APPENDIX B
EVALUATION REPORT DUNGENESS CRAB (REVISED)

Summary of Projected Entrainment, Adult Equivalent Loss, and Loss to Fishery.
Lower Columbia River
WH Pearson and GD Williams

Variance Estimators (derived from June 2002 field sampling)

	CV %		
E	5.01	Z at 0.975	1.95996
AEL	7.37		
LF	8.11		

Construction Dredging to 40 ft - Age 2+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	593,812

Results:

Parameter	Projected Value	SE	95% CI
E	132,790	6,653	13,039
AEL	20,078	1,480	2,900
AEL Male	12,052	888	1,741
AEL Female	8,026	592	1,159
Loss to Fishery	3,796	308	603

Construction Dredging to 40 ft - Age 3+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	593,812

Results:

Parameter	Projected Value	SE	95% CI
E	132,790	6,653	13,039
AEL	9,035	666	1,305
AEL Male	5,423	400	783
AEL Female	3,612	266	522
Loss to Fishery	3,796	308	603

Construction Dredging from 40 to 43 ft - Age 2+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	473,893

Results:

Parameter	Projected Value	SE	95% CI
E	105,974	5,309	10,406
AEL	16,024	1,181	2,315
AEL Male	9,618	709	1,389
AEL Female	6,405	472	925
Loss to Fishery	3,030	246	482

Construction Dredging from 40 to 43 ft - Age 3+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	473,893

Results:

Parameter	Projected Value	SE	95% CI
E	105,974	5,309	10,406
AEL	7,211	531	1,042
AEL Male	4,328	319	625
AEL Female	2,882	212	416
Loss to Fishery	3,030	246	482

Annual Maintenance Dredging 40' Year 1 - Age 2+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	40,000

Results:

Parameter	Projected Value	SE	95% CI
E	8,945	448	878
AEL	1,353	100	195
AEL Male	812	60	117
AEL Female	541	40	78
Loss to Fishery	256	21	41

Annual Maintenance Dredging 40' Year 1 - Age 3+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	40,000

Results:

Parameter	Projected Value	SE	95% CI
E	8,945	448	878
AEL	609	45	88
AEL Male	365	27	53
AEL Female	243	18	35
Loss to Fishery	256	21	41

Annual Maintenance Dredging 40' Year 20 - Age 2+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	40,000

Results:

Parameter	Projected Value	SE	95% CI
E	8,945	448	878
AEL	1,353	100	195
AEL Male	812	60	117
AEL Female	541	40	78
Loss to Fishery	256	21	41

Annual Maintenance Dredging 40' Year 20 - Age 3+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	40,000

Results:

Parameter	Projected Value	SE	95% CI
E	8,945	448	878
AEL	609	45	88
AEL Male	365	27	53
AEL Female	243	18	35
Loss to Fishery	256	21	41

Annual Maintenance Dredging 43' Year 1 - Age 2+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	60,000

Results:

Parameter	Projected Value	SE	95% CI
E	13,417	672	1,318
AEL	2,029	150	293
AEL Male	1,218	90	176
AEL Female	811	60	117
Loss to Fishery	384	31	61

Annual Maintenance Dredging 43' Year 1 - Age 3+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	60,000

Results:

Parameter	Projected Value	SE	95% CI
E	13,417	672	1,318
AEL	913	67	132
AEL Male	548	40	79
AEL Female	365	27	53
Loss to Fishery	384	31	61

Annual Maintenance Dredging 43' Year 20 - Age 2+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	40,000

Results:

Parameter	Projected Value	SE	95% CI
E	8,945	448	878
AEL	1,353	100	195
AEL Male	812	60	117
AEL Female	541	40	78
Loss to Fishery	256	21	41

Annual Maintenance Dredging 43' Year 20 - Age 3+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	40,000

Results:

Parameter	Projected Value	SE	95% CI
E	8,945	448	878
AEL	609	45	88
AEL Male	365	27	53
AEL Female	243	18	35
Loss to Fishery	256	21	41

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	**Desdemona, June**	**Construction Dredging to 40 ft**	***593812***

VOLUME OF DREDGED MATERIALS - to 40 ft

Volume to be Dredged (cy)			
River Mile	Location Name	Volume (cy)	Data from Portland District (10 Sept 2002)
4	Lower Desdem	222412	
5		353916	
6	Upper Desdem	0	
7		0	
8		8742	
9		8742	
10	Flavel Bar	49732	
11		298900	
12		121292	
13		72425	
14	Upper Sands	54583	
15		51945	
16		47557	
17		0	
18	Tongue Point	14775	
19		6976	
20		13283	
Total		1325282	

Dredged Yardage (cy) **593812** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	3071.8		0.10	0.017	5.07		2.28	
1+	0.19327	114767.6		0.60	0.160	11017.69		4957.96	
2+	0.02429	14425.5		0.86	0.649	8051.43		3623.14	
3+	0.00088	525.5		0.86	2.222	1004.22		451.90	
All		**132790.3**				**20078.41**		**9035.28**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations
Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male			
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)	
YOY	0.50	2.53		0.50	2.53		R = Crab Entrainment Rate (crabs/cy)
1+	0.50	5508.84		0.50	5508.84		E = Crabs Entrained (number of Crabs)
2+	0.25	2012.86		0.75	6038.57		M = Post-Entrainment Mortality (proportion)
3+	0.50	502.11		0.50	502.11		S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
All		**8026.34**			**12052.06**		AEL = Adult Equivalent Loss
							VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations
Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male			
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)	
YOY	0.50	1.14		0.50	1.14		R = Crab Entrainment Rate (crabs/cy)
1+	0.50	2478.98		0.50	2478.98		E = Crabs Entrained (number of Crabs)
2+	0.25	905.79		0.75	2717.36		M = Post-Entrainment Mortality (proportion)
3+	0.50	225.95		0.50	225.95		S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
All		**3611.86**			**5423.43**		AEL = Adult Equivalent Loss
					9035.283		VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	132790.3
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	20078.4
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	9035.3
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	5423.4
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	3611.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY
(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)	
5423.4	0.70	**3796.4**	Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	3796.4
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:
Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	**Desdemona, June**	**Construction Dredging from 40 to 43 ft**	***473893***

VOLUME OF DREDGED MATERIALS - from 40 to 43 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem	94688
5		196724
6	Upper Desdem	66193
7		1039
8		52398
9		62851
10	Flavel Bar	329296
11		335074
12		239608
13		65743
14	Upper Sands	171432
15		271842
16		306717
17		108631
18	Tongue Point	174113
19		162864
20		127219
Total		2966432

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **473893** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	2451.4		0.10	0.017	4.04		1.82	
1+	0.19327	91590.5		0.60	0.160	8792.69		3956.71	
2+	0.02429	11512.3		0.86	0.649	6425.46		2891.46	
3+	0.00088	419.4		0.86	2.222	801.42		360.64	
All		**105973.6**				**16023.62**		**7210.63**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	2.02		0.50	2.02	
1+	0.50	4396.35		0.50	4396.35	
2+	0.25	1606.37		0.75	4819.10	
3+	0.50	400.71		0.50	400.71	
All		**6405.44**			**9618.17**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

	Proportion of Total AEL	
Age Class	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.91		0.50	0.91	
1+	0.50	1978.36		0.50	1978.36	
2+	0.25	722.86		0.75	2168.59	
3+	0.50	180.32		0.50	180.32	
All		**2882.45**			**4328.18**	
					7210.628	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL 3+
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

	Proportion of Total AEL at 3+	
Age Class	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	105973.6
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	16023.6
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	7210.6
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	4328.2
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	2882.4
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
4328.2	0.70	**3029.7**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	3029.7
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	**Desdemona, June**	**Post Construction Maintenance, 40 ft Yr 1**	***40000***

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40,000
10 to 13	Flavel Bar	400000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		760000

Data from Portland District (4 Dec 2002)

Dredged Yardage (cy) **40,000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	206.9		0.10	0.017	0.34		0.15	
1+	0.19327	7730.9		0.60	0.160	742.17		333.98	
2+	0.02429	971.7		0.86	0.649	542.36		244.06	
3+	0.00088	35.4		0.86	2.222	67.65		30.44	
All		**8944.9**				**1352.51**		**608.63**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.17		0.50	0.17	
1+	0.50	371.08		0.50	371.08	
2+	0.25	135.59		0.75	406.77	
3+	0.50	33.82		0.50	33.82	
All		**540.67**			**811.84**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.08		0.50	0.08	
1+	0.50	166.99		0.50	166.99	
2+	0.25	61.02		0.75	183.05	
3+	0.50	15.22		0.50	15.22	
All		**243.30**			**365.33**	
					608.629	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	8944.9
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	1352.5
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	608.6
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	365.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	243.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
365.3	0.70	**255.7**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	255.7
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	**Desdemona, June**	**Post Construction Maintenance, 40 ft Yr 20**	***40000***

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		570000

Data from Portland District (4 Dec 2002)

Dredged Yardage (cy) **40000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	206.9		0.10	0.017	0.34		0.15	
1+	0.19327	7730.9		0.60	0.160	742.17		333.98	
2+	0.02429	971.7		0.86	0.649	542.36		244.06	
3+	0.00088	35.4		0.86	2.222	67.65		30.44	
All		**8944.9**				**1352.51**		**608.63**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.17		0.50	0.17	
1+	0.50	371.08		0.50	371.08	
2+	0.25	135.59		0.75	406.77	
3+	0.50	33.82		0.50	33.82	
All		**540.67**			**811.84**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.08		0.50	0.08	
1+	0.50	166.99		0.50	166.99	
2+	0.25	61.02		0.75	183.05	
3+	0.50	15.22		0.50	15.22	
All		**243.30**			**365.33**	
					608.629	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	8944.9
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	1352.5
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	608.6
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	365.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	243.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
365.3	0.70	**255.7**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	255.7
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	**Desdemona, June**	**Post Construction Maintenance, 43 ft Yr 1**	***60000***

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	60000
10 to 13	Flavel Bar	500000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		990000

Data from Portland District (4 Dec 2002)

Dredged Yardage (cy) **60000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	310.4		0.10	0.017	0.51		0.23	
1+	0.19327	11596.4		0.60	0.160	1113.25		500.96	
2+	0.02429	1457.6		0.86	0.649	813.53		366.09	
3+	0.00088	53.1		0.86	2.222	101.47		45.66	
All		**13417.4**				**2028.76**		**912.94**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.26		0.50	0.26	
1+	0.50	556.63		0.50	556.63	
2+	0.25	203.38		0.75	610.15	
3+	0.50	50.73		0.50	50.73	
All		**811.00**			**1217.77**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.12		0.50	0.12	
1+	0.50	250.48		0.50	250.48	
2+	0.25	91.52		0.75	274.57	
3+	0.50	22.83		0.50	22.83	
All		**364.95**			**547.99**	
					912.944	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	13417.4
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	2028.8
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	912.9
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	548.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	364.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
548.0	0.70	**383.6**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	383.6
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	**Desdemona, June**	**Post Construction Maintenance, 43 ft Yr 20**	***40000***

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		680000

Data from Portland District (4 Dec 2002)

Dredged Yardage (cy) **40000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	206.9		0.10	0.017	0.34		0.15	
1+	0.19327	7730.9		0.60	0.160	742.17		333.98	
2+	0.02429	971.7		0.86	0.649	542.36		244.06	
3+	0.00088	35.4		0.86	2.222	67.65		30.44	
All		**8944.9**				**1352.51**		**608.63**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.17		0.50	0.17	
1+	0.50	371.08		0.50	371.08	
2+	0.25	135.59		0.75	406.77	
3+	0.50	33.82		0.50	33.82	
All		**540.67**			**811.84**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.08		0.50	0.08	
1+	0.50	166.99		0.50	166.99	
2+	0.25	61.02		0.75	183.05	
3+	0.50	15.22		0.50	15.22	
All		**243.30**			**365.33**	
					608.629	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	8944.9
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	1352.5
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	608.6
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	365.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	243.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
365.3	0.70	**255.7**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	255.7
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

Summary of Projected Entrainment, Adult Equivalent Loss, and Loss to Fishery
Lower Columbia River
WH Pearson and GD Williams

Variance Estimators (derived from Sept 2002 field sampling)

	CV %		
E	29.43	Z at 0.975	1.95996
AEL	20.25		
LF	20.25		

Construction Dredging to 40 ft - Age 2+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	593,812

