Part B: California

Find the other parts of this document at http://www.epa.gov/waterscience/316b/

Chapter B1: Background

Introduction

This chapter presents an overview of the potential Phase III existing facilities in the California study region and summarizes their key cooling water and compliance characteristics. For further discussion of

the technical and compliance characteristics of potential Phase III existing facilities, refer to the *Economic Analysis for the Final Section 316(b) Rule for Phase III Facilities* and the *Technical Development Document for the Final Section 316(b) Rule for Phase III Facilities* (U.S. EPA, 2006a,c).
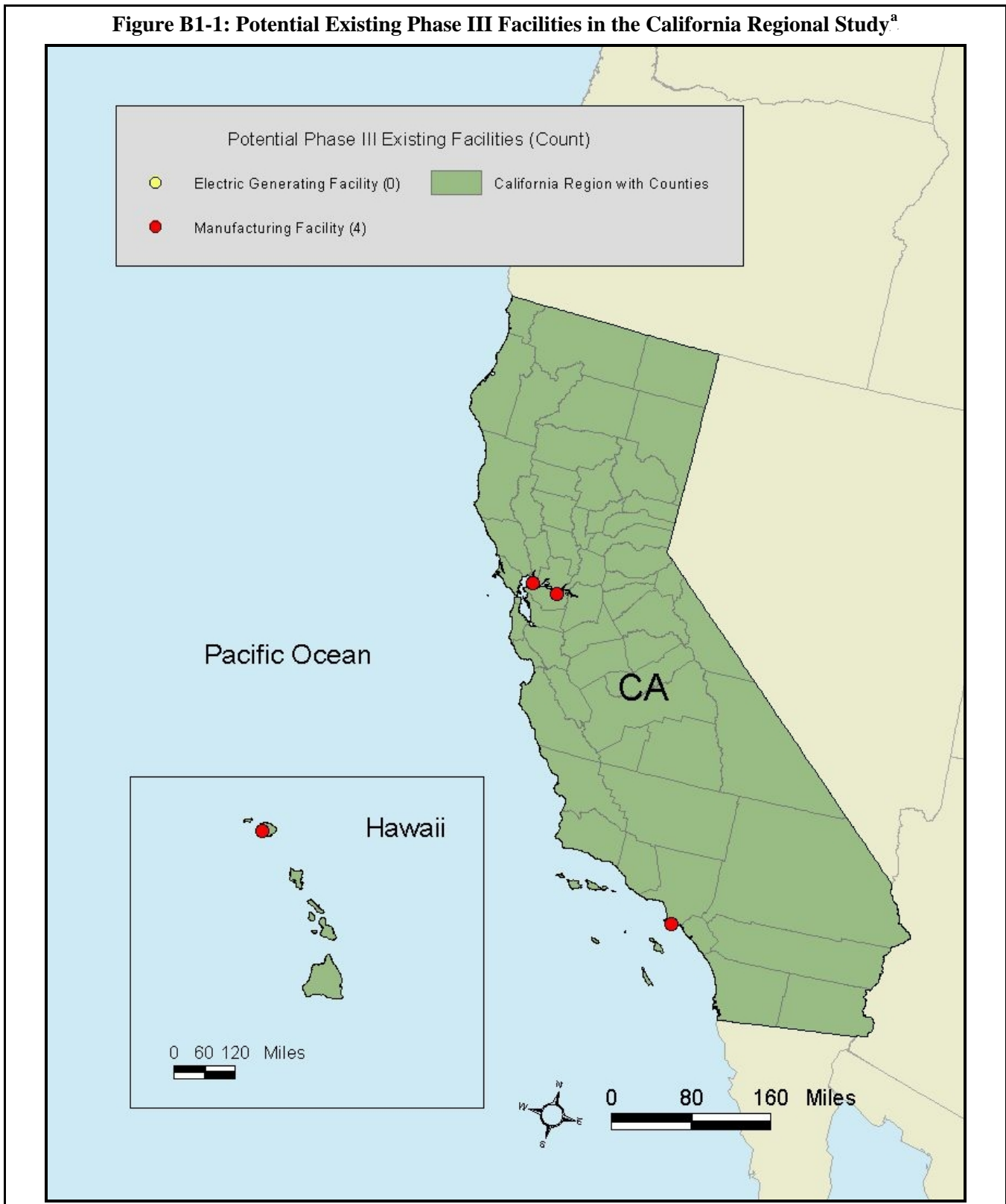
B1-1   Facility Characteristics

The California Regional Study includes four sample facilities that are potentially subject to the national standards for Phase III existing facilities. Figure B1-1 presents a map of these facilities. All four facilities are manufacturing facilities. Industry-wide, these four sample facilities represent nine manufacturing facilities.[1]

---

[1] EPA applied sample weights to the survey respondents to account for non-sampled facilities and facilities that did not respond to the survey. For more information on EPA's 2000 Section 316(b) Industry Survey, please refer to the Information Collection Request (U.S. EPA, 2000b).

Figure B1-1: Potential Existing Phase III Facilities in the California Regional Study[a]

[a] The map includes locations of sample facilities only.

Source: U.S. EPA analysis for this report.

Table B1-1 summarizes key technical and compliance characteristics for all potentially regulated Phase III existing facilities in the California study region for the regulatory analysis options considered by EPA for this rule (the "50 MGD for All Waterbodies" option, the "200 MGD for All Waterbodies" option, and the "100 MGD for Certain Waterbodies" option). Facilities with a design intake flow below the three applicability thresholds would be subject to permitting based on best professional judgment and are excluded from EPA's analyses.[2] Therefore, a different number of facilities is affected under each option.

Table B1-1 shows that nine Phase III existing facilities in the California study region would potentially be subject to the national requirements. Under the "50 MGD for All Waterbodies" option, the most inclusive of the regulatory analysis options, only one facility would be subject to the national requirements for Phase III existing facilities. Under the less inclusive "200 MGD for All Waterbodies" option and the "100 MGD for Certain Waterbodies" option (which includes all facilities in the California study region), no facilities would be subject to the national requirements. One facility in the California study region has a recirculating system in the baseline. Data on design intake flow for the California study facilities have been withheld due to data confidentiality reasons.

Table B1-1: Technical and Compliance Characteristics of Phase III Existing Facilities (sample-weighted)

	All Potentially Regulated Facilities	**Regulatory Analysis Options**		
		50 MGD All	**200 MGD All**	**100 MGD CWB**
Total Number of Facilities (sample-weighted)	**9**	**1**	**-**	**-**
Number of Facilities with Recirculating System in Baseline	**1**	**-**	**-**	**-**
Design Intake Flow (MGD)	**w**[a]	**w**[a]	**-**	**-**
Number of Facilities by Compliance Response				
New larger intake structure with fine mesh and fish H&R	1	1	-	-
Passive fine mesh screens	-	-	-	-
None	8	-	-	-
Compliance Cost, Discounted at 3%[b]	$1.79	$0.40	$0.00	$0.00
Compliance Cost, Discounted at 7%[b]	$1.69	$0.42	$0.00	$0.00

[a] Data withheld because of confidentiality reasons.
[b] Annualized pre-tax compliance cost (2004$, millions).

Sources: U.S. EPA, 2000b; U.S. EPA analysis for this report.

---

[2] Also excluded are facilities that are estimated to be baseline closures. For additional information on EPA's baseline closure analyses, please refer to the *Economic Analysis for the Final Section 316(b) Rule for Phase III Facilities* (U.S. EPA, 2006a).

Appendix B1: Life History Parameter Values Used to Evaluate I&E in the California Region

The tables in this appendix present the life history parameter values used by EPA to calculate age-1 equivalents and fishery yields from impingement and entrainment (I&E) data for the California region. Because of differences in the number of life stages represented in the loss data, there are cases where more than one life stage sequence was needed for a given species or species group. Alternative parameter sets were developed for this purpose and are indicated with a number following the species or species group name (i.e., Anchovies 1, Anchovies 2).

Table B1-1: American Shad Life History Parameters				
Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.496	0	0	0.000000716
Larvae	3.01	0	0	0.000000728
Juvenile	7.40	0	0	0.000746
Age 1+	0.300	0	0	0.309
Age 2+	0.300	0	0	1.17
Age 3+	0.300	0	0	2.32
Age 4+	0.540	0.21	0.45	3.51
Age 5+	1.02	0.21	0.90	4.56
Age 6+	1.50	0.21	1.0	5.47
Age 7+	1.50	0.21	1.0	6.20
Age 8+	1.50	0.21	1.0	6.77

Sources: USFWS, 1978; Able and Fahay, 1998; and PSE&G, 1999.

Table B1-2: Anchovies Life History Parameters 1[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.669	0	0	0.00000138
Larvae	7.99	0	0	0.00000151
Juvenile	2.12	0	0	0.0132
Age 1+	0.700	0.03	0.50	0.0408
Age 2+	0.700	0.03	1.00	0.529
Age 3+	0.700	0.03	1.00	0.0609
Age 4+	0.700	0.03	1.00	0.0684
Age 5+	0.700	0.03	1.00	0.0763
Age 6+	0.700	0.03	1.00	0.0789

[a] Includes northern anchovy, deepbody anchovy, slough anchovy, and other anchovies not identified to species.

Sources: Ecological Analysts, 1981b; Wang, 1986; PFMC, 1998; Virginia Tech, 1998; Tenera Environmental Services, 2000a; and Froese and Pauly, 2002.

Table B1-3: Anchovies Life History Parameters 2[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.669	0	0	0.00000138
Larvae 3 mm	0.172	0	0	0.00000151
Larvae 4 mm	0.172	0	0	0.00000173
Larvae 5 mm	0.172	0	0	0.00000334
Larvae 6 mm	0.172	0	0	0.00000572
Larvae 7 mm	0.172	0	0	0.00000901
Larvae 8 mm	0.172	0	0	0.0000134
Larvae 9 mm	0.172	0	0	0.0000189
Larvae 10 mm	0.172	0	0	0.0000258
Larvae 11 mm	0.172	0	0	0.0000342
Larvae 12 mm	0.172	0	0	0.0000442
Larvae 13 mm	0.172	0	0	0.0000559
Larvae 14 mm	0.172	0	0	0.0000696
Larvae 15 mm	0.172	0	0	0.0000853
Larvae 16 mm	0.172	0	0	0.000103
Larvae 17 mm	0.172	0	0	0.000123
Larvae 18 mm	0.172	0	0	0.000146
Larvae 19 mm	0.172	0	0	0.000171
Larvae 20 mm	0.172	0	0	0.000199
Larvae 21 mm	0.172	0	0	0.000230

Table B1-3: Anchovies Life History Parameters 2[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Larvae 22 mm	0.172	0	0	0.000264
Larvae 23 mm	0.172	0	0	0.000301
Larvae 24 mm	0.172	0	0	0.000341
Larvae 25 mm	0.172	0	0	0.000385
Larvae 26 mm	0.172	0	0	0.000432
Larvae 27 mm	0.172	0	0	0.000483
Larvae 28 mm	0.172	0	0	0.000538
Larvae 29 mm	0.172	0	0	0.000597
Larvae 30 mm	0.172	0	0	0.000659
Larvae 31 mm	0.172	0	0	0.000726
Larvae 32 mm	0.172	0	0	0.000798
Larvae 33 mm	0.172	0	0	0.000873
Larvae 34 mm	0.172	0	0	0.000954
Larvae 35 mm	0.172	0	0	0.00104
Larvae 36 mm	0.172	0	0	0.00113
Larvae 37 mm	0.172	0	0	0.00122
Larvae 38 mm	0.172	0	0	0.00132
Larvae 39 mm	0.172	0	0	0.00143
Larvae 40 mm	0.172	0	0	0.00154
Larvae 41 mm	1.249	0	0	0.00166
Larvae 59 mm	0.208	0	0	0.00485
Juvenile	2.12	0	0	0.0132
Age 1+	0.700	0.03	0.50	0.0408
Age 2+	0.700	0.03	1.0	0.0529
Age 3+	0.700	0.03	1.0	0.0609
Age 4+	0.700	0.03	1.0	0.0684
Age 5+	0.700	0.03	1.0	0.0763
Age 6+	0.700	0.03	1.0	0.0789

[a] Includes northern anchovy.

Sources: Ecological Analysts, 1980b, 1981b; Wang, 1986; PFMC, 1998; Tenera Environmental Services, 2000a; and Froese and Pauly, 2002.

Table B1-4: Anchovies Life History Parameters 3[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.669	0	0	0.00000138
Larvae 6 mm	0.104	0	0	0.00000572
Larvae 7 mm	0.207	0	0	0.00000901
Larvae 9 mm	0.104	0	0	0.0000189
Larvae 10 mm	0.104	0	0	0.0000258
Larvae 11 mm	0.104	0	0	0.0000342
Larvae 12 mm	0.104	0	0	0.0000442
Larvae 13 mm	0.104	0	0	0.0000559
Larvae 14 mm	0.104	0	0	0.0000696
Larvae 15 mm	0.207	0	0	0.0000853
Larvae 17 mm	0.207	0	0	0.000123
Larvae 19 mm	0.104	0	0	0.000171
Larvae 20 mm	0.104	0	0	0.000199
Larvae 21 mm	0.207	0	0	0.000230
Larvae 23 mm	0.311	0	0	0.000301
Larvae 26 mm	0.207	0	0	0.000432
Larvae 28 mm	0.104	0	0	0.000538
Larvae 29 mm	0.104	0	0	0.000597
Larvae 30 mm	0.104	0	0	0.000659
Larvae 31 mm	0.104	0	0	0.000726
Larvae 32 mm	0.622	0	0	0.000798
Larvae 38 mm	1.97	0	0	0.00132
Larvae 57 mm	0.519	0	0	0.00438
Larvae 62 mm	0.207	0	0	0.00561
Larvae 64 mm	0.104	0	0	0.00616
Larvae 65 mm	0.104	0	0	0.00645
Larvae 66 mm	0.104	0	0	0.00675
Larvae 67 mm	0.311	0	0	0.00706
Larvae 70 mm	0.519	0	0	0.00803
Larvae 75 mm	0.622	0	0	0.00984
Larvae 81 mm	0.104	0	0	0.0123
Larvae 82 mm	0.104	0	0	0.0128
Juvenile	2.12	0	0	0.0132
Age 1+	0.700	0.03	0.50	0.0408
Age 2+	0.700	0.03	1.0	0.0529
Age 3+	0.700	0.03	1.0	0.0609
Age 4+	0.700	0.03	1.0	0.0684
Age 5+	0.700	0.03	1.0	0.0763
Age 6+	0.700	0.03	1.0	0.0789

[a] Includes northern anchovy.

Sources: Ecological Analysts, 1980b, 1981b, 1982a; Wang, 1986; PFMC, 1998; Tenera Environmental Services, 2000a; and Froese and Pauly, 2002.

Table B1-5: Blennies Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.105	0	0	0.00000176
Larvae	3.98	0	0	0.00000193
Juvenile	0.916	0	0	0.000501
Age 1+	1.34	0	0	0.00314
Age 2+	1.34	0	0	0.00745
Age 3+	1.34	0	0	0.0101
Age 4+	1.34	0	0	0.0113
Age 5+	1.34	0	0	0.0119
Age 6+	1.34	0	0	0.0122
Age 7+	1.34	0	0	0.0123
Age 8+	1.34	0	0	0.0123
Age 9+	1.34	0	0	0.0124

[a] Includes bay blenny, combtooth blenny, mussel blenny, orangethroat pikeblenny, rockpool blenny, tube blenny, and other blennies not identified to species.

Sources: Froese and Binohlan, 2000; Tenera Environmental Services, 2000b; and Froese and Pauly, 2003.

Table B1-6: Cabezon Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000430
Larvae	3.79	0	0	0.000605
Juvenile	0.916	0	0	0.00825
Age 1+	0.288	0	0	0.169
Age 2+	0.144	0.14	0.50	1.06
Age 3+	0.144	0.14	1.0	3.26
Age 4+	0.144	0.14	1.0	4.72
Age 5+	0.144	0.14	1.0	5.30
Age 6+	0.144	0.14	1.0	6.13
Age 7+	0.144	0.14	1.0	6.78
Age 8+	0.144	0.14	1.0	7.37
Age 9+	0.144	0.14	1.0	8.76
Age 10+	0.144	0.14	1.0	9.23
Age 11+	0.144	0.14	1.0	10.5
Age 12+	0.144	0.14	1.0	12.0
Age 13+	0.144	0.14	1.0	13.7

Sources: O'Connell, 1953; Tenera Environmental Services, 1988; Cailliet, 2000; Leet et al., 2001; and personal communication with Y. DeReynier (NMFS, November 19, 2002).

Table B1-7: California Halibut Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.223	0	0	0.000000548
Larvae	2.86	0	0	0.00000444
Juvenile	0.555	0	0	0.0170
Age 1+	0.160	0	0	0.130
Age 2+	0.160	0	0	0.739
Age 3+	0.160	0	0	1.94
Age 4+	0.160	0	0	3.87
Age 5+	0.160	0	0	6.21
Age 6+	0.160	0.16	1.0	8.89
Age 7+	0.160	0.16	1.0	12.2
Age 8+	0.160	0.16	1.0	15.3
Age 9+	0.160	0.16	1.0	18.9
Age 10+	0.160	0.16	1.0	21.3
Age 11+	0.160	0.16	1.0	23.8
Age 12+	0.160	0.16	1.0	26.6

Table B1-7: California Halibut Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Age 13+	0.160	0.16	1.0	28.6
Age 14+	0.160	0.16	1.0	30.7
Age 15+	0.160	0.16	1.0	33.0
Age 16+	0.160	0.16	1.0	35.3
Age 17+	0.160	0.16	1.0	37.7
Age 18+	0.160	0.16	1.0	40.2
Age 19+	0.160	0.16	1.0	42.9
Age 20+	0.160	0.16	1.0	45.7
Age 21+	0.160	0.16	1.0	48.5
Age 22+	0.160	0.16	1.0	51.5
Age 23+	0.160	0.16	1.0	54.7
Age 24+	0.160	0.16	1.0	57.9
Age 25+	0.160	0.16	1.0	61.3
Age 26+	0.160	0.16	1.0	64.8
Age 27+	0.160	0.16	1.0	68.4
Age 28+	0.160	0.16	1.0	72.2
Age 29+	0.160	0.16	1.0	76.1
Age 30+	0.160	0.16	1.0	80.1

Sources: Kucas and Hassler, 1986; Cailliet, 2000; Tenera Environmental Services, 2000a; Leet et al., 2001; Froese and Pauly, 2002; and personal communication with Y. DeReynier (NMFS, November 19, 2002).

