2. SEMEN

2.1 Introduction

The significance of the association between dioxin level and sperm count and the percentage of abnormal sperm was assessed based on semen specimens collected during the baseline physical examination in 1982. Group differences (Ranch Hand versus Comparison) with regard to these attributes of the semen were assessed in the baseline report and no significant differences were found.

The semen data for the analyses in this report has been derived directly from hard copy baseline information in the case report folders. Thus, this data has been subjected to 100% quality control and data entry review. Additionally, exclusion criteria have been verified against medical records.

Of the 2269 participants in the baseline examination, 973 gave semen specimens which met the criteria for analysis. Additionally, 107 of the 973 were excluded from these dioxin exposure analyses for diagnostic and therapeutic reasons. Table 2-1 explains these exclusions. Thus, semen data on 866 participants (417 Ranch Hands and 449 Comparisons) was available for analysis. All of the 866 had counts and 844 had percentages of abnormal sperm.

Table 2-1

Reasons for Exclusion from the Dioxin Analysis of Semen and Frequencies Associated with Each Reason

a) Exclusions of Specimens from Analysis

	RH	COMP
Refused to provide semen specimen	187	199
Specimen obtained but no sperm due to vasectomy	258	295
Attempted but unable to produce specimen	15	22
Had ejaculation within 8 hours of collection	2	2
Injury to testes	1	2
Pre-SEA sterility	1	1
Laboratory error	2	1
Participants without valid dioxin values or not meeting criteria for Models 1, 2 or 3	121	187
Total semen specimens available for analysis	458	515

Table 2-1 (Continued)

b) Diagnostic and Therapeutic Exclusions from Analysis:

Diagnosis	Description	RH	COMP
0720	Mumps orchitis	4	6
0971	Latent syphilis unspecified	1	0
0979	Syphilis unspecified	1	0
0994	Other nongonococcal urethritis	0	1
1869	Malignant neoplasm testis, other & unspecified	3	0
1889	Malignant neoplasm bladder part unspecified	1	2
20190	Hodgkin's disease, unspecified	0	1
4564	Scrotal varices	8	16
59780	Urethritis, unspecified	1	1
6010	Acute prostatitis	3	0
6011	Chronic prostatitis	1	3
6019	Prostatitis unspecified	10	23
60490	Orchitis & epididymitis, unspecified	2	8
7525	Undescended testicle	1	2
7587	Klinefelter's syndrome	1	0
X623	Unilateral orchiectomy	1	2
X9221	Superficial radiation	1	0
X9229	Other radiotherapeutic procedure	1	0
X1000	Antineoplastic agents	1	1
	Total	41	66
	Total number of participants available for statistical analysis of semen data	417	449

2.2 Exposure Analyses

Tables 2-2 through 2-10 show the results of Models 1, 2 and 3 dioxin analyses of sperm count (million/ml), low sperm count (counts less than or equal to 60 million/ml), and percent abnormal sperm. The unit of measurement for sperm count is million/ml. Candidate covariates were the father's age and exposure to industrial chemicals.

Sperm Count (Logarithmic Transformation)

Model 1: Ranch Hands - Log_2(Initial Dioxin)

Without adjustment for covariates (Table 2-2 [a] and [b]), there is no association between sperm count and initial dioxin level among Ranch Hands having more than 10 ppt (p=0.736) or more than 5 ppt (p=0.813) current dioxin.

After adjustment for the father's age and reported exposure to industrial chemicals (Table 2-2 [c] and [d]), there is no association between sperm count and initial dioxin among Ranch Hands having more than 10 ppt (p=0.707) or more than 5 ppt (p=0.819) current dioxin.