Results:

Parameter	Projected Value	SE	95% CI
E	70,955	20,882	40,928
AEL	59,819	12,113	23,742
AEL Male	29,910	6,057	11,871
AEL Female	29,910	6,057	11,871
Loss to Fishery	9,422	1,908	3,739

Construction Dredging to 40 ft - Age 3+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	593,812

Results:

Parameter	Projected Value	SE	95% CI
E	70,955	20,882	40,928
AEL	26,919	5,451	10,684
AEL Male	13,459	2,726	5,342
AEL Female	13,459	2,726	5,342
Loss to Fishery	9,422	1,908	3,739

Construction Dredging from 40 to 43 ft - Age 2+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	473,893

Results:

Parameter	Projected Value	SE	95% CI
E	56,626	16,665	32,663
AEL	47,739	9,667	18,947
AEL Male	23,869	4,834	9,474
AEL Female	23,869	4,834	9,474
Loss to Fishery	7,519	1,523	2,984

Construction Dredging from 40 to 43 ft - Age 3+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	473,893

Results:

Parameter	Projected Value	SE	95% CI
E	56,626	16,665	32,663
AEL	21,482	4,350	8,526
AEL Male	10,741	2,175	4,263
AEL Female	10,741	2,175	4,263
Loss to Fishery	7,519	1,523	2,984

Annual Maintenance Dredging 40' Year 1 - Age 2+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	40,000

Results:

Parameter	Projected Value	SE	95% CI
E	4,780	1,407	2,757
AEL	4,030	816	1,599
AEL Male	2,015	408	800
AEL Female	2,015	408	800
Loss to Fishery	635	129	252

Annual Maintenance Dredging 40' Year 1 - Age 3+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	40,000

Results:

Parameter	Projected Value	SE	95% CI
E	4,780	1,407	2,757
AEL	1,813	367	720
AEL Male	907	184	360
AEL Female	907	184	360
Loss to Fishery	635	129	252

Annual Maintenance Dredging 40' Year 20 - Age 2+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	40,000

Results:

Parameter	Projected Value	SE	95% CI
E	4,780	1,407	2,757
AEL	4,030	816	1,599
AEL Male	2,015	408	800
AEL Female	2,015	408	800
Loss to Fishery	635	129	252

Annual Maintenance Dredging 40' Year 20 - Age 3+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	40,000

Results:

Parameter	Projected Value	SE	95% CI
E	4,780	1,407	2,757
AEL	1,813	367	720
AEL Male	907	184	360
AEL Female	907	184	360
Loss to Fishery	635	129	252

Annual Maintenance Dredging 43' Year 1 - Age 2+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	60,000

Results:

Parameter	Projected Value	SE	95% CI
E	7,169	2,110	4,135
AEL	6,044	1,224	2,399
AEL Male	3,022	612	1,199
AEL Female	3,022	612	1,199
Loss to Fishery	952	193	378

Annual Maintenance Dredging 43' Year 1 - Age 3+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	60,000

Results:

Parameter	Projected Value	SE	95% CI
E	7,169	2,110	4,135
AEL	2,720	551	1,080
AEL Male	1,360	275	540
AEL Female	1,360	275	540
Loss to Fishery	952	193	378

Annual Maintenance Dredging 43' Year 20 - Age 2+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	40,000

Results:

Parameter	Projected Value	SE	95% CI
E	4,780	1,407	2,757
AEL	4,030	816	1,599
AEL Male	2,015	408	800
AEL Female	2,015	408	800
Loss to Fishery	635	129	252

Annual Maintenance Dredging 43' Year 20 - Age 3+

Assumptions:

Projected Location	Desdemona
Planned dredged volume (cy)	40,000

Results:

Parameter	Projected Value	SE	95% CI
E	4,780	1,407	2,757
AEL	1,813	367	720
AEL Male	907	184	360
AEL Female	907	184	360
Loss to Fishery	635	129	252

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Desdemona, Sept	Construction Dredging to 40 ft	*593812*

VOLUME OF DREDGED MATERIALS - to 40 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem.	222412
5		353916
6	Upper Desdem	0
7		0
8		8742
9		8742
10	Flavel Bar	49732
11		298900
12		121292
13		72425
14	Upper Sands	54585
15		51945
16		47557
17		0
18	Tongue Point	14775
19		6976
20		13283
Total		1325282

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **593812** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion	
	Male	Female	Sexed	Male	Female
YOY	0	0	0	0.5*	0.5*
1+	0	0	0	0.5*	0.5*
2+	2	0	2	0.5*	0.5*
3+	0	1	1	0.5*	0.5*

* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	12901.0		0.60	0.160	1238.49		557.32	
2+	0.06518	38702.9		0.86	0.649	21601.63		9720.73	
3+	0.03259	19351.4		0.86	2.222	36979.06		16640.58	
All		**70955.3**				**59819.18**		**26918.63**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	619.25		0.50	619.25	
2+	0.50	10800.81		0.50	10800.81	
3+	0.50	18489.53		0.50	18489.53	
All		**29909.59**			**29909.59**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	278.66		0.50	278.66	
2+	0.50	4860.37		0.50	4860.37	
3+	0.50	8320.29		0.50	8320.29	
All		**13459.32**			**13459.32**	
					26918.632	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	70955.3
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	59819.2
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	26918.6
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	13459.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	13459.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
13459.3	0.70	**9421.5**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	9421.5
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Desdemona, Sept	Construction Dredging to 40 ft	*473893*

VOLUME OF DREDGED MATERIALS - from 40 to 43 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem.	94688
5		196724
6	Upper Desdem	66193
7		1039
8		52398
9		62851
10	Flavel Bar	329296
11		535074
12		239605
13		65743
14	Upper Sands	171433
15		271843
16		306717
17		108631
18	Tongue Point	174113
19		162864
20		127219
Total		2966432

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **473893** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	10295.6		0.60	0.160	988.38		444.77	
2+	0.06518	30886.9		0.86	0.649	17239.23		7757.65	
3+	0.03259	15443.5		0.86	2.222	29511.22		13280.05	
All		**56626.0**				**47738.83**		**21482.47**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	494.19		0.50	494.19	
2+	0.50	8619.61		0.50	8619.61	
3+	0.50	14755.61		0.50	14755.61	
All		**23869.42**			**23869.42**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	222.39		0.50	222.39	
2+	0.50	3878.83		0.50	3878.83	
3+	0.50	6640.02		0.50	6640.02	
All		**10741.24**			**10741.24**	
					21482.474	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	56626.0
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	47738.8
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	21482.5
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	10741.2
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	10741.2
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
10741.2	0.70	**7518.9**

Harvest rate of 0.70 is taken from Armstrong et al. (1991).

Loss to Fishery with Confidence Limits

Loss to Fishery	7518.9
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Desdemona, Sept	Post Construction Maintenance, 40 ft Yr 1	*40000*

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40,000
10 to 13	Flavel Bar	400000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		760000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **40,000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	869.0		0.60	0.160	83.43		37.54	
2+	0.06518	2607.1		0.86	0.649	1455.12		654.80	
3+	0.03259	1303.5		0.86	2.222	2490.96		1120.93	
All		**4779.6**				**4029.50**		**1813.28**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	41.71		0.50	41.71	
2+	0.50	727.56		0.50	727.56	
3+	0.50	1245.48		0.50	1245.48	
All		**2014.75**			**2014.75**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.02
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	18.77		0.50	18.77	
2+	0.50	327.40		0.50	327.40	
3+	0.50	560.47		0.50	560.47	
All		**906.64**			**906.64**	
					1813.276	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	4779.6
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	4029.5
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	1813.3
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	906.6
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	906.6
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
906.6	0.70	**634.6**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	634.6
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Desdemona, Sept	Post Construction Maintenance, 40 ft Yr 20	*40000*

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		570000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **40,000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	869.0		0.60	0.160	83.43		37.54	
2+	0.06518	2607.1		0.86	0.649	1455.12		654.80	
3+	0.03259	1303.5		0.86	2.222	2490.96		1120.93	
All		**4779.6**				**4029.50**		**1813.28**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	41.71		0.50	41.71	
2+	0.50	727.56		0.50	727.56	
3+	0.50	1245.48		0.50	1245.48	
All		**2014.75**			**2014.75**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.02
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	18.77		0.50	18.77	
2+	0.50	327.40		0.50	327.40	
3+	0.50	560.47		0.50	560.47	
All		**906.64**			**906.64**	
					1813.276	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	4779.6
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	4029.5
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	1813.3
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution
C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	906.6
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	906.6
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
906.6	0.70	**634.6**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	634.6
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Desdemona, Sept	Post Construction Maintenance, 43 ft Yr 1	*60000*

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	60000
10 to 13	Flavel Bar	500000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		990000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **60,000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	1303.5		0.60	0.160	125.14		56.31	
2+	0.06518	3910.6		0.86	0.649	2182.67		982.20	
3+	0.03259	1955.3		0.86	2.222	3736.44		1681.40	
All		**7169.5**				**6044.25**		**2719.91**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	62.57		0.50	62.57	
2+	0.50	1091.34		0.50	1091.34	
3+	0.50	1868.22		0.50	1868.22	
All		**3022.13**			**3022.13**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.01
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	28.16		0.50	28.16	
2+	0.50	491.10		0.50	491.10	
3+	0.50	840.70		0.50	840.70	
All		**1359.96**			**1359.96**	
					2719.915	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	7169.5
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	6044.3
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	2719.9
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution
C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	1360.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	1360.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
1360.0	0.70	**952.0**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	952.0
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Desdemona, Sept	Post Construction Maintenance, 43 ft Yr 20	*40000*

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		680000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **40000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	869.0		0.60	0.160	83.43		37.54	
2+	0.06518	2607.1		0.86	0.649	1455.12		654.80	
3+	0.03259	1303.5		0.86	2.222	2490.96		1120.93	
All		**4779.6**				**4029.50**		**1813.28**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	41.71		0.50	41.71	
2+	0.50	727.56		0.50	727.56	
3+	0.50	1245.48		0.50	1245.48	
All		**2014.75**			**2014.75**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.02
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	18.77		0.50	18.77	
2+	0.50	327.40		0.50	327.40	
3+	0.50	560.47		0.50	560.47	
All		**906.64**			**906.64**	
					1813.276	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	4779.6
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	4029.5
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	1813.3
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	906.6
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	906.6
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY
(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
906.6	0.70	**634.6**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	634.6
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

Summary of Projected Entrainment, Adult Equivalent Loss, and Loss to Fishery.
Lower Columbia River
WH Pearson and GD Williams

Variance Estimators (derived from June 2002 field sampling at Desdemona Shoals)

	CV %		
E	5.01	Z at 0.975	1.95996
AEL	7.37		
LF	8.11		

Construction Dredging to 40 ft - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	542,349

Results:

Parameter	Projected Value	SE	95% CI
E	121,282	6,076	11,909
AEL	18,338	1,352	2,649
AEL Male	11,008	811	1,590
AEL Female	7,331	540	1,059
Loss to Fishery	3,467	281	551

Construction Dredging to 40 ft - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	542,349

Results:

Parameter	Projected Value	SE	95% CI
E	121,282	6,076	11,909
AEL	8,252	608	1,192
AEL Male	4,953	365	716
AEL Female	3,299	243	477
Loss to Fishery	3,467	281	551

Construction Dredging from 40 to 43 ft - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	1,169,721

Results:

Parameter	Projected Value	SE	95% CI
E	261,577	13,105	25,685
AEL	39,551	2,915	5,713
AEL Male	23,741	1,750	3,429
AEL Female	15,811	1,165	2,284
Loss to Fishery	7,478	606	1,189

Construction Dredging from 40 to 43 ft - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	1,169,721

Results:

Parameter	Projected Value	SE	95% CI
E	261,577	13,105	25,685
AEL	17,798	1,312	2,571
AEL Male	10,683	787	1,543
AEL Female	7,115	524	1,028
Loss to Fishery	7,478	606	1,189

Annual Maintenance Dredging 40' Year 1 - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	400,000

Results:

Parameter	Projected Value	SE	95% CI
E	89,449	4,481	8,783
AEL	13,525	997	1,954
AEL Male	8,118	598	1,173
AEL Female	5,407	398	781
Loss to Fishery	2,557	207	406

Annual Maintenance Dredging 40' Year 1 - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	400,000

Results:

Parameter	Projected Value	SE	95% CI
E	89,449	4,481	8,783
AEL	6,086	449	879
AEL Male	3,653	269	528
AEL Female	2,433	179	351
Loss to Fishery	2,557	207	406

Annual Maintenance Dredging 40' Year 20 - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	210,000

Results:

Parameter	Projected Value	SE	95% CI
E	46,961	2,353	4,611
AEL	7,101	523	1,026
AEL Male	4,262	314	616
AEL Female	2,838	209	410
Loss to Fishery	1,343	109	213

Annual Maintenance Dredging 40' Year 20 - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	210,000

Results:

Parameter	Projected Value	SE	95% CI
E	46,961	2,353	4,611
AEL	3,195	235	462
AEL Male	1,918	141	277
AEL Female	1,277	94	185
Loss to Fishery	1,343	109	213

Annual Maintenance Dredging 43' Year 1 - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	500,000

Results:

Parameter	Projected Value	SE	95% CI
E	111,812	5,602	10,979
AEL	16,906	1,246	2,442
AEL Male	10,148	748	1,466
AEL Female	6,758	498	976
Loss to Fishery	3,197	259	508

Annual Maintenance Dredging 43' Year 1 - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	500,000

Results:

Parameter	Projected Value	SE	95% CI
E	111,812	5,602	10,979
AEL	7,608	561	1,099
AEL Male	4,567	337	660
AEL Female	3,041	224	439
Loss to Fishery	3,197	259	508

Annual Maintenance Dredging 43' Year 20 - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	210,000

Results:

Parameter	Projected Value	SE	95% CI
E	46,961	2,353	4,611
AEL	7,101	523	1,026
AEL Male	4,262	314	616
AEL Female	2,838	209	410
Loss to Fishery	1,343	109	213

Annual Maintenance Dredging 43' Year 20 - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	210,000

Results:

Parameter	Projected Value	SE	95% CI
E	46,961	2,353	4,611
AEL	3,195	235	462
AEL Male	1,918	141	277
AEL Female	1,277	94	185
Loss to Fishery	1,343	109	213

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	**Total Volume Dredged (cy)**
Projected	**Flavel Bar**	**Construction Dredging to 40 ft**	***542349***

**Based on Desdemona June crab entrainment data

VOLUME OF DREDGED MATERIALS - to 40 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem.	222412
5		353916
6	Upper Desdem	0
7		0
8		8742
9		8742
10	Flavel Bar	49732
11		298900
12		121292
13		72425
14	Upper Sands	54585
15		51945
16		47557
17		0
18	Tongue Point	14775
19		6976
20		13283
Total		1325282

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **542349** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	2805.5		0.10	0.017	4.63		2.08	
1+	0.19327	104821.2		0.60	0.160	10062.84		4528.28	
2+	0.02429	13175.3		0.86	0.649	7353.65		3309.14	
3+	0.00088	480.0		0.86	2.222	917.18		412.73	
All		**121282.0**				**18338.30**		**8252.24**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations
Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	2.31		0.50	2.31	
1+	0.50	5031.42		0.50	5031.42	
2+	0.25	1838.41		0.75	5515.24	
3+	0.50	458.59		0.50	458.59	
All		**7330.74**			**11007.56**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations
Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	1.04		0.50	1.04	
1+	0.50	2264.14		0.50	2264.14	
2+	0.25	827.29		0.75	2481.86	
3+	0.50	206.37		0.50	206.37	
All		**3298.83**			**4953.40**	
					8252.235	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	2.31	0.02
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	121282.0
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	18338.3
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	8252.2
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	4953.4
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	3298.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY
(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
4953.4	0.70	**3467.4**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	3467.4
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:
Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	**Total Volume Dredged (cy)**
Projected	**Flavel Bar**	**Construction Dredging from 40 to 43 ft**	***1169721***

**Based on Desdemona June crab entrainment data

VOLUME OF DREDGED MATERIALS - from 40 to 43 ft

: and Surface Area to be Dredged (ha)

River Mile	Location Name	Volume (cy)
4	Lower Desdem.	94688
5		196724
6	Upper Desdem	66193
7		1039
8		52398
9		62851
10	Flavel Bar	329296
11		535074
12		239608
13		65743
14	Upper Sands	171433
15		271843
16		306711
17		108631
18	Tongue Point	174113
19		162864
20		127219
Total		2966432

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **1169721** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	**Female**	**Sexed**	**Male**	**Female**	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	6050.9		0.10	0.017	9.98		4.49	
1+	0.19327	226075.0		0.60	0.160	21703.20		9766.44	
2+	0.02429	28416.0		0.86	0.649	15860.12		7137.05	
3+	0.00088	1035.2		0.86	2.222	1978.16		890.17	
All		**261577.1**				**39551.46**		**17798.16**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	**AEL**	**VAR(AEL)**	**Proportion**	**AEL**	**VAR(AEL)**
YOY	0.50	4.99		0.50	4.99	
1+	0.50	10851.60		0.50	10851.60	
2+	0.25	3965.03		0.75	11895.09	
3+	0.50	989.08		0.50	989.08	
All		**15810.70**			**23740.76**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	**of AEL**
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

	Proportion of Total AEL	
Age Class	**Male**	**Female**
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	**AEL**	**VAR(AEL)**	**Proportion**	**AEL**	**VAR(AEL)**
YOY	0.50	2.25		0.50	2.25	
1+	0.50	4883.22		0.50	4883.22	
2+	0.25	1784.26		0.75	5352.79	
3+	0.50	445.09		0.50	445.09	
All		**7114.82**			**10683.34**	
					17798.158	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	**of AEL at 3+**
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

	Proportion of Total AEL at 3+	
Age Class	**Male**	**Female**
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	261577.1
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	39551.5
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	17798.2
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	10683.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY
(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
10683.3	0.70	**7478.3**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	7478.3
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:
Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 40 ft Yr 1	*400000*

**Based on Desdemona June crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40,000
10 to 13	Flavel Bar	400000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		760000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **400,000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	2069.2		0.10	0.017	3.41		1.54	
1+	0.19327	77309.0		0.60	0.160	7421.67		3339.75	
2+	0.02429	9717.2		0.86	0.649	5423.56		2440.60	
3+	0.00088	354.0		0.86	2.222	676.45		304.40	
All		**89449.4**				**13525.09**		**6086.29**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	1.71		0.50	1.71	
1+	0.50	3710.83		0.50	3710.83	
2+	0.25	1355.89		0.75	4067.67	
3+	0.50	338.23		0.50	338.23	
All		**5406.66**			**8118.44**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.77		0.50	0.77	
1+	0.50	1669.88		0.50	1669.88	
2+	0.25	610.15		0.75	1830.45	
3+	0.50	152.20		0.50	152.20	
All		**2433.00**			**3653.30**	
					6086.292	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	89449.4
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	13525.1
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	6086.3
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	3653.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	2433.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
3653.3	0.70	**2557.3**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	2557.3
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 40 ft Yr 20	*210000*

**Based on Desdemona June crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		570000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **210000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	1086.3		0.10	0.017	1.79		0.81	
1+	0.19327	40587.2		0.60	0.160	3896.38		1753.37	
2+	0.02429	5101.5		0.86	0.649	2847.37		1281.32	
3+	0.00088	185.8		0.86	2.222	355.14		159.81	
All		**46960.9**				**7100.67**		**3195.30**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.90		0.50	0.90	
1+	0.50	1948.19		0.50	1948.19	
2+	0.25	711.84		0.75	2135.53	
3+	0.50	177.57		0.50	177.57	
All		**2838.50**			**4262.18**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.40		0.50	0.40	
1+	0.50	876.68		0.50	876.68	
2+	0.25	320.33		0.75	960.99	
3+	0.50	79.91		0.50	79.91	
All		**1277.32**			**1917.98**	
					3195.303	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	46960.9
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	7100.7
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	3195.3
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	1918.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	1277.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
1918.0	0.70	**1342.6**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	1342.6
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 43 ft Yr 1	*500000*

**Based on Desdemona June crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	60000
10 to 13	Flavel Bar	500000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		990000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **500000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	2586.5		0.10	0.017	4.27		1.92	
1+	0.19327	96636.3		0.60	0.160	9277.08		4174.69	
2+	0.02429	12146.5		0.86	0.649	6779.45		3050.75	
3+	0.00088	442.5		0.86	2.222	845.57		380.51	
All		**111811.8**				**16906.37**		**7607.86**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	2.13		0.50	2.13	
1+	0.50	4638.54		0.50	4638.54	
2+	0.25	1694.86		0.75	5084.58	
3+	0.50	422.78		0.50	422.78	
All		**6758.32**			**10148.04**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.96		0.50	0.96	
1+	0.50	2087.34		0.50	2087.34	
2+	0.25	762.69		0.75	2288.06	
3+	0.50	190.25		0.50	190.25	
All		**3041.24**			**4566.62**	
					7607.865	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	111811.8
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	16906.4
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	7607.9
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	4566.6
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	3041.2
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
4566.6	0.70	**3196.6**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	3196.6
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 43 ft Yr 20	*210000*

**Based on Desdemona June crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		680000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **210000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	1086.3		0.10	0.017	1.79		0.81	
1+	0.19327	40587.2		0.60	0.160	3896.38		1753.37	
2+	0.02429	5101.5		0.86	0.649	2847.37		1281.32	
3+	0.00088	185.8		0.86	2.222	355.14		159.81	
All		**46960.9**				**7100.67**		**3195.30**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.90		0.50	0.90	
1+	0.50	1948.19		0.50	1948.19	
2+	0.25	711.84		0.75	2135.53	
3+	0.50	177.57		0.50	177.57	
All		**2838.50**			**4262.18**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.40		0.50	0.40	
1+	0.50	876.68		0.50	876.68	
2+	0.25	320.33		0.75	960.99	
3+	0.50	79.91		0.50	79.91	
All		**1277.32**			**1917.98**	
					3195.303	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	46960.9
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	7100.7
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	3195.3
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	1918.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	1277.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
1918.0	0.70	**1342.6**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	1342.6
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	**Total Volume Dredged (cy)**	**Based on Desdemona June crab entrainment data
Projected	**Flavel Bar**	**Construction Dredging to 40 ft**	***542349***	

VOLUME OF DREDGED MATERIALS - to 40 ft

Volume to be Dredged (cy)			Data from Portland District (10 Sept 2002)
River Mile	Location Name	Volume (cy)	
4	Lower Desdem.	222412	
5		353916	
6	Upper Desdem	0	
7		0	
8		8742	
9		8742	
10	Flavel Bar	49732	
11		298900	
12		121292	
13		72425	
14	Upper Sands	54585	
15		51945	
16		47557	
17		0	
18	Tongue Point	14775	
19		6976	
20		13283	
Total		1325282	

Dredged Yardage (cy) **542349** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	**Total**			**Proportion**		
	Male	**Female**	**Sexed**	**Male**	**Female**	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	**R**	**E**	**Var(E)**	**M**	**S to 2+**	**AEL at 2+**	**VAR(AEL 2+)**	**AEL at 3+**	**VAR(AEL 3+)**
YOY	0.00517	2805.5		0.10	0.017	4.63		2.08	
1+	0.19327	104821.2		0.60	0.160	10062.84		4528.28	
2+	0.02429	13175.3		0.86	0.649	7353.65		3309.14	
3+	0.00088	480.0		0.86	2.222	917.18		412.73	
All		**121282.0**				**18338.30**		**8252.24**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations
Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	**Female**			**Male**		
	Proportion	**AEL**	**VAR(AEL)**	**Proportion**	**AEL**	**VAR(AEL)**
YOY	0.50	2.31		0.50	2.31	
1+	0.50	5031.42		0.50	5031.42	
2+	0.25	1838.41		0.75	5515.24	
3+	0.50	458.59		0.50	458.59	
All		**7330.74**			**11007.56**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	**% of Total**	
	of Entrained	**of AEL**
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	**Proportion of Total AEL**	
	Male	**Female**
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations
Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	**Female**			**Male**		
	Proportion	**AEL**	**VAR(AEL)**	**Proportion**	**AEL**	**VAR(AEL)**
YOY	0.50	1.04		0.50	1.04	
1+	0.50	2264.14		0.50	2264.14	
2+	0.25	827.29		0.75	2481.86	
3+	0.50	206.37		0.50	206.37	
All		**3298.83**			**4953.40**	
					8252.235	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	**% of Total**	
	of Entrained	**of AEL at 3+**
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	**Proportion of Total AEL at 3+**	
	Male	**Female**
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	121282.0
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	18338.3
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	8252.2
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	4953.4
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	3298.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY
(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)	Harvest rate of 0.70 is taken from Armstrong et al. (1987).
4953.4	0.70	**3467.4**	