Table B1-8: California Scorpionfish Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000200
Larvae	1.00	0	0	0.00000219
Juvenile	1.00	0	0	0.000712
Age 1+	0.130	0	0	0.281
Age 2+	0.130	0.13	0.50	0.445
Age 3+	0.130	0.13	1.0	0.662
Age 4+	0.130	0.13	1.0	0.940
Age 5+	0.130	0.13	1.0	1.42
Age 6+	0.130	0.13	1.0	1.80
Age 7+	0.130	0.13	1.0	2.19
Age 8+	0.130	0.13	1.0	2.58
Age 9+	0.130	0.13	1.0	2.95

Table B1-8: California Scorpionfish Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Age 10+	0.130	0.13	1.0	3.31
Age 11+	0.130	0.13	1.0	3.65
Age 12+	0.130	0.13	1.0	3.96
Age 13+	0.130	0.13	1.0	4.25
Age 14+	0.130	0.13	1.0	4.51
Age 15+	0.130	0.13	1.0	4.75
Age 16+	0.130	0.13	1.0	4.97
Age 17+	0.130	0.13	1.0	5.17
Age 18+	0.130	0.13	1.0	5.35
Age 19+	0.130	0.13	1.0	5.51
Age 20+	0.130	0.13	1.0	5.65
Age 21+	0.130	0.13	1.0	6.18

[a] Includes California scorpionfish and spotted scorpionfish.

Sources: Cailliet, 2000; Froese and Binohlan, 2000; and Leet et al., 2001.

Table B1-9: Chinook Salmon Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.000317
Larvae	5.04	0	0	0.000349
Juvenile	0.916	0	0	0.199
Age 1+	0.160	0	0	0.397
Age 2+	0.160	0	0	4.50
Age 3+	0.160	0	0	12.2
Age 4+	0.160	0	0	23.8
Age 5+	0.160	0	0	33.8

Sources: Beauchamp et al., 1983; Allen and Hassler, 1986; Wang, 1986; and Froese and Pauly, 2001.

Table B1-10: Commercial Sea Basses/Recreational Sea Basses Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.288	0	0	0.00000101
Larvae	1.00	0	0	0.0000216
Juvenile	0.190	0	0	0.000138
Age 1+	0.190	0	0	0.0313

Table B1-10: Commercial Sea Basses/Recreational Sea Basses Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Age 2+	0.190	0	0	0.0625
Age 3+	0.190	0	0	0.125
Age 4+	0.190	0	0	0.312
Age 5+	0.190	0.26	0.50	0.531
Age 6+	0.190	0.26	1.0	0.813
Age 7+	0.287	0.26	1.0	1.13
Age 8+	0.287	0.26	1.0	1.50
Age 9+	0.287	0.26	1.0	1.88
Age 10+	0.287	0.26	1.0	2.19
Age 11+	0.287	0.26	1.0	2.30
Age 12+	0.287	0.26	1.0	2.41
Age 13+	0.287	0.26	1.0	2.67
Age 14+	0.287	0.26	1.0	2.93
Age 15+	0.287	0.26	1.0	3.19
Age 16+	0.287	0.26	1.0	3.44
Age 17+	0.287	0.26	1.0	3.69
Age 18+	0.287	0.26	1.0	3.94
Age 19+	0.287	0.26	1.0	4.19
Age 20+	0.287	0.26	1.0	4.42
Age 21+	0.287	0.26	1.0	4.66
Age 22+	0.287	0.26	1.0	4.88
Age 23+	0.287	0.26	1.0	5.10
Age 24+	0.287	0.26	1.0	5.31
Age 25+	0.287	0.26	1.0	5.51
Age 26+	0.287	0.26	1.0	5.71
Age 27+	0.287	0.26	1.0	5.90
Age 28+	0.287	0.26	1.0	6.08
Age 29+	0.287	0.26	1.0	6.25
Age 30+	0.287	0.26	1.0	6.42
Age 31+	0.287	0.26	1.0	6.58
Age 32+	0.287	0.26	1.0	6.73
Age 33+	0.287	0.26	1.0	6.88

[a] Commercial sea bass species includes giant sea bass; recreational sea bass species includes barred sand bass, paralabrax species, broomtail grouper, kelp bass, spotted bass, and spotted sand bass.

Sources: Cailliet, 2000; Froese and Binohlan, 2000; Leet et al., 2001; California Department of Fish and Game, 2002; and Froese and Pauly, 2002.

Table B1-11: Commercial Shrimp Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.693	0	0	0.000000249
Larvae	3.00	0	0	0.000000736
Juvenile	2.16	0.14	1.0	0.0000865
Age 1+	2.16	0.14	1.0	0.000452
Age 2+	2.16	0.14	1.0	0.00236

[a] Includes Alaskan bay shrimp, bay shrimp, black tailed bay shrimp, blackspotted shrimp, Franscican bay shrimp, ghost shrimp, smooth bay shrimp, spot shrimp, and spotted bay shrimp.

Sources: Bielsa et al., 1983; Siegfried, 1989; Virginia Tech, 1998; Leet et al., 2001; and Tenera Environmental Services, 2001.

Table B1-12: Delta Smelt Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.90	0	0	0.00000115
Larvae	4.89	0	0	0.00000120
Juvenile	0.916	0	0	0.0000462
Age 1+	1.28	0	0	0.00418

Sources: Wang, 1986; Buckley, 1989; Moyle et al., 1992; Froese and Pauly, 2001, 2003; and Brown and Kimmerer, 2002.

Table B1-13: Drums/Croakers Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.500	0	0	0.000000722
Larvae	4.61	0	0	0.00000464
Juvenile	3.38	0	0	0.000212
Age 1+	0.420	0	0	0.120
Age 2+	0.420	0	0	0.156
Age 3+	0.210	0.21	0.50	0.195
Age 4+	0.210	0.21	1.0	0.239
Age 5+	0.210	0.21	1.0	0.287
Age 6+	0.210	0.21	1.0	0.340
Age 7+	0.210	0.21	1.0	0.398
Age 8+	0.10	0.21	1.0	0.458
Age 9+	0.210	0.21	1.0	0.519
Age 10+	0.210	0.21	1.0	0.584
Age 11+	0.210	0.21	1.0	0.648
Age 12+	0.210	0.21	1.0	0.723

[a] Includes black croaker, California corbina, queenfish, spotfin croaker, white croaker, white seabass, yellowfin croaker, and other drums or croakers not identified to species.

Sources: Isaacson, 1964; Tenera Environmental Services, 1988, 2000b, 2001; and Cailliet, 2000.

Table B1-14: Dungeness Crab Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.223	0	0	0.000000153
Zoea/larvae[a]	1.20	0	0	0.000134
Megalopae	1.20	0	0	0.590
Age 1+	0.500	0	0	1.10
Age 2+	0.500	0.50	0.50	1.37
Age 3+	0.500	0.50	1.0	2.48
Age 4+	1.71	0.50	1.0	4.04
Age 5+	1.71	0.50	1.0	4.41
Age 6+	1.71	0.50	1.0	4.79
Age 7+	1.71	0.50	1.0	5.20
Age 8+	1.71	0.50	1.0	5.63
Age 9+	1.71	0.50	1.0	6.08
Age 10+	1.71	0.50	1.0	6.56

[a] Life stages reported as larvae and zoea were assigned the same life history parameters.

Sources: Carroll, 1982; Wild and Tasto, 1983; Pauley et al., 1989; Virginia Tech, 1998; Tenera Environmental Services, 2000a; University of Washington, 2000; and Leet et al., 2001.

Table B1-15: Flounders Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.223	0	0	0.000000303
Larvae	6.28	0	0	0.00121
Juvenile	1.14	0	0	0.00882
Age 1+	0.363	0.24	0.50	0.0672
Age 2+	0.649	0.43	1.0	0.226
Age 3+	0.752	0.50	1.0	0.553
Age 4+	0.752	0.50	1.0	1.13

[a] Includes bigmouth sole, CO turbot, California halibut, curlfin sole, diamond turbot, Dover sole, English sole, fantail sole, hornyhead turbot, longfin sanddab, Pacific sanddab, petrale sole, rock sole, sand sole, slender sole, speckled sanddab, spotted turbot, starry flounder, and other flounders not identified to species.

Sources: Cailliet, 2000; ENSR and Marine Research, 2000; Tenera Environmental Services, 2000a, 2001; Leet et al., 2001; and personal communication with Y. DeReynier (NMFS, November 19, 2002).

Table B1-16: Forage Shrimp Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.693	0	0	0.000000249
Larvae	3.00	0	0	0.000000736
Juvenile	2.30	0	0	0.0000865
Age 1+	2.30	0	0	0.000131
Age 2+	2.30	0	0	0.00236

[a] Includes anemone shrimp, blue mud shrimp, broken back shrimp, brown shrimp, California green shrimp, dock shrimp, mysids, opossum shrimp, oriental shrimp, pistol shrimp, sidestriped shrimp, skeleton shrimp, stout bodied shrimp, striped shrimp, tidepool shrimp, twistclaw pistol shrimp, and other shrimp not identified to species.

Sources: Siegfried, 1989; Virginia Tech, 1998; and Tenera Environmental Services, 2001.

Table B1-17: Gobies Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0	0	0	0.0000115
Larvae	5.77	0	0	0.0000190
Juvenile	0.871	0	0	0.000169
Age 1+	1.10	0	0	0.00194
Age 2+	1.10	0	0	0.00414
Age 3+	1.10	0	0	0.00763
Age 4+	1.10	0	0	0.0310
Age 5+	1.10	0	0	0.0810

[a] Includes arrow goby, bay goby, blackeye goby, blind goby, chameleon goby, cheekspot goby, longjaw mudsucker shadow goby, yellowfin goby, and other gobies not identified to species.

Sources: Wang, 1986; Froese and Pauly, 2000, 2002; Tenera Environmental Services, 2000a; and NMFS, 2003a.

Table B1-18: Herrings Life History Parameters 1[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000164
Larvae	4.61	0	0	0.00000180
Juvenile	0.693	0	0	0.00161
Age 1+	0.473	0	0	0.0408
Age 2+	0.474	0	0	0.128
Age 3+	0.474	0	0	0.167
Age 4+	0.474	0	0	0.211
Age 5+	0.474	0	0	0.258
Age 6+	0.474	0	0	0.288
Age 7+	0.474	0	0	0.330
Age 8+	0.474	0	0	0.345
Age 9+	0.474	0	0	0.353
Age 10+	0.474	0	0	0.364
Age 11+	0.474	0	0	0.375

[a] Includes middle thread herring, Pacific herring, Pacific sardine, round herring, threadfin shad, and other herrings not identified to species.

Sources: Ecological Analysts, 1981b, 1982a; Lassuy, 1989; Tenera Environmental Services, 2001; Froese and Pauly, 2002; and NMFS, 2003a.

Table B1-19: Herrings Life History Parameters 2[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000164
Larvae 6 mm	0.140	0	0	0.00000182
Larvae 7 mm	0.121	0	0	0.00000299
Larvae 8 mm	0.107	0	0	0.00000461
Larvae 9 mm	0.096	0	0	0.00000675
Larvae 10 mm	0.087	0	0	0.00000948
Larvae 11 mm	0.079	0	0	0.0000129
Larvae 12 mm	0.221	0	0	0.0000171
Larvae 13 mm	0.221	0	0	0.0000221
Larvae 14 mm	0.221	0	0	0.0000281
Larvae 15 mm	0.221	0	0	0.0000352
Larvae 16 mm	0.221	0	0	0.0000433
Larvae 17 mm	0.221	0	0	0.0000527
Larvae 18 mm	0.221	0	0	0.0000634
Larvae 19 mm	0.221	0	0	0.0000755

Table B1-19: Herrings Life History Parameters 2[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Larvae 20 mm	0.221	0	0	0.0000891
Larvae 22 mm	0.221	0	0	0.000121
Larvae 23 mm	0.221	0	0	0.000140
Larvae 24 mm	0.221	0	0	0.000161
Larvae 25 mm	0.221	0	0	0.000183
Larvae 26 mm	0.221	0	0	0.000208
Larvae 27 mm	0.221	0	0	0.000235
Larvae 28 mm	0.221	0	0	0.000264
Larvae 29 mm	0.221	0	0	0.000296
Larvae 30 mm	0.221	0	0	0.000330
Juvenile	0.693	0	0	0.00161
Age 1+	0.473	0	0	0.0408
Age 2+	0.474	0	0	0.128
Age 3+	0.474	0	0	0.167
Age 4+	0.474	0	0	0.211
Age 5+	0.474	0	0	0.258
Age 6+	0.474	0	0	0.288
Age 7+	0.474	0	0	0.330
Age 8+	0.474	0	0	0.345
Age 9+	0.474	0	0	0.353
Age 10+	0.474	0	0	0.364
Age 11+	0.474	0	0	0.375

[a] Includes Pacific herring and other herrings not identified to species.

Sources: Ecological Analysts, 1981b; Wang, 1986; Lassuy, 1989; Tenera Environmental Services, 2001; Froese and Pauly, 2002; and NMFS, 2003a.

Table B1-20: Herrings Life History Parameters 3[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000164
Larvae 6 mm	0.107	0	0	0.00000182
Larvae 7 mm	0.107	0	0	0.00000299
Larvae 8 mm	0.107	0	0	0.00000461
Larvae 9 mm	0.107	0	0	0.00000675
Larvae 10 mm	0.107	0	0	0.00000948
Larvae 11 mm	0.107	0	0	0.0000129
Larvae 12 mm	0.107	0	0	0.0000171

Table B1-20: Herrings Life History Parameters 3[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Larvae 13 mm	0.214	0	0	0.0000221
Larvae 15 mm	0.107	0	0	0.0000352
Larvae 16 mm	0.107	0	0	0.0000433
Larvae 17 mm	0.107	0	0	0.0000527
Larvae 18 mm	0.107	0	0	0.0000634
Larvae 19 mm	0.107	0	0	0.0000755
Larvae 20 mm	0.107	0	0	0.0000891
Larvae 21 mm	0.107	0	0	0.000104
Larvae 22 mm	0.107	0	0	0.000121
Larvae 23 mm	0.107	0	0	0.000140
Larvae 24 mm	0.107	0	0	0.000161
Larvae 25 mm	2.36	0	0	0.000183
Larvae 47 mm	0.107	0	0	0.00141
Larvae 48 mm	0.107	0	0	0.00151
Juvenile	0.693	0	0	0.00161
Age 1+	0.473	0	0	0.0408
Age 2+	0.474	0	0	0.128
Age 3+	0.474	0	0	0.167
Age 4+	0.474	0	0	0.211
Age 5+	0.474	0	0	0.258
Age 6+	0.474	0	0	0.288
Age 7+	0.474	0	0	0.330
Age 8+	0.474	0	0	0.345
Age 9+	0.474	0	0	0.353
Age 10+	0.474	0	0	0.364
Age 11+	0.474	0	0	0.375

[a] Includes Pacific herring.

Sources: Ecological Analysts, 1981b, 1982a; Wang, 1986; Lassuy, 1989; Tenera Environmental Services, 2001; Froese and Pauly, 2002; and NMFS, 2003a.

Table B1-21: Longfin Smelt Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.90	0	0	0.00000115
Larvae	6.38	0	0	0.00000186
Juvenile	0.916	0	0	0.000213
Age 1+	0.670	0	1.0	0.00355
Age 2+	0.670	0	1.0	0.0157
Age 3+	0.670	0	1.0	0.0434

Sources: Wang, 1986; Buckley, 1989; USFWS, 1996a; and Froese and Pauly, 2001.

Table B1-22: Northern Anchovy Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.669	0	0	0.00000138
Larvae 5 mm	1.71	0	0	0.00000334
Larvae 6 mm	0.196	0	0	0.00000572
Larvae 7 mm	0.196	0	0	0.00000901
Larvae 8 mm	0.196	0	0	0.0000134
Larvae 9 mm	0.196	0	0	0.0000189
Larvae 10 mm	0.196	0	0	0.0000258
Larvae 11 mm	0.196	0	0	0.0000342
Larvae 12 mm	0.196	0	0	0.0000442
Larvae 13 mm	0.196	0	0	0.0000559
Larvae 14 mm	0.196	0	0	0.0000696
Larvae 15 mm	0.196	0	0	0.0000853
Larvae 16 mm	0.196	0	0	0.000103
Larvae 17 mm	0.196	0	0	0.000123
Larvae 18 mm	0.196	0	0	0.000146
Larvae 19 mm	0.196	0	0	0.000171
Larvae 20 mm	0.196	0	0	0.000199
Larvae 21 mm	0.196	0	0	0.000230
Larvae 22 mm	0.196	0	0	0.000264
Larvae 23 mm	0.196	0	0	0.000301
Larvae 24 mm	0.196	0	0	0.000341
Larvae 25 mm	0.196	0	0	0.000385
Larvae 26 mm	0.196	0	0	0.000432
Larvae 27 mm	0.196	0	0	0.000483
Larvae 28 mm	0.196	0	0	0.000538
Larvae 29 mm	0.196	0	0	0.000597

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Larvae 30 mm	0.196	0	0	0.000659
Larvae 31 mm	0.196	0	0	0.000726
Larvae 32 mm	0.196	0	0	0.000798
Larvae 33 mm	0.196	0	0	0.000873
Larvae 34 mm	0.196	0	0	0.000954
Larvae 35 mm	0.196	0	0	0.00104
Larvae 36 mm	0.196	0	0	0.00113
Larvae 37 mm	0.196	0	0	0.00122
Juvenile	2.12	0	0	0.0132
Age 1+	0.700	0.03	0.50	0.0408
Age 2+	0.700	0.03	1.0	0.0529
Age 3+	0.700	0.03	1.0	0.0609
Age 4+	0.700	0.03	1.0	0.0684
Age 5+	0.700	0.03	1.0	0.0763
Age 6+	0.700	0.03	1.0	0.0789

Table B1-22: Northern Anchovy Life History Parameters

Sources: Ecological Analysts, 1980b; Wang, 1986; Virginia Tech, 1998; Tenera Environmental Services, 2000a; and Froese and Pauly, 2002.

Table B1-23: Other Commercial Crabs Life History Parameters 1[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0	0	0	0.000000153
Zoea 1	1.58	0	0	0.00000195
Zoea 2	0.948	0	0	0.00000726
Zoea 3	0.948	0	0	0.0000177
Zoea 4	0.948	0	0	0.0000347
Zoea 5	1.26	0	0	0.0000598
Megalopae	2.31	0	0	0.000134
Age 1+	2.43	0	0	0.289
Age 2+	2.43	0	0	0.654
Age 3+	2.43	0	0	1.26
Age 4+	1.82	0.61	0.50	1.97
Age 5+	1.82	0.61	1.0	2.55
Age 6+	1.82	0.61	1.0	3.00

[a] Includes Anthony's rock crab, black clawed crab, brown rock crab, common rock crab, cryptic kelp crab, dwarf crab, elbow crab, graceful kelp crab, hairy crab, hairy rock crab, kelp crab, lined shore crab, lumpy crab, majid crab, masking crab, mole crab, moss crab, northern kelp crab, porcelain crab, purple shore crab, red crab, red rock crab, sharp nosed crab, shore crab family, slender crab, southern kelp crab, spider crab, striped shore crab, thickclaw porcelain crab, yellow crab, yellow shore crab, and other commercial crabs not identified to species.