Table 2-2

Sperm Count versus Initial Dioxin Level

Variable: Log(Sperm Count) (Million/ml)
Restriction: None
Model 1: Log_2(Initial Dioxin)

Ranch Hands - Log_2(Initial Dioxin) - Unadjusted

Exposure Restriction	Initial Dioxin	n	Mean	Slope (Std. Error)	p-Value
a) D>10 ppt	Low	65	4.363	-0.024(0.071)	0.736
(n=266)	Medium	125	4.190		
(R^2=0.0004)	High	76	4.186		
b) D>5 ppt	Low	93	4.301	-0.011(0.050)	0.813
(n=371)	Medium	168	4.201		
(R^2=0.0002)	High	110	4.214		

Ranch Hands - Log_2(Initial Dioxin) - Adjusted

Exposure Restriction	Initial Dioxin	n	Adj. Mean	Adj. Slope (Std. Error)	p-Value	Covariate Remarks
c) D>10 ppt	Low	64	4.369	-0.027(0.072)	0.707	None
(n=262)	Medium	123	4.197			
	High	75	4.178			
d) D>5 ppt	Low	93	4.301	-0.012(0.050)	0.819	None
(n=366)	Medium	165	4.197			
	High	108	4.212			

Sperm Count

Model 2: Ranch Hands - Log_2(Current Dioxin) and Time

Without adjustment for covariates (Table 2-3 [a]), there is no significant variation in the association between sperm count and current dioxin with time since duty in SEA (p=0.407) among Ranch Hands having more than 10 ppt current dioxin. Furthermore, there is no significant association between sperm count and current dioxin in Ranch Hands who had late (p=0.371) or early (p=0.753) tours.

Without adjustment for covariates (Table 2-3 [b]), there is no significant variation in the association between sperm count and current dioxin with time since duty in SEA among Ranch Hands having more than 5 ppt current dioxin (p=0.662). Furthermore, there is no significant association between sperm count and current dioxin in Ranch Hands who had late (p=0.635) or early (p=0.852) tours.

After adjustment for covariates (Table 2-3 [c]), there is no significant variation in the association between sperm count and current dioxin with time since duty in SEA in Ranch Hands having more than 10 ppt current dioxin (p=0.379). Furthermore, there is no significant association between sperm count and current dioxin in Ranch Hands who had late (p=0.326) or early (p=0.760) tours.

After adjustment for covariates (Table 2-3 [d]), there is no significant variation in the association between sperm count and current dioxin with time since duty in SEA in Ranch Hands having more than 5 ppt current dioxin (p=0.591). Furthermore, there is no significant association between sperm count and current dioxin in Ranch Hands who had late (p=0.587) or early (p=0.798) tours.

Table 2-3

Sperm Count versus Current Dioxin and Time Since SEA Tour

Variable: Log(Sperm Count) (Million/ml)
Restrictions: None
Model 2: Log_2(Current Dioxin) and Time

Ranch Hands - Log_2(Current Dioxin), Time - Unadjusted

Exposure Restriction	Time Since SEA (years)	Mean/(n) Current Dioxin Low	Medium	High	Slope (Std. Error)	p-Value
a) D>10 ppt (n=266) (R^2=0.005)						0.407
	≤18.6	4.588 (34)	4.197 (58)	4.220 (31)	-0.093(0.103)	0.371
	>18.6	4.257 (32)	4.149 (65)	4.115 (46)	0.032(0.100)	0.753
b) D>5 ppt (n=371) (R^2=0.004)						0.662
	≤18.6	4.214 (54)	4.425 (85)	4.192 (49)	-0.031(0.065)	0.635
	>18.6	4.418 (33)	4.025 (89)	4.198 (61)	0.015(0.079)	0.852

Table 2-3 (Continued)

Ranch Hands - Log_2(Current Dioxin), Time - Adjusted

Exposure Restriction	Time Since SEA (years)	Adj. Mean/(n) Current Dioxin Low	Medium	High	Adj. Slope (Std. Error)	p-Value	Covariate Remarks
c) D>10 ppt (n=262)						0.379	
	≤18.6	4.606 (33)	4.197 (58)	4.202 (30)	-0.105(0.106)	0.326	None
	>18.6	4.257 (32)	4.161 (63)	4.115 (46)	0.031(0.101)	0.760	
d) D>5 ppt (n=366)						0.591	
	≤18.6	4.214 (54)	4.430 (84)	4.180 (48)	-0.036(0.066)	0.587	None
	>18.6	4.388 (32)	4.028 (88)	4.204 (60)	0.020(0.080)	0.798	

Sperm Count

Model 3: Ranch Hands and Comparisons - Categorized Current Dioxin

Without adjustment for covariates (Table 2-4 [a]), the overall association between sperm count and categorized current dioxin is not significant (p=0.778). Furthermore, the average counts among Ranch Hands in the High (p=0.876), Low (p=0.810) and Unknown (p=0.330) categories are not significantly different from the average count in Comparisons in the Background category.