Loss to Fishery with Confidence Limits

Loss to Fishery	3467.4
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:
Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	**Total Volume Dredged (cy)**
Projected	**Flavel Bar**	**Construction Dredging from 40 to 43 ft**	***1169721***

**Based on Desdemona June crab entrainment data

VOLUME OF DREDGED MATERIALS - from 40 to 43 ft

: and Surface Area to be Dredged (ha)

River Mile	Location Name	Volume (cy)
4	Lower Desdem.	94688
5		196724
6	Upper Desdem.	66193
7		1039
8		52398
9		62851
10	Flavel Bar	329296
11		535074
12		239608
13		65743
14	Upper Sands	171433
15		271843
16		306711
17		108631
18	Tongue Point	174113
19		162864
20		127219
Total		2966432

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **1169721** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	**Female**	**Sexed**	**Male**	**Female**	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	6050.9		0.10	0.017	9.98		4.49	
1+	0.19327	226075.0		0.60	0.160	21703.20		9766.44	
2+	0.02429	28416.0		0.86	0.649	15860.12		7137.05	
3+	0.00088	1035.2		0.86	2.222	1978.16		890.17	
All		**261577.1**				**39551.46**		**17798.16**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	**AEL**	**VAR(AEL)**	**Proportion**	**AEL**	**VAR(AEL)**
YOY	0.50	4.99		0.50	4.99	
1+	0.50	10851.60		0.50	10851.60	
2+	0.25	3965.03		0.75	11895.09	
3+	0.50	989.08		0.50	989.08	
All		**15810.70**			**23740.76**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	**of AEL**
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	**Female**
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	**AEL**	**VAR(AEL)**	**Proportion**	**AEL**	**VAR(AEL)**
YOY	0.50	2.25		0.50	2.25	
1+	0.50	4883.22		0.50	4883.22	
2+	0.25	1784.26		0.75	5352.79	
3+	0.50	445.09		0.50	445.09	
All		**7114.82**			**10683.34**	
					17798.158	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	**of AEL at 3+**
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	**Female**
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	261577.1
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	39551.5
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	17798.2
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	10683.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY
(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
10683.3	0.70	**7478.3**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	7478.3
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:
Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 40 ft Yr 1	*400000*

**Based on Desdemona June crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40,000
10 to 13	Flavel Bar	400000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		760000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **400,000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	2069.2		0.10	0.017	3.41		1.54	
1+	0.19327	77309.0		0.60	0.160	7421.67		3339.75	
2+	0.02429	9717.2		0.86	0.649	5423.56		2440.60	
3+	0.00088	354.0		0.86	2.222	676.45		304.40	
All		**89449.4**				**13525.09**		**6086.29**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	1.71		0.50	1.71	
1+	0.50	3710.83		0.50	3710.83	
2+	0.25	1355.89		0.75	4067.67	
3+	0.50	338.23		0.50	338.23	
All		**5406.66**			**8118.44**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.77		0.50	0.77	
1+	0.50	1669.88		0.50	1669.88	
2+	0.25	610.15		0.75	1830.45	
3+	0.50	152.20		0.50	152.20	
All		**2433.00**			**3653.30**	
					6086.292	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	89449.4
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	13525.1
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	6086.3
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	3653.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	2433.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
3653.3	0.70	**2557.3**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	2557.3
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 40 ft Yr 20	*210000*

**Based on Desdemona June crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		570000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **210000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	1086.3		0.10	0.017	1.79		0.81	
1+	0.19327	40587.2		0.60	0.160	3896.38		1753.37	
2+	0.02429	5101.5		0.86	0.649	2847.37		1281.32	
3+	0.00088	185.8		0.86	2.222	355.14		159.81	
All		**46960.9**				**7100.67**		**3195.30**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.90		0.50	0.90	
1+	0.50	1948.19		0.50	1948.19	
2+	0.25	711.84		0.75	2135.53	
3+	0.50	177.57		0.50	177.57	
All		**2838.50**			**4262.18**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.40		0.50	0.40	
1+	0.50	876.68		0.50	876.68	
2+	0.25	320.33		0.75	960.99	
3+	0.50	79.91		0.50	79.91	
All		**1277.32**			**1917.98**	
					3195.303	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	46960.9
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	7100.7
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	3195.3
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	1918.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	1277.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
1918.0	0.70	**1342.6**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	1342.6
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 43 ft Yr 1	*500000*

**Based on Desdemona June crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	60000
10 to 13	Flavel Bar	500000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		990000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **500000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	2586.5		0.10	0.017	4.27		1.92	
1+	0.19327	96636.3		0.60	0.160	9277.08		4174.69	
2+	0.02429	12146.5		0.86	0.649	6779.45		3050.75	
3+	0.00088	442.5		0.86	2.222	845.57		380.51	
All		**111811.8**				**16906.37**		**7607.86**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	2.13		0.50	2.13	
1+	0.50	4638.54		0.50	4638.54	
2+	0.25	1694.86		0.75	5084.58	
3+	0.50	422.78		0.50	422.78	
All		**6758.32**			**10148.04**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.96		0.50	0.96	
1+	0.50	2087.34		0.50	2087.34	
2+	0.25	762.69		0.75	2288.06	
3+	0.50	190.25		0.50	190.25	
All		**3041.24**			**4566.62**	
					7607.865	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	111811.8
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	16906.4
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	7607.9
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	4566.6
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	3041.2
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
4566.6	0.70	**3196.6**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	3196.6
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 43 ft Yr 20	*210000*

**Based on Desdemona June crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		680000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **210000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.50	0.50	* binomial distribution p>0.05; low sample size - assumed to be 1:1.
1+	70	68	138	0.51	0.49	binomial distribution p=0.067 - not sign different from 1:1
2+	12	4	16	0.75	0.25	binomial distribution p<0.05
3+	0	0	0	0.50	0.50	* low sample size - assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00517	1086.3		0.10	0.017	1.79		0.81	
1+	0.19327	40587.2		0.60	0.160	3896.38		1753.37	
2+	0.02429	5101.5		0.86	0.649	2847.37		1281.32	
3+	0.00088	185.8		0.86	2.222	355.14		159.81	
All		**46960.9**				**7100.67**		**3195.30**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.90		0.50	0.90	
1+	0.50	1948.19		0.50	1948.19	
2+	0.25	711.84		0.75	2135.53	
3+	0.50	177.57		0.50	177.57	
All		**2838.50**			**4262.18**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	2.31	0.00
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.40		0.50	0.40	
1+	0.50	876.68		0.50	876.68	
2+	0.25	320.33		0.75	960.99	
3+	0.50	79.91		0.50	79.91	
All		**1277.32**			**1917.98**	
					3195.303	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	2.31	0.03
1+	86.43	54.87
2+	10.86	40.10
3+	0.40	5.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0001	0.0001
1+	0.2744	0.2744
2+	0.3007	0.1002
3+	0.0250	0.0250
ALL	0.60	0.40

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	46960.9
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	7100.7
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	3195.3
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	1918.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	1277.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
1918.0	0.70	**1342.6**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	1342.6
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

Summary of Projected Entrainment, Adult Equivalent Loss, and Lost Recruits
Lower Columbia River
WH Pearson and GD Williams

Variance Estimators (derived from Sept 2002 field sampling at Desdemona Shoals)

	CV %		
E	29.43	Z at 0.975	1.95996
AEL	20.25		
LF	20.25		

Construction Dredging to 40 ft - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	542,349

Results:

Parameter	Projected Value	SE	95% CI
E	64,806	19,072	37,381
AEL	54,635	11,064	21,684
AEL Male	27,317	5,532	10,842
AEL Female	27,317	5,532	10,842
Loss to Fishery	8,605	1,743	3,415

Construction Dredging to 40 ft - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	542,349

Results:

Parameter	Projected Value	SE	95% CI
E	64,806	19,072	37,381
AEL	24,586	4,979	9,758
AEL Male	12,293	2,489	4,879
AEL Female	12,293	2,489	4,879
Loss to Fishery	8,605	1,743	3,415

Construction Dredging from 40 to 43 ft - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	1,169,721

Results:

Parameter	Projected Value	SE	95% CI
E	139,771	41,135	80,622
AEL	117,835	23,862	46,768
AEL Male	58,917	11,931	23,384
AEL Female	58,917	11,931	23,384
Loss to Fishery	18,559	3,758	7,366

Construction Dredging from 40 to 43 ft - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	1,169,721

Results:

Parameter	Projected Value	SE	95% CI
E	139,771	41,135	80,622
AEL	53,026	10,738	21,045
AEL Male	26,513	5,369	10,523
AEL Female	26,513	5,369	10,523
Loss to Fishery	18,559	3,758	7,366

Annual Maintenance Dredging 40' Year 1 - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	400,000

Results:

Parameter	Projected Value	SE	95% CI
E	47,796	14,067	27,570
AEL	40,295	8,160	15,993
AEL Male	20,148	4,080	7,996
AEL Female	20,148	4,080	7,996
Loss to Fishery	6,346	1,285	2,519

Annual Maintenance Dredging 40' Year 1 - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	400,000

Results:

Parameter	Projected Value	SE	95% CI
E	47,796	14,067	27,570
AEL	18,133	3,672	7,197
AEL Male	9,066	1,836	3,598
AEL Female	9,066	1,836	3,598
Loss to Fishery	6,346	1,285	2,519

Annual Maintenance Dredging 40' Year 20 - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	210,000

Results:

Parameter	Projected Value	SE	95% CI
E	25,093	7,385	14,474
AEL	21,155	4,284	8,396
AEL Male	10,577	2,142	4,198
AEL Female	10,577	2,142	4,198
Loss to Fishery	3,332	675	1,322

Annual Maintenance Dredging 40' Year 20 - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	210,000

Results:

Parameter	Projected Value	SE	95% CI
E	25,093	7,385	14,474
AEL	9,520	1,928	3,778
AEL Male	4,760	964	1,889
AEL Female	4,760	964	1,889
Loss to Fishery	3,332	675	1,322

Annual Maintenance Dredging 43' Year 1 - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	500,000

Results:

Parameter	Projected Value	SE	95% CI
E	59,746	17,583	34,462
AEL	50,369	10,200	19,991
AEL Male	25,184	5,100	9,995
AEL Female	25,184	5,100	9,995
Loss to Fishery	7,933	1,606	3,149

Annual Maintenance Dredging 43' Year 1 - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	500,000

Results:

Parameter	Projected Value	SE	95% CI
E	59,746	17,583	34,462
AEL	22,666	4,590	8,996
AEL Male	11,333	2,295	4,498
AEL Female	11,333	2,295	4,498
Loss to Fishery	7,933	1,606	3,149

Annual Maintenance Dredging 43' Year 20 - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	210,000

Results:

Parameter	Projected Value	SE	95% CI
E	25,093	7,385	14,474
AEL	21,155	4,284	8,396
AEL Male	10,577	2,142	4,198
AEL Female	10,577	2,142	4,198
Loss to Fishery	3,332	675	1,322

Annual Maintenance Dredging 43' Year 20 - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	210,000

Results:

Parameter	Projected Value	SE	95% CI
E	25,093	7,385	14,474
AEL	9,520	1,928	3,778
AEL Male	4,760	964	1,889
AEL Female	4,760	964	1,889
Loss to Fishery	3,332	675	1,322

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Construction Dredging to 40 ft	*542349*

**Based on Desdemona September crab entrainment data

VOLUME OF DREDGED MATERIALS - to 40 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem	222413
5		353916
6	Upper Desdem	0
7		0
8		8742
9		8742
10	Flavel Bar	49732
11		298900
12		121292
13		72425
14	Upper Sands	54585
15		51945
16		47557
17		0
18	Tongue Point	14775
19		6976
20		13283
Total		1325282