Sources: Carroll, 1982; Tenera Environmental Services, 2000a; University of Washington, 2000; and Leet et al., 2001.

Table B1-24: Other Commercial Crabs Life History Parameters 2[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0	0	0	0.000000153
Larvae	7.99	0	0	0.0000192
Megalopae	2.31	0	0	0.000134
Age 1+	2.43	0	0	0.289
Age 2+	2.43	0	0	0.654
Age 3+	2.43	0	0	1.26
Age 4+	1.82	0.61	0.50	1.97
Age 5+	1.82	0.61	1.0	2.55
`Age 6+	1.82	0.61	1.0	3.00

[a] Includes brown rock crab, European green crab, hairy rock crab, hermit crab, lined shore crab, mud crab, Pacific sand crab, pea crab, pebble crab, porcelain crab, red crab, red rock crab, shore crab, slender crab, slender rock crab, spider crab, stone crab, yellow crab, yellow rock crab, yellow shore crab, and other commercial crabs not identified to species.

Sources: Carroll, 1982; Tenera Environmental Services, 2000a, 2001; University of Washington, 2000; and Leet et al., 2001.

Table B1-25: Pacific Herring Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000164
Larvae 6 mm	1.44	0	0	0.00000182
Larvae 7 mm	0.703	0	0	0.00000299
Larvae 8 mm	0.609	0	0	0.00000461
Larvae 9 mm	0.537	0	0	0.00000675
Larvae 10 mm	0.481	0	0	0.00000948
Larvae 11 mm	0.435	0	0	0.0000129
Larvae 12 mm	0.397	0	0	0.0000171
Juvenile	0.693	0	0	0.00161
Age 1+	0.473	0	0	0.243
Age 2+	0.474	0	0	0.351
Age 3+	0.474	0	0	0.388
Age 4+	0.474	0	0	0.410
Age 5+	0.474	0	0	0.434
Age 6+	0.474	0	0	0.450
Age 7+	0.474	0	0	0.472
Age 8+	0.474	0	0	0.485

Sources: Ecological Analysts, 1981b; Lassuy, 1989; Washington Department of Fish and Wildlife, 1997; Tenera Environmental Services, 2001; Froese and Pauly, 2002, 2003; and NMFS, 2003a.

Table B1-26: Rockfish Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Larvae	1.00	0	0	0.000181
Juvenile	1.00	0	0	0.00760
Age 1+	0.215	0	0	0.0444
Age 2+	0.215	0	0	0.150
Age 3+	0.261	0	0	0.308
Age 4+	0.131	0.13	0.25	0.458
Age 5+	0.131	0.13	0.50	0.689
Age 6+	0.131	0.13	0.75	0.878
Age 7+	0.131	0.13	1.0	1.05
Age 8+	0.131	0.13	1.0	1.21
Age 9+	0.131	0.13	1.0	1.34
Age 10+	0.131	0.13	1.0	1.46
Age 11+	0.131	0.13	1.0	1.55
Age 12+	0.131	0.13	1.0	1.63

Table B1-26: Rockfish Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Age 13+	0.131	0.13	1.0	1.70
Age 14+	0.131	0.13	1.0	1.75
Age 15+	0.131	0.13	1.0	1.80
Age 16+	0.131	0.13	1.0	1.83
Age 17+	0.131	0.13	1.0	1.86
Age 18+	0.131	0.13	1.0	1.88
Age 19+	0.131	0.13	1.0	1.90
Age 20+	0.131	0.13	1.0	1.92
Age 21+	0.131	0.13	1.0	1.93
Age 22+	0.131	0.13	1.0	1.94
Age 23+	0.131	0.13	1.0	1.95
Age 24+	0.131	0.13	1.0	1.95

[a] Includes aurora rockfish, black and yellow rockfish, black rockfish, blue rockfish, bocaccio, brown rockfish, calico rockfish, chilipepper, copper rockfish, flag rockfish, gopher rockfish, grass rockfish, kelp rockfish, olive rockfish, shortbelly rockfish, treefish, vermilion rockfish, yellowtail rockfish, and other rockfish not identified to species.

Sources: Russell and Hanson, 1990; Cailliet, 2000; Froese and Binohlan, 2000; Leet et al., 2001; and Tenera Environmental Services, 2001.

Table B1-27: Sacramento Splittail Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000352
Larvae	11.3	0	0	0.0000140
Juvenile	0.916	0	0	0.00103
Age 1+	0.370	0	1.0	0.0683
Age 2+	0.370	0	1.0	0.252
Age 3+	0.370	0	1.0	0.480
Age 4+	0.370	0	1.0	0.704
Age 5+	0.370	0	1.0	1.05

Sources: Daniels and Moyle, 1983; CDWR, 1994; and Froese and Pauly, 2001.

Table B1-28: Salmon Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.000317
Larvae	5.04	0	0	0.000349
Juvenile	0.916	0	0	0.199
Age 1+	0.160	0.16	0.50	0.397
Age 2+	0.160	0.16	1.0	4.50
Age 3+	0.160	0.16	1.0	12.2
Age 4+	0.160	0.16	1.0	23.8
Age 5+	0.160	0.16	1.0	33.8

Sources: Beauchamp et al., 1983; Allen and Hassler, 1986; Wang, 1986; Froese and Pauly, 2001; and California Department of Fish and Game, 2003.

Table B1-29: Sculpins Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000338
Larvae	3.79	0	0	0.00000371
Juvenile	0.916	0	0	0.0120
Age 1+	0.420	0.50	0.50	0.0400
Age 2+	0.420	0.50	1.0	0.104
Age 3+	0.420	0.50	1.0	0.219

[a] Includes bonehead sculpin, brown Irish lord, buffalo sculpin, coralline sculpin, fluffy sculpin, manacled sculpin, Pacific staghorn sculpin, prickly sculpin, rosy sculpin, roughcheek sculpin, roughneck sculpin, smoothhead sculpin, snubnose sculpin, spotted scorpionfish, staghorn sculpin, tidepool sculpin, woolly sculpin, and other sculpins not identified to species.

Sources: Cailliet, 2000; Leet et al., 2001; Froese and Pauly, 2002; and personal communication with Y. DeReynier (NMFS, November 19, 2002).

Table B1-30: Silversides Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.669	0	0	0.00000924
Larvae	7.99	0	0	0.0000528
Juvenile	0.420	0	0	0.000472
Age 1+	0.420	0	0	0.0207
Age 2+	0.420	0	0	0.106
Age 3+	0.420	0	0	0.166
Age 4+	0.420	0	0	0.246
Age 5+	0.420	0	0	0.349
Age 6+	0.420	0	0	0.476
Age 7+	0.420	0	0	0.632
Age 8+	0.420	0	0	0.818
Age 9+	0.420	0	0	1.04
Age 10+	0.420	0	0	1.30
Age 11+	0.420	0	0	1.59

[a] Includes California grunion, jacksmelt, topsmelt, and other silversides not identified to species.

Sources: Wang, 1986; Cailliet, 2000; Leet et al., 2001; Froese and Pauly, 2002; and NMFS, 2003a.

Table B1-31: Smelts Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.90	0	0	0.00000154
Larvae	7.99	0	0	0.000389
Juvenile	0.740	0.15	0.50	0.00520
Age 1+	0.740	0.15	1.0	0.0364
Age 2+	0.740	0.15	1.0	0.147
Age 3+	0.740	0.15	1.0	0.393
Age 4+	0.740	0.15	1.0	0.738
Age 5+	0.740	0.15	1.0	1.25

[a] Includes night smelt, popeye smelt, surf smelt, and other smelts not identified to species.

Sources: Dryfoos, 1965; Buckley, 1989; Cailliet, 2000; Leet et al., 2001; and Froese and Pauly, 2002.

Table B1-32: Steelhead Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.000317
Larvae	5.04	0	0	0.000349
Juvenile	0.916	0	0	0.199
Age 1+	0.160	0	0	0.397
Age 2+	0.160	0	0.50	4.50
Age 3+	0.160	0	1.0	12.2
Age 4+	0.160	0	1.0	23.8
Age 5+	0.160	0	1.0	33.8
Age 6+	0.160	0	1.0	37.9
Age 7+	0.160	0	1.0	40.1
Age 8+	0.160	0	1.0	41.9
Age 9+	0.160	0	1.0	43.0

Sources: Beauchamp et al., 1983; Wang, 1986; and Froese and Pauly, 2001.

	Table B1-33: Striped Bass Life History Parameters 1			
Stage Name	**Instantaneous Natural Mortality (M)**	**Instantaneous Fishing Mortality (F)**	**Fraction Vulnerable to Fishery**	**Weight (lbs)**
Eggs	1.50	0	0	0.0000416
Larvae 5 to 6 mm	1.00	0	0	0.0000457
Larvae 7 to 10 mm	2.01	0	0	0.0000503
Larvae 11 to 14 mm	0.939	0	0	0.0000553
Larvae 15 to 18 mm	0.651	0	0	0.0000898
Larvae 19 mm	0.0610	0	0	0.000135
Larvae 20 to 24 mm	0.312	0	0	0.000207
Larvae 25 to 29 mm	0.286	0	0	0.000397
Larvae 30 to 34 mm	0.334	0	0	0.000616
Larvae 35 to 39 mm	0.375	0	0	0.000977
Larvae 40 to 44 mm	0.441	0	0	0.00136
Larvae 45 to 49 mm	0.904	0	0	0.00194
Larvae 51 to 75 mm	0.700	0	0	0.00421
Larvae 76 to 100 mm	0.350	0	0	0.0105
Juvenile	0.916	0	0	0.0174
Age 1+	0.320	0	0	0.100
Age 2+	0.320	0.18	0.06	0.500
Age 3+	0.320	0.18	0.20	2.30
Age 4+	0.320	0.18	0.63	4.30
Age 5+	0.320	0.18	0.94	6.00
Age 6+	0.320	0.18	1.0	8.50
Age 7+	0.320	0.18	1.0	11.8
Age 8+	0.320	0.18	1.0	13.8
Age 9+	0.320	0.18	1.0	16.0

Sources: Setzler et al., 1980; Ecological Analysts, 1981b; PSE&G, 1999; California Department of Fish and Game, 2000a; Froese and Pauly, 2001; and Leet et al., 2001.

Table B1-34: Striped Bass Life History Parameters 2

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.50	0	0	0.0000416
Larvae	7.44	0	0	0.0000457
Juvenile	0.916	0	0	0.0174
Age 1+	0.320	0	0	0.100
Age 2+	0.320	0.18	0.06	0.500
Age 3+	0.320	0.18	0.20	2.30
Age 4+	0.320	0.18	0.63	4.30
Age 5+	0.320	0.18	0.94	6.00
Age 6+	0.320	0.18	1.0	8.50
Age 7+	0.320	0.18	1.0	11.8
Age 8+	0.320	0.18	1.0	13.8
Age 9+	0.320	0.18	1.0	16.0

Sources: Setzler et al., 1980; Ecological Analysts, 1981b; PSE&G, 1999; California Department of Fish and Game, 2000a; Froese and Pauly, 2001; and Leet et al., 2001.

Table B1-35: Surfperches Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Juvenile	0.560	0	0	0.00443
Age 1+	0.280	0	0	0.0429
Age 2+	0.280	0.28	0.50	0.125
Age 3+	0.280	0.28	1.0	0.203
Age 4+	0.280	0.28	1.0	0.261
Age 5+	0.280	0.28	1.0	0.300
Age 6+	0.280	0.28	1.0	0.324

[a] Includes barred surfperch, black surfperch, calico surfperch, dwarf surfperch, island surfperch, kelp surfperch, pile surfperch, pink seaperch, rainbow surfperch, rubberlip surfperch, shiner surfperch, silver surfperch, spotfin surfperch, striped surfperch, walleye surfperch, white seaperch, and other surfperches not identified to species.

Sources: Cailliet, 2000; Froese and Binohlan, 2000; Leet et al., 2001; and Froese and Pauly, 2002.

Table B1-36: Other Commercial Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.08	0	0	0.000000716
Larvae	5.71	0	0	0.00000204
Juvenile	2.85	0	0	0.000746
Age 1+	0.450	0	0	0.0937
Age 2+	0.450	0.80	0.50	0.356
Age 3+	0.450	0.80	1.0	0.679
Age 4+	0.450	0.80	1.0	0.974
Age 5+	0.450	0.80	1.0	1.21
Age 6+	0.450	0.80	1.0	1.38

[a] See Table B1-40 for a list of species.

Sources: USFWS, 1978; Durbin et al., 1983; Ruppert et al., 1985; Able and Fahay, 1998; PSE&G, 1999; Entergy Nuclear Generation Company, 2000; and ASMFC, 2001b.

Table B1-37: Other Recreational Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.08	0	0	0.000000716
Larvae	5.71	0	0	0.00000204
Juvenile	2.85	0	0	0.000746
Age 1+	0.450	0	0	0.0937
Age 2+	0.450	0.80	0.50	0.356
Age 3+	0.450	0.80	1.0	0.679
Age 4+	0.450	0.80	1.0	0.974
Age 5+	0.450	0.80	1.0	1.21
Age 6+	0.450	0.80	1.0	1.38

[a] See Table B1-41 for a list of species.

Sources: USFWS, 1978; Durbin et al., 1983; Ruppert et al., 1985; Able and Fahay, 1998; PSE&G, 1999; Entergy Nuclear Generation Company, 2000; and ASMFC, 2001b.

Table B1-38: Other Recreational and Commercial Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.08	0	0	0.000000716
Yolk-sac larvae	2.85	0	0	0.000000728
Post yolk-sac larvae	2.85	0	0	0.00000335
Juvenile 1	1.43	0	0	0.000746
Juvenile 2	1.43	0	0	0.0472
Age 1+	0.450	0	0	0.0937
Age 2+	0.450	0.80	0.50	0.356
Age 3+	0.450	0.80	1.0	0.679
Age 4+	0.450	0.80	1.0	0.974
Age 5+	0.450	0.80	1.0	1.21
Age 6+	0.450	0.80	1.0	1.38

[a] Includes barracuda, California sheephead, jack mackerel, lingcod, piked dogfish, and spiny dogfish.

Sources: USFWS, 1978; Durbin et al., 1983; Ruppert et al., 1985; Able and Fahay, 1998; PSE&G, 1999; Entergy Nuclear Generation Company, 2000; and ASMFC, 2001b.

Table B1-39: Other Forage Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.04	0	0	0.0000000186
Larvae	7.70	0	0	0.00000158
Juvenile	1.29	0	0	0.000481
Age 1+	1.62	0	0	0.00381
Age 2+	1.62	0	0	0.00496
Age 3+	1.62	0	0	0.00505

[a] See Table B1-42 for a list of species.

Sources: Derickson and Price, 1973; and PSE&G, 1999.

Table B1-40: Other Commercial Species[a]

Basketweave cusk-eel	Monkeyface eel	Pacific hake	Spotted cusk-eel
California moray	Monkeyface prickleback	Pricklebreast poacher	Yellow snake-eel
Catalina conger	Moray eel	Ribbon prickleback	
Leopard shark	Pacific hagfish	Rock prickleback	

[a] Includes other organisms not identified to species.

Table B1-41: Other Recreational Species[a]

Angel shark	Chub mackerel	Pacific angel shark	Round stingray
Bat ray	Diamond stingray	Pacific bonito	Senorita
Big skate	Gray smoothhound	Pacific bumper	Sevengill shark
Black skate	Halfmoon	Pacific electric ray	Soupfin shark
Broadnose sevengill shark	Horn shark	Pacific mackerel	Striped mullet
Brown smoothhound	Kelp greenling	Pacific moonfish	Swell shark
California butterfly ray	Mexican scad	Pacific pompano	Thornback ray
California electric ray	Monterey Spanish mackerel	Painted greenling	
California ray	Opaleye	Rock wrasse	

[a] Includes other organisms not identified to species.

Table B1-42: Other Forage Species[a]

Barcheek pipefish	Finescale triggerfish	Ocean sunfish	Sea porcupine
Bay pipefish	Flathead mullet	Ocean whitefish	Sharksucker
Bigscale goatfish	Fringehead	Onespot fringehead	Shovelnose guitarfish
Bigscale logperch	Garibaldi	Pacific butterfish	Slimy snailfish
Black bullhead	Giant kelpfish	Pacific cornetfish	Smalleye squaretail
Blacksmith	Grunt	Pacific cutlassfish	Snailfishes
Blue lanternfish	Gunnels	Pacific lamprey	Snubnose pipefish
Broadfin lampfish	Hatchet fish	Pacific sand lance	Southern poacher
Bullseye puffer	High cockscomb	Penpoint gunnel	Southern spearnose poacher
California clingfish	Hitch	Pipefishes	Specklefin midshipman
California flyingfish	Island kelpfish	Plainfin midshipman	Spotted kelpfish
California killifish	Kelp gunnel	Pygmy poacher	Spotted ratfish
California lizardfish	Kelp pipefish	Ratfish	Squid
California needlefish	Kelpfish	Red brotula	Stickleback
California tonguefish	Lampfish	Reef finspot	Striped kelpfish
Californian needlefish	Lanternfish	Ribbonfish	Sunfish family
Catfish family	Longfin lanternfish	Rockweed gunnel	Thornback
Clingfishes	Longspine combfish	Ronquils	Threespine stickleback
Clinids	Medusafish	Saddleback gunnel	Tubesnout
Codfishes	Mexican lampfish	Salema	White catfish
Combfish	Northern clingfish	Sarcastic fringehead	Zebra perch
Cortez angelfish	Northern lampfish	Sargo	
Crevice kelpfish	Northern spearnose poacher	Scarlet kelpfish	

[a] Includes other organisms not identified to species.

Chapter B2: Evaluation of Impingement and Entrainment in California

Background: California Marine Fisheries

California marine fisheries are managed by the Pacific Fishery Management Council (PFMC), which governs commercial and recreational fisheries in Federal waters from 3 to 200 nautical miles off the coasts of Washington, Oregon, and California (PFMC, 2003a). The individual states control waters within three miles. NOAA Fisheries (formerly the National Marine Fisheries Service) Northwest Fisheries Science Center provides scientific and technical support for management, conservation, and fisheries development for Northern California. The Southwest Fisheries Science Center provides support for Southern California.

