	0.06	0.05	0.83	0.02

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Endosulfan II	Endrin	HCB	Heptachlor	Heptachlor epoxide	Mirex	Oxychlordane	Total PCBs	trans-nonachlor
89YR013AIE	YUKO239.5	American	1989	NA	ND	0.02	NA	0.62	0.19	0.18	3.38	0.07
89YR014AIE	YUKO191.5	American	1989	NA	ND	1.02	NA	0.05	0.02	0.03	1.33	0.02
89CO015AIE	COLV601.0	Arctic	1989	NA	ND	0.02	NA	0.25	0.10	0.17	8.47	0.13
89TA016AIE	TANA299.0	American	1989	NA	ND	0.02	NA	0.21	0.35	0.14	3.67	0.06
89TA017AIE	TANA272.0	American	1989	NA	ND	ND	NA	0.05	0.09	0.05	1.59	0.02
89SR018AIE	SAGA158.0	Arctic	1989	NA	ND	0.11	NA	0.22	0.17	0.16	2.22	0.04
89YR019AIE	YUKO243.5	American	1989	NA	ND	0.09	NA	0.23	0.15	0.33	4.63	0.21
89YR020AIE	YUKO3.5	American	1989	NA	ND	0.04	NA	0.15	0.20	0.12	2.68	0.03
89YR021AIE	YUKO138.0	American	1989	NA	ND	0.16	NA	0.36	0.10	0.11	1.86	0.02
89CO022AIE	COLV334.0	Arctic	1989	NA	ND	0.02	NA	0.18	0.07	0.07	1.63	0.06
89CO023AIE	COLV336.5	Arctic	1989	NA	ND	0.01	NA	0.10	0.18	0.07	1.50	0.02
89CO024AIE	COLV311.0	Arctic	1989	NA	ND	0.02	NA	0.16	0.08	0.12	5.63	0.03
89CO025AIE	COLV453.0	Arctic	1989	NA	ND	0.01	NA	0.10	0.13	0.06	1.20	0.04
89YR026AIE	YUKO1110.5	American	1989	NA	ND	0.01	NA	0.38	0.11	0.07	1.41	0.02
89NA027AIE	NANUOOA	Arctic	1989	NA	ND	0.47	NA	0.14	0.03	0.09	2.24	0.02
89YR030AIE	YUKO1643.5	American	1989	NA	ND	0.01	NA	0.23	0.18	0.07	1.11	0.01
89TA031AIE	TANA288.5	American	1989	NA	ND	0.02	NA	0.34	0.10	0.17	0.75	0.15
89YR032AIE	YUKO198.5	American	1989	NA	ND	0.01	NA	0.45	0.06	0.10	0.75	0.08
89CO041AIE	COLV536.0	Arctic	1989	NA	ND	0.02	NA	0.18	0.25	0.09	3.11	0.05
89CO043AIE	COLV464.0	Arctic	1989	NA	ND	0.26	NA	0.07	0.07	0.05	1.16	0.02
89CO044AIE	COLV482.8	Arctic	1989	NA	ND	0.03	NA	0.09	0.15	0.09	1.79	0.03
89NS046AIE	NORT767.5	Arctic	1989	NA	ND	0.13	NA	0.06	0.22	0.06	1.56	0.02
90CO001AIE	COLV281.8	Arctic	1990	NA	ND	0.02	NA	0.16	0.20	0.10	4.99	0.03
90CO002ZIE	COLV533.5	Arctic	1990	NA	ND	0.01	NA	0.10	0.15	0.07	3.32	0.03
90CO004AIE	COLV503.9	Arctic	1990	NA	ND	0.01	NA	0.14	0.10	0.06	1.54	0.04
90CO005AIE	COLV395.0	Arctic	1990	NA	ND	0.01	NA	0.05	0.07	0.04	0.99	0.02
90YR006AIE	YUKO233.0	American	1990	NA	ND	0.03	NA	0.08	0.08	0.08	15.03	0.06
90SR007ZIE	SAGA146.9	Arctic	1988	NA	ND	0.02	NA	0.19	0.16	0.13	1.9	0.04
90TA009AIE	TANA299.0	American	1990	NA	ND	0.01	NA	0.07	0.03	0.04	1.83	0.01
90YR010AIE	YUKO235.0	American	1990	NA	ND	0.01	NA	0.05	0.16	0.06	2.26	0.02