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **542349** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from Desdemona Sept Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	11782.9		0.60	0.160	1131.16		509.02	
2+	0.06518	35348.7		0.86	0.649	19729.51		8878.28	
3+	0.03259	17674.3		0.86	2.222	33774.25		15198.41	
All		**64805.9**				**54634.92**		**24585.72**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	565.58		0.50	565.58	
2+	0.50	9864.76		0.50	9864.76	
3+	0.50	16887.13		0.50	16887.13	
All		**27317.46**			**27317.46**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	254.51		0.50	254.51	
2+	0.50	4439.14		0.50	4439.14	
3+	0.50	7599.21		0.50	7599.21	
All		**12292.86**			**12292.86**	
					24585.715	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	64805.9
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	54634.9
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	24585.7
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	12292.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	12292.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
12292.9	0.70	**8605.0**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	8605.0
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Construction Dredging from 40 to 43 ft	*1169721*

**Based on Desdemona September crab entrainment data

VOLUME OF DREDGED MATERIALS - from 40 to 43 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem	94688
5		196724
6	Upper Desdem	66193
7		1039
8		52398
9		62851
10	Flavel Bar	329296
11		535074
12		239608
13		65743
14	Upper Sands	171432
15		271842
16		306717
17		108631
18	Tongue Point	174113
19		162864
20		127219
Total		2966432

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **1169721** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	25413.0		0.60	0.160	2439.65		1097.84	
2+	0.06518	76238.9		0.86	0.649	42551.98		19148.39	
3+	0.03259	38119.5		0.86	2.222	72843.23		32779.45	
All		**139771.3**				**117834.86**		**53025.69**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	1219.82		0.50	1219.82	
2+	0.50	21275.99		0.50	21275.99	
3+	0.50	36421.61		0.50	36421.61	
All		**58917.43**			**58917.43**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	548.92		0.50	548.92	
2+	0.50	9574.20		0.50	9574.20	
3+	0.50	16389.73		0.50	16389.73	
All		**26512.84**			**26512.84**	
					53025.686	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	139771.3
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	117834.9
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	53025.7
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	26512.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	26512.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
26512.8	0.70	**18559.0**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	18559.0
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Construction Dredging to 40 ft	*542349*

**Based on Desdemona September crab entrainment data

VOLUME OF DREDGED MATERIALS - to 40 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem	222413
5		353916
6	Upper Desdem	0
7		0
8		8742
9		8742
10	Flavel Bar	49732
11		298900
12		121292
13		72425
14	Upper Sands	54585
15		51945
16		47557
17		0
18	Tongue Point	14775
19		6976
20		13283
Total		1325282

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **542349** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from Desdemona Sept Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	11782.9		0.60	0.160	1131.16		509.02	
2+	0.06518	35348.7		0.86	0.649	19729.51		8878.28	
3+	0.03259	17674.3		0.86	2.222	33774.25		15198.41	
All		**64805.9**				**54634.92**		**24585.72**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	565.58		0.50	565.58	
2+	0.50	9864.76		0.50	9864.76	
3+	0.50	16887.13		0.50	16887.13	
All		**27317.46**			**27317.46**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	254.51		0.50	254.51	
2+	0.50	4439.14		0.50	4439.14	
3+	0.50	7599.21		0.50	7599.21	
All		**12292.86**			**12292.86**	
					24585.715	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	64805.9
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	54634.9
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	24585.7
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	12292.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	12292.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
12292.9	0.70	**8605.0**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	8605.0
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 40 ft Yr 1	*400000*

**Based on Desdemona September crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40,000
10 to 13	Flavel Bar	400000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		760000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **400,000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from Desdemona Sept Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	8690.3		0.60	0.160	834.27		375.42	
2+	0.06518	26070.8		0.86	0.649	14551.16		6548.02	
3+	0.03259	13035.4		0.86	2.222	24909.61		11209.32	
All		**47796.5**				**40295.03**		**18132.76**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	417.13		0.50	417.13	
2+	0.50	7275.58		0.50	7275.58	
3+	0.50	12454.80		0.50	12454.80	
All		**20147.52**			**20147.52**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	187.71		0.50	187.71	
2+	0.50	3274.01		0.50	3274.01	
3+	0.50	5604.66		0.50	5604.66	
All		**9066.38**			**9066.38**	
					18132.764	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	47796.5
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	40295.0
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	18132.8
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	9066.4
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	9066.4
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
9066.4	0.70	**6346.5**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	6346.5
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 40 ft Yr 20	*210000*

**Based on Desdemona September crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		570000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **210000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from Desdemona Sept Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	4562.4		0.60	0.160	437.99		197.10	
2+	0.06518	13687.2		0.86	0.649	7639.36		3437.71	
3+	0.03259	6843.6		0.86	2.222	13077.54		5884.89	
All		**25093.1**				**21154.89**		**9519.70**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	218.99		0.50	218.99	
2+	0.50	3819.68		0.50	3819.68	
3+	0.50	6538.77		0.50	6538.77	
All		**10577.45**			**10577.45**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	98.55		0.50	98.55	
2+	0.50	1718.86		0.50	1718.86	
3+	0.50	2942.45		0.50	2942.45	
All		**4759.85**			**4759.85**	
					9519.701	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	25093.1
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	21154.9
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	9519.7
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	4759.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	4759.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
4759.9	0.70	**3331.9**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	3331.9
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 43 ft Yr 1	*500000*

**Based on Desdemona September crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	60000
10 to 13	Flavel Bar	500000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		990000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **500000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from Desdemona Sept Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	10862.8		0.60	0.160	1042.83		469.27	
2+	0.06518	32588.5		0.86	0.649	18188.95		8185.03	
3+	0.03259	16294.3		0.86	2.222	31137.01		14011.65	
All		**59745.6**				**50368.79**		**22665.95**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	521.42		0.50	521.42	
2+	0.50	9094.47		0.50	9094.47	
3+	0.50	15568.50		0.50	15568.50	
All		**25184.39**			**25184.39**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

	Proportion of Total AEL	
Age Class	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	234.64		0.50	234.64	
2+	0.50	4092.51		0.50	4092.51	
3+	0.50	7005.83		0.50	7005.83	
All		**11332.98**			**11332.98**	
					22665.954	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

	Proportion of Total AEL at 3+	
Age Class	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	59745.6
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	50368.8
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	22666.0
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	11333.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	11333.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
11333.0	0.70	**7933.1**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	7933.1
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Construction Dredging to 40 ft	*542349*

**Based on Desdemona September crab entrainment data

VOLUME OF DREDGED MATERIALS - to 40 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem	222413
5		353916
6	Upper Desdem	0
7		0
8		8742
9		8742
10	Flavel Bar	49732
11		298900
12		121292
13		72425
14	Upper Sands	54585
15		51945
16		47557
17		0
18	Tongue Point	14775
19		6976
20		13283
Total		1325282

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **542349** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from Desdemona Sept Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	11782.9		0.60	0.160	1131.16		509.02	
2+	0.06518	35348.7		0.86	0.649	19729.51		8878.28	
3+	0.03259	17674.3		0.86	2.222	33774.25		15198.41	
All		**64805.9**				**54634.92**		**24585.72**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	565.58		0.50	565.58	
2+	0.50	9864.76		0.50	9864.76	
3+	0.50	16887.13		0.50	16887.13	
All		**27317.46**			**27317.46**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	254.51		0.50	254.51	
2+	0.50	4439.14		0.50	4439.14	
3+	0.50	7599.21		0.50	7599.21	
All		**12292.86**			**12292.86**	
					24585.715	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	64805.9
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	54634.9
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	24585.7
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	12292.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	12292.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
12292.9	0.70	**8605.0**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	8605.0
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 43 ft Yr 20	*210000*

**Based on Desdemona September crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		680000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **210000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from Desdemona Sept Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	4562.4		0.60	0.160	437.99		197.10	
2+	0.06518	13687.2		0.86	0.649	7639.36		3437.71	
3+	0.03259	6843.6		0.86	2.222	13077.54		5884.89	
All		**25093.1**				**21154.89**		**9519.70**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	218.99		0.50	218.99	
2+	0.50	3819.68		0.50	3819.68	
3+	0.50	6538.77		0.50	6538.77	
All		**10577.45**			**10577.45**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	98.55		0.50	98.55	
2+	0.50	1718.86		0.50	1718.86	
3+	0.50	2942.45		0.50	2942.45	
All		**4759.85**			**4759.85**	
					9519.701	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	25093.1
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	21154.9
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	9519.7
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution
C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	4759.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	4759.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
4759.9	0.70	**3331.9**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	3331.9
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Construction Dredging from 40 to 43 ft	*1169721*

**Based on Desdemona September crab entrainment data

VOLUME OF DREDGED MATERIALS - from 40 to 43 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem	94688
5		196724
6	Upper Desdem	66193
7		1039
8		52398
9		62851
10	Flavel Bar	329296
11		535074
12		239608
13		65743
14	Upper Sands	171432
15		271842
16		306717
17		108631
18	Tongue Point	17411
19		162864
20		127219
Total		2966432

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **1169721** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	25413.0		0.60	0.160	2439.65		1097.84	
2+	0.06518	76238.9		0.86	0.649	42551.98		19148.39	
3+	0.03259	38119.5		0.86	2.222	72843.23		32779.45	
All		**139771.3**				**117834.86**		**53025.69**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	1219.82		0.50	1219.82	
2+	0.50	21275.99		0.50	21275.99	
3+	0.50	36421.61		0.50	36421.61	
All		**58917.43**			**58917.43**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	548.92		0.50	548.92	
2+	0.50	9574.20		0.50	9574.20	
3+	0.50	16389.73		0.50	16389.73	
All		**26512.84**			**26512.84**	
					53025.686	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	139771.3
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	117834.9
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	53025.7
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	26512.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	26512.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
26512.8	0.70	**18559.0**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	18559.0
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Construction Dredging from 40 to 43 ft	*1169721*

**Based on Desdemona September crab entrainment data

VOLUME OF DREDGED MATERIALS - from 40 to 43 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem	94688
5		196724
6	Upper Desdem	66193
7		1039
8		52398
9		62851
10	Flavel Bar	329296
11		535074
12		239608
13		65743
14	Upper Sands	171432
15		271842
16		306717
17		108631
18	Tongue Point	17411
19		162864
20		127219
Total		2966432

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **1169721** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from June Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	25413.0		0.60	0.160	2439.65		1097.84	
2+	0.06518	76238.9		0.86	0.649	42551.98		19148.39	
3+	0.03259	38119.5		0.86	2.222	72843.23		32779.45	
All		**139771.3**				**117834.86**		**53025.69**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	1219.82		0.50	1219.82	
2+	0.50	21275.99		0.50	21275.99	
3+	0.50	36421.61		0.50	36421.61	
All		**58917.43**			**58917.43**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	548.92		0.50	548.92	
2+	0.50	9574.20		0.50	9574.20	
3+	0.50	16389.73		0.50	16389.73	
All		**26512.84**			**26512.84**	
					53025.686	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	139771.3
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	117834.9
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	53025.7
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	26512.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	26512.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
26512.8	0.70	**18559.0**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	18559.0
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 40 ft Yr 1	*400000*

**Based on Desdemona September crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40,000
10 to 13	Flavel Bar	400000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		760000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **400,000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from Desdemona Sept Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	8690.3		0.60	0.160	834.27		375.42	
2+	0.06518	26070.8		0.86	0.649	14551.16		6548.02	
3+	0.03259	13035.4		0.86	2.222	24909.61		11209.32	
All		**47796.5**				**40295.03**		**18132.76**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	417.13		0.50	417.13	
2+	0.50	7275.58		0.50	7275.58	
3+	0.50	12454.80		0.50	12454.80	
All		**20147.52**			**20147.52**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	187.71		0.50	187.71	
2+	0.50	3274.01		0.50	3274.01	
3+	0.50	5604.66		0.50	5604.66	
All		**9066.38**			**9066.38**	
					18132.764	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	47796.5
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	40295.0
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	18132.8
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	9066.4
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	9066.4
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
9066.4	0.70	**6346.5**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	6346.5
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 40 ft Yr 20	*210000*

**Based on Desdemona September crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		570000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **210000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from Desdemona Sept Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	4562.4		0.60	0.160	437.99		197.10	
2+	0.06518	13687.2		0.86	0.649	7639.36		3437.71	
3+	0.03259	6843.6		0.86	2.222	13077.54		5884.89	
All		**25093.1**				**21154.89**		**9519.70**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	218.99		0.50	218.99	
2+	0.50	3819.68		0.50	3819.68	
3+	0.50	6538.77		0.50	6538.77	
All		**10577.45**			**10577.45**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	98.55		0.50	98.55	
2+	0.50	1718.86		0.50	1718.86	
3+	0.50	2942.45		0.50	2942.45	
All		**4759.85**			**4759.85**	
					9519.701	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	25093.1
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	21154.9
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	9519.7
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	4759.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	4759.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
4759.9	0.70	**3331.9**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	3331.9
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 43 ft Yr 1	*500000*