There are 83 species of groundfish included under PFMC's Groundfish Fishery Management Plan, including nearly 50 species of rockfish (*Sebastes* spp.) (Table 3 in NMFS, 2002a). The midwater trawl fishery for Pacific whiting (*Merluccius productus*) dominates the commercial fishery, accounting for 78% of Pacific Coast landings (NMFS, 1999a). Important deepwater trawl fisheries also exist for sablefish, Dover sole, and thornyheads. During the 1990s a major fishery developed for nearshore species, including rockfishes, cabezon, and sheephead (Leet et al., 2001). Rockfishes are important for both commercial and recreational fisheries (NMFS, 1999a). In 1994, a limited entry program was implemented for the groundfish fishery because of concerns about overfishing (NMFS, 1999a). Most major Pacific Coast groundfishes are now fully harvested, and catches have recently been controlled by quotas and trip limits (PFMC, 2003c).

Pacific Coast pelagic species managed by the PFMC include Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), and California market squid (*Loligo opalescens*) (NMFS, 2002a). These species typically fluctuate widely in abundance, and currently most stocks are low relative to historical levels (NMFS, 1999a). Pacific mackerel and Pacific sardine are not overfished, but the stock size of the other species governed by the Coastal Pelagic FMP is unknown (Table 3 in NMFS, 2002a). Because of increases in abundance in recent years, Pacific mackerel now accounts for over half of recent landings of Pacific Coast pelagic species (NMFS, 1999a). At times, Pacific sardine has been the most abundant fish species in the California current. When the population is large, it is abundant from the tip of Baja California to southeastern Alaska (PFMC, 2003b).

Five species of anadromous Pacific salmon support coastal and freshwater commercial and recreational fisheries along the Pacific Coast, including chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), sockeye (*O. nerka*), pink (*O. gorbuscha*), and chum (*O. keta*) salmon (NMFS, 1999a). The Sacramento River is a major producer of chinook salmon in California. Since 1991, NOAA Fisheries has listed 20 Evolutionary Significant Units (ESUs)[1].

---

[1] An Evolutionarily Significant Unit (ESU) is a term introduced by NOAA Fisheries in 1991 to refer to the Endangered Species Act (ESA) interpretation of "distinct population segment." A stock must satisfy two criteria to be considered an ESU: (1) "it must be substantially reproductively isolated from other conspecific population units," and (2) "it must represent an important component in the evolutionary legacy of the species."

of Pacific Coast salmon and steelhead trout (*O. mykiss*) under the Federal Endangered Species Act (ESA) (NMFS, 1999b). In NOAA Fisheries Northern California region, listed species include steelhead, coho salmon, and chinook salmon of the central California Coast, and steelhead and chinook salmon of California's Central Valley.

Ocean fisheries for chinook and coho salmon are managed by the PFMC under the Pacific Coast Salmon FMP. In Puget Sound and the Columbia River, chinook and coho fisheries are managed by the States and Tribal fishery agencies. Declines in chinook and coho salmon along the coast have led to reductions and closures of ocean fisheries in recent years (NMFS, 1999a).

The Pacific Salmon FMP contains no fishery management objectives for sockeye, chum, even-year pink, and steelhead stocks because fishery impacts are considered inconsequential (Table 3 in NMFS, 2002a). Pink, chum, and sockeye salmon are managed jointly by the Pacific Salmon Commission, Washington State, and Tribal agencies (NMFS, 1999a).

Pacific Coast shellfish resources are important both commercially and recreationally (NMFS, 1999a). Shrimps, crabs, abalones, and clams command high prices and contribute substantially to the value of Pacific Coast fisheries, even though landings are small.

B2-1   I&E Species/Species Groups Evaluated

Table B2-1 provides a list of species/species groups in California that are impinged and entrained at cooling water intake structures. The life history data used in EPA's analysis and associated data sources are provided in Appendix B1. Copies of the facility studies used in EPA's analysis are provided in the 316(b) docket.

Table B2-1: Species/Species Groups Evaluated by EPA that are Subject to I&E in California				
Species/Species Group	**Recreational**	**Commercial**	**Forage**	**Special Status[a]**
American shad		X		
Anchovies		X		
Blennies			X	
Cabezon	X	X		
California halibut	X	X		
California scorpionfish	X	X		
Chinook salmon			X	X (FT, ST, FE, SE, FCT)
Commercial crabs		X		
Commercial sea basses		X		
Commercial shrimp		X		
Commercial shrimp		X		
Delta smelt			X	X (FT, ST)
Drums and croakers	X	X		
Dungeness		X		
Flounders	X	X		
Forage shrimp			X	
Gobies			X	
Herrings			X	
Longfin smelt			X	X (SOC)

Table B2-1: Species/Species Groups Evaluated by EPA that are Subject to I&E in California				
Species/Species Group	**Recreational**	**Commercial**	**Forage**	**Special Status**[a]
Northern anchovy		X		
Other (commercial)		X		
Other (forage)			X	
Other (recreational and commercial)	X	X		
Other (recreational)	X			
Pacific herring			X	
Recreational sea basses	X			
Rockfishes	X	X		
Sacramento splittail			X	X (FT)
Salmon	X			
Sculpins	X	X		
Silversides			X	
Smelts	X	X		
Steelhead			X	X (FT)
Striped bass	X			
Surfperches	X	X		

[a] FT = Federally listed as threatened.
ST = State listed as threatened.
FE = Federally listed as endangered.
SE = State listed as endangered.
FCT = Federal candidate for listing as threatened.
SOC = Species of concern.

B2-2 I&E Data Evaluated

Table B2-2 lists the facility impingement and entrainment (I&E) data evaluated by EPA to estimate I&E losses at Phase III facilities in California. None of the Phase III facilities in California have conducted I&E studies, so it was necessary to estimate I&E rates at these facilities by extrapolation from Phase II facility studies. See Chapter A1 of Part A for a discussion of extrapolation methods. Facility studies used in EPA's analysis are provided in the 316(b) docket.

Table B2-2: Phase II Facility I&E Data Evaluated for California Analysis	
Facility	**Years of Data**
Contra Costa	1978-1992
Diablo Canyon Nuclear	1985-1998
El Segundo	1990-2001
Encina	1979
Harbor	1979
Haynes	1979-2001
Humboldt Bay	1980

Table B2-2: Phase II Facility I&E Data Evaluated for California Analysis

Facility	Years of Data
Hunter's Point	1978
Huntington Beach	1979-2001
Mandalay	2001
Morro Bay	2000
Moss Landing	1979-1999
Ormond Beach	1979-2001
Pittsburg	1978-1992
Potrero	1978-2001
AES Redondo Beach	1979-2001
San Onofre Nuclear	1979-2001
Scattergood	1990-2002

B2-3 EPA's Estimate of Current I&E at Phase III Facilities in California Expressed as Age-1 Equivalents and Foregone Yield

Table B2-3 provides EPA's estimates of the annual age-1 equivalents and foregone fishery yield resulting from the impingement of aquatic species at Phase III facilities in California. Table B2-4 displays this information for entrainment. Note that in these tables, "total yield" includes direct losses of harvested species and the yield of harvested species that is lost due to losses of forage species (trophic transfer).

Table B2-3: Estimated Current Annual Impingement at Phase III Facilities in California Expressed as Age-1 Equivalents and Foregone Fishery Yield

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
American shad	<1	<1
Anchovies	12,300	20
Blennies	15	<1
Cabezon	3	6
California halibut	21	78
California scorpionfish	9	6
Chinook salmon	<1	<1
Crabs (commercial)	1	<1
Delta smelt	4	<1
Drums and croakers	1,630	95
Dungeness	14	6
Flounders	397	38
Gobies	109	<1
Herrings	1,950	<1
Longfin smelt	38	<1
Northern anchovy	<1	<1

Table B2-3: Estimated Current Annual Impingement at Phase III Facilities in California Expressed as Age-1 Equivalents and Foregone Fishery Yield

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
Other (commercial)	4	1
Other (forage)	1,740	<1
Other (recreational and commercial)	34	7
Other (recreational)	75	15
Pacific herring	<1	<1
Rockfishes	576	139
Sacramento splittail	5	<1
Salmon	<1	<1
Sculpins	527	21
Sea basses (commercial)	<1	<1
Sea basses (recreational)	37	9
Shrimp (commercial)	278	<1
Shrimp (forage)	10	<1
Silversides	3,290	<1
Smelts	212	5
Steelhead	<1	<1
Striped bass	247	215
Surfperches	4,100	267
Trophic transfer[a]	<1	32

[a] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

Table B2-4: Estimated Current Annual Entrainment at Phase III Facilities in California Expressed as Age-1 Equivalents and Foregone Fishery Yield

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
American shad	<1	<1
Anchovies	1,480	2
Blennies	467,000	<1
Cabezon	3,470	5,890
California halibut	4,040	15,200
California scorpionfish	<1	<1
Chinook salmon	<1	<1
Crabs (commercial)	127,000	26
Delta smelt	1	<1
Drums and croakers	18,600	1,090
Dungeness	446	206
Flounders	864	83

Table B2-4: Estimated Current Annual Entrainment at Phase III Facilities in California Expressed as Age-1 Equivalents and Foregone Fishery Yield

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
Gobies	97,900	<1
Herrings	16,400	<1
Longfin smelt	<1	<1
Northern anchovy	<1	<1
Other (commercial)	306	60
Other (forage)	369,000	<1
Other (recreational and commercial)	<1	<1
Other (recreational)	42	8
Pacific herring	200	<1
Rockfishes	372,000	89,700
Sacramento splittail	<1	<1
Salmon	<1	<1
Sculpins	25,300	1,000
Sea basses (commercial)	<1	<1
Sea basses (recreational)	26,400	6,500
Shrimp (commercial)	36,800	1
Shrimp (forage)	116,000	<1
Silversides	108	<1
Smelts	12	<1
Steelhead	<1	<1
Striped bass	62	54
Surfperches	<1	<1
Trophic transfer[a]	<1	244

[a] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

B2-4   Reductions in I&E at Phase III Facilities in the California Region Under Alternative Options

Table B2-5 presents estimated reductions in I&E under the "50 MGD for All Waterbodies" option, the "200 MGD for All Waterbodies" option, and the "100 MGD for Certain Waterbodies" option. Reductions under all other options are presented in Appendix B2.

Table B2-5: Estimated Reductions in I&E Under Three Alternative Options

Option	Age-One Equivalents (#s)	Foregone Fishery Yield (lbs)
50 MGD All Option	474,000	33,400
200 MGD All Option	0	0
100 MGD Option	0	0

B2-5   Assumptions Used in Calculating Recreational and Commercial Losses

The lost yield estimates presented in Tables B2-3 and B2-4 are expressed as total pounds and include losses to both commercial and recreational catch. To estimate the economic value of these losses, total yield was partitioned between commercial and recreational fisheries based on the landings in each fishery. Table B2-6 presents the percentage impacts assumed for each species/species group.

Table B2-6: Percentage of Total Impacts Occurring to the Commercial and Recreational Fisheries as a Result of I&E at Phase III Facilities

Species/Species Group	Percent Impact to Recreational Fishery[a,b]	Percent Impact to Commercial Fishery[a,b]
American shad	0.0%	100.0%
Anchovies	0.0%	100.0%
Cabezon	45.9%	54.1%
California halibut	85.6%	14.4%
California scorpionfish	83.7%	16.3%
Crabs (commercial)	0.0%	100.0%
Sea basses (commercial)	0.0%	100.0%
Shrimp (commercial)	0.0%	100.0%
Drums and croakers	69.1%	30.9%
Dungeness	0.0%	100.0%
Flounders	1.0%	99.0%
Northern anchovy	0.0%	100.0%
Other (commercial)	0.0%	100.0%
Other (recreational)	100.0%	0.0%
Other (recreational and commercial)	50.0%	50.0%
Sea basses (recreational)	100.0%	0.0%
Rockfishes	23.6%	76.4%
Salmon	100.0%	0.0%
Sculpins	85.0%	15.0%
Smelts	6.2%	93.8%
Striped bass	100.0%	0.0%
Surfperches	93.0%	7.0%
Trophic transfer[c]	44.0%	56.0%

[a] Based on landings from 1993 to 2001.
[b] Calculated using recreational landings data from NMFS (2003b, http://www.st.nmfs.gov/recreational/queries/catch/snapshot.html) and commercial landings data from NMFS (2003a, http://www.st.nmfs.gov/commercial/landings/annual_landings.html).
[c] Assumed equally likely to be caught by recreational or commercial fishers. Commercial value calculated as overall average for region based on data from NMFS (2003a).

See Chapter B3 for results of the commercial fishing benefits analysis and Chapter B4 for recreational fishing results. As discussed in Chapter A8, benefits were discounted to account for (1) the time to achieve compliance once a Phase III final regulation for existing facilities would have become effective, and (2) the time it takes for fish spared from I&E to reach a harvestable age.

Appendix B2: Reductions in I&E Under Supplemental Policy Options

**Table B2-1: Estimated Reductions in I&E in the
California Region Under Eight Supplemental Options**

Option	Age-1 Equivalents (#s)	Foregone Fishery Yield (lbs)
Electric Generators 2-50 MGD		
I-only Everywhere	0	0
I&E like Phase II	0	0
I&E Everywhere	0	0
Manufacturers 2-50 MGD		
I-only Everywhere	10,300	358
I&E like Phase II	481,000	33,900
I&E Everywhere	534,000	37,700
Manufacturers 50+ MGD		
I-only Everywhere	10,200	353
I&E Everywhere	474,000	33,400

For additional information on the options, please see the TDD.

Chapter B3: Commercial Fishing Benefits

Introduction

This chapter presents the results of the commercial fishing benefits analysis for the California region. The chapter presents EPA's estimates of baseline (i.e., current) annual commercial fishery losses from impingement and entrainment (I&E) at potentially regulated facilities in the California region and annual reductions in these losses under the regulatory analysis options for Phase III existing facilities[1]:

- ▸ the "50 MGD for All Waterbodies" option,
- ▸ the "200 MGD for All Waterbodies" option, and
- ▸ the "100 MGD for Certain Waterbodies" option.

The chapter then presents the estimated benefits to commercial fisheries from eliminating baseline losses from I&E, and the expected benefits under the regulatory analysis options. Results for the California region include commercial benefits from both Northern and Southern California.

Chapter A4, "Methods for Estimating Commercial Fishing Benefits," details the methods used by EPA to estimate the commercial fishing benefits of reducing and eliminating I&E losses.

EPA considered a wide range of policy options in developing this regulation. In addition to the regulatory analysis options, EPA evaluated 8 supplemental options. Appendix B3 presents results of the commercial fishing benefits analysis for the supplemental options.

B3-1   Baseline Commercial Losses

Table B3-1 provides EPA's estimate of the value of gross revenues lost in commercial fisheries resulting from the impingement of aquatic species at facilities in the California region. Table B3-2 displays this information for entrainment. Total annualized revenue losses are approximately $57,679 (undiscounted).

---

[1] See the Introduction to this report for a description of the regulatory analysis options.

Table B3-1: Annualized Commercial Fishing Gross Revenues Lost due to Impingement at Facilities in the California Region

Species[a]	Estimated Pounds of Harvest Lost	Commercial Value per Pound (2004$)	Estimated Value of Harvest Lost (2004$) Undiscounted
Anchovies	20	$0.06	$1
Cabezon	3	$3.88	$12
California halibut	11	$2.79	$32
California scorpionfish	1	$1.92	$2
Drums and croakers	29	$1.06	$31
Dungeness	6	$1.76	$11
Flounders	38	$0.40	$15
Other[b]	3	$0.56	$2
Rockfishes	106	$0.55	$58
Sculpins	3	$2.68	$8
Smelts	5	$0.28	$1
Surfperches	19	$1.68	$31
Trophic transfer[c]	18	$0.92	$16
Total	**262**		**$220**

[a] Species included are only those that have baseline losses greater than $1.
[b] Includes only species that are commercially, but not recreationally, fished.
[c] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

Table B3-2: Annualized Commercial Fishing Gross Revenues Lost due to Entrainment at Facilities in the California Region

Species[a]	Estimated Pounds of Harvest Lost	Commercial Value per Pound (2004$)	Estimated Value of Harvest Lost (2004$) Undiscounted
Cabezon	3,188	$3.88	$12,369
California halibut	2,195	$2.79	$6,135
Commercial crabs	26	$1.21	$31
Commercial shrimp	1	$1.04	$1
Drums and croakers	335	$1.06	$355
Dungeness crab	206	$1.76	$362
Flounders	82	$0.40	$33
Other[b]	60	$0.56	$34
Rockfishes	68,486	$0.55	$37,607
Sculpins	150	$2.68	$402
Trophic transfer[c]	137	$0.92	$125
Total	**78,866**		**$57,454**

[a] Species included are only those that have baseline losses greater than $1.
[b] Includes only species that are commercially, but not recreationally, fished.
[c] Contribution of forage fish to yield based on trophic transfer (see Chapter

**Table B3-2: Annualized Commercial Fishing Gross Revenues Lost due
to Entrainment at Facilities in the California Region**

Species[a]	Estimated Pounds of Harvest Lost	Commercial Value per Pound (2004$)	Estimated Value of Harvest Lost (2004$) Undiscounted
A1).			

B3-2 Expected Benefits Under Regulatory Analysis Options

As described in Chapter A4, EPA estimates for California that, depending on species, 0 to 74% of the gross
revenue losses represent surplus losses to producers, assuming no change in prices or fishing costs. Earlier EPA
analysis assumed a rate of 40%. The 0% estimate, of course, results in loss estimates of $0.

The expected reductions in I&E attributable to changes at facilities required by the "50 MGD for All
Waterbodies" option (50 MGD All option) are 36.8% for impingement and 27.6% for entrainment. The
"200 MGD for All Waterbodies" option (200 MGD All option) and the "100 MGD for Certain Waterbodies"
option (100 MGD CWB option) do not prevent any losses in the California region. Total annualized benefits are
estimated by applying these estimated reductions to the annual baseline producer surplus loss. As presented in
Table B3-3, this results in total annualized benefits of up to approximately $8,190 for the 50 MGD All option,
assuming a 3% discount rate and a species specific net benefits ratio.[2]

B3-2.1 Commercial Fishing Benefits of the "50 MGD for All Waterbodies" Option

Table B3-3 shows EPA's analysis of the commercial benefits of the "50 MGD for All Waterbodies" option for the
California region. The table shows that this option, assuming a species-specific net benefits ratio, will result in
undiscounted total annualized commercial benefits of approximately $9,504. When evaluated at 3% and
7% discount rates, the annualized commercial benefits are $8,190 and $6,772, respectively.