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Endosulfan II	Endrin	HCB	Heptachlor	Heptachlor epoxide	Mirex	Oxychlordane	Total PCBs	trans-nonachlor
90CO011AIE	COLV474.0	Arctic	1990	NA	ND	0.01	NA	0.19	0.08	0.08	1.75	0.03
90YR015AIE	YUKO1225.2	American	1990	NA	ND	0.01	NA	0.14	0.06	0.06	3.12	0.02
91AA015ZIE	PORC137.0	American	1991	NA	ND	0.04	NA	0.08	0.31	0.08	1.3	0.04
91CO001AIE	COLV283.0	Arctic	1991	NA	ND	0.03	NA	0.03	0.21	0.12	2.2	0.12
91CO002ZIE	COLV409.3	Arctic	1991	NA	ND	0.05	NA	0.13	0.10	0.08	1.1	0.03
91NA025AIE	ITKI	Arctic	1991	NA	ND	0.02	NA	0.03	0.22	0.03	0.8	ND
91NS019AIE	NORT372.0	Arctic	1991	NA	ND	0.06	NA	0.05	0.09	0.05	1.1	0.01
91NS020ZIE	NORT306.0	Arctic	1991	NA	ND	0.01	NA	0.02	0.27	0.02	2.6	0.01
91NS023ZIE	STUA6.4	Arctic	1991	NA	ND	0.04	NA	0.02	0.08	0.03	0.6	ND
91SR004AIE	SAGA101.8	Arctic	1991	NA	ND	0.05	NA	0.15	0.15	0.10	2.8	0.05
91YR005AIE	YUKO239.0	American	1991	NA	ND	0.05	NA	0.07	0.42	0.08	2.3	0.03
91YR006AIE	YUKO183.0	American	1991	NA	ND	0.02	NA	0.55	0.06	0.10	1.3	0.02
91YR007ZIE	YUKO138.0	American	1991	NA	ND	0.06	NA	0.56	0.18	0.13	1.3	0.04
91YR009AIE	YUKO1225.2	American	1991	NA	ND	0.01	NA	0.26	0.13	0.06	1.7	0.02
91YR010AIE	YUKO1250.5	American	1991	NA	ND	0.36	NA	0.02	0.09	0.05	0.7	0.03
91YR011AIE	YUKO1282.4	American	1991	NA	ND	0.04	NA	0.07	0.09	0.04	1.1	0.02
91YR012AIE	YUKO1291.3	American	1991	NA	ND	0.36	NA	0.10	0.29	0.10	2.6	0.04
91YR013AIE	YUKO1350.0	American	1991	NA	ND	0.01	NA	0.02	0.12	0.02	0.4	0.01
91YR014AIE	YUKO1433.0	American	1991	NA	ND	0.02	NA	0.08	0.09	0.05	3.9	0.04
91YR026AIE	YUKO1132.8	American	1991	NA	ND	0.07	NA	0.04	0.12	0.08	8.5	0.03
95CO01ABIE	COLV497.0	Arctic	1995	ND	ND	0.0099	ND	0.0582	0.1015	0.0470	0.882	0.0215
95CO01ACIE	COLV509.0	Arctic	1995	ND	ND	0.0106	ND	0.0988	0.1129	0.0545	0.621	0.0270
95CO01ADIE	COLV515.0	Arctic	1995	0.0023	ND	0.0093	ND	0.0769	0.1757	0.0587	0.926	0.0220
95CO01FAIE	COLV497.0	Arctic	1995	ND	ND	0.0103	ND	0.0597	0.1145	0.0521	0.963	0.0229
95CO01FEIE	COLV551.0	Arctic	1995	0.0019	ND	0.0107	ND	0.0483	0.2220	0.0608	0.858	0.0233
95CO01FFIE	KOGO	Arctic	1995	0.0031	ND	0.0258	ND	0.0917	0.3758	0.0934	1.285	0.0436
95PR01AAIE	PORC2.0	American	1995	0.0031	ND	0.1873	ND	0.0578	0.2445	0.0950	4.057	0.0375
95PR01ABIE	PORC80.0	American	1995	ND	ND	0.0035	ND	0.0081	0.0508	0.0151	0.524	0.0035
94SR01AAIE	SAGA123.5	Arctic	1994	ND	ND	0.0359	ND	0.0247	0.0522	0.0256	1.375	0.0164
93SR01ABIE	SAGA157.0	Arctic	1993	0.0046	0.0142	0.0304	ND	0.1345	0.0949	0.1142	1.088	0.0362

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Endosulfan II	Endrin	HCB	Heptachlor	Heptachlor epoxide	Mirex	Oxychlordane	Total PCBs	trans-nonachlor
93SR01ACIE	SAGA191.9	Arctic	1993	0.0074	0.0239	1.2772	ND	0.1621	0.0949	0.1376	2.584	0.0639
SR01ADIEz	SAGA199.5	Arctic	1993	0.0029	0.0012	0.0149	ND	0.0698	0.1354	0.0982	1.399	0.1253
95SR01AFIE	SAGA200.0	Arctic	1995	0.0029	0.0081	0.0161	ND	0.0412	0.1624	0.0685	1.289	0.0294
93SR01AGIE	SAGA207.0	Arctic	1993	0.0020	ND	0.1598	ND	0.1061	0.5332	0.1295	5.988	0.0398
95SR01AHIE	SAGA209.0	Arctic	1995	0.0030	ND	0.0160	0.0033	0.0483	0.1283	0.0525	1.416	0.0165
93TA01AAIEz	TANA232.5	American	1993	0.0011	ND	0.0429	ND	0.0811	0.1416	0.0559	1.905	0.0221
93TA01ACIE	TANA247.5	American	1993	0.0011	ND	0.0328	ND	0.0938	0.1256	0.0648	1.583	0.0415
93TA01ADIE	TANA258.5	American	1993	ND	ND	0.0093	ND	0.0281	0.0756	0.0250	1.018	0.0148
94TA01AEIE	TANA299.0	American	1994	ND	ND	0.1953	0.0011	0.1196	0.1782	0.0522	3.155	0.0106
94TA01AFIE	TANA336.5	American	1994	0.0030	ND	0.0117	ND	0.0609	0.1737	0.0803	2.471	0.0361
94TA01AGIE	TANA407.8	American	1994	0.0088	0.0066	0.0234	ND	0.1343	0.2432	0.0994	2.045	0.0674
93TA01AHIE	TANA427.0	American	1993	ND	0.0022	0.0094	ND	0.0349	0.1000	0.0303	0.434	0.0095
93TA01AIIEz	TANA460.0	American	1993	0.0053	0.0011	0.2217	ND	0.0274	0.1508	0.0682	6.201	0.0341
95TA02ALIE	TANA221.5D	American	1995	0.0034	0.0053	0.0324	ND	0.0346	0.1240	0.0798	2.353	0.0315
93YR01AAIE	YUKO3.5	American	1993	0.0025	0.0032	0.0116	ND	0.0358	0.2402	0.0600	1.215	0.0217
93YR01ACIEz	YUKO166.0	American	1993	ND	ND	0.0038	ND	0.0146	0.0167	0.0153	0.505	0.0045
95YR01AEIE	YUKO167.0	American	1995	0.0024	ND	0.0278	ND	0.0663	0.1375	0.0702	3.679	0.0289
95YR01AHIEz	YUKO25.0	American	1995	0.0015	0.0011	0.0162	ND	0.0378	0.0786	0.0594	1.557	0.0203
95YR01AJIE	YUKO48.5	American	1995	ND	0.0021	0.0378	ND	0.0126	0.0542	0.0243	0.803	0.0141
95YR01AKIE	YUKO76.5	American	1995	0.0053	ND	0.0253	ND	0.0349	0.1012	0.0656	2.187	0.1276
95YR01FFIE	YUKO117.0	American	1995	0.0056	ND	0.0281	ND	0.1752	0.2880	0.1145	3.917	0.0567
95YR01FGIE	YUKO229.0	American	1995	ND	0.0021	0.0450	ND	0.0204	0.1512	0.0378	1.122	0.0154
95YR01FLIE	YUKO208.5	American	1995	ND	0.0016	0.0157	ND	0.0345	0.1094	0.0495	1.677	0.0176
95YR02AAIE	70 Mile R.(#305)	American	1995	ND	ND	0.0061	ND	0.0283	0.0699	0.0291	0.907	0.0107