**Based on Desdemona September crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	60000
10 to 13	Flavel Bar	500000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		990000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **500000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from Desdemona Sept Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	10862.8		0.60	0.160	1042.83		469.27	
2+	0.06518	32588.5		0.86	0.649	18188.95		8185.03	
3+	0.03259	16294.3		0.86	2.222	31137.01		14011.65	
All		**59745.6**				**50368.79**		**22665.95**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	521.42		0.50	521.42	
2+	0.50	9094.47		0.50	9094.47	
3+	0.50	15568.50		0.50	15568.50	
All		**25184.39**			**25184.39**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	234.64		0.50	234.64	
2+	0.50	4092.51		0.50	4092.51	
3+	0.50	7005.83		0.50	7005.83	
All		**11332.98**			**11332.98**	
					22665.954	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	59745.6
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	50368.8
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	22666.0
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	11333.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	11333.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
11333.0	0.70	**7933.1**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	7933.1
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 43 ft Yr 20	*210000*

**Based on Desdemona September crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		680000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **210000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class, Derived from Desdemona Sept Data

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	2	0	2	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.00000	0.0		0.10	0.017	0.00		0.00	
1+	0.02173	4562.4		0.60	0.160	437.99		197.10	
2+	0.06518	13687.2		0.86	0.649	7639.36		3437.71	
3+	0.03259	6843.6		0.86	2.222	13077.54		5884.89	
All		**25093.1**				**21154.89**		**9519.70**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	218.99		0.50	218.99	
2+	0.50	3819.68		0.50	3819.68	
3+	0.50	6538.77		0.50	6538.77	
All		**10577.45**			**10577.45**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.00		0.50	0.00	
1+	0.50	98.55		0.50	98.55	
2+	0.50	1718.86		0.50	1718.86	
3+	0.50	2942.45		0.50	2942.45	
All		**4759.85**			**4759.85**	
					9519.701	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	0.00	0.00
1+	18.18	2.07
2+	54.55	36.11
3+	27.27	61.82

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0000	0.0000
1+	0.0104	0.0104
2+	0.1806	0.1806
3+	0.3091	0.3091
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	25093.1
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	21154.9
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	9519.7
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	4759.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	4759.9
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
4759.9	0.70	**3331.9**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	3331.9
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

Summary of Projected Entrainment, Adult Equivalent Loss, and Loss to Fishery.
Lower Columbia River
WH Pearson and GD Williams

Variance Estimators (derived from Sept 2002 field sampling at Upper Sands)

	CV %		
E	70.70	Z at 0.975	1.95996
AEL	98.30		
LF	98.30		

Construction Dredging to 40 ft - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	542,349

Results:

Parameter	Projected Value	SE	95% CI
E	11,136	7,873	15,431
AEL	539	530	1,039
AEL Male	270	265	519
AEL Female	270	265	519
Loss to Fishery	85	83	164

Construction Dredging to 40 ft - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	542,349

Results:

Parameter	Projected Value	SE	95% CI
E	11,136	7,873	15,431
AEL	243	238	467
AEL Male	121	119	234
AEL Female	121	119	234
Loss to Fishery	85	83	164

Construction Dredging from 40 to 43 ft - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	1,169,721

Results:

Parameter	Projected Value	SE	95% CI
E	24,017	16,980	33,280
AEL	1,163	1,143	2,240
AEL Male	581	571	1,120
AEL Female	581	571	1,120
Loss to Fishery	183	180	353

Construction Dredging from 40 to 43 ft - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	1,169,721

Results:

Parameter	Projected Value	SE	95% CI
E	24,017	16,980	33,280
AEL	523	514	1,008
AEL Male	262	257	504
AEL Female	262	257	504
Loss to Fishery	183	180	353

Annual Maintenance Dredging 40' Year 1 - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	400,000

Results:

Parameter	Projected Value	SE	95% CI
E	8,213	5,807	11,381
AEL	398	391	766
AEL Male	199	195	383
AEL Female	199	195	383
Loss to Fishery	63	62	121

Annual Maintenance Dredging 40' Year 1 - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	400,000

Results:

Parameter	Projected Value	SE	95% CI
E	8,213	5,807	11,381
AEL	179	176	345
AEL Male	89	88	172
AEL Female	89	88	172
Loss to Fishery	63	62	121

Annual Maintenance Dredging 40' Year 20 - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	210,000

Results:

Parameter	Projected Value	SE	95% CI
E	4,312	3,048	5,975
AEL	209	205	402
AEL Male	104	103	201
AEL Female	104	103	201
Loss to Fishery	33	32	63

Annual Maintenance Dredging 40' Year 20 - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	210,000

Results:

Parameter	Projected Value	SE	95% CI
E	4,312	3,048	5,975
AEL	94	92	181
AEL Male	47	46	90
AEL Female	47	46	90
Loss to Fishery	33	32	63

Annual Maintenance Dredging 43' Year 1 - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	500,000

Results:

Parameter	Projected Value	SE	95% CI
E	10,266	7,258	14,226
AEL	497	489	958
AEL Male	248	244	479
AEL Female	248	244	479
Loss to Fishery	78	77	151

Annual Maintenance Dredging 43' Year 1 - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	500,000

Results:

Parameter	Projected Value	SE	95% CI
E	10,266	7,258	14,226
AEL	224	220	431
AEL Male	112	110	215
AEL Female	112	110	215
Loss to Fishery	78	77	151

Annual Maintenance Dredging 43' Year 20 - Age 2+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	210,000

Results:

Parameter	Projected Value	SE	95% CI
E	4,312	3,048	5,975
AEL	209	205	402
AEL Male	104	103	201
AEL Female	104	103	201
Loss to Fishery	33	32	63

Annual Maintenance Dredging 43' Year 20 - Age 3+

Assumptions:

Projected Location	Flavel Bar
Planned dredged volume (cy)	210,000

Results:

Parameter	Projected Value	SE	95% CI
E	4,312	3,048	5,975
AEL	94	92	181
AEL Male	47	46	90
AEL Female	47	46	90
Loss to Fishery	33	32	63

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Construction Dredging to 40 ft	*542349*

**Based on Upper Sands crab entrainment data

VOLUME OF DREDGED MATERIALS - to 40 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem	222413
5		353916
6	Upper Desdem	0
7		0
8		8742
9		8742
10	Flavel Bar	49732
11		298900
12		121292
13		72425
14	Upper Sands	54585
15		51945
16		47557
17		0
18	Tongue Point	14775
19		6976
20		13283
Total		1325282

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **542349** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	5616.7		0.10	0.017	9.27		4.17	
1+	0.01018	5519.0		0.60	0.160	529.83		238.42	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**11135.7**				**539.09**		**242.59**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	4.63		0.50	4.63	
1+	0.50	264.91		0.50	264.91	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**269.55**			**269.55**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	2.09		0.50	2.09	
1+	0.50	119.21		0.50	119.21	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**121.30**			**121.30**	
					242.592	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	11135.7
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	539.1
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	242.6
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	121.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	121.3
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
121.3	0.70	**84.9**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	84.9
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Construction Dredging from 40 to 43 ft	*1169721*

**Based on Upper Sands crab entrainment data

VOLUME OF DREDGED MATERIALS - from 40 to 43 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem	94688
5		196724
6	Upper Desdem	66193
7		1039
8		52398
9		62851
10	Flavel Bar	329296
11		535074
12		239608
13		65743
14	Upper Sands	171432
15		271842
16		306717
17		108631
18	Tongue Point	174113
19		162864
20		127219
Total		2966432

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **1169721** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	12113.9		0.10	0.017	19.99		8.99	
1+	0.01018	11903.3		0.60	0.160	1142.71		514.22	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**24017.2**				**1162.70**		**523.22**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	9.99		0.50	9.99	
1+	0.50	571.36		0.50	571.36	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**581.35**			**581.35**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	4.50		0.50	4.50	
1+	0.50	257.11		0.50	257.11	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**261.61**			**261.61**	
					523.215	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	24017.2
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	1162.7
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	523.2
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	261.6
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	261.6
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
261.6	0.70	**183.1**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	183.1
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	**Total Volume Dredged (cy)**
Projected	**Flavel Bar**	**Post Construction Maintenance, 40 ft Yr 1**	***400000***

**Based on Upper Sands crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40,000
10 to 13	Flavel Bar	400000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		760000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **400,000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	**Total**			**Proportion**		
	Male	**Female**	**Sexed**	**Male**	**Female**	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	**R**	**E**	**Var(E)**	**M**	**S to 2+**	**AEL at 2+**	**VAR(AEL 2+)**	**AEL at 3+**	**VAR(AEL 3+)**
YOY	0.01036	4142.5		0.10	0.017	6.84		3.08	
1+	0.01018	4070.5		0.60	0.160	390.76		175.84	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**8213.0**				**397.60**		**178.92**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	**Female**			**Male**		
	Proportion	**AEL**	**VAR(AEL)**	**Proportion**	**AEL**	**VAR(AEL)**
YOY	0.50	3.42		0.50	3.42	
1+	0.50	195.38		0.50	195.38	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**198.80**			**198.80**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	**% of Total**	
	of Entrained	**of AEL**
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

	Proportion of Total AEL	
Age Class	**Male**	**Female**
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	**Female**			**Male**		
	Proportion	**AEL**	**VAR(AEL)**	**Proportion**	**AEL**	**VAR(AEL)**
YOY	0.50	1.54		0.50	1.54	
1+	0.50	87.92		0.50	87.92	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**89.46**			**89.46**	
					178.920	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	**% of Total**	
	of Entrained	**of AEL at 3+**
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

	Proportion of Total AEL at 3+	
Age Class	**Male**	**Female**
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	8213.0
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	397.6
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	178.9
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution
C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	89.5
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	89.5
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY
(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
89.5	0.70	**62.6**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	62.6
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:
Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 40 ft Yr 20	*210000*

**Based on Upper Sands crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		570000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **210000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	2174.8		0.10	0.017	3.59		1.61	
1+	0.01018	2137.0		0.60	0.160	205.15		92.32	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**4311.8**				**208.74**		**93.93**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	1.79		0.50	1.79	
1+	0.50	102.58		0.50	102.58	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**104.37**			**104.37**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.81		0.50	0.81	
1+	0.50	46.16		0.50	46.16	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**46.97**			**46.97**	
					93.933	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	4311.8
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	208.7
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	93.9
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution
C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	47.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	47.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY
(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
47.0	0.70	**32.9**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	32.9
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:
Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 43 ft Yr 1	*500000*

**Based on Upper Sands crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	60000
10 to 13	Flavel Bar	500000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		990000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **500000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	5178.1		0.10	0.017	8.54		3.84	
1+	0.01018	5088.1		0.60	0.160	488.46		219.80	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**10266.2**				**497.00**		**223.65**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	4.27		0.50	4.27	
1+	0.50	244.23		0.50	244.23	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**248.50**			**248.50**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	1.92		0.50	1.92	
1+	0.50	109.90		0.50	109.90	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**111.82**			**111.82**	
					223.650	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	10266.2
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	497.0
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	223.6
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	111.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	111.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
111.8	0.70	**78.3**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	78.3
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Flavel Bar	Post Construction Maintenance, 43 ft Yr 20	*210000*

**Based on Upper Sands crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		680000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **210000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	2174.8		0.10	0.017	3.59		1.61	
1+	0.01018	2137.0		0.60	0.160	205.15		92.32	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**4311.8**				**208.74**		**93.93**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	1.79		0.50	1.79	
1+	0.50	102.58		0.50	102.58	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**104.37**			**104.37**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.81		0.50	0.81	
1+	0.50	46.16		0.50	46.16	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**46.97**			**46.97**	
					93.933	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	4311.8
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	208.7
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	93.9
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution
C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	47.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	47.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
47.0	0.70	**32.9**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	32.9
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

Summary of Projected Entrainment, Adult Equivalent Loss, and Loss to Fishery.
Lower Columbia River
WH Pearson and GD Williams

Variance Estimators (derived from Sept 2002 field sampling)