**Table B3-3: Annualized Commercial Fishing Benefits Attributable to
the 50 MGD All Option at Facilities in the California Region (2004$)[a]**

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$223	$57,456	$57,679
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$122	$34,308	$34,429
Expected reduction due to rule	36.8%	27.6%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$9,504
3% discount rate			$8,190
7% discount rate			$6,772

[2] The net benefits ratio is the fractional share of gross revenue associated with net benefits, by gear and vessel
type. See Chapter A4, section A4-10, for a description of the species-specific net benefits ratios and how they are
calculated.

---

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

B3-2.2 Commercial Fishing Benefits of the "200 MGD for All Waterbodies" Option

No facilities located in the California region have design intake flows greater than 200 MGD, so no facilities would have technology requirements under the "200 MGD for All Waterbodies" option. Thus, no commercial benefits are expected under this option in the California region.

B3-2.3 Commercial Fishing Benefits of the "100 MGD for Certain Waterbodies" Option

No facilities located in the California region have design intake flows greater than 100 MGD, so no facilities would have technology requirements under the "100 MGD for Certain Waterbodies" option. Thus, no commercial benefits are expected under this option in the California region.

Appendix B3: Commercial Fishing Benefits Under Supplemental Policy Options

Introduction

Chapter B3 presents EPA's estimates of the commercial benefits of the regulatory options for the section 316(b) rule for Phase III facilities in the California region. To facilitate comparisons among the options, this appendix presents estimates of the

commercial fishing benefits of several supplemental options that EPA evaluated in preparation for this rule:

- ▸ "Electric Generators 2-50 MGD I-only Everywhere" option;
- ▸ "Electric Generators 2-50 MGD I&E like Phase II" option;
- ▸ "Electric Generators 2-50 MGD I&E Everywhere" option;
- ▸ "Manufacturers 2-50 MGD I-only Everywhere" option;
- ▸ "Manufacturers 2-50 MGD I&E like Phase II" option;
- ▸ "Manufacturers 2-50 MGD I&E Everywhere" option;
- ▸ "Manufacturers 50+ MGD I-only Everywhere" option; and
- ▸ "Manufacturers 50+ MGD I&E Everywhere" option.

Commercial fishing benefits presented in this chapter were estimated using the benefit transfer approach discussed in Chapter B3 and in Chapter A4, "Methods for Estimating Commercial Fishing Benefits."

B3-1   Commercial Fishing Benefits of the Supplemental Options

No facilities located in the California region are electric generators with design intake flows greater than 2 MGD and less than 50 MGD, so no facilities would have technology requirements under the "Electric Generators 2-50 MGD I-only Everywhere" option, the "Electric Generators 2-50 MGD I&E like Phase II" option, or the "Electric Generators 2-50 MGD I&E Everywhere" option. Thus no commercial benefits are expected under these options in the California region. For additional information on the options, please see the TDD.

Tables B3-1 through B3-5 present EPA's estimates of the annualized commercial benefits of the remaining supplemental options in the California region.

Table B3-1: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 2-50 MGD I-only Everywhere" Option at Facilities in the California Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$223	$57,456	$57,679
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$122	$34,308	$34,429
Expected reduction due to rule	37%	0%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$45
3% discount rate			$36
7% discount rate			$26

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table B3-2: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 2-50 MGD I&E like Phase II" Option at Facilities in the California Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$223	$57,456	$57,679
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$122	$34,308	$34,429
Expected reduction due to rule	37%	28%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$9,638
3% discount rate			$7,602
7% discount rate			$5,606

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table B3-3: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 2-50 MGD I&E Everywhere" Option at Facilities in the California Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$223	$57,456	$57,679
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$122	$34,308	$34,429
Expected reduction due to rule	37%	31%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$10,720
3% discount rate			$8,455
7% discount rate			$6,236

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table B3-4: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 50+ MGD I-only Everywhere" Option at Facilities in the California Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$223	$57,456	$57,679
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$122	$34,308	$34,429
Expected reduction due to rule	37%	0%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$45
3% discount rate			$39
7% discount rate			$32

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table B3-5: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 50+ MGD I&E Everywhere" Option at Facilities in the California Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$223	$57,456	$57,679
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$122	$34,308	$34,429
Expected reduction due to rule	37%	28%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$9,504
3% discount rate			$8,190
7% discount rate			$6,772

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Chapter B4: Recreational Use Benefits

Introduction

This chapter presents the results of the recreational fishing benefits analysis for the California region. The chapter presents EPA's estimates of baseline (i.e., current) annual recreational fishery losses from impingement and entrainment (I&E) at potentially regulated facilities in the California region and annual reductions in these losses under the regulatory analysis options for Phase III existing facilities[1]:

> ▸ the "50 MGD for All Waterbodies" option,
> ▸ the "200 MGD for All Waterbodies" option, and
> ▸ the "100 MGD for Certain Waterbodies" option.

The chapter then presents the estimated welfare gain to California anglers from eliminating baseline recreational fishing losses from I&E and the expected benefits under the regulatory analysis options.

EPA estimated the recreational benefits of reducing and eliminating I&E losses using a benefit transfer methodology based on a meta-analysis of the marginal value of catching different species of fish. This meta-analysis is discussed in detail in Chapter A5, "Recreational Fishing Benefits Methodology."

EPA considered a wide range of policy options in developing this regulation. In addition to the regulatory analysis options, EPA evaluated 8 supplemental options. Appendix B4 presents results of the recreational fishing benefits analysis for the supplemental options.

B4-1   Benefit Transfer Approach Based on Meta-Analysis

EPA estimated the recreational welfare gain from the reduction in annual I&E losses expected under the policy options, and the welfare gain from eliminating I&E at potentially regulated facilities, using a benefit transfer approach. As discussed in Chapter A5, the Agency used a meta-analysis regression equation to estimate the marginal recreational value per additional fish caught by anglers, for different species in different regions. Since I&E at potentially regulated facilities affects a variety of species, EPA assigned each species with I&E losses to one of the general species groups used in the meta-analysis. The Agency then calculated the economic value of reducing or eliminating baseline I&E losses, for each species group, by multiplying the value per fish for that species group by the number of fish in the group that are lost in the baseline or saved under the policy options.[2]

---

[1] See the Introduction to this report for a description of the regulatory analysis options.

[2] The estimates of I&E presented in this chapter include only the fraction of impinged and entrained recreational fish that would be caught by anglers. The total amount of I&E of recreational fish is actually much higher.

In general, the fit between the species with I&E losses and the species groups in the meta-analysis was good. However, EPA's estimates of baseline I&E losses and reductions in I&E under the policy options included losses of "unidentified" species. The "unidentified" group includes fish lost indirectly through trophic transfer, as well as species for which no species information was available.[3] Rather than using the meta-analysis regression to try to predict the value per fish for an "unidentified" species, EPA assumed that per-fish values for these species can be approximated by the weighted average value per fish for all species affected by I&E in the California region.[4]

B4-1.1 Baseline Losses and Reductions in Recreational Fishery Losses Under the Regulatory Analysis Options

Table B4-1 presents EPA's estimates of baseline (i.e., current) annual recreational I&E losses at potentially regulated facilities, and annual reductions in these losses under each of the regulatory analysis options, in the California region. The table shows that total baseline losses to recreational fisheries are 32.8 thousand fish per year. In comparison, the "50 MGD for All Waterbodies" option prevents losses of 9.2 thousand fish per year. The "200 MGD for All Waterbodies" option and the "100 MGD for Certain Waterbodies" option do not prevent any losses in the California region. Of all the affected species, rockfish and sculpin have the highest losses in the baseline and the highest prevented losses under the "50 MGD for All Waterbodies" option.

---

[3] In addition to recreational fish that are lost because they are impinged or entrained, some recreational fish are lost because the forage fish that they feed on are impinged or entrained, and thus removed from the food chain. These trophic transfer losses of recreational species are included in EPA's estimates of total I&E losses. Since it is difficult to predict which recreational species would be affected by losses of forage fish, these losses are classified as "unidentified" recreational species. Also included in the "unidentified" group are losses of fish that were reported by facilities without information about their exact species.

[4] EPA used the estimated level of baseline recreational losses for each species group as a weighting factor.

Table B4-1: Baseline Recreational Fishing Losses from I&E at Potentially Regulated Phase III Facilities and Reductions in Recreational Losses under the Regulatory Analysis Options in the California Region

Species[a]	Baseline Annual Recreational Fishing Losses (# of fish)	Annual Reductions in Recreational Fishing Losses (# of fish)		
		50 MGD All	200 MGD All[b]	100 MGD CWB[b]
Striped bass	31.0	10.8	0	0
Total (small game)	**31.0**	**10.8**	**0**	**0**
California halibut	670.4	185.2	0	0
Flounders	2.9	0.9	0	0
Total (flatfish)	**673.4**	**186.1**	**0**	**0**
Cabezon	420.2	115.9	0	0
California scorpionfish	2.0	0.7	0	0
Croakers	2,374.3	672.3	0	0
Rockfish	16,727.6	4,614.4	0	0
Sculpin	6,565.4	1,822.4	0	0
Sea bass	4,774.8	1,317.1	0	0
Smelts	0.7	0.3	0	0
Surfperch	1,076.2	395.6	0	0
Total (other saltwater)	**31,941.2**	**8,938.7**	**0**	**0**
Total (unidentified)	**147.9**	**43.7**	**0**	**0**
Total (all species)	***32,793.5***	***9,179.3***	***0***	***0***

[a] EPA assigned each species with I&E losses to one of the species groups used in the meta-analysis. The "other saltwater" group includes bottomfish and other miscellaneous species. The "unidentified" group includes fish lost indirectly through trophic transfer and fish reported lost without information about their species.

[b] No facilities located in the California region have design intake flows greater than 100 MGD. Thus, no facilities would have technology requirements under the "200 MGD for All Waterbodies" or "100 MGD for Certain Waterbodies" options.

Source: U.S. EPA analysis for this report.

B4-1.2 Recreational Fishing Benefits from Eliminating Baseline I&E Losses

Table B4-2 shows the results of EPA's analysis of the welfare gain to recreational anglers from eliminating baseline recreational fishery losses at potentially regulated facilities in the California region. The table presents baseline annual recreational I&E losses, the estimated value per fish, and the monetized annual welfare gain from eliminating recreational losses, for each species group. Total baseline recreational fishing losses for the California region are 32.8 thousand fish per year. The undiscounted annual welfare gain to California anglers from eliminating these losses is $85.6 thousand (2004$), with lower and upper bounds of $44.8 thousand and $164.1 thousand. Evaluated at 3% and 7% discount rates, the mean annualized welfare gain from eliminating these losses is $80.7 thousand and $74.8 thousand, respectively. The majority of monetized recreational losses from I&E under baseline conditions are attributable to losses of species in the "other saltwater" group, such as rockfish and sculpin.

Table B4-2: Recreational Fishing Benefits from Eliminating Baseline I&E at Potentially Regulated Phase III Facilities in the California Region (2004$)

Species Group	Baseline Annual Recreational Fishing Losses (thousands of fish)[a]	Value per Fish[b]			Annualized Benefits from Eliminating Recreational Fishing Losses (thousands)[c,d]		
		Low	Mean	High	Low	Mean	High
Small game	0.0[e]	$3.34	$6.11	$11.16	$0.1	$0.2	$0.3
Flatfish	0.7	$3.93	$8.22	$16.94	$2.6	$5.5	$11.4
Other saltwater	31.9	$1.31	$2.49	$4.75	$41.9	$79.5	$151.6
Unidentified	0.1	$1.37	$2.61	$5.00	$0.2	$0.4	$0.7
Total (undiscounted)	**32.8**				**$44.8**	**$85.6**	**$164.1**
Total (3% discount rate)[d]	**32.8**				**$42.2**	**$80.7**	**$154.5**
Total (7% discount rate)[d]	**32.8**				**$39.1**	**$74.8**	**$143.2**

[a] Recreational fishing losses include only the portion of impinged and entrained fish that would have been caught by recreational anglers.

[b] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.

[c] Monetized benefits are calculated by multiplying baseline losses by the estimated value per fish.

[d] Annualized values represent the total welfare gain over the time frame of the analysis from eliminating recreational losses, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting and annualization methodology, refer to Chapter A8.

[e] Denotes a positive value less than 50 fish.

Source: U.S. EPA analysis for this report.

B4-1.3 Recreational Fishing Benefits of the "50 MGD for All Waterbodies" Option

Table B4-3 shows the results of EPA's analysis of the recreational benefits of the "50 MGD for All Waterbodies" option for the California region. The table presents the annual reduction in recreational I&E losses expected under this option, the estimated value per fish, and annual monetized recreational welfare gain from this option, by species group. The table shows that this option reduces recreational losses by 9.2 thousand fish per year, resulting in an undiscounted welfare gain to recreational anglers of $24.0 thousand (2004$), with lower and upper bounds of $12.5 thousand and $45.9 thousand. Evaluated at 3% and 7% discount rates, the mean annualized welfare gain from this reduction in recreational losses is $20.7 thousand and $17.1 thousand, respectively. The majority of benefits result from reduced losses of species in the "other saltwater" group, such as rockfish and sculpin.

**Table B4-3: Recreational Fishing Benefits of the "50 MGD for All Waterbodies" Option
in the California Region (2004$)**

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)[a]	Value per Fish[b]			Annualized Recreational Fishing Benefits (thousands)[c,d]		
		Low	Mean	High	Low	Mean	High
Small game	0.0[e]	$3.34	$6.11	$11.16	$0.0[f]	$0.1	$0.1
Flatfish	0.2	$3.93	$8.22	$16.94	$0.7	$1.5	$3.2
Other saltwater	8.9	$1.31	$2.49	$4.75	$11.7	$22.3	$42.4
Unidentified	0.0[e]	$1.37	$2.61	$5.00	$0.1	$0.1	$0.2
Total (undiscounted)	**9.2**				**$12.5**	**$24.0**	**$45.9**
Total (3% discount rate)[d]	**9.2**				**$10.8**	**$20.7**	**$39.6**
Total (7% discount rate)[d]	**9.2**				**$8.9**	**$17.1**	**$32.7**

[a] Recreational fishing losses include only the portion of impinged and entrained fish that would have been caught by recreational anglers.
[b] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[c] Monetized benefits are calculated by multiplying the annual reduction in recreational losses by the estimated value per fish.
[d] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting and annualization methodology, refer to Chapter A8.
[e] Denotes a positive value less than 50 fish.
[f] Denotes a positive value less than $50.

Source: U.S. EPA analysis for this report.

B4-1.4 Recreational Fishing Benefits of the "200 MGD for All Waterbodies" Option

No facilities located in the California region have design intake flows greater than 200 MGD, so no facilities would have technology requirements under the "200 MGD for All Waterbodies" option. Thus, no recreational benefits are expected under this option in the California region.

B4-1.5 Recreational Fishing Benefits of the "100 MGD for Certain Waterbodies" Option

No facilities located in the California region have design intake flows greater than 100 MGD, so no facilities would have technology requirements under the "100 MGD for Certain Waterbodies" option. Thus, no recreational benefits are expected under this option in the California region.

B4-2 Limitations and Uncertainty

The results of the benefit transfer based on a meta-analysis represent EPA's best estimate of the recreational benefits of the regulatory analysis options. Nonetheless, there are a number of limitations and uncertainties inherent in these estimates. General limitations pertaining to the development of the meta-analysis model, the use of the model to estimate per-fish values, and the validity of the benefit transfer are discussed in section A5-3.3e and section A5-5.3 of the recreational fishing benefits methodology chapter (A5). In addition to these general concerns about the analysis, there are some limitations and uncertainties that are specific to the California region.

The main limitation of applying the meta-analysis to the California region is that California is a large state with varied recreational fishing resources. The species that are targeted in the northern and southern parts of the state are somewhat different, and assigning a single value to each species based on an average for California may introduce some error into the resulting benefit estimates.

Appendix B4: Recreational Use Benefits Under Supplemental Policy Options

Introduction

Chapter B4 presents EPA's estimates of the recreational benefits of the regulatory options for the section 316(b) rule for Phase III facilities in the California region. To facilitate comparisons among the options, this appendix presents estimates of the recreational fishing benefits of supplemental options that EPA evaluated in preparation for this rule:

- ▸ "Electric Generators 2-50 MGD I-only Everywhere" option;
- ▸ "Electric Generators 2-50 MGD I&E like Phase II" option;
- ▸ "Electric Generators 2-50 MGD I&E Everywhere" option;
- ▸ "Manufacturers 2-50 MGD I-only Everywhere" option;
- ▸ "Manufacturers 2-50 MGD I&E like Phase II" option;
- ▸ "Manufacturers 2-50 MGD I&E Everywhere" option;
- ▸ "Manufacturers 50+ MGD I-only Everywhere" option; and
- ▸ "Manufacturers 50+ MGD I&E Everywhere" option.

Recreational fishing benefits presented in this chapter were estimated using the benefit transfer approach discussed in Chapter B4 and in Chapter A5, "Recreational Fishing Benefits Methodology."

B4-1   Recreational Fishing Benefits of the Supplemental Options

B4-1.1 Estimated Reductions in Recreational Fishing Losses Under the Supplemental Options

Table B4-1 presents EPA's estimates of the annual reduction in baseline (i.e., current) recreational fishing losses from impingement and entrainment (I&E) in the California region under the supplemental options. For additional information on the options, please see the TDD.

Table B4-1: Reductions in Recreational Fishing Losses from I&E Under the Supplemental Options in the California Region

	Annual Reduction in Recreational Losses (# of fish)							
	Electric Generators 2-50 MGD[b]			Manufacturers 2-50 MGD			Manufacturers 50+ MGD	
Species[a]	I-only Everywhere	I&E like Phase II	I&E Everywhere	I-only Everywhere	I&E like Phase II	I&E Everywhere	I-only Everywhere	I&E Everywhere
Striped bass	0	0	0	9.2	11.0	11.2	9.1	10.8
Total (small game)	**0**	**0**	**0**	**9.2**	**11.0**	**11.2**	**9.1**	**10.8**
California halibut	0	0	0	1.3	187.8	208.8	1.3	185.2
Flounders	0	0	0	0.3	0.9	1.0	0.3	0.9
Total (flatfish)	**0**	**0**	**0**	**1.6**	**188.7**	**209.8**	**1.6**	**186.1**
Cabezon	0	0	0	0.2	117.5	130.8	0.2	115.9
California scorpionfish	0	0	0	0.7	0.7	0.7	0.7	0.7
Croakers	0	0	0	71.6	681.8	750.6	70.6	672.3
Rockfish	0	0	0	9.6	4,679.7	5,206.3	9.5	4,614.4
Sculpin	0	0	0	49.9	1,848.3	2,051.0	49.2	1,822.4
Sea bass	0	0	0	2.5	1,335.7	1,486.1	2.5	1,317.1
Smelts	0	0	0	0.3	0.3	0.3	0.3	0.3
Surfperch	0	0	0	401.3	401.3	401.3	395.6	395.6
Total (other saltwater)	**0**	**0**	**0**	**536.0**	**9,065.3**	**10,027.0**	**528.5**	**8,938.7**
Total (generic saltwater)	**0**	**0**	**0**	**12.0**	**44.4**	**48.0**	**11.8**	**43.7**
Total (all species)	**0**	**0**	**0**	**558.8**	**9,309.3**	**10,296.0**	**551.0**	**9,179.3**

[a] EPA assigned each species with I&E losses to one of the species groups used in the meta-analysis. The "other saltwater" group includes bottomfish and other miscellaneous species. The "unidentified" group includes fish lost indirectly through trophic transfer and fish reported lost without information about their species.
[b] No facilities located in the California region are electric generators with design intake flows greater than 2 MGD and less than 50 MGD. Thus no facilities would have technology requirements under the "Electric Generators 2-50 MGD I-only Everywhere" option, the "Electric Generators 2-50 MGD I&E like Phase II" option, or the "Electric Generators 2-50 MGD I&E Everywhere" option.