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron
86PR013AIE	PORC	American	1986	ND	ND	NA	ND	ND	71.90	ND	ND	NA	ND	144.00
87YR014AIE	MY-13	American	1987	13.9	ND	NA	ND	ND	26.10	ND	3.99	NA	5.39	105.00
88CO024AIE	COLVILLE R.	Arctic	1988	48.9	ND	NA	ND	ND	16.30	ND	ND	NA	4.29	85.40
88CO026AIE	COLV497.0	Arctic	1988	71.6	ND	NA	ND	ND	10.60	ND	ND	NA	2.81	60.80
88CO027AIE	COLV528.0	Arctic	1988	ND	ND	NA	ND	ND	17.80	ND	ND	NA	ND	41.70
88SA021ZIE	T7NR14ES28	Arctic	1988	ND	ND	NA	ND	ND	14.60	ND	ND	NA	2.54	67.30
88TA002AIE	TANA436.0	American	1988	ND	ND	NA	ND	ND	29.20	ND	2.22	NA	4.56	140.00
88YR001AIE	YUKO205.5	American	1988	6.6	ND	NA	ND	ND	27.20	ND	ND	NA	3.71	105.00
88YR003AIE	YUKO3.5	American	1988	ND	ND	NA	ND	ND	25.00	ND	1.36	NA	4.86	148.00
88YR004AIE	YUKO138.0	American	1988	6.7	ND	NA	ND	ND	25.20	ND	0.48	NA	4.04	82.10
88YR015AIE	MY-4	American	1988	11.0	ND	NA	ND	ND	13.80	ND	7.86	NA	6.83	207.00
89SR001AIE	SAGA203.5	Arctic	1989	QA/QC	QA/QC	ND	0.4	ND	ND	ND	ND	ND	2.9	75
89NS002AIE	NORT725.8	Arctic	1989	QA/QC	QA/QC	ND	0.7	ND	ND	ND	2.0	ND	3.4	140
89SR003AIE	SAGA122.0	Arctic	1989	QA/QC	QA/QC	ND	0.5	ND	ND	ND	ND	ND	2.4	106
89SR004AIE	NORT767.5	Arctic	1989	QA/QC	QA/QC	ND	0.4	ND	ND	ND	ND	ND	1.7	80
89CO005AIE	COLV592.5	Arctic	1989	QA/QC	QA/QC	ND	0.4	ND	ND	ND	ND	ND	2.3	109
89YR006AIE	YUKO254.0	American	1989	QA/QC	QA/QC	ND	0.9	ND	ND	ND	ND	1.7	3.0	121
89CO007AIE	COLV541.8	Arctic	1989	QA/QC	QA/QC	ND	0.6	ND	ND	ND	ND	ND	2.2	104
89NS008AIE	NORT541.8	Arctic	1989	QA/QC	QA/QC	ND	0.3	0.03	0.5	0.2	ND	ND	2.4	101
89CO009AIE	COLV515.5	Arctic	1989	QA/QC	QA/QC	ND	0.5	ND	ND	ND	ND	ND	2.7	110
89YR010AIE	YUKO229.0	American	1989	QA/QC	QA/QC	ND	0.4	ND	ND	ND	ND	ND	3.0	133
89YR011AIE	YUKO95.0	American	1989	QA/QC	QA/QC	ND	0.5	ND	ND	ND	ND	ND	2.5	86
89TA012AIE	TANA443.0	American	1989	QA/QC	QA/QC	ND	0.4	ND	ND	ND	ND	ND	2.1	101
89YR013AIE	YUKO239.5	American	1989	QA/QC	QA/QC	ND	0.6	ND	ND	ND	ND	ND	2.3	127
89YR014AIE	YUKO191.5	American	1989	QA/QC	QA/QC	ND	0.7	ND	ND	ND	ND	ND	3.1	136
89CO015AIE	COLV601.0	Arctic	1989	QA/QC	QA/QC	ND	0.6	ND	ND	ND	ND	ND	2.6	99
89TA016AIE	TANA299.0	American	1989	QA/QC	QA/QC	ND	0.3	ND	ND	ND	1.5	ND	2.6	107
89TA017AIE	TANA272.0	American	1989	QA/QC	QA/QC	ND	0.5	ND	ND	ND	ND	ND	3.5	69