After adjustment for covariates (Table 2-4 [b]), the overall association between sperm count and categorized current dioxin is not significant (p=0.807). Furthermore, the average counts among Ranch Hands in the High (p=0.819), Low (p=0.884) and Unknown (p=0.355) categories are not significantly different from the average count in Comparisons in the Background category.

Table 2-4

Sperm Count versus Categorized Current Dioxin

Variable: Log(Sperm Count) (Million/ml)
Restrictions: None
Model 3: Categorized Current Dioxin

a) Unadjusted

Exposure Category	n	Mean	Category Contrast	Difference of Means (95% C.I.)	p-Value
Background	449	4.171	All Exp Categ		0.778
Unknown	151	4.299	Unk vs Bkgd	0.128(-0.138,0.394)	0.330
Low	85	4.128	Low vs Bkgd	-0.043(-0.378,0.292)	0.810
High	110	4.195	High vs Bkgd	0.024(-0.077,0.325)	0.876
Total	795	(R^2=0.001)			

b) Adjusted

Exposure Category	n	Adj. Mean	Category Contrast	Diff. of Adj. Means (95% C.I.)	p-Value	Covariate Remarks
Background	441	4.157	All Exp Categ		0.807	None
Unknown	149	4.285	Unk vs Bkgd	0.128(-0.142,0.398)	0.355	
Low	84	4.133	Low vs Bkgd	-0.024(-0.363,0.315)	0.884	
High	108	4.194	High vs Bkgd	0.037(-0.268,0.342)	0.819	
Total	782	(R^2=0.001)				

Low Sperm Count (Counts Less than or Equal 60 million/ml)

Model 1: Ranch Hands - Log_2(Initial Dioxin)

Without adjustment for covariates (Table 2-5 [a] and [b]), there is no association between low sperm count and initial dioxin among Ranch Hands having more than 10 ppt (p=0.302) or more than 5 ppt (p=0.962) current dioxin.

After adjustment for covariates (Table 2-5 [c] and [d]), there is no association between low sperm count and initial dioxin among Ranch Hands having more than 10 ppt (p=0.230) or than 5 ppt (p=0.599) current dioxin.

Table 2-5

Low Sperm Count
Versus Initial Dioxin

Variable: Low Sperm Count (Discrete)
Restrictions: None
Model 1: Log_2(Initial Dioxin)

Ranch Hands - Log_2(Initial Dioxin) - Unadjusted

Exposure Restriction	Initial Dioxin	n	Abnormal Rate (n)	Est. Relative Risk (95% C.I.)	p-Value
a) D>10 ppt (n=266)	Low	65	307.7(20)	1.11(0.91,1.37)	0.302
	Medium	125	288.0(36)		
	High	76	381.6(29)		
b) D>5 ppt (n=371)	Low	93	354.8(33)	1.00(0.86,1.16)	0.962
	Medium	168	327.4(55)		
	High	110	336.4(37)		

Ranch Hands - Log_2(Initial Dioxin) - Adjusted

Exposure Restriction	Adj. Relative Risk (95% C.I.)	p-Value	Covariate Remarks
c) D>10 ppt (n=262)	1.13(0.92,1.40)	0.230	F-AGE*DIOXIN(P=0.058)
d) D>5 ppt (n=366)	0.96(0.82,1.12)	0.599	F-AGE(P=0.020)

Low Sperm Count

Model 2: Ranch Hands - Log_2(Current Dioxin) and Time

Without adjustment for covariates (Table 2-6 [a]), there is no significant variation in the association between low sperm count and current dioxin with time since duty in SEA among Ranch Hands having more than 10 ppt current dioxin (p=0.888). Furthermore, there is no significant association between low sperm count and current dioxin in Ranch Hands with late (p=0.512) or early (p=0.782) tours.