Source: U.S. EPA analysis for this report.

B4-1.2 Recreational Fishing Benefits of the Supplemental Options

No facilities located in California region are electric generators with design intake flows greater than 2 MGD and less than 50 MGD, so no facilities would have technology requirements under the "Electric Generators 2-50 MGD I-only Everywhere" option, the "Electric Generators 2-50 MGD I&E like Phase II" option, or the "Electric Generators 2-50 MGD I&E Everywhere" option. Thus no recreational benefits are expected under these options in the California region.

Tables B4-2 through B4-6 present EPA's estimates of the annualized recreational benefits of the five remaining supplemental options in the California region.

Table B4-2: Recreational Fishing Benefits of the "Manufacturers 2-50 MGD I-only Everywhere" Option in the California Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	0.0[d]	$3.34	$6.11	$11.16	$0.0[e]	$0.1	$0.1
Flatfish	0.0[d]	$3.93	$8.22	$16.94	$0.0[e]	$0.0[e]	$0.0[e]
Other saltwater	0.5	$1.31	$2.49	$4.75	$0.7	$1.3	$2.5
Unidentified	0.0[d]	$1.37	$2.61	$5.00	$0.0[e]	$0.0[e]	$0.1
Total (undiscounted)	**0.6**				**$0.8**	**$1.4**	**$2.7**
Total (evaluated at 3% discount rate)	**0.6**				**$0.6**	**$1.1**	**$2.2**
Total (evaluated at 7% discount rate)	**0.6**				**$0.4**	**$0.8**	**$1.6**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.
[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.
[d] Denotes a non-zero value less than 50 fish.
[e] Denotes a non-zero value less than $50.

Source: U.S. EPA analysis for this report.

Table B4-3: Recreational Fishing Benefits of the "Manufacturers 2-50 MGD I&E like Phase II" Option in the California Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	0.0[d]	$3.34	$6.11	$11.16	$0.0[e]	$0.1	$0.1
Flatfish	0.2	$3.93	$8.22	$16.94	$0.7	$1.6	$3.2
Other saltwater	9.1	$1.31	$2.49	$4.75	$11.9	$22.6	$43.0
Unidentified	0.0[d]	$1.37	$2.61	$5.00	$0.1	$0.1	$0.2
Total (undiscounted)	**9.3**				**$12.7**	**$24.3**	**$46.6**
Total (evaluated at 3% discount rate)[c]	**9.3**				**$10.0**	**$19.2**	**$36.7**
Total (evaluated at 7% discount rate)[c]	**9.3**				**$7.4**	**$14.1**	**$27.1**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.
[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.
[d] Denotes a non-zero value less than 50 fish.
[e] Denotes a non-zero value less than $50.
Source: U.S. EPA analysis for this report.

Table B4-4: Recreational Fishing Benefits of the "Manufacturers 2-50 MGD I&E Everywhere" Option in the California Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	0.0[d]	$3.34	$6.11	$11.16	$0.0[e]	$0.1	$0.1
Flatfish	0.2	$3.93	$8.22	$16.94	$0.8	$1.7	$3.6
Other saltwater	10.0	$1.31	$2.49	$4.75	$13.1	$25.0	$47.6
Unidentified	0.0[d]	$1.37	$2.61	$5.00	$0.1	$0.1	$0.2
Total (undiscounted)	**10.3**				**$14.1**	**$26.9**	**$51.5**
Total (evaluated at 3% discount rate)[c]	**10.3**				**$11.1**	**$21.2**	**$40.6**
Total (evaluated at 7% discount rate)[c]	**10.3**				**$8.2**	**$15.6**	**$30.0**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.
[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.
[d] Denotes a non-zero value less than 50 fish.
[e] Denotes a non-zero value less than $50.
Source: U.S. EPA analysis for this report.

Table B4-5: Recreational Fishing Benefits of the "Manufacturers 50+ MGD I-only Everywhere" Option in the California Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	0.0[d]	$3.34	$6.11	$11.16	$0.0[e]	$0.1	$0.1
Flatfish	0.0[d]	$3.93	$8.22	$16.94	$0.0[e]	$0.0[e]	$0.0[e]
Other saltwater	0.5	$1.31	$2.49	$4.75	$0.7	$1.3	$2.5
Unidentified	0.0[d]	$1.37	$2.61	$5.00	$0.0[e]	$0.0[e]	$0.1
Total (undiscounted)	**0.6**				**$0.7**	**$1.4**	**$2.7**
Total (evaluated at 3% discount rate)[c]	**0.6**				**$0.6**	**$1.2**	**$2.3**
Total (evaluated at 7% discount rate)[c]	**0.6**				**$0.5**	**$1.0**	**$1.9**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.
[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.
[d] Denotes a non-zero value less than 50 fish.
[e] Denotes a non-zero value less than $50.

Source: U.S. EPA analysis for this report.

Table B4-6: Recreational Fishing Benefits of the "Manufacturers 50+ MGD I&E Everywhere" Option in the California Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	0.0[d]	$3.34	$6.11	$11.16	$0.0[e]	$0.1	$0.1
Flatfish	0.2	$3.93	$8.22	$16.94	$0.7	$1.5	$3.2
Other saltwater	8.9	$1.31	$2.49	$4.75	$11.7	$22.3	$42.4
Unidentified	0.0[d]	$1.37	$2.61	$5.00	$0.1	$0.1	$0.2
Total (undiscounted)	**9.2**				**$12.5**	**$24.0**	**$45.9**
Total (evaluated at 3% discount rate)	**9.2**				**$10.8**	**$20.7**	**$39.6**
Total (evaluated at 7% discount rate)	**9.2**				**$8.9**	**$17.1**	**$32.7**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.
[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.
[d] Denotes a non-zero value less than 50 fish.
[e] Denotes a non-zero value less than $50.

Source: U.S. EPA analysis for this report.

B4-2 Comparison of Recreational Fishing Benefits by Option

Table B4-7 compares the recreational fishing benefits of the various supplemental options.

	Annual Reduction in Recreational Fishing Losses from I&E (thousands of fish)	Undiscounted Recreational Fishing Benefits (thousands; 2004$)[a]		
Policy Option		**Low**	**Mean**	**High**
Electric Generators 2-50 MGD[b]				
I-Only Everywhere	0.0	$0.0	$0.0	$0.0
I&E Like Phase II	0.0	$0.0	$0.0	$0.0
I&E Everywhere	0.0	$0.0	$0.0	$0.0
Manufacturers 2-50 MGD				
I-Only Everywhere	0.6	$0.8	$1.4	$2.7
I&E Like Phase II	9.3	$12.7	$24.3	$46.6
I&E Everywhere	10.3	$14.1	$26.9	$51.5
Manufacturers 50+ MGD				
I-Only Everywhere	0.6	$0.7	$1.4	$2.7
I&E Everywhere	9.2	$12.5	$24.0	$45.9

Table B4-7: Annual Recreational Benefits of the Supplemental Options in the California Region

[a] These benefit estimates were calculated using the meta-analysis approach discussed in Chapter A5 and Chapter B4.
[b] No facilities located in the California region are electric generators with design intake flows greater than 2 MGD and less than 50 MGD, so no facilities would have technology requirements under the "Electric Generators 2-50 MGD I-only Everywhere" option, the "Electric Generators 2-50 MGD I&E like Phase II" option, or the "Electric Generators 2-50 MGD I&E Everywhere" option. Thus no recreational benefits are expected under these options in the California region.

Source: U.S. EPA analysis for this report.

Chapter B5: Federally Listed T&E Species in the California Region

This chapter lists current federally listed threatened and endangered (T&E) fish and shellfish species in the California region. This list does not address proposed or candidate species. In addition, fish and shellfish listed as cave species, marine mammals, reptiles, amphibians, and snails are not included in this chapter. There are currently no federally listed fish or shellfish species for the states of Alaska and Hawaii which meet the above criteria.

Table B5-1: California Federally Listed T&E Fish and Shellfish		
Status	**Scientific Name**	**Common Name**
E	*Branchinecta conservatio*	Conservancy fairy shrimp
E	*Branchinecta longiantenna*	Longhorn fairy shrimp
T	*Branchinecta lynchi*	Vernal pool fairy shrimp
E	*Branchinecta sandiegonensis*	San Diego fairy shrimp
E	*Catostomus microps*	Modoc sucker
T	*Catostomus santaanae*	Santa Ana sucker (3 California river basins)
E	*Chasmistes brevirostris*	Shortnose sucker
E	*Cyprinodon macularius*	Desert pupfish
E	*Cyprinodon radiosus*	Owens pupfish
E	*Deltistes luxatus*	Lost River sucker
E	*Eucyclogobius newberryi*	Tidewater goby
E	*Gasterosteus aculeatus williamsoni*	Unarmored threespine stickleback
E	*Gila bicolor mohavensis*	Mohave tui chub
E	*Gila bicolor snyderi*	Owens tui chub
E	*Gila elegans*	Bonytail chub
T	*Haliotis sorenseni*	White abalone
T	*Hypomesus transpacificus*	Delta smelt
E	*Lepidurus packardi*	Vernal pool tadpole shrimp
T	*Oncorhynchus (= Salmo) kisutch*	Coho salmon (Oregon and California populations)
E	*Oncorhynchus (= Salmo) kisutch*	Coho salmon (central California coast)
T	*Oncorhynchus (= Salmo) mykiss*	Steelhead (Central Valley, California)
T	*Oncorhynchus (= Salmo) mykiss*	Steelhead (central California coast)
T	*Oncorhynchus (= Salmo) mykiss*	Steelhead (northern California)
T	*Oncorhynchus (= Salmo) mykiss*	Steelhead (south central California coast)
E	*Oncorhynchus (= Salmo) mykiss*	Steelhead (southern California coast)
T	*Oncorhynchus (= Salmo) tshawytscha*	Chinook salmon (California Central Valley) (spring run)
T	*Oncorhynchus (= Salmo) tshawytscha*	Chinook salmon (California coastal)
E	*Oncorhynchus (= Salmo) tshawytscha*	Chinook salmon (Sacramento River) (winter run)

Table B5-1: California Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
T	*Oncorhynchus aguabonita whitei*	Little Kern golden trout
T	*Oncorhynchus clarki henshawi*	Lahontan cutthroat trout
T	*Oncorhynchus clarki seleniris*	Paiute cutthroat trout
E	*Pacifastacus fortis*	Shasta crayfish
E	*Ptychocheilus lucius*	Pikeminnow (= squawfish), Colorado except Salt and Verde River drainages, AZ
T	*Salvelinus confluentus*	Bull trout (U.S., conterminous, lower 48 states)
E	*Streptocephalus woottoni*	Riverside fairy shrimp
E	*Syncaris pacifica*	California freshwater shrimp
E	*Xyrauchen texanus*	Razorback sucker

Source: USFWS, 2006a.

Part C: North Atlantic

Chapter C1: Background

Introduction

This chapter presents an overview of the potential Phase III existing facilities in the North Atlantic study region and summarizes their key cooling water and compliance characteristics. For further

discussion of the technical and compliance characteristics of potential Phase III existing facilities, refer to the *Economic Analysis for the Final Section 316(b) Rule for Phase III Facilities* and the *Technical Development Document for the Final Section 316(b) Rule for Phase III Facilities* (U.S. EPA, 2006a,c).
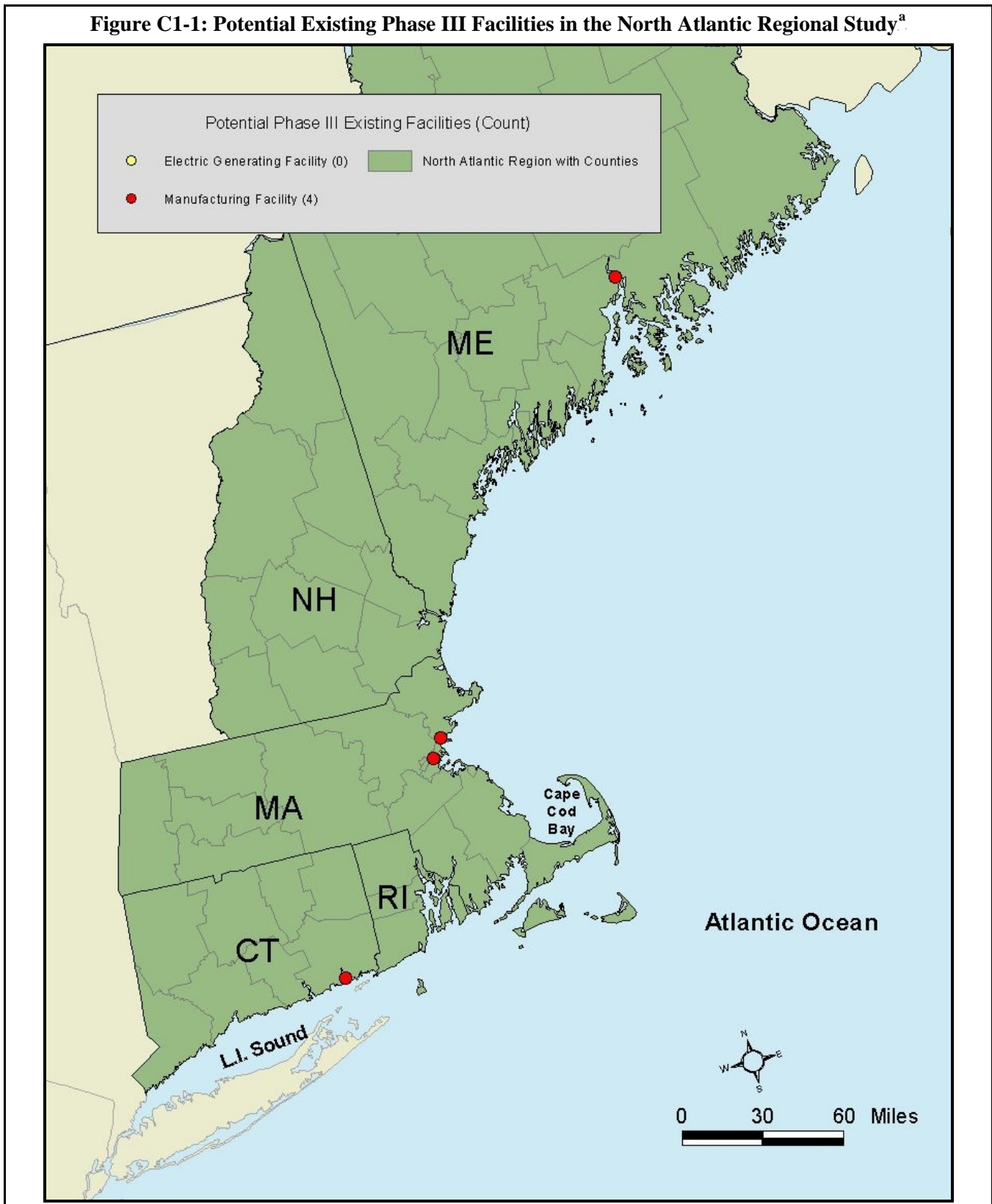
C1-1   Facility Characteristics

The North Atlantic Regional Study includes four sample facilities that are potentially subject to the national standards for Phase III existing facilities. Figure C1-1 presents a map of these facilities. All four facilities are manufacturing facilities. Industry-wide, these four sample facilities represent five manufacturing facilities.[1]

---

[1] EPA applied sample weights to the survey respondents to account for non-sampled facilities and facilities that did not respond to the survey. For more information on EPA's 2000 Section 316(b) Industry Survey, please refer to the Information Collection Request (U.S. EPA, 2000b).

Figure C1-1: Potential Existing Phase III Facilities in the North Atlantic Regional Study[a]

[a] The map includes locations of sample facilities only.

Source: U.S. EPA analysis for this report.

Table C1-1 summarizes key technical and compliance characteristics for all potentially regulated Phase III existing facilities in the North Atlantic study region for the regulatory options considered by EPA for this rule (the "50 MGD for All Waterbodies" option, the "200 MGD for All Waterbodies" option, and the "100 MGD for Certain Waterbodies" option). Facilities with a design intake flow below the three applicability thresholds would be subject to permitting based on best professional judgment and are excluded from EPA's analyses.[2] Therefore, a different number of facilities is affected under each option.

Table C1-1 shows that five Phase III existing facilities in the North Atlantic study region would potentially be subject to the national requirements. Under the "50 MGD for All Waterbodies" option, the most inclusive of the regulatory options, five facilities would be subject to the national requirements for Phase III existing facilities. Under the less inclusive "200 MGD for All Waterbodies" option only one facility would be subject to the nation requirements. Three facilities are subject to the national standards under the "100 MGD for Certain Waterbodies" option. No facility in the North Atlantic study region has a recirculating system in the baseline. Data on design intake flow for the North Atlantic study facilities have been withheld due to data confidentiality reasons.

Table C1-1: Technical and Compliance Characteristics of Existing Phase III Facilities (sample-weighted)

	All Potentially Regulated Facilities	Regulatory Options		
		50 MGD All	200 MGD All	100 MGD CWB
Total Number of Facilities (sample-weighted)	**5**	**5**	**1**	**3**
Number of Facilities with Recirculating System in Baseline	-	-	-	-
Design Intake Flow (MGD)	w[a]	w[a]	w[a]	w[a]
Number of Facilities by Compliance Response				
New larger intake structure with fine mesh and fish H&R	2	2	-	2
Fine mesh traveling screens with fish H&R	1	1	-	-
Passive fine mesh screens	1	1	1	1
None	1	1	-	-
Compliance Cost, Discounted at 3%[b]	$2.03	$2.03	$0.48	$1.56
Compliance Cost, Discounted at 7%[b]	$1.97	$1.97	$0.44	$1.52

[a] Data withheld because of confidentiality reasons.
[b] Annualized pre-tax compliance cost (2004$, millions).