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron
89SR018AIE	SAGA158.0	Arctic	1989	QA/QC	QA/QC	ND	1.0	ND	ND	ND	ND	ND	1.5	111
89YR019AIE	YUKO243.5	American	1989	QA/QC	QA/QC	ND	0.6	0.07	1.4	0.3	1.0	ND	4.9	124
89YR020AIE	YUKO3.5	American	1989	QA/QC	QA/QC	ND	0.3	ND	0.5	ND	ND	ND	2.5	99
89YR021AIE	YUKO138.0	American	1989	QA/QC	QA/QC	ND	0.3	ND	ND	ND	ND	ND	2.7	102
89CO022AIE	COLV334.0	Arctic	1989	QA/QC	QA/QC	ND	0.4	ND	ND	ND	ND	ND	2.7	82
89CO023AIE	COLV336.5	Arctic	1989	QA/QC	QA/QC	ND	1.4	ND	ND	ND	ND	ND	2.9	80
89CO024AIE	COLV311.0	Arctic	1989	QA/QC	QA/QC	ND	0.5	ND	ND	ND	ND	ND	2.9	116
89CO025AIE	COLV453.0	Arctic	1989	QA/QC	QA/QC	ND	1.0	ND	ND	ND	ND	ND	3.6	135
89YR026AIE	YUKO1110.5	American	1989	QA/QC	QA/QC	ND	0.7	ND	ND	ND	ND	ND	3.0	130
89NA027AIE	NANUOOA	Arctic	1989	QA/QC	QA/QC	ND	0.3	ND	ND	ND	ND	ND	2.4	64
89YR030AIE	YUKO1643.5	American	1989	QA/QC	QA/QC	ND	0.2	ND	ND	ND	ND	ND	3.0	80
89TA031AIE	TANA288.5	American	1989	QA/QC	QA/QC	ND	0.2	ND	ND	ND	1.0	ND	2.7	81
89YR032AIE	YUKO198.5	American	1989	QA/QC	QA/QC	ND	0.2	ND	ND	ND	ND	ND	2.5	67
89CO041AIE	COLV536.0	Arctic	1989	QA/QC	QA/QC	ND	0.5	ND	ND	ND	0.9	ND	2.6	131
89CO043AIE	COLV464.0	Arctic	1989	QA/QC	QA/QC	ND	0.4	ND	ND	ND	ND	ND	3.1	58
89CO044AIE	COLV482.8	Arctic	1989	QA/QC	QA/QC	ND	0.7	0.13	0.1	0.7	ND	ND	3.3	89
89TK046AIE	NORT767.5	Arctic	1989	QA/QC	QA/QC	ND	0.3	ND	ND	ND	ND	ND	2.3	81
91AA015ZIE	PORC137.0	American	1991	ND	NA	ND	ND	ND	4.0	ND	ND	NA	2.33	80.80
91CO001AIE	COLV283.0	Arctic	1991	ND	NA	ND	ND	ND	3.8	ND	ND	NA	2.47	42.09
91CO002ZIE	COLV409.3	Arctic	1991	ND	NA	ND	ND	ND	4.1	ND	ND	NA	2.63	85.39
91NS019AIE	NORT372.0	Arctic	1991	ND	NA	ND	ND	ND	ND	ND	ND	NA	3.18	27.95
91NS020BIE	NORT306.0	Arctic	1991	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.71	80.91
91NS023ZIE	STUA6.4	Arctic	1991	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.68	70.75
91SR004AIE	SAGA101.8	Arctic	1991	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.60	45.22
91YR006AIE	YUKO183.0	American	1991	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.75	69.58
91YR007ZIE	YUKO138.0	American	1991	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.83	74.79
91YR009AIE	YUKO1225.2	American	1991	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.35	82.27
91YR010AIE	YUKO1250.5	American	1991	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.29	89.05

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron
91YR011AIE	YUKO1282.4	American	1991	ND	NA	ND	ND	ND	ND	ND	ND	NA	3.00	60.50
91YR012AIE	YUKO1291.3	American	1991	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.00	70.00
91YR013AIE	YUKO1350.0	American	1991	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.69	86.19
91YR014AIE	YUKO1433.0	American	1991	ND	NA	ND	ND	ND	ND	ND	ND	NA	1.77	57.14
91NA025AIE	ITKI	Arctic	1991	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
91YR005AIE	YUKO239.0	American	1991	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
91YR026AIE	YUKO1132.8	American	1991	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
93SR01ABIE	SAGA157.0	Arctic	1993	11	NA	ND	ND	ND	ND	ND	ND	NA	2.2	71
93SR01ACIE	SAGA191.9	Arctic	1993	134	NA	ND	2	ND	6	ND	ND	NA	2.5	163
93SR01ADIEz	SAGA199.5	Arctic	1993	ND	NA	ND	ND	0.8	ND	ND	ND	NA	2.4	53
93SR01AGIE	SAGA207.0	Arctic	1993	ND	NA	ND	ND	ND	3	ND	ND	NA	4.0	111
93TA01AAIEz	TANA232.5	Arctic	1993	ND	NA	ND	ND	ND	2	ND	ND	NA	2.2	64
93TA01ACIE	TANA247.5	Arctic	1993	ND	NA	ND	ND	ND	ND	ND	ND	NA	3.2	132
93TA01ADIE	TANA258.5	American	1993	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.3	43
93TA01AHIE	TANA427.0	American	1993	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.3	40
93TA01AIIEz	TANA460.0	Arctic	1993	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.1	41
93YR01AAIE	YUKO3.5	Arctic	1993	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.4	40
93YR01ACIEz	YUKO166.0	Arctic	1993	14	NA	ND	ND	ND	ND	ND	ND	NA	3.7	107
94SR01AAIE	SAGA123.5	Arctic	1994	ND	NA	ND	ND	ND	5	ND	ND	NA	3.1	59
94TA01AEIE	TANA299.0	Arctic	1994	ND	NA	ND	ND	ND	ND	ND	ND	NA	1.8	73
94TA01AFIE	TANA336.5	Arctic	1994	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.6	45
94TA01AGIE	TANA407.8	Arctic	1994	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.7	36
94YR01FBIE	YUKO233.0	American	1994	5	NA	ND	1	ND	ND	ND	ND	NA	3.7	174
95CO01ABIE	COLV497.0	American	1995	ND	NA	ND	ND	ND	2	ND	ND	NA	2.3	105
95CO01ACIE	COLV509.0	American	1995	ND	NA	ND	ND	ND	2	ND	ND	NA	2.2	98
95CO01ADIE	COLV515.0	American	1995	ND	NA	ND	ND	ND	3	ND	ND	NA	2.2	69
95CO01FAIE	COLV497.0	American	1995	ND	NA	ND	ND	ND	ND	ND	ND	NA	1.7	84
95CO01FEIE	COLV551.0	American	1995	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.4	73