Without adjustment for covariates (Table 2-6 [b]), there is no significant variation in the association between low sperm count and current dioxin with time since duty in SEA among Ranch Hands having more than 5 ppt current dioxin (p=0.382). Furthermore, there is no significant association between low sperm count and current dioxin in Ranch Hands who had late (p=0.478) or early (p=0.817) tours.

After adjustment for covariates (Table 2-6 [c]), there is no significant variation in the association between low sperm count and current dioxin with time since duty in SEA among Ranch Hands having more than 10 ppt current dioxin (p=0.722). Furthermore, there is no significant association between low sperm count and current dioxin in Ranch Hands who had late (p=0.347) or early (p=0.773) tours.

After adjustment for covariates (Table 2-6 [d]), there is no significant variation in the association between low sperm count and current dioxin with time since duty in SEA among Ranch Hands having more than 5 ppt current dioxin (p=0.501). Furthermore, there is no significant association between low sperm count and current dioxin among in Ranch Hands who had late tour (p=0.289) or early (p=0.911) tours.

Table 2-6

Low Sperm Count versus Current Dioxin and Time Since Duty in SEA

Variable: Low Sperm Count (Discrete)
Restriction: None
Model 2: Log_2(Current Dioxin) and Time

Ranch Hands - Log_2(Current Dioxin), Time - Unadjusted

Exposure Restriction	Time Since SEA (years)	Abnormal/Rate/(n) Current Dioxin Low	Medium	High	Est. Relative Risk (95% C.I.)	p-Value
a) D>10 ppt (n=266)						0.888
	≤18.6	264.7 (9/34)	275.9 (16/58)	322.6 (10/31)	1.13(0.79,1.61)	0.512
	>18.6	343.8 (11/32)	292.3 (19/65)	434.8 (20/46)	1.09(0.59,2.03)	0.782
b) D>5 ppt (n=371)						0.382
	≤18.6	425.9 (23/54)	258.8 (22/85)	306.1 (15/49)	0.92(0.72,1.17)	0.478
	>18.6	272.7 (9/33)	359.6 (32/89)	393.4 (24/61)	1.05(0.67,1.65)	0.817

Ranch Hands - Log_2(Current Dioxin), Time - Adjusted

Exposure Restriction	Time Since SEA (years)	Adj. Relative Risk (95% C.I.)	p-Value	Covariate Remarks
c) D>10 ppt (n=262)			0.722	None
	≤18.6	1.19(0.83,1.71)	0.347	
	>18.6	1.10(0.59,2.06)	0.773	
d) D>5 ppt (n=366)			0.501	F-AGE(p=0.009)
	≤18.6	0.87(0.68,1.12)	0.289	
	>18.6	0.97(0.62,1.54)	0.911	

Low Sperm Count

Model 3: Ranch Hands and Comparisons - Categorized Current Dioxin

Without adjustment for covariates (Table 2-7 [a]), the overall association between low sperm count and categorized current dioxin is not significant (p=0.298). However, the rate among Ranch Hands in the low current dioxin category (282.4 per 1000) is borderline significantly less than that of Comparisons in the Background category (383.1 per 1000); p=0.078. Corresponding contrasts of rates between Ranch Hands in the Unknown (p=0.319) and High (p=0.580) categories with Comparisons in the Background category are not significant.

After adjustment for covariates (Table 2-7 [b]), the overall association between low sperm count and categorized current dioxin is not significant (p=0.140). However, the rate among Ranch Hands in the low current dioxin category is significantly less than that of Comparisons in the Background category (OR=0.58, 95% CI 0.34-0.97, p=0.037). Corresponding contrasts of rates between Ranch Hands in the Unknown (p=0.334) and High (p=0.230) categories with Comparisons in the Background category are not significant.