Sources: U.S. EPA, 2000b; U.S. EPA analysis for this report.

[2] Also excluded are facilities that are estimated to be baseline closures. For additional information on EPA's baseline closure analyses, please refer to the *Economic Analysis for the Final Section 316(b) Rule for Phase III Facilities* (U.S. EPA, 2006a).

Appendix C1: Life History Parameter Values Used to Evaluate I&E in the North Atlantic Region

The tables in this appendix present the life history parameter values used by EPA to calculate age-1 equivalents and fishery yields from impingement and entrainment (I&E) data for the North Atlantic region. Because of differences in the number of life stages represented in the loss data, there are cases where more than one life stage sequence was needed for a given species or species group. Alternative parameter sets were developed for this purpose and are indicated with a number following the species or species group name (i.e., Winter flounder 1, Winter flounder 2).

Table C1-1: Alewife Life History Parameters				
Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.544	0	0	0.00000128
Larvae	5.50	0	0	0.00000141
Juvenile	2.57	0	0	0.00478
Age 1+	1.04	0	0	0.0443
Age 2+	1.04	0	0	0.139
Age 3+	1.04	0	0	0.264
Age 4+	1.04	0	0	0.386
Age 5+	1.04	0	0	0.489
Age 6+	1.04	0	0	0.568
Age 7+	1.04	0	0	0.626
Age 8+	1.04	0	0	0.667
Age 9+	1.04	0	0	0.696
Sources: PG&E National Energy Group, 2001; and Froese and Pauly, 2003.				

Table C1-2: American Plaice Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.0000115
Larvae	8.22	0	0	0.0000126
Juvenile	0.916	0	0	0.000110
Age 1+	0.200	0	0	0.00903
Age 2+	0.200	0.32	0.50	0.0871
Age 3+	0.200	0.32	1.0	0.190
Age 4+	0.200	0.32	1.0	0.328
Age 5+	0.200	0.32	1.0	0.494
Age 6+	0.200	0.32	1.0	0.711
Age 7+	0.200	0.32	1.0	0.986
Age 8+	0.200	0.32	1.0	1.24
Age 9+	0.200	0.32	1.0	1.53
Age 10+	0.200	0.32	1.0	1.86
Age 11+	0.200	0.32	1.0	2.24
Age 12+	0.200	0.32	1.0	2.68
Age 13+	0.200	0.32	1.0	3.17
Age 14+	0.200	0.32	1.0	3.52
Age 15+	0.200	0.32	1.0	3.91
Age 16+	0.200	0.32	1.0	4.32
Age 17+	0.200	0.32	1.0	4.77
Age 18+	0.200	0.32	1.0	5.24
Age 19+	0.200	0.32	1.0	5.75
Age 20+	0.200	0.32	1.0	6.28
Age 21+	0.200	0.32	1.0	6.86
Age 22+	0.200	0.32	1.0	7.46
Age 23+	0.200	0.32	1.0	8.11
Age 24+	0.200	0.32	1.0	8.44
Age 25+	0.200	0.32	1.0	8.55

Sources: Stone & Webster Engineering Corporation, 1977; Scott and Scott, 1988; NOAA, 1993; O'Brien, 2000; Schultz, 2000; and Froese and Pauly, 2001.

Table C1-3: American Sand Lance Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.41	0	0	0.00000126
Larvae	2.97	0	0	0.00000139
Juvenile	2.90	0	0	0.00119
Age 1+	1.89	0	0	0.00384
Age 2+	0.364	0	0	0.00730
Age 3+	0.364	0	0	0.0113
Age 4+	0.364	0	0	0.0153
Age 5+	0.364	0	0	0.0191
Age 6+	0.364	0	0	0.0225
Age 7+	0.720	0	0	0.0255
Age 8+	0.720	0	0	0.0280
Age 9+	0.720	0	0	0.0301
Age 10+	0.720	0	0	0.0319
Age 11+	0.720	0	0	0.0333

Sources: PG&E National Energy Group, 2001; and Froese and Pauly, 2003.

Table C1-4: American Shad Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.496	0	0	0.000000716
Yolksac larvae	0.496	0	0	0.000000728
Post-yolksac larvae	2.52	0	0	0.00000335
Juvenile	7.40	0	0	0.000746
Age 1+	0.300	0	0	0.309
Age 2+	0.300	0	0	1.17
Age 3+	0.300	0	0	2.32
Age 4+	0.540	0.21	0.45	3.51
Age 5+	1.02	0.21	0.90	4.56
Age 6+	1.50	0.21	1.0	5.47
Age 7+	1.50	0.21	1.0	6.20
Age 8+	1.50	0.21	1.0	6.77

Sources: USFWS, 1978; Able and Fahay, 1998; PSE&G, 1999; and Froese and Pauly, 2001.

Table C1-5: Atlantic Cod Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	4.87	0	0	0.00000567
Larvae	5.83	0	0	0.00000624
Juvenile	0.916	0	0	0.000337
Age 1+	0.400	0	0	0.0225
Age 2+	0.200	0.29	0.50	0.245
Age 3+	0.200	0.29	1.0	0.628
Age 4+	0.200	0.29	1.0	1.29
Age 5+	0.200	0.29	1.0	2.45
Age 6+	0.200	0.29	1.0	3.33

Sources: Scott and Scott, 1988; Entergy Nuclear Generation Company, 2000; Mayo and O'Brien, 2000; Froese and Pauly, 2001, 2003; and NOAA, 2001b.

Table C1-6: Atlantic Herring Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	3.36	0	0	0.00000473
Larvae	3.26	0	0	0.00000531
Juvenile	3.26	0	0	0.00126
Age 1+	0.200	0.28	0.50	0.0314
Age 2+	0.200	0.28	1.0	0.173
Age 3+	0.200	0.28	1.0	0.302
Age 4+	0.200	0.28	1.0	0.420
Age 5+	0.200	0.28	1.0	0.463
Age 6+	0.200	0.28	1.0	0.525
Age 7+	0.200	0.28	1.0	0.588
Age 8+	0.200	0.28	1.0	0.642
Age 9+	0.200	0.28	1.0	0.699
Age 10+	0.200	0.28	1.0	0.732
Age 11+	0.200	0.28	1.0	0.766
Age 12+	0.200	0.28	1.0	0.848
Age 13+	0.200	0.28	1.0	0.855
Age 14+	0.200	0.28	1.0	0.862
Age 15+	0.200	0.28	1.0	0.869
Age 16+	0.200	0.28	1.0	0.877

[a] Includes Atlantic herring, hickory shad, round herring, and other herring not identified to species.

Sources: Scott and Scott, 1988; Able and Fahay, 1998; Entergy Nuclear Generation Company, 2000; ASMFC, 2001a; Froese and Pauly, 2001; NOAA, 2001b; and Overholtz, 2002a.

Table C1-7: Atlantic Mackerel Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.39	0	0	0.00000176
Larvae	5.30	0	0	0.00000193
Juvenile	5.30	0	0	0.000833
Age 1+	0.520	0	0	0.309
Age 2+	0.370	0.25	0.50	0.510
Age 3+	0.370	0.25	1.0	0.639
Age 4+	0.370	0.25	1.0	0.752
Age 5+	0.370	0.25	1.0	0.825
Age 6+	0.370	0.25	1.0	0.918
Age 7+	0.370	0.25	1.0	1.02
Age 8+	0.370	0.25	1.0	1.10
Age 9+	0.370	0.25	1.0	1.13
Age 10+	0.370	0.25	1.0	1.15
Age 11+	0.370	0.25	1.0	1.22
Age 12+	0.370	0.25	1.0	1.22
Age 13+	0.370	0.25	1.0	1.22
Age 14+	0.370	0.25	1.0	1.22

Sources: Scott and Scott, 1988; Overholtz et al., 1991; Studholme et al., 1999; Entergy Nuclear Generation Company, 2000; Froese and Pauly, 2001, 2003; NOAA, 2001b; and Overholtz, 2002b.

Table C1-8: Atlantic Menhaden Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.20	0	0	0.00000482
Larvae	4.47	0	0	0.00000530
Juvenile	6.19	0	0	0.000684
Age 1+	0.540	0	0	0.0251
Age 2+	0.450	1.1	1.0	0.235
Age 3+	0.450	1.1	1.0	0.402
Age 4+	0.450	1.1	1.0	0.586
Age 5+	0.450	1.1	1.0	0.863
Age 6+	0.450	1.1	1.0	1.08
Age 7+	0.450	1.1	1.0	1.27
Age 8+	0.450	1.1	1.0	1.43

Sources: PG&E National Energy Group, 2001; and Froese and Pauly, 2003.

Table C1-9: Atlantic Silverside Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.41	0	0	0.00000473
Larvae	5.81	0	0	0.00000520
Juvenile	2.63	0	0	0.00490
Age 1+	3.00	0	0	0.0205
Age 2+	6.91	0	0	0.0349

Sources: PG&E National Energy Group, 2001; and Froese and Pauly, 2003.

Table C1-10: Atlantic Tomcod Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	8.46	0	0	0.00000126
Larvae	8.46	0	0	0.0000185
Juvenile	8.46	0	0	0.0145
Age 1+	8.46	0	0	0.0804
Age 2+	2.83	0	0	0.270
Age 3+	2.83	0	0	0.486

Sources: Stewart and Auster, 1987; McLaren et al., 1988; Virginia Tech, 1998; and NMFS, 2003a.

Table C1-11: Bay Anchovy Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.10	0	0	0.000000517
Larvae	7.19	0	0	0.000000569
Juvenile	2.09	0	0	0.00104
Age 1+	2.30	0	0	0.00370
Age 2+	2.30	0	0	0.00765
Age 3+	2.30	0	0	0.0126

[a] Includes bay anchovy, striped anchovy, and other anchovies not identified to species.

Sources: PG&E National Energy Group, 2001; and Froese and Pauly, 2003.

Table C1-12: Blueback Herring Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.558	0	0	0.00000115
Yolksac larvae	1.83	0	0	0.00321
Post-yolksac larvae	1.74	0	0	0.00640
Juvenile 1	3.13	0	0	0.00959
Juvenile 2	3.13	0	0	0.0128
Age 1+	0.300	0	0	0.0160
Age 2+	0.300	0	0	0.0905
Age 3+	0.300	0	0	0.204
Age 4+	0.900	0	0	0.318
Age 5+	1.50	0	0	0.414
Age 6+	1.50	0	0	0.488
Age 7+	1.50	0	0	0.540
Age 8+	1.50	0	0	0.576

Sources: PSE&G, 1999; and PG&E National Energy Group, 2001.

Table C1-13: Bluefish Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.35	0	0	0.0000123
Larvae	8.24	0	0	0.0000135
Juvenile	5.07	0.06	1.0	0.194
Age 1+	0.350	0.28	1.0	1.06
Age 2+	0.350	0.28	1.0	2.81
Age 3+	0.350	0.28	1.0	5.21
Age 4+	0.350	0.28	1.0	7.95
Age 5+	0.350	0.28	1.0	10.7
Age 6+	0.350	0.28	1.0	13.4
Age 7+	0.350	0.28	1.0	15.9
Age 8+	0.350	0.28	1.0	18.0
Age 9+	0.350	0.28	1.0	19.9
Age 10+	0.350	0.28	1.0	21.6
Age 11+	0.350	0.28	1.0	22.9
Age 12+	0.350	0.28	1.0	24.1
Age 13+	0.350	0.28	1.0	25.0
Age 14+	0.350	0.28	1.0	25.8

Sources: Wang and Kernehan, 1979; and PG&E National Energy Group, 2001.

Table C1-14: Butterfish Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.000000396
Larvae	6.64	0	0	0.000000436
Juvenile	0.916	0	0	0.000251
Age 1+	0.800	0.28	0.50	0.0272
Age 2+	0.800	0.28	1.0	0.0986
Age 3+	0.800	0.28	1.0	0.944

Sources: Stone & Webster Engineering Corporation, 1977; Scott and Scott, 1988; Able and Fahay, 1998; Froese and Pauly, 2001; and NOAA, 2001a.

Table C1-15: Commercial Crab Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Megalops	1.30	0	0	0.00000291
Juvenile	1.73	0.48	0.50	0.00000293
Age 1+	1.10	0.48	1.0	0.00719
Age 2+	1.38	0.48	1.0	0.113
Age 3+	1.27	0.48	1.0	0.326

[a] Includes green crab, jonah crab, lady crab, lesser blue crab, narrow mud crab, and spider crab.

Sources: Hartman, 1993; and PSE&G, 1999.

Table C1-16: Cunner Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	3.49	0	0	0.000000787
Larvae	2.90	0	0	0.00000236
Juvenile	2.90	0	0	0.0000814
Age 1+	0.831	0	0	0.00311
Age 2+	0.831	0.10	0.50	0.0246
Age 3+	0.286	0.10	1.0	0.0749
Age 4+	0.342	0.10	1.0	0.145
Age 5+	0.645	0.10	1.0	0.229
Age 6+	1.26	0.10	1.0	0.624

Sources: Serchuk and Cole, 1974; Scott and Scott, 1988; Able and Fahay, 1998; and Entergy Nuclear Generation Company, 2000.

Table C1-17: Fourbeard Rockling Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.000000637
Larvae	4.25	0	0	0.000000700
Juvenile	0.916	0	0	0.00187
Age 1+	0.490	0	0	0.0142
Age 2+	0.490	0	0	0.0209
Age 3+	0.490	0	0	0.0402
Age 4+	0.490	0	0	0.0617
Age 5+	0.490	0	0	0.0906
Age 6+	0.490	0	0	0.151
Age 7+	0.490	0	0	0.188
Age 8+	0.490	0	0	0.251
Age 9+	0.490	0	0	0.323

Sources: Deree, 1999; Froese and Pauly, 2001, 2003; and NMFS, 2003a.

Table C1-18: Grubby Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000473
Larvae	3.79	0	0	0.00000520
Juvenile	0.916	0	0	0.0000197
Age 1+	0.460	0	0	0.00633
Age 2+	0.460	0	0	0.0115
Age 3+	0.460	0	0	0.0190
Age 4+	0.460	0	0	0.0292
Age 5+	0.460	0	0	0.0424
Age 6+	0.460	0	0	0.0592
Age 7+	0.460	0	0	0.0799
Age 8+	0.460	0	0	0.105
Age 9+	0.460	0	0	0.135

Sources: Clayton et al., 1978; Scott and Scott, 1988; Able and Fahay, 1998; Froese and Pauly, 2001, 2003; and NMFS, 2003a.

Table C1-19: Hogchoker Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.04	0	0	0.000000487
Larvae	5.20	0	0	0.00110
Juvenile	2.31	0	0	0.00207
Age 1+	2.56	0	0	0.0113
Age 2+	0.705	0	0	0.0313
Age 3+	0.705	0	0	0.0610
Age 4+	0.705	0	0	0.0976
Age 5+	0.705	0	0	0.138
Age 6+	0.705	0	0	0.178

Sources: PG&E National Energy Group, 2001; and Froese and Pauly, 2003.

Table C1-20: Lumpfish Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000317
Larvae	8.48	0	0	0.0000169
Juvenile	0.916	0	0	0.00472
Age 1+	0.190	0.26	0.50	0.0138
Age 2+	0.190	0.26	1.0	0.0573
Age 3+	0.190	0.26	1.0	0.149
Age 4+	0.190	0.26	1.0	0.686
Age 5+	0.190	0.26	1.0	1.86

Sources: Bigelow and Schroeder, 1953; Scott and Scott, 1988; Able and Fahay, 1998; Froese and Pauly, 2001; and NMFS, 2003a.

Table C1-21: Northern Pipefish Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.000000773
Larvae	2.40	0	0	0.0000122
Juvenile	0.916	0	0	0.00785
Age 1+	0.750	0	0	0.0151
Age 2+	0.750	0	0	0.0180
Age 3+	0.750	0	0	0.0212
Age 4+	0.750	0	0	0.0247
Age 5+	0.750	0	0	0.0285

Sources: Scott and Scott, 1988; Able and Fahay, 1998; Froese and Pauly, 2001; and NMFS, 2003a.

Table C1-22: Pollock Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.922	0	0	0.00000154
Larvae	4.07	0	0	0.00000169
Juvenile	6.93	0	0	0.00166
Age 1+	0.200	0	0	0.657
Age 2+	0.200	0.20	0.50	1.30
Age 3+	0.200	0.20	1.0	1.73
Age 4+	0.200	0.20	1.0	3.24
Age 5+	0.200	0.20	1.0	4.93
Age 6+	0.200	0.20	1.0	5.70
Age 7+	0.200	0.20	1.0	6.83
Age 8+	0.200	0.20	1.0	8.46
Age 9+	0.200	0.20	1.0	9.93
Age 10+	0.200	0.20	1.0	12.0
Age 11+	0.200	0.20	1.0	14.8
Age 12+	0.200	0.20	1.0	16.4
Age 13+	0.200	0.20	1.0	18.1
Age 14+	0.200	0.20	1.0	19.9
Age 15+	0.200	0.20	1.0	21.2

Sources: Saila et al., 1997; Able and Fahay, 1998; Froese and Pauly, 2001; and NOAA, 2001b.

Table C1-23: Radiated Shanny Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000430
Larvae	2.20	0	0	0.00000473
Juvenile	0.916	0	0	0.0000559
Age 1+	0.440	0	0	0.000472
Age 2+	0.440	0	0	0.00163
Age 3+	0.440	0	0	0.00374
Age 4+	0.440	0	0	0.00719
Age 5+	0.440	0	0	0.00988
Age 6+	0.440	0	0	0.0132
Age 7+	0.440	0	0	0.0258
Age 8+	0.440	0	0	0.0448

Sources: Scott and Scott, 1988; Froese and Pauly, 2001; Pepin et al., 2002; and NMFS, 2003a.

Table C1-24: Rainbow Smelt Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	4.44	0	0	0.000000990
Larvae	3.12	0	0	0.00110
Juvenile	1.39	0	0	0.00395
Age 1+	1.00	0	0	0.0182
Age 2+	1.00	0	0	0.0460
Age 3+	1.00	0	0	0.0850
Age 4+	1.00	0	0	0.131
Age 5+	1.00	0	0	0.180
Age 6+	1.00	0	0	0.228

Sources: PG&E National Energy Group, 2001; and Froese and Pauly, 2003.