	CV %		
E	70.70	Z at 0.975	1.95996
AEL	98.30		
LF	98.30		

Construction Dredging to 40 ft - Age 2+

Assumptions:

Projected Location	Upper Sands
Planned dredged volume (cy)	154,087

Results:

Parameter	Projected Value	SE	95% CI
E	3,164	2,237	4,384
AEL	153	151	295
AEL Male	77	75	148
AEL Female	77	75	148
Loss to Fishery	24	24	46

Construction Dredging to 40 ft - Age 3+

Assumptions:

Projected Location	Upper Sands
Planned dredged volume (cy)	154,087

Results:

Parameter	Projected Value	SE	95% CI
E	3,164	2,237	4,384
AEL	69	68	133
AEL Male	34	34	66
AEL Female	34	34	66
Loss to Fishery	24	24	46

Construction Dredging from 40 to 43 ft - Age 2+

Assumptions:

Projected Location	Upper Sands
Planned dredged volume (cy)	858,622

Results:

Parameter	Projected Value	SE	95% CI
E	17,630	12,464	24,429
AEL	853	839	1,644
AEL Male	427	419	822
AEL Female	427	419	822
Loss to Fishery	134	132	259

Construction Dredging from 40 to 43 ft - Age 3+

Assumptions:

Projected Location	Upper Sands
Planned dredged volume (cy)	858,622

Results:

Parameter	Projected Value	SE	95% CI
E	17,630	12,464	24,429
AEL	384	378	740
AEL Male	192	189	370
AEL Female	192	189	370
Loss to Fishery	134	132	259

Annual Maintenance Dredging 40' Year 1 - Age 2+

Assumptions:

Projected Location	Upper Sands
Planned dredged volume (cy)	50,000

Results:

Parameter	Projected Value	SE	95% CI
E	1,027	726	1,423
AEL	50	49	96
AEL Male	25	24	48
AEL Female	25	24	48
Loss to Fishery	8	8	15

Annual Maintenance Dredging 40' Year 1 - Age 3+

Assumptions:

Projected Location	Upper Sands
Planned dredged volume (cy)	50,000

Results:

Parameter	Projected Value	SE	95% CI
E	1,027	726	1,423
AEL	22	22	43
AEL Male	11	11	22
AEL Female	11	11	22
Loss to Fishery	8	8	15

Annual Maintenance Dredging 40' Year 20 - Age 2+

Assumptions:

Projected Location	Upper Sands
Planned dredged volume (cy)	50,000

Results:

Parameter	Projected Value	SE	95% CI
E	1,027	726	1,423
AEL	50	49	96
AEL Male	25	24	48
AEL Female	25	24	48
Loss to Fishery	8	8	15

Annual Maintenance Dredging 40' Year 20 - Age 3+

Assumptions:

Projected Location	Upper Sands
Planned dredged volume (cy)	50,000

Results:

Parameter	Projected Value	SE	95% CI
E	1,027	726	1,423
AEL	22	22	43
AEL Male	11	11	22
AEL Female	11	11	22
Loss to Fishery	8	8	15

Annual Maintenance Dredging 43' Year 1 - Age 2+

Assumptions:

Projected Location	Upper Sands
Planned dredged volume (cy)	100,000

Results:

Parameter	Projected Value	SE	95% CI
E	2,053	1,452	2,845
AEL	99	98	192
AEL Male	50	49	96
AEL Female	50	49	96
Loss to Fishery	16	15	30

Annual Maintenance Dredging 43' Year 1 - Age 3+

Assumptions:

Projected Location	Upper Sands
Planned dredged volume (cy)	100,000

Results:

Parameter	Projected Value	SE	95% CI
E	2,053	1,452	2,845
AEL	45	44	86
AEL Male	22	22	43
AEL Female	22	22	43
Loss to Fishery	16	15	30

Annual Maintenance Dredging 43' Year 20 - Age 2+

Assumptions:

Projected Location	Upper Sands
Planned dredged volume (cy)	100,000

Results:

Parameter	Projected Value	SE	95% CI
E	2,053	1,452	2,845
AEL	99	98	192
AEL Male	50	49	96
AEL Female	50	49	96
Loss to Fishery	16	15	30

Annual Maintenance Dredging 43' Year 20 - Age 3+

Assumptions:

Projected Location	Upper Sands
Planned dredged volume (cy)	100,000

Results:

Parameter	Projected Value	SE	95% CI
E	2,053	1,452	2,845
AEL	45	44	86
AEL Male	22	22	43
AEL Female	22	22	43
Loss to Fishery	16	15	30

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	**Upper Sands**	**Construction Dredging to 40 ft**	***154087***

VOLUME OF DREDGED MATERIALS - to 40 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem	222413
5		353916
6	Upper Desdem	0
7		0
8		8742
9		8742
10	Flavel Bar	49732
11		298900
12		121292
13		72425
14	Upper Sands	54585
15		51945
16		47557
17		0
18	Tongue Point	14775
19		6976
20		13283
Total		1325282

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **154087** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	1595.8		0.10	0.017	2.63		1.18	
1+	0.01018	1568.0		0.60	0.160	150.53		67.74	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**3163.8**				**153.16**		**68.92**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	1.32		0.50	1.32	
1+	0.50	75.26		0.50	75.26	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**76.58**			**76.58**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

	Proportion of Total AEL	
Age Class	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.59		0.50	0.59	
1+	0.50	33.87		0.50	33.87	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**34.46**			**34.46**	
					68.923	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

	Proportion of Total AEL at 3+	
Age Class	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	3163.8
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	153.2
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	68.9
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	34.5
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	34.5
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
34.5	0.70	**24.1**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	24.1
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	**Upper Sands**	**Construction Dredging from 40 to 43 ft**	***858622***

VOLUME OF DREDGED MATERIALS - from 40 to 43 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem	94688
5		196724
6	Upper Desdem	66193
7		1039
8		52398
9		62851
10	Flavel Bar	329296
11		535074
12		239608
13		65743
14	Upper Sands	171432
15		271842
16		306717
17		108631
18	Tongue Point	174113
19		162864
20		127219
Total		2966432

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **858622** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	8892.1		0.10	0.017	14.67		6.60	
1+	0.01018	8737.5		0.60	0.160	838.80		377.46	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**17629.6**				**853.47**		**384.06**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	7.34		0.50	7.34	
1+	0.50	419.40		0.50	419.40	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**426.73**			**426.73**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	3.30		0.50	3.30	
1+	0.50	188.73		0.50	188.73	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**192.03**			**192.03**	
					384.061	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	17629.6
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	853.5
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	384.1
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	192.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	192.0
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
192.0	0.70	**134.4**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	134.4
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Upper Sands	Post Construction Maintenance, 40 ft Yr 1	*50000*

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40,000
10 to 13	Flavel Bar	400000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		760000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **50000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	517.8		0.10	0.017	0.85		0.38	
1+	0.01018	508.8		0.60	0.160	48.85		21.98	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**1026.6**				**49.70**		**22.36**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.43		0.50	0.43	
1+	0.50	24.42		0.50	24.42	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**24.85**			**24.85**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.19		0.50	0.19	
1+	0.50	10.99		0.50	10.99	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**11.18**			**11.18**	
					22.365	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	1026.6
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	49.7
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	22.4
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution
C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	11.2
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	11.2
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
11.2	0.70	**7.8**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	7.8
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	**Upper Sands**	**Post Construction Maintenance, 40 ft Yr 20**	***50000***

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		570000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **50000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	517.8		0.10	0.017	0.85		0.38	
1+	0.01018	508.8		0.60	0.160	48.85		21.98	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**1026.6**				**49.70**		**22.36**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.43		0.50	0.43	
1+	0.50	24.42		0.50	24.42	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**24.85**			**24.85**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.19		0.50	0.19	
1+	0.50	10.99		0.50	10.99	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**11.18**			**11.18**	
					22.365	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	1026.6
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	49.7
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	22.4
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	11.2
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	11.2
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY
(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
11.2	0.70	**7.8**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	7.8
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Upper Sands	Post Construction Maintenance, 43 ft Yr 1	*100000*

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	60000
10 to 13	Flavel Bar	500000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		990000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **100000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	1035.6		0.10	0.017	1.71		0.77	
1+	0.01018	1017.6		0.60	0.160	97.69		43.96	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**2053.2**				**99.40**		**44.73**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.85		0.50	0.85	
1+	0.50	48.85		0.50	48.85	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**49.70**			**49.70**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.38		0.50	0.38	
1+	0.50	21.98		0.50	21.98	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**22.36**			**22.36**	
					44.730	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	2053.2
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	99.4
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	44.7
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution
C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	22.4
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	22.4
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY
(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
22.4	0.70	**15.7**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	15.7
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Upper Sands	Post Construction Maintenance, 43 ft Yr 20	*100000*

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		680000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **100000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	1035.6		0.10	0.017	1.71		0.77	
1+	0.01018	1017.6		0.60	0.160	97.69		43.96	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**2053.2**				**99.40**		**44.73**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.85		0.50	0.85	
1+	0.50	48.85		0.50	48.85	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**49.70**			**49.70**	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

	Proportion of Total AEL	
Age Class	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.38		0.50	0.38	
1+	0.50	21.98		0.50	21.98	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**22.36**			**22.36**	
					44.730	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

	Proportion of Total AEL at 3+	
Age Class	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	2053.2
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	99.4
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	44.7
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution
C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	22.4
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	22.4
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY
(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
22.4	0.70	**15.7**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	15.7
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

Summary of Projected Entrainment, Adult Equivalent Loss, and Loss to Fishery.
Lower Columbia River
WH Pearson and GD Williams

Variance Estimators (derived from Sept 2002 field sampling at Upper Sands)

	CV %		
E	70.70	Z at 0.975	1.95996
AEL	98.30		
LF	98.30		

Construction Dredging to 40 ft - Age 2+

Assumptions:

Projected Location	Tongue Pt
Planned dredged volume (cy)	35,034

Results:

Parameter	Projected Value	SE	95% CI
E	719	509	997
AEL	35	34	67
AEL Male	17	17	34
AEL Female	17	17	34
Loss to Fishery	5	5	11

Construction Dredging to 40 ft - Age 3+

Assumptions:

Projected Location	Tongue Pt
Planned dredged volume (cy)	35,034

Results:

Parameter	Projected Value	SE	95% CI
E	719	509	997
AEL	16	15	30
AEL Male	8	8	15
AEL Female	8	8	15
Loss to Fishery	5	5	11

Construction Dredging from 40 to 43 ft - Age 2+

Assumptions:

Projected Location	Tongue Pt
Planned dredged volume (cy)	464,196

Results:

Parameter	Projected Value	SE	95% CI
E	9,531	6,738	13,207
AEL	461	454	889
AEL Male	231	227	444
AEL Female	231	227	444
Loss to Fishery	73	71	140

Construction Dredging from 40 to 43 ft - Age 3+

Assumptions:

Projected Location	Tongue Pt
Planned dredged volume (cy)	464,196

Results:

Parameter	Projected Value	SE	95% CI
E	9,531	6,738	13,207
AEL	208	204	400
AEL Male	104	102	200
AEL Female	104	102	200
Loss to Fishery	73	71	140

Annual Maintenance Dredging 40' Year 1 - Age 2+

Assumptions:

Projected Location	Tongue Pt
Planned dredged volume (cy)	270,000

Results:

Parameter	Projected Value	SE	95% CI
E	5,544	3,919	7,682
AEL	268	264	517
AEL Male	134	132	259
AEL Female	134	132	259
Loss to Fishery	42	42	81

Annual Maintenance Dredging 40' Year 1 - Age 3+

Assumptions:

Projected Location	Tongue Pt
Planned dredged volume (cy)	270,000

Results:

Parameter	Projected Value	SE	95% CI
E	5,544	3,919	7,682
AEL	121	119	233
AEL Male	60	59	116
AEL Female	60	59	116
Loss to Fishery	42	42	81

Annual Maintenance Dredging 40' Year 20 - Age 2+

Assumptions:

Projected Location	Tongue Pt
Planned dredged volume (cy)	270,000

Results:

Parameter	Projected Value	SE	95% CI
E	5,544	3,919	7,682
AEL	268	264	517
AEL Male	134	132	259
AEL Female	134	132	259
Loss to Fishery	42	42	81

Annual Maintenance Dredging 40' Year 20 - Age 3+

Assumptions:

Projected Location	Tongue Pt
Planned dredged volume (cy)	270,000

Results:

Parameter	Projected Value	SE	95% CI
E	5,544	3,919	7,682
AEL	121	119	233
AEL Male	60	59	116
AEL Female	60	59	116
Loss to Fishery	42	42	81

Annual Maintenance Dredging 43' Year 1 - Age 2+

Assumptions:

Projected Location	Tongue Pt
Planned dredged volume (cy)	330,000

Results:

Parameter	Projected Value	SE	95% CI
E	6,776	4,790	9,389
AEL	328	322	632
AEL Male	164	161	316
AEL Female	164	161	316
Loss to Fishery	52	51	100

Annual Maintenance Dredging 43' Year 1 - Age 3+

Assumptions:

Projected Location	Tongue Pt
Planned dredged volume (cy)	330,000

Results:

Parameter	Projected Value	SE	95% CI
E	6,776	4,790	9,389
AEL	148	145	284
AEL Male	74	73	142
AEL Female	74	73	142
Loss to Fishery	52	51	100

Annual Maintenance Dredging 43' Year 20 - Age 2+

Assumptions:

Projected Location	Tongue Pt
Planned dredged volume (cy)	330,000

Results:

Parameter	Projected Value	SE	95% CI
E	6,776	4,790	9,389
AEL	328	322	632
AEL Male	164	161	316
AEL Female	164	161	316
Loss to Fishery	52	51	100

Annual Maintenance Dredging 43' Year 20 - Age 3+

Assumptions:

Projected Location	Tongue Pt
Planned dredged volume (cy)	330,000

Results:

Parameter	Projected Value	SE	95% CI
E	6,776	4,790	9,389
AEL	148	145	284
AEL Male	74	73	142
AEL Female	74	73	142
Loss to Fishery	52	51	100

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Tongue Pt	Construction Dredging to 40 ft	*35034*

**Based on Upper Sands crab entrainment data

VOLUME OF DREDGED MATERIALS - to 40 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem	222413
5		353916
6	Upper Desdem	0
7		0
8		8742
9		8742
10	Flavel Bar	49732
11		298900
12		121292
13		72425
14	Upper Sands	54585
15		51945
16		47557
17		0
18	Tongue Point	14775
19		6976
20		13283
Total		1325282

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **35034** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	362.8		0.10	0.017	0.60		0.27	
1+	0.01018	356.5		0.60	0.160	34.23		15.40	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**719.3**				**34.82**		**15.67**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.30		0.50	0.30	
1+	0.50	17.11		0.50	17.11	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**17.41**			**17.41**	
						0.00

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	0.13		0.50	0.13	
1+	0.50	7.70		0.50	7.70	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**7.84**			**7.84**	
					15.671	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	719.3
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	34.8
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	15.7
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	7.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	7.8
Var(AEL)	0.0
SE AEL	0.0
Z at 0.975	1.95996
95% C. I.	0.0
CV AEL (%)	0.00

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
7.8	0.70	**5.5**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	5.5
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Tongue Pt	Construction Dredging from 40 to 43 ft	*464196*

**Based on Upper Sands crab entrainment data

VOLUME OF DREDGED MATERIALS - from 40 to 43 ft

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4	Lower Desdem	94688
5		196724
6	Upper Desdem	66193
7		1039
8		52398
9		62851
10	Flavel Bar	329296
11		535074
12		239608
13		65743
14	Upper Sands	171432
15		271842
16		306717
17		108631
18	Tongue Point	174113
19		162864
20		127219
Total		2966432

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **464196** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	4807.3		0.10	0.017	7.93		3.57	
1+	0.01018	4723.7		0.60	0.160	453.48		204.07	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**9531.1**				**461.41**		**207.63**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	3.97		0.50	3.97	
1+	0.50	226.74		0.50	226.74	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**230.70**			**230.70**	

0.00

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

	Proportion of Total AEL	
Age Class	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	1.78		0.50	1.78	
1+	0.50	102.03		0.50	102.03	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**103.82**			**103.82**	

207.634

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

	Proportion of Total AEL at 3+	
Age Class	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	9531.1
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	461.4
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	207.6
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	103.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	103.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
103.8	0.70	**72.7**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	72.7
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Tongue Pt	Post Construction Maintenance, 40 ft Yr 1	*270000*

**Based on Upper Sands crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 1

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40,000
10 to 13	Flavel Bar	400000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		760000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **270000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	2796.2		0.10	0.017	4.61		2.08	
1+	0.01018	2747.6		0.60	0.160	263.77		118.69	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**5543.7**				**268.38**		**120.77**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	2.31		0.50	2.31	
1+	0.50	131.88		0.50	131.88	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**134.19**			**134.19**	
					0.00	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	1.04		0.50	1.04	
1+	0.50	59.35		0.50	59.35	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**60.39**			**60.39**	
					120.771	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	5543.7
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	268.4
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	120.8
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution
C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	60.4
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	60.4
Var(AEL)	0.0
SE AEL	0.0
Z at 0.975	1.95996
95% C. I.	0.0
CV AEL (%)	0.00

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
60.4	0.70	**42.3**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	42.3
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	**Total Volume Dredged (cy)**
Projected	**Tongue Pt**	**Post Construction Maintenance, 40 ft Yr 20**	***270000***

**Based on Upper Sands crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 40' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	50000
18 to 20	Tongue Point	270000
Total		570000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **270000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	**Total**			**Proportion**		
	Male	**Female**	**Sexed**	**Male**	**Female**	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	**R**	**E**	**Var(E)**	**M**	**S to 2+**	**AEL at 2+**	**VAR(AEL 2+)**	**AEL at 3+**	**VAR(AEL 3+)**
YOY	0.01036	2796.2		0.10	0.017	4.61		2.08	
1+	0.01018	2747.6		0.60	0.160	263.77		118.69	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**5543.7**				**268.38**		**120.77**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	**Female**			**Male**		
	Proportion	**AEL**	**VAR(AEL)**	**Proportion**	**AEL**	**VAR(AEL)**
YOY	0.50	2.31		0.50	2.31	
1+	0.50	131.88		0.50	131.88	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**134.19**			**134.19**	
					0.00	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	**% of Total**	
	of Entrained	**of AEL**
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

	Proportion of Total AEL	
Age Class	**Male**	**Female**
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	**Female**			**Male**		
	Proportion	**AEL**	**VAR(AEL)**	**Proportion**	**AEL**	**VAR(AEL)**
YOY	0.50	1.04		0.50	1.04	
1+	0.50	59.35		0.50	59.35	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**60.39**			**60.39**	
					120.771	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	**% of Total**	
	of Entrained	**of AEL at 3+**
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

	Proportion of Total AEL at 3+	
Age Class	**Male**	**Female**
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	5543.7
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	268.4
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	120.8
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution
C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	60.4
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	60.4
Var(AEL)	0.0
SE AEL	0.0
Z at 0.975	1.95996
95% C. I.	0.0
CV AEL (%)	0.00

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
60.4	0.70	**42.3**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	42.3
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Tongue Pt	Post Construction Maintenance, 43 ft Yr 1	*330000*

**Based on Upper Sands crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 1

Volume to be Dredged (cy)

River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	60000
10 to 13	Flavel Bar	500000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		990000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **330000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	3417.6		0.10	0.017	5.64		2.54	
1+	0.01018	3358.1		0.60	0.160	322.38		145.07	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**6775.7**				**328.02**		**147.61**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	2.82		0.50	2.82	
1+	0.50	161.19		0.50	161.19	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**164.01**			**164.01**	
					0.00	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	1.27		0.50	1.27	
1+	0.50	72.54		0.50	72.54	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**73.80**			**73.80**	
					147.609	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

Age Class	Proportion of Total AEL at 3+	
	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	6775.7
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	328.0
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	147.6
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution

C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	73.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	73.8
Var(AEL)	0.0
SE AEL	0.0
Z at 0.975	1.95996
95% C. I.	0.0
CV AEL (%)	0.00

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
73.8	0.70	**51.7**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	51.7
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.

MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB

Field Date	Field Location	Projection	Total Volume Dredged (cy)
Projected	Tongue Pt	Post Construction Maintenance, 43 ft Yr 20	*330000*

**Based on Upper Sands crab entrainment data

VOLUME OF DREDGED MATERIALS - Maintenance 43' Yr 20

Volume to be Dredged (cy)		
River Mile	Location Name	Volume (cy)
4 to 9	Desdemona	40000
10 to 13	Flavel Bar	210000
14 to 17	Upper Sands	100000
18 to 20	Tongue Point	330000
Total		680000

Data from Portland District (10 Sept 2002)

Dredged Yardage (cy) **330000** Amount (cy) dredged during dredging period

Sex Ratios by Age Class

Age Class	Total			Proportion		
	Male	Female	Sexed	Male	Female	
YOY	1	0	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
1+	0	1	1	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
2+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.
3+	0	0	0	0.5*	0.5*	* Sample sizes low; assumed to be 1:1.

Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)

Age Class	R	E	Var(E)	M	S to 2+	AEL at 2+	VAR(AEL 2+)	AEL at 3+	VAR(AEL 3+)
YOY	0.01036	3417.6		0.10	0.017	5.64		2.54	
1+	0.01018	3358.1		0.60	0.160	322.38		145.07	
2+	0.00000	0.0		0.86	0.649	0.00		0.00	
3+	0.00000	0.0		0.86	2.222	0.00		0.00	
All		**6775.7**				**328.02**		**147.61**	

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

AGE 2+ Calculations

Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	2.82		0.50	2.82	
1+	0.50	161.19		0.50	161.19	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**164.01**			**164.01**	
					0.00	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL
YOY	50.44	0.00
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

	Proportion of Total AEL	
Age Class	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

AGE 3+ Calculations

Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class

Age Class	Female			Male		
	Proportion	AEL	VAR(AEL)	Proportion	AEL	VAR(AEL)
YOY	0.50	1.27		0.50	1.27	
1+	0.50	72.54		0.50	72.54	
2+	0.50	0.00		0.50	0.00	
3+	0.50	0.00		0.50	0.00	
All		**73.80**			**73.80**	
					147.609	

R = Crab Entrainment Rate (crabs/cy)
E = Crabs Entrained (number of Crabs)
M = Post-Entrainment Mortality (proportion)
S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% (Armstrong et al. 1987)
AEL = Adult Equivalent Loss
VAR(AEL) =AEL Variance

Age Class Distribution

Age Class	% of Total	
	of Entrained	of AEL at 3+
YOY	50.44	1.72
1+	49.56	98.28
2+	0.00	0.00
3+	0.00	0.00

	Proportion of Total AEL at 3+	
Age Class	Male	Female
YOY	0.0086	0.0086
1+	0.4914	0.4914
2+	0.0000	0.0000
3+	0.0000	0.0000
ALL	0.50	0.50

SUMMARY VARIANCE DATA

Entrainment with Confidence Limits

E	6775.7
Var(E)	
SE E	
Z at 0.975	1.95996
95% C. I.	
CV E (%)	

TOTAL AEL at 2+ with Confidence Limits

AEL at 2+	328.0
Var(AEL2+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

TOTAL AEL at 3+ with Confidence Limits

AEL at 3+	147.6
Var(AEL3+)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

SE = Standard Error
Z = Value of Z from Normal Distribution
C.I. = Confidence Interval
CV = Coefficient of Variation in %

MALE AEL at 3+ with Confidence Limits

AEL at 3+	73.8
Var(AEL)	
SE AEL	
Z at 0.975	1.95996
95% C. I.	
CV AEL (%)	

FEMALE AEL at 3+ with Confidence Limits

AEL at 3+	73.8
Var(AEL)	0.0
SE AEL	0.0
Z at 0.975	1.95996
95% C. I.	0.0
CV AEL (%)	0.00

TOTAL LOSS TO MALE FISHERY

(This total would be distributed over 3-4 years)

Male Age 3+ (number of crab)	Harvest Rate (proportion)	Lost to Fishery (number of crab)
73.8	0.70	**51.7**

Harvest rate of 0.70 is taken from Armstrong et al. (1987).

Loss to Fishery with Confidence Limits

Loss to Fishery	51.7
Var(AEL)	
SE LF	
Z at 0.975	1.95996
95% C. I.	
CV LF (%)	

ADDITIONAL NOTES:

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)
Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).
Sex ratios used were those observed or assumed to be 1:1 where sample size was low.