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron
95CO01FFIE	KOGO	American	1995	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.1	94
95PR01AAIE	PORC2.0	American	1995	ND	NA	ND	ND	ND	ND	ND	1.5	NA	3.6	107
95PR01ABIE	PORC80.0	American	1995	ND	NA	ND	ND	ND	3	ND	ND	NA	2.5	91
95SR01AFIE	SAGA200.0	American	1995	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.5	42
95SR01AHIE	SAGA209.0	American	1995	6	NA	ND	ND	ND	ND	ND	ND	NA	2.6	67
95TA02ALIE	TANA221.5D	American	1995	ND	NA	ND	ND	ND	ND	ND	ND	NA	1.8	53
95YR01AEIE	YUKO167.0	American	1995	ND	NA	ND	ND	ND	ND	ND	ND	NA	1.9	83
95YR01AHIEz	YUKO25.0	American	1995	ND	NA	ND	ND	ND	ND	ND	0.5	NA	2.5	98
95YR01AJIE	YUKO48.5	American	1995	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.6	79
95YR01AKIE	YUKO76.5	American	1995	7	NA	ND	ND	ND	3	ND	ND	NA	1.8	64
95YR01FFIE	YUKO117.0	American	1995	ND	NA	ND	ND	ND	ND	ND	0.8	NA	2.0	71
95YR01FGIE	YUKO229.0	American	1995	ND	NA	ND	ND	ND	ND	ND	ND	NA	2.8	99
95YR01FLIE	YUKO208.5	American	1995	ND	NA	ND	ND	ND	ND	ND	ND	NA	1.8	91
95YR02AAIE	70 Mile R.(#305)	American	1995	ND	NA	ND	1	ND	ND	ND	ND	NA	3.3	74

Sample ID	Sample Location	Subspecies	Year	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Silver	Selenium	Strontium	Thallium
86PR013AIE	PORC	American	1986	ND	ND	ND	2.180	ND	ND	ND	NA	ND	ND
87YR014AIE	MY-13	American	1987	ND	483.00	ND	2.430	ND	ND	ND	NA	1.33	ND
88CO024AIE	COLVILLE R.	Arctic	1988	ND	548.00	1.1	2.250	ND	ND	ND	NA	2.05	ND
88CO026AIE	COLV497.0	Arctic	1988	ND	372.00	ND	1.750	ND	ND	ND	NA	0.45	ND
88CO027AIE	COLV528.0	Arctic	1988	ND	388.00	ND	1.480	ND	ND	ND	NA	0.71	ND
88SA021ZIE	T7NR14ES28	Arctic	1988	ND	335.00	0.7	1.950	ND	1.62	ND	NA	0.88	ND
88TA002AIE	TANA436.0	American	1988	ND	582.00	1.4	4.040	ND	ND	ND	NA	1.48	ND
88YR001AIE	YUKO205.5	American	1988	ND	563.00	0.7	0.820	ND	ND	ND	NA	1.41	ND
88YR003AIE	YUKO3.5	American	1988	ND	273.00	1.8	3.190	ND	ND	ND	NA	1.70	ND
88YR004AIE	YUKO138.0	American	1988	ND	556.00	1.0	1.990	ND	ND	ND	NA	1.78	ND
88YR015AIE	MY-4	American	1988	ND	689.00	3.7	2.020	ND	5.75	ND	NA	2.45	ND
89SR001AIE	SAGA203.5	Arctic	1989	0.3	381	1.2	1.57	ND	ND	QA/QC	2.7	0.9	NA

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Silver	Selenium	Strontium	Thallium
89NS002AIE	NORT725.8	Arctic	1989	0.1	461	2.9	1.48	ND	1.1	QA/QC	2.9	1.7	NA
89SR003AIE	SAGA122.0	Arctic	1989	ND	408	1.7	2.70	ND	ND	QA/QC	2.6	1.5	NA
89SR004AIE	NORT767.5	Arctic	1989	ND	391	1.2	1.77	ND	ND	QA/QC	2.6	0.6	NA
89CO005AIE	COLV592.5	Arctic	1989	0.2	404	2.0	2.13	ND	ND	QA/QC	2.1	1.1	NA
89YR006AIE	YUKO254.0	American	1989	ND	459	2.3	1.61	ND	ND	QA/QC	2.3	1.3	NA
89CO007AIE	COLV541.8	Arctic	1989	0.1	435	1.4	1.96	ND	ND	QA/QC	2.1	1.2	NA
89NS008AIE	NORT541.8	Arctic	1989	ND	453	1.9	1.67	1.1	0.7	QA/QC	2.2	0.7	NA
89CO009AIE	COLV515.5	Arctic	1989	ND	419	1.4	1.48	ND	ND	QA/QC	1.9	0.6	NA
89YR010AIE	YUKO229.0	American	1989	ND	414	2.0	1.44	ND	ND	QA/QC	2.8	0.9	NA
89YR011AIE	YUKO95.0	American	1989	ND	417	1.2	1.35	1.1	ND	QA/QC	2.7	0.6	NA
89TA012AIE	TANA443.0	American	1989	0.1	437	1.5	1.69	ND	ND	QA/QC	0.9	0.5	NA
89YR013AIE	YUKO239.5	American	1989	0.1	385	1.7	1.18	ND	ND	QA/QC	2.5	1.3	NA
89YR014AIE	YUKO191.5	American	1989	0.2	540	1.4	0.85	ND	ND	QA/QC	2.5	1.2	NA
89CO015AIE	COLV601.0	Arctic	1989	ND	368	1.3	1.96	ND	ND	QA/QC	2.5	0.7	NA
89TA016AIE	TANA299.0	American	1989	0.1	358	1.8	2.53	ND	ND	QA/QC	2.4	0.7	NA
89TA017AIE	TANA272.0	American	1989	ND	479	1.0	1.25	ND	ND	QA/QC	2.5	0.9	NA
89SR018AIE	SAGA158.0	Arctic	1989	0.1	415	1.5	1.88	ND	ND	QA/QC	2.7	1.0	NA
89YR019AIE	YUKO243.5	American	1989	ND	393	2.0	1.13	4.2	1.0	QA/QC	2.7	1.0	NA
89YR020AIE	YUKO3.5	American	1989	0.1	435	1.7	1.77	ND	ND	QA/QC	2.6	0.6	NA
89YR021AIE	YUKO138.0	American	1989	0.1	415	0.9	1.06	ND	ND	QA/QC	2.5	0.6	NA
89CO022AIE	COLV334.0	Arctic	1989	0.2	516	0.7	7.69	ND	ND	QA/QC	2.5	1.6	NA
89CO023AIE	COLV336.5	Arctic	1989	ND	480	1.9	1.75	ND	ND	QA/QC	2.6	1.3	NA
89CO024AIE	COLV311.0	Arctic	1989	0.1	576	1.1	1.87	ND	ND	QA/QC	2.7	1.1	NA
89CO025AIE	COLV453.0	Arctic	1989	0.2	488	1.7	1.95	ND	ND	QA/QC	2.5	1.0	NA
89YR026AIE	YUKO1110.5	American	1989	ND	426	1.6	1.50	ND	ND	QA/QC	2.2	1.2	NA
89NA027AIE	NANUOOA	Arctic	1989	ND	513	1.0	3.66	ND	ND	QA/QC	2.9	1.1	NA
89YR030AIE	YUKO1643.5	American	1989	ND	482	0.7	1.01	ND	ND	QA/QC	0.8	0.7	NA
89TA031AIE	TANA288.5	American	1989	ND	549	1.1	2.08	ND	ND	QA/QC	2.9	0.9	NA