Table 2-7

Low Sperm Count versus Categorized Current Dioxin

Variable: Low Sperm Count (Discrete)
Restrictions: None
Model 3: Categorized Current Dioxin

Current Dioxin (Categorized Within Group)

a) Unadjusted

Exposure Category	n	Abnormal Rate (n)	Category Contrast	Est. Relative Risk (95% C.I.)	p-Value
Background	449	383.1(172)	All Exp Categ		0.298
Unknown	151	337.7(51)	Unk vs Bkgd	0.82(0.56,1.21)	0.319
Low	85	282.4(24)	Low vs Bkgd	0.63(0.38,1.06)	0.078
High	110	354.5(39)	High vs Bkgd	0.88(0.57,1.37)	0.580
Total	795				

Table 2-7 (Continued)

b) **Adjusted**

Exposure Category	n	Category Contrast	Est. Relative Risk (95% C.I.)	p-Value	Covariate Remarks
Background	441	All Exp Categ		0.140	F-AGE(p=0.003)
Unknown	149	Unk vs Bkgd	0.82(0.56,1.22)	0.334	
Low	84	Low vs Bkgd	0.58(0.34,0.97)	0.037	
High	108	High vs Bkgd	0.76(0.49,1.19)	0.230	
Total	782				

Percent Abnormal Sperm

Model 1: Ranch Hands - Log_2(Initial Dioxin)

Without adjustment for covariates (Table 2-8 [a] and [b]), there is no association between percent abnormal sperm and initial dioxin among Ranch Hands having more than 10 ppt (p=0.934) or more than 5 ppt (p=0.587) current dioxin.

After adjustment for covariates (Table 2-8 [c] and [d]), there is no association between percent abnormal sperm and initial dioxin among Ranch Hands having more than 10 ppt (p=0.902) or more than 5 ppt (p=0.523) current dioxin.

Table 2-8

Percent Abnormal Sperm versus Initial Dioxin

Variable: Log(Percent Abnormal Sperm)
Restrictions: None
Model 1: Log_2 (Initial Dioxin)

Ranch Hands - Log_2(Initial Dioxin) - Unadjusted

Exposure Restriction	Initial Dioxin	n	Mean	Adj. Slope (Std. Error)	p-Value
a) D>10 ppt	Low	64	2.206	-0.002(0.025)	0.934
(n=257)	Medium	120	2.020		
(R^2=0.0000)	High	73	2.166		
b) D>5 ppt	Low	93	2.165	-0.010(0.018)	0.587
(n=361)	Medium	162	2.092		
(R^2=0.0008)	High	106	2.129		

Ranch Hands - Log_2(Initial Dioxin) - Adjusted

Exposure Restriction	Initial Dioxin	n	Adj. Mean	Adj. Slope (Std. Error)	p-Value	Covariate Remarks
c) D>10 ppt	Low	63	2.209	0.004(0.004)	0.902	None
(n=253)	Medium	118	2.015			
	High	72	2.169			
d) D>5 ppt	Low	93	2.156	-0.012(0.018)	0.523	None
(n=356)	Medium	159	2.099			
	High	104	2.127			

Percent Abnormal Sperm

Model 2: Ranch Hands - Log_2(Current Dioxin) and Time Since Duty in SEA

Without adjustment for covariates (Table 2-9 [a]), there is no significant variation in the association between percent abnormal sperm and current dioxin with time since duty in SEA among Ranch Hands having more than 10 ppt current dioxin (p=0.483). Furthermore, there is no significant association between percent abnormal sperm and current dioxin in Ranch Hands who had late (p=0.781) or early (p=0.438) tours.

Without adjustment for covariates (Table 2-9 [b]), there is no significant variation in the association between percent abnormal sperm and current dioxin with time since SEA tour of duty among Ranch Hands having more than 5 ppt current dioxin (p=0.761). Furthermore, there is no significant association between percent abnormal sperm and current dioxin in Ranch Hands who had late (p=0.681) or early (p=0.382) tours.

After adjustment for covariates (Table 2-9 [c]), there is no significant variation in the association between percent abnormal sperm and current dioxin with time since duty in SEA among Ranch Hands having more than 10 ppt current dioxin (p=0.459). Furthermore, there is no significant association between percent abnormal sperm and current dioxin in Ranch Hands who had late (p=0.774) or early (p=0.424) tours.

After adjustment for covariates (Table 2-9 [d]), there is no significant variation in the association between percent abnormal sperm and current dioxin with time since SEA tour of duty among Ranch Hands having more than 5 ppt current dioxin (p=0.638). Furthermore, there is no significant association between percent abnormal sperm and current dioxin in Ranch Hands who had late (p=0.699) or early (p=0.276) tours.

Table 2-9

Percent Abnormal Sperm versus Current Dioxin and Time Since Duty in SEA

Variable: Log(Percent Abnormal Sperm)
Restrictions: None
Model 2: Log_2(Current Dioxin) and Time

Ranch Hands - Log_2(Current Dioxin), Time - Unadjusted

Exposure Restriction	Time Since SEA (years)	Mean/(n) Current Dioxin Low	Medium	High	Adj. Slope (Std. Error)	p-Value
a) D>10 ppt (n=257) (R^2=0.0088)						0.483
	≤18.6	2.117 (34)	1.998 (57)	2.139 (30)	0.011(0.040)	0.781
	>18.6	2.298 (31)	2.054 (61)	2.161 (44)	-0.026(0.033)	0.438
b) D>5 ppt (n=361) (R^2=0.0076)						0.761
	≤18.6	2.137 (54)	2.049 (85)	2.095 (47)	-0.011(0.027)	0.681
	>18.6	2.154 (33)	2.173 (83)	2.129 (59)	-0.023(0.026)	0.382

Table 2-9 (Continued)

Ranch Hands - Log_2(Current Dioxin), Time - Adjusted

Exposure Restriction	Time Since SEA (years)	Adj. Means/(n) Current Dioxin Low	Medium	High	Adj. Slope (Std. Error)	p-Value	Covariate Remarks
c) D>10 ppt (n=253)						0.459	
	≤18.6	2.121 (33)	1.998 (57)	2.145 (29)	0.012(0.042)	0.774	None
	>18.6	2.298 (31)	2.045 (59)	2.161 (44)	-0.027(0.033)	0.424	
d) D>5 ppt (n=356)						0.638	
	≤18.6	2.137 (54)	2.050 (84)	2.098 (46)	-0.011(0.028)	0.699	None
	>18.6	2.186 (32)	2.174 (82)	2.122 (58)	-0.028(0.026)	0.276	

Percent Abnormal Sperm

Model 3: Ranch Hands and Comparisons - Categorized Current Dioxin

Without adjustment for covariates (Table 2-10 [a]), the overall association between percent abnormal sperm and categorized current dioxin is not significant (p=0.111). Furthermore, the average percent abnormal sperm among Ranch Hands in the High (p=0.869) and Unknown (p=0.176) categories are not significantly different from that of Comparisons in the Background category, while the average percent abnormal sperm among Ranch Hands in the Low category is borderline significantly less than that of Comparisons in the Background category (p=0.088).

After adjustment for covariates (Table 2-10 [b]), the overall association between percent abnormal sperm and categorized current dioxin is borderline significant (p=0.096). However, the average percent abnormal sperm among Ranch Hands in the High (p=0.842) and Unknown (p=0.128) categories are not significantly different from that of Comparisons in the Background category, while the average percent abnormal sperm among Ranch Hands in the Low category is borderline significantly less than that of Comparisons in the Background category ((p=0.097).

Table 2-10

Percent Abnormal Sperm versus Categorized Current Dioxin

Variable: Log(Percent Abnormal Sperm)
Restrictions: None
Model 3: Categorized Current Dioxin

a) Unadjusted

Exposure Category	n	Mean	Category Contrast	Difference of Means (95% C.I.)	p-Value
Background	437	2.105	All Exp Categ		0.111
Unknown	150	2.171	Unk vs Bkgd	0.066(-0.030,0.162)	0.176
Low	81	1.997	Low vs Bkgd	-0.108(-0.230,0.014)	0.088
High	106	2.114	High vs Bkgd	0.009(-0.100,0.118)	0.869
Total	774	(R^2=0.0078)			

b) Adjusted

Exposure Category	n	Mean	Category Contrast	Diff. of Adj. Means (95% C.I.)	p-Value	Covariate Remarks
Background	429	2.100	All Exp Categ		0.096	None
Unknown	148	2.175	Unk vs Bkgd	0.075(-0.021,0.171)	0.128	
Low	80	1.996	Low vs Bkgd	-0.104(-0.227,0.019)	0.097	
High	104	2.111	High vs Bkgd	0.011(-0.099,0.121)	0.842	
Total	761	(R^2=0.0083)				

High Percent Abnormal

Only two fathers (Comparisons) had percent abnormal sperm greater than 30, hence this categorized variable was not analyzed.