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Silver	Selenium	Strontium	Thallium
89YR032AIE	YUKO198.5	American	1989	ND	456	0.8	1.46	ND	ND	QA/QC	1.8	0.9	NA
89CO041AIE	COLV536.0	Arctic	1989	0.1	511	2.3	1.68	ND	ND	QA/QC	1.6	1.2	NA
89CO043AIE	COLV464.0	Arctic	1989	ND	381	0.6	0.91	ND	ND	QA/QC	1.7	0.8	NA
89CO044AIE	COLV482.8	Arctic	1989	ND	601	1.2	1.75	4	1.2	QA/QC	2.2	1.2	NA
89TK046AIE	NORT767.5	Arctic	1989	ND	479	1.0	1.91	ND	ND	QA/QC	2.5	0.9	NA
91AA015ZIE	PORC137.0	American	1991	NA	343.06	1.08	2.238	ND	ND	NA	NA	0.70	NA
91CO001AIE	COLV283.0	Arctic	1991	NA	378.26	0.43	2.339	ND	ND	NA	NA	0.52	NA
91CO002ZIE	COLV409.3	Arctic	1991	NA	460.68	1.10	2.006	ND	ND	NA	NA	1.19	NA
91NS019AIE	NORT372.0	Arctic	1991	NA	464.50	ND	1.890	ND	ND	NA	NA	0.86	NA
91NS020BIE	NORT306.0	Arctic	1991	NA	378.18	1.18	1.315	ND	ND	NA	NA	0.74	NA
91NS023ZIE	STUA6.4	Arctic	1991	NA	468.25	1.12	1.570	ND	ND	NA	NA	2.79	NA
91SR004AIE	SAGA101.8	Arctic	1991	NA	327.83	0.46	2.396	ND	ND	NA	NA	0.59	NA
91YR006AIE	YUKO183.0	American	1991	NA	354.17	0.60	1.171	ND	ND	NA	NA	0.83	NA
91YR007ZIE	YUKO138.0	American	1991	NA	340.32	0.69	1.336	ND	ND	NA	NA	0.61	NA
91YR009AIE	YUKO1225.2	American	1991	NA	432.27	1.13	0.973	ND	ND	NA	NA	0.86	NA
91YR010AIE	YUKO1250.5	American	1991	NA	390.48	0.80	1.914	ND	ND	NA	NA	0.51	NA
91YR011AIE	YUKO1282.4	American	1991	NA	424.50	0.84	2.390	ND	ND	NA	NA	1.13	NA
91YR012AIE	YUKO1291.3	American	1991	NA	408.57	0.82	0.681	ND	ND	NA	NA	0.86	NA
91YR013AIE	YUKO1350.0	American	1991	NA	451.90	0.91	0.762	ND	ND	NA	NA	0.72	NA
91YR014AIE	YUKO1433.0	American	1991	NA	198.29	1.04	2.320	ND	ND	NA	NA	0.49	NA
91NA025AIE	ITKI	Arctic	1991	NA	NA	NA	3.082	NA	NA	NA	NA	NA	NA
91YR005AIE	YUKO239.0	American	1991	NA	NA	NA	1.365	NA	NA	NA	NA	NA	NA
91YR026AIE	YUKO1132.8	American	1991	NA	NA	NA	5.680	NA	NA	NA	NA	NA	NA
93SR01ABIE	SAGA157.0	Arctic	1993	ND	491	ND	1.98	ND	ND	NA	2.5	1.8	NA
93SR01ACIE	SAGA191.9	Arctic	1993	2.2	572	3	1.52	ND	ND	NA	1.9	2.8	NA
93SR01ADIEz	SAGA199.5	Arctic	1993	ND	479	ND	2.60	ND	0.8	NA	1.9	0.6	NA
93SR01AGIE	SAGA207.0	Arctic	1993	ND	166	2	1.80	ND	0.7	NA	2.2	1.1	NA
93TA01AAIEz	TANA232.5	Arctic	1993	ND	457	ND	2.80	ND	1.4	NA	2.4	0.5	NA

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Silver	Selenium	Strontium	Thallium
93TA01ACIE	TANA247.5	Arctic	1993	ND	376	2	9.16	ND	ND	NA	3.7	1.0	NA
93TA01ADIE	TANA258.5	American	1993	ND	589	ND	1.25	ND	0.6	NA	2.5	ND	NA
93TA01AHIE	TANA427.0	American	1993	ND	637	ND	1.58	ND	1.3	NA	3.0	1.0	NA
93TA01AIIEz	TANA460.0	Arctic	1993	ND	217	ND	3.24	ND	1.0	NA	2.5	ND	NA
93YR01AAIE	YUKO3.5	Arctic	1993	ND	511	ND	1.58	ND	ND	NA	2.3	0.6	NA
93YR01ACIEz	YUKO166.0	Arctic	1993	ND	631	2	1.10	ND	ND	NA	3.3	1.3	NA
94SR01AAIE	SAGA123.5	Arctic	1994	ND	602	ND	2.37	ND	ND	NA	2.5	0.7	NA
94TA01AEIE	TANA299.0	Arctic	1994	ND	460	ND	0.93	ND	1.0	NA	2.3	ND	NA
94TA01AFIE	TANA336.5	Arctic	1994	ND	406	ND	2.07	ND	1.8	NA	2.2	ND	NA
94TA01AGIE	TANA407.8	Arctic	1994	ND	506	ND	2.70	ND	ND	NA	2.3	ND	NA
94YR01FBIE	YUKO233.0	American	1994	ND	734	3	9.58	ND	ND	NA	4.2	2.7	NA
95CO01ABIE	COLV497.0	American	1995	ND	456	ND	1.51	ND	ND	NA	2.0	1.0	NA
95CO01ACIE	COLV509.0	American	1995	ND	363	ND	3.05	ND	ND	NA	2.3	ND	NA
95CO01ADIE	COLV515.0	American	1995	ND	407	ND	1.66	ND	ND	NA	2.7	ND	NA
95CO01FAIE	COLV497.0	American	1995	ND	426	ND	1.32	ND	ND	NA	1.9	0.8	NA
95CO01FEIE	COLV551.0	American	1995	ND	582	2	1.45	ND	ND	NA	2.9	0.8	NA
95CO01FFIE	KOGO	American	1995	ND	485	2	1.29	ND	ND	NA	2.1	ND	NA
95PR01AAIE	PORC2.0	American	1995	ND	885	ND	4.44	ND	ND	NA	4.5	ND	NA
95PR01ABIE	PORC80.0	American	1995	ND	681	ND	0.48	ND	ND	NA	2.7	1.1	NA
95SR01AFIE	SAGA200.0	American	1995	ND	380	ND	1.20	ND	1.4	NA	2.2	ND	NA
95SR01AHIE	SAGA209.0	American	1995	ND	428	1	3.12	ND	ND	NA	1.9	1.2	NA
95TA02ALIE	TANA221.5D	American	1995	ND	398	ND	1.92	ND	0.9	NA	2.7	ND	NA
95YR01AEIE	YUKO167.0	American	1995	ND	405	1	2.73	ND	ND	NA	2.9	0.7	NA
95YR01AHIEz	YUKO25.0	American	1995	ND	434	ND	2.43	ND	0.4	NA	3.0	0.5	NA
95YR01AJIE	YUKO48.5	American	1995	ND	393	ND	1.79	ND	ND	NA	2.5	0.7	NA
95YR01AKIE	YUKO76.5	American	1995	ND	434	ND	3.90	ND	ND	NA	2.9	ND	NA
95YR01FFIE	YUKO117.0	American	1995	ND	319	2	2.47	ND	0.5	NA	2.6	0.5	NA
95YR01FGIE	YUKO229.0	American	1995	ND	316	2	2.27	ND	ND	NA	2.4	0.5	NA
95YR01FLIE	YUKO208.5	American	1995	ND	356	2	1.79	ND	ND	NA	2.4	0.7	NA
95YR02AAIE	70 Mile R.(#305)	American	1995	ND	677	3	1.13	ND	ND	NA	3.3	1.7	NA

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Tin	Vanadium	Zinc
86PR013AIE	PORC	American	1986	ND	ND	67.90
87YR014AIE	MY-13	American	1987	9.59	ND	45.60
88CO024AIE	COLVILLE R.	Arctic	1988	10.80	ND	37.00
88CO026AIE	COLV497.0	Arctic	1988	ND	ND	25.40
88CO027AIE	COLV528.0	Arctic	1988	ND	ND	38.10
88SA021ZIE	T7NR14ES28	Arctic	1988	7.14	ND	33.20
88TA002AIE	TANA436.0	American	1988	11.50	ND	48.40
88YR001AIE	YUKO205.5	American	1988	11.40	ND	40.00
88YR003AIE	YUKO3.5	American	1988	15.00	ND	57.00
88YR004AIE	YUKO138.0	American	1988	11.00	ND	44.00
88YR015AIE	MY-4	American	1988	10.80	ND	89.70
89SR001AIE	SAGA203.5	Arctic	1989	QA/QC	ND	37
89NS002AIE	NORT725.8	Arctic	1989	QA/QC	ND	79
89SR003AIE	SAGA122.0	Arctic	1989	QA/QC	ND	47
89SR004AIE	NORT767.5	Arctic	1989	QA/QC	ND	36
89CO005AIE	COLV592.5	Arctic	1989	QA/QC	ND	40
89YR006AIE	YUKO254.0	American	1989	QA/QC	ND	59
89CO007AIE	COLV541.8	Arctic	1989	QA/QC	ND	47
89NS008AIE	NORT541.8	Arctic	1989	QA/QC	ND	43
89CO009AIE	COLV515.5	Arctic	1989	QA/QC	ND	44
89YR010AIE	YUKO229.0	American	1989	QA/QC	ND	50
89YR011AIE	YUKO95.0	American	1989	QA/QC	ND	33
89TA012AIE	TANA443.0	American	1989	QA/QC	ND	44
89YR013AIE	YUKO239.5	American	1989	QA/QC	ND	53
89YR014AIE	YUKO191.5	American	1989	QA/QC	ND	49
89CO015AIE	COLV601.0	Arctic	1989	QA/QC	ND	43
89TA016AIE	TANA299.0	American	1989	QA/QC	ND	46
89SR018AIE	SAGA158.0	Arctic	1989	QA/QC	ND	49
89YR019AIE	YUKO243.5	American	1989	QA/QC	ND	47
89YR020AIE	YUKO3.5	American	1989	QA/QC	ND	44
89YR021AIE	YUKO138.0	American	1989	QA/QC	ND	35