2.3 Conclusion

The statistical significance of the association between the father's dioxin level and sperm count, the rate of abnormally low sperm count, and the percentage of abnormal sperm was assessed based on semen specimens collected during the initial examination in 1982.

The association between semen characteristics and dioxin were assessed with Models 1, 2 and 3. The results are summarized in Table 2-11 through Table 2-13.

Throughout this section, nonsignificant results are indicated by NS, borderline significant results are indicated by NS* and the presence of interactions with the p-value greater than or equal to 0.01 and less than 0.05 are indicated with a preceding double asterisk (**). Four asterisks (****) represent the presence of an interaction between a covariate and dioxin with a p-value less than 0.01. The p-value is replace by a double hyphen (--) when the analysis was not carried out due to sparse data.

Table 2-11

P-Value Summary of Sperm Count, Low Sperm Count (≤60 Million/ml) and Percentage Abnormal Forms versus Initial Dioxin Level (Model 1)

Variable	Unadjusted D>10 ppt	Unadjusted D>5 ppt	Adjusted D>10 ppt	Adjusted D>5 ppt
Sperm Count (continuous)	NS	NS	NS	NS
Low Sperm Count	NS	NS	NS	NS
Percentage Abnormal Sperm	NS	NS	NS	NS

Table 2-12

P-Value Summary of Sperm Count, Low Sperm Count (≤60 Million/ml) and Percentage Abnormal Forms versus Current Dioxin and Time Since SEA Tour (Model 2)

a) Unadjusted

Variable	D>10 ppt Dioxin by Time	D>10 ppt Time Since SEA ≤18.6	D>10 ppt Time Since SEA >18.6	D>5 ppt Dioxin by Time	D>5 ppt Time Since SEA ≤18.6	D>5 ppt Time Since SEA >18.6
Sperm Count (continuous)	NS	NS	NS	NS	NS	NS
Low Sperm Count	NS	NS	NS	NS	NS	NS
Percentage Abnormal Sperm	NS	NS	NS	NS	NS	NS

Table 2-12 (Continued)

b) Adjusted

Variable	D>10 ppt Dioxin by Time	D>10 ppt Time Since SEA ≤18.6	D>10 ppt Time Since SEA >18.6	D>5 ppt Dioxin by Time	D>5 ppt Time Since SEA ≤18.6	D>5 ppt Time Since SEA >18.6
Sperm Count (continuous)	NS	NS	NS	NS	NS	NS
Low Sperm Count	NS	NS	NS	NS	NS	NS
Percentage Abnormal Sperm	NS	NS	NS	NS	NS	NS

Table 2-13

P-Value Summary of Categorized Current Dioxin Analyses of Sperm Count, Low Sperm Count (≤60 Million/ml) and Percentage Abnormal Forms (Model 3)

a) Unadjusted

Variable	All	Unknown versus Background	Low versus Background	High versus Background
Sperm Count (continuous)	NS	NS	NS	NS
Low Sperm Count	NS	NS	NS*	NS
Percentage Abnormal Sperm	NS	NS	NS*	NS

b) Adjusted

Variable	All	Unknown versus Background	Low versus Background	High versus Background
Sperm Count (continuous)	NS	NS	NS	NS
Low Sperm Count	NS	NS	0.037	NS
Percentage Abnormal Sperm	NS*	NS	NS*	NS

The one significant result and the few borderline findings in these analyses indicate lower risks in exposed individuals. We conclude there is no association in these data between dioxin and sperm count, the low sperm count or percentage of abnormal sperm.