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Tin	Vanadium	Zinc
89CO024AIE	COLV311.0	Arctic	1989	QA/QC	ND	37
89CO025AIE	COLV453.0	Arctic	1989	QA/QC	ND	46
89YR026AIE	YUKO1110.5	American	1989	QA/QC	ND	42
89NA027AIE	NANUOOA	Arctic	1989	QA/QC	ND	34
89YR030AIE	YUKO1643.5	American	1989	QA/QC	ND	38
89TA031AIE	TANA288.5	American	1989	QA/QC	ND	40
89YR032AIE	YUKO198.5	American	1989	QA/QC	ND	31
89CO041AIE	COLV536.0	Arctic	1989	QA/QC	ND	48
89CO043AIE	COLV464.0	Arctic	1989	QA/QC	ND	32
89CO044AIE	COLV482.8	Arctic	1989	QA/QC	ND	35
89TK046AIE	NORT767.5	Arctic	1989	QA/QC	ND	34
91AA015ZIE	PORC137.0	American	1991	NA	ND	32.62
91CO001AIE	COLV283.0	Arctic	1991	NA	ND	26.13
91CO002ZIE	COLV409.3	Arctic	1991	NA	ND	36.26
91NS019AIE	NORT372.0	Arctic	1991	NA	ND	29.75
91NS020BIE	NORT306.0	Arctic	1991	NA	ND	33.41
91NS023ZIE	STUA6.4	Arctic	1991	NA	ND	30.75
91SR004AIE	SAGA101.8	Arctic	1991	NA	ND	29.48
91YR006AIE	YUKO183.0	American	1991	NA	ND	35.25
91YR007ZIE	YUKO138.0	American	1991	NA	ND	32.29
91YR009AIE	YUKO1225.2	American	1991	NA	ND	35.95
91YR010AIE	YUKO1250.5	American	1991	NA	ND	31.38
91YR011AIE	YUKO1282.4	American	1991	NA	ND	36.85
91YR012AIE	YUKO1291.3	American	1991	NA	ND	31.48
91YR013AIE	YUKO1350.0	American	1991	NA	ND	41.52
91YR014AIE	YUKO1433.0	American	1991	NA	ND	26.03
91NA025AIE	ITKI	Arctic	1991	NA	NA	NA
91YR005AIE	YUKO239.0	American	1991	NA	NA	NA
91YR026AIE	YUKO1132.8	American	1991	NA	NA	NA
93SR01ABIE	SAGA157.0	Arctic	1993	NA	ND	22
93SR01ACIE	SAGA191.9	Arctic	1993	NA	0.7	31

Appendix E (cont.)

Sample ID	Sample Location	Subspecies	Year	Tin	Vanadium	Zinc
93SR01ADIEz	SAGA199.5	Arctic	1993	NA	ND	30
93SR01AGIE	SAGA207.0	Arctic	1993	NA	0.8	41
93TA01AAIEz	TANA232.5	Arctic	1993	NA	ND	27
93TA01ACIE	TANA247.5	Arctic	1993	NA	0.7	38
93TA01ADIE	TANA258.5	American	1993	NA	ND	28
93TA01AHIE	TANA427.0	American	1993	NA	1.2	28
93TA01AIIEz	TANA460.0	Arctic	1993	NA	0.3	24
93YR01AAIE	YUKO3.5	Arctic	1993	NA	0.8	32
93YR01ACIEz	YUKO166.0	Arctic	1993	NA	0.7	48
94SR01AAIE	SAGA123.5	Arctic	1994	NA	0.6	33
94TA01AGIE	TANA407.8	Arctic	1994	NA	0.9	32
94YR01FBIE	YUKO233.0	American	1994	NA	ND	55
95CO01ABIE	COLV497.0	American	1995	NA	ND	34
95CO01ACIE	COLV509.0	American	1995	NA	ND	36
95CO01ADIE	COLV515.0	American	1995	NA	ND	32
95CO01FAIE	COLV497.0	American	1995	NA	ND	44
95CO01FEIE	COLV551.0	American	1995	NA	ND	34
95CO01FFIE	KOGO	American	1995	NA	ND	44
95PR01AAIE	PORC2.0	American	1995	NA	ND	41
95PR01ABIE	PORC80.0	American	1995	NA	ND	39
95SR01AFIE	SAGA200.0	American	1995	NA	0.5	29
95SR01AHIE	SAGA209.0	American	1995	NA	ND	35
95TA02ALIE	TANA221.5D	American	1995	NA	0.7	34
95YR01AHIEz	YUKO25.0	American	1995	NA	ND	34
95YR01AJIE	YUKO48.5	American	1995	NA	ND	33
95YR01AKIE	YUKO76.5	American	1995	NA	ND	37
95YR01FFIE	YUKO117.0	American	1995	NA	ND	35
95YR01FGIE	YUKO229.0	American	1995	NA	ND	45
95YR01FLIE	YUKO208.5	American	1995	NA	ND	46
95YR02AAIE	70 Mile R.(#305)	American	1995	NA	ND	66