Table C1-25: Red Hake Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.22	0	0	0.000000487
Larvae 2 mm	0.670	0	0	0.000000536
Larvae 2.5 mm	0.670	0	0	0.000000589
Larvae 3.0 mm	0.670	0	0	0.000000744
Larvae 3.5 mm	0.670	0	0	0.00000118
Larvae 4.0 mm	0.670	0	0	0.00000176
Larvae 4.5 mm	3.35	0	0	0.00000251
Juvenile	4.83	0	0	0.00345
Age 1+	0.400	0.39	0.50	0.231
Age 2+	0.400	0.39	1.0	0.805
Age 3+	0.400	0.39	1.0	0.991
Age 4+	0.400	0.39	1.0	1.22
Age 5+	0.400	0.39	1.0	1.55
Age 6+	0.400	0.39	1.0	1.93
Age 7+	0.400	0.39	1.0	2.36
Age 8+	0.400	0.39	1.0	2.86
Age 9+	0.400	0.39	1.0	3.42
Age 10+	0.400	0.39	1.0	3.66

[a] Includes red hake, spotted hake, and white hake.

Sources: Scott and Scott, 1988; Saila et al., 1997; Able and Fahay, 1998; Froese and Pauly, 2001; and NOAA, 2001b.

Table C1-26: Rock Gunnel Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000924
Larvae	1.66	0	0	0.0000102
Juvenile	0.916	0	0	0.000701
Age 1+	0.440	0	0	0.00382
Age 2+	0.440	0	0	0.0128
Age 3+	0.440	0	0	0.0223
Age 4+	0.440	0	0	0.0371
Age 5+	0.440	0	0	0.0490

Sources: Scott and Scott, 1988; Froese and Pauly, 2001; and NMFS, 2003a.

Table C1-27: Sculpin Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.0000107
Larvae	3.79	0	0	0.0000118
Juvenile	0.916	0	0	0.000754
Age 1+	0.460	0.50	0.50	0.00404
Age 2+	0.460	0.50	1.0	0.139
Age 3+	0.460	0.50	1.0	0.332
Age 4+	0.460	0.50	1.0	0.420
Age 5+	0.460	0.50	1.0	0.475
Age 6+	0.460	0.50	1.0	0.541
Age 7+	0.460	0.50	1.0	0.576
Age 8+	0.460	0.50	1.0	0.612
Age 9+	0.460	0.50	1.0	0.637

[a] Includes longhorn sculpin, moustache sculpin, shorthorn sculpin, and other sculpin not identified to species.

Sources: Clayton et al., 1978; Scott and Scott, 1988; Froese and Pauly, 2001; and personal communication with Y. DeReynier (NMFS, November 19, 2002).

Table C1-28: Scup Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.43	0	0	0.000000773
Larvae	4.55	0	0	0.00110
Juvenile	3.36	0	0	0.0280
Age 1+	0.383	0	0	0.132
Age 2+	0.383	0	0	0.322
Age 3+	0.383	0.26	1.0	0.572
Age 4+	0.383	0.26	1.0	0.845
Age 5+	0.383	0.26	1.0	1.12
Age 6+	0.383	0.26	1.0	1.37
Age 7+	0.383	0.26	1.0	1.59
Age 8+	0.383	0.26	1.0	1.78
Age 9+	0.383	0.26	1.0	1.94
Age 10+	0.383	0.26	1.0	2.07
Age 11+	0.383	0.26	1.0	2.23

Sources: PG&E National Energy Group, 2001; and Froese and Pauly, 2003.

Table C1-29: Seaboard Goby Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.288	0	0	0.0000164
Larvae	4.09	0	0	0.0000180
Juvenile	2.30	0	0	0.000485
Age 1+	2.55	0	0	0.00205

Sources: PG&E National Energy Group, 2001; and Froese and Pauly, 2003.

Table C1-30: Searobin Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000132
Larvae	3.66	0	0	0.00000145
Juvenile	0.916	0	0	0.000341
Age 1+	0.420	0.10	0.50	0.0602
Age 2+	0.420	0.10	1.0	0.176
Age 3+	0.420	0.10	1.0	0.267
Age 4+	0.420	0.10	1.0	0.386
Age 5+	0.420	0.10	1.0	0.537
Age 6+	0.420	0.10	1.0	0.721
Age 7+	0.420	0.10	1.0	0.944
Age 8+	0.420	0.10	1.0	1.21

[a] Includes northern searobin, striped searobin, and other searobin not identified to species.

Sources: Virginia Tech, 1998; Entergy Nuclear Generation Company, 2000; and Froese and Pauly, 2001, 2003.

Table C1-31: Silver Hake Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.43	0	0	0.0000203
Larvae	6.62	0	0	0.0000223
Juvenile	4.58	0	0	0.00516
Age 1+	0.400	0	0	0.0729
Age 2+	0.400	0	0	0.242
Age 3+	0.400	0.40	1.0	0.456
Age 4+	0.400	0.40	1.0	0.646
Age 5+	0.400	0.40	1.0	0.788
Age 6+	0.400	0.40	1.0	0.889
Age 7+	0.400	0.40	1.0	0.958
Age 8+	0.400	0.40	1.0	1.00
Age 9+	0.400	0.40	1.0	1.03
Age 10+	0.400	0.40	1.0	1.05
Age 11+	0.400	0.40	1.0	1.06
Age 12+	0.400	0.40	1.0	1.06

Source: PG&E National Energy Group, 2001.

Table C1-32: Skate Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	3.00	0	0	0.0125
Larvae	2.30	0	0	0.0138
Juvenile	0.916	0	0	0.0593
Age 1+	0.400	0.40	0.50	0.157
Age 2+	0.400	0.40	1.0	0.394
Age 3+	0.400	0.40	1.0	0.750
Age 4+	0.400	0.40	1.0	1.15
Age 5+	0.400	0.40	1.0	1.51
Age 6+	0.400	0.40	1.0	1.62
Age 7+	0.400	0.40	1.0	1.65
Age 8+	0.400	0.40	1.0	1.72

[a] Includes clearnose skate, little skate, and other skates not identified to species.

Sources: Scott and Scott, 1988; NOAA, 1993, 2001b; and Froese and Pauly, 2000.

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.28	0	0	0.0000282
Larvae	6.28	0	0	0.0000310
Juvenile	5.63	0	0	0.0405
Age 1+	1.11	0	0	0.386
Age 2+	0.150	0.02	1.0	1.37
Age 3+	0.150	0.06	1.0	3.06
Age 4+	0.150	0.20	1.0	5.35
Age 5+	0.150	0.29	1.0	8.07
Age 6+	0.150	0.31	1.0	11.0
Age 7+	0.150	0.31	1.0	14.1
Age 8+	0.150	0.31	1.0	17.1
Age 9+	0.150	0.31	1.0	20.0
Age 10+	0.150	0.31	1.0	22.8
Age 11+	0.150	0.31	1.0	25.3
Age 12+	0.150	0.31	1.0	27.6
Age 13+	0.150	0.31	1.0	29.7
Age 14+	0.150	0.31	1.0	31.6
Age 15+	0.150	0.31	1.0	33.3
Age 16+	0.150	0.31	1.0	34.7
Age 17+	0.150	0.31	1.0	36.0
Age 18+	0.150	0.31	1.0	37.2
Age 19+	0.150	0.31	1.0	38.2
Age 20+	0.150	0.31	1.0	39.0
Age 21+	0.150	0.31	1.0	39.8
Age 22+	0.150	0.31	1.0	40.4
Age 23+	0.150	0.31	1.0	41.0
Age 24+	0.150	0.31	1.0	41.5

Table C1-33: Striped Bass Life History Parameters

Source: PG&E National Energy Group, 2001.

Table C1-34: Striped Killifish Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.0000180
Larvae	3.00	0	0	0.0000182
Juvenile	0.916	0	0	0.000157
Age 1+	0.777	0	0	0.0121
Age 2+	0.777	0	0	0.0327
Age 3+	0.777	0	0	0.0551
Age 4+	0.777	0	0	0.0778
Age 5+	0.777	0	0	0.0967
Age 6+	0.777	0	0	0.113
Age 7+	0.777	0	0	0.158

[a] Includes mummichog, striped killifish, and other killifish not identified to species.

Sources: Carlander, 1969; Meredith and Lotrich, 1979; Able and Fahay, 1998; and NMFS, 2003a.

Table C1-35: Tautog Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.40	0	0	0.00000123
Larvae	5.86	0	0	0.0221
Juvenile	5.02	0	0	0.0637
Age 1+	0.175	0	0	0.217
Age 2+	0.175	0	0	0.440
Age 3+	0.175	0	0	0.734
Age 4+	0.175	0	0	1.08
Age 5+	0.175	0	0	1.48
Age 6+	0.175	0	0	1.89
Age 7+	0.175	0	0	2.32
Age 8+	0.175	0	0	2.76
Age 9+	0.175	0.24	1.0	3.18
Age 10+	0.175	0.24	1.0	3.60
Age 11+	0.175	0.24	1.0	4.00
Age 12+	0.175	0.24	1.0	4.38
Age 13+	0.175	0.24	1.0	4.73
Age 14+	0.175	0.24	1.0	5.07
Age 15+	0.175	0.24	1.0	5.38
Age 16+	0.175	0.24	1.0	5.67
Age 17+	0.175	0.24	1.0	5.94
Age 18+	0.175	0.24	1.0	6.19
Age 19+	0.175	0.24	1.0	6.42
Age 20+	0.175	0.24	1.0	6.63
Age 21+	0.175	0.24	1.0	6.82
Age 22+	0.175	0.24	1.0	6.99
Age 23+	0.175	0.24	1.0	7.15
Age 24+	0.175	0.24	1.0	10.0

Sources: PG&E National Energy Group, 2001; and Froese and Pauly, 2003.

Table C1-36: Threespine Stickleback Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.288	0	0	0.00000567
Larvae	2.12	0	0	0.00110
Juvenile	1.70	0	0	0.00377
Age 1+	1.42	0	0	0.00917
Age 2+	1.42	0	0	0.0112
Age 3+	1.42	0	0	0.0116

[a] Includes blackspotted stickleback, fourspine stickleback, ninespine stickleback, threespine stickleback, and other stickleback not identified to species.

Sources: Wang, 1986; and PG&E National Energy Group, 2001.

Table C1-37: Weakfish Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.498	0	0	0.00000115
Larvae	2.84	0	0	0.0650
Juvenile 1	3.39	0	0	0.130
Juvenile 2	5.47	0	0	0.195
Age 1+	0.694	0.25	1.0	0.260
Age 2+	0.730	0.50	1.0	0.680
Age 3+	0.657	0.50	1.0	1.12
Age 4+	0.511	0.50	1.0	1.79
Age 5+	0.511	0.50	1.0	2.91
Age 6+	0.511	0.50	1.0	6.21
Age 7+	0.511	0.50	1.0	7.14
Age 8+	0.511	0.50	1.0	9.16
Age 9+	0.511	0.50	1.0	10.8
Age 10+	0.511	0.50	1.0	12.5
Age 11+	0.511	0.50	1.0	12.5
Age 12+	0.511	0.50	1.0	12.5
Age 13+	0.511	0.50	1.0	12.5
Age 14+	0.511	0.50	1.0	12.5
Age 15+	0.511	0.50	1.0	12.5

[a] Includes northern kingcroaker and weakfish.

Sources: PSE&G, 1999; PG&E National Energy Group, 2001; and Froese and Pauly, 2003.

Table C1-38: White Perch Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.42	0	0	0.000000842
Larvae	4.59	0	0	0.00110
Juvenile	9.06	0	0	0.00302
Age 1+	0.693	0	0	0.0516
Age 2+	0.693	0	0	0.156
Age 3+	0.543	0.15	1.0	0.248
Age 4+	0.543	0.15	1.0	0.331
Age 5+	1.46	0.15	1.0	0.423
Age 6+	1.46	0.15	1.0	0.523
Age 7+	1.46	0.15	1.0	0.613
Age 8+	1.46	0.15	1.0	0.658
Age 9+	1.46	0.15	1.0	0.794

Sources: Stanley and Danie, 1983; and PG&E National Energy Group, 2001.

Table C1-39: Windowpane Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.41	0	0	0.00000154
Larvae	6.99	0	0	0.00165
Juvenile	2.98	0	0	0.00223
Age 1+	0.420	0	0	0.0325
Age 2+	0.420	0	0	0.122
Age 3+	0.420	0	0	0.265
Age 4+	0.420	0	0	0.433
Age 5+	0.420	0	0	0.603
Age 6+	0.420	0.10	1.0	0.761
Age 7+	0.420	0.10	1.0	0.899
Age 8+	0.420	0.10	1.0	1.01
Age 9+	0.420	0.10	1.0	1.11
Age 10+	0.420	0.10	1.0	1.19

[a] Includes American fourspot flounder, smallmouth flounder, summer flounder, and windowpane.

Sources: PG&E National Energy Group, 2001; and Froese and Pauly, 2003.

Table C1-40: Winter Flounder Life History Parameters 1[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.288	0	0	0.00000115
Larvae 1	2.05	0	0	0.00441
Larvae 2	3.42	0	0	0.0110
Larvae 3	3.52	0	0	0.0176
Larvae 4	0.177	0	0	0.0221
Juvenile	2.38	0	0	0.0330
Age 1+	1.10	0.0066	1.0	0.208
Age 2+	0.924	0.082	1.0	0.562
Age 3+	0.200	0.20	1.0	0.997
Age 4+	0.200	0.33	1.0	1.42
Age 5+	0.200	0.33	1.0	1.78
Age 6+	0.200	0.33	1.0	2.07
Age 7+	0.200	0.33	1.0	2.29
Age 8+	0.200	0.33	1.0	2.45
Age 9+	0.200	0.33	1.0	2.57
Age 10+	0.200	0.33	1.0	2.65
Age 11+	0.200	0.33	1.0	2.71
Age 12+	0.200	0.33	1.0	2.75
Age 13+	0.200	0.33	1.0	2.78
Age 14+	0.200	0.33	1.0	2.80
Age 15+	0.200	0.33	1.0	2.82
Age 16+	0.200	0.33	1.0	2.83

[a] Includes winter flounder, yellowtail founder, and other flounder not identified to species.

Sources: Able and Fahay, 1998; and PG&E National Energy Group, 2001.

Table C1-41: Winter Flounder Life History Parameters 2[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.288	0	0	0.00000115
Larvae 3.0 mm	0.705	0	0	0.00000127
Larvae 3.5 mm	0.705	0	0	0.00000137
Larvae 4.0 mm	0.705	0	0	0.00000146
Larvae 4.5 mm	0.705	0	0	0.00000156
Larvae 5.0 mm	0.705	0	0	0.00000216
Larvae 5.5 mm	0.705	0	0	0.00000291
Larvae 6.0 mm	0.705	0	0	0.00000382
Larvae 6.5 mm	0.705	0	0	0.00000489
Larvae 7.0 mm	0.705	0	0	0.00000616
Larvae 7.5 mm	0.705	0	0	0.00000764
Larvae 8.0 mm	0.705	0	0	0.00000933
Larvae 8.5 mm	0.705	0	0	0.0000113
Larvae 9.0 mm	0.705	0	0	0.0000135
Juvenile	2.38	0	0	0.0330
Age 1+	1.10	0.0066	1.0	0.208
Age 2+	0.924	0.082	1.0	0.562
Age 3+	0.200	0.20	1.0	0.997
Age 4+	0.200	0.33	1.0	1.42
Age 5+	0.200	0.33	1.0	1.78
Age 6+	0.200	0.33	1.0	2.07
Age 7+	0.200	0.33	1.0	2.29
Age 8+	0.200	0.33	1.0	2.45
Age 9+	0.200	0.33	1.0	2.57
Age 10+	0.200	0.33	1.0	2.65
Age 11+	0.200	0.33	1.0	2.71
Age 12+	0.200	0.33	1.0	2.75
Age 13+	0.200	0.33	1.0	2.78
Age 14+	0.200	0.33	1.0	2.80
Age 15+	0.200	0.33	1.0	2.82
Age 16+	0.200	0.33	1.0	2.83

[a] Includes winter flounder, witch founder, and other flounder not identified to species.

Sources: Saila et al., 1997; Able and Fahay, 1998; Colarusso, 2000; and PG&E National Energy Group, 2001.

Table C1-42: Winter Flounder Life History Parameters 3[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.288	0.00	0.00	0.00000115
Larvae	9.17	0.00	0.00	0.00441
Juvenile	2.38	0.00	0.00	0.0330
Age 1+	1.10	0.0066	1.0	0.208
Age 2+	0.924	0.082	1.0	0.562
Age 3+	0.200	0.20	1.0	0.997
Age 4+	0.200	0.33	1.0	1.42
Age 5+	0.200	0.33	1.0	1.78
Age 6+	0.200	0.33	1.0	2.07
Age 7+	0.200	0.33	1.0	2.29
Age 8+	0.200	0.33	1.0	2.45
Age 9+	0.200	0.33	1.0	2.57
Age 10+	0.200	0.33	1.0	2.65
Age 11+	0.200	0.33	1.0	2.71
Age 12+	0.200	0.33	1.0	2.75
Age 13+	0.200	0.33	1.0	2.78
Age 14+	0.200	0.33	1.0	2.80
Age 15+	0.200	0.33	1.0	2.82
Age 16+	0.200	0.33	1.0	2.83

[a] Includes fourspot flounder, smooth flounder, witch flounder, yellowtail flounder, and other flounder not identified to species.

Sources: Able and Fahay, 1998; Colarusso, 2000; and PG&E National Energy Group, 2001.

Table C1-43: Other Commercial Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.08	0	0	0.000000716
Larvae	5.71	0	0	0.00000204
Juvenile	2.85	0	0	0.000746
Age 1+	0.450	0	0	0.0937
Age 2+	0.450	0.80	0.50	0.356
Age 3+	0.450	0.80	1.0	0.679
Age 4+	0.450	0.80	1.0	0.974
Age 5+	0.450	0.80	1.0	1.21
Age 6+	0.450	0.80	1.0	1.38

[a] Includes goosefish, redfish, spot, and wolffish.

Sources: USFWS, 1978; Durbin et al., 1983; Ruppert et al., 1985; Able and Fahay, 1998; PSE&G, 1999; Entergy Nuclear Generation Company, 2000; and ASMFC, 2001b.

Table C1-44: Other Recreational Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.08	0	0	0.000000716
Larvae	5.71	0	0	0.00000204
Juvenile	2.85	0	0	0.000746
Age 1+	0.450	0	0	0.0937
Age 2+	0.450	0.80	0.50	0.356
Age 3+	0.450	0.80	1.0	0.679
Age 4+	0.450	0.80	1.0	0.974
Age 5+	0.450	0.80	1.0	1.21
Age 6+	0.450	0.80	1.0	1.38

[a] Includes Atlantic torpedo, blue runner, cownose ray, dusky smooth hound, flathead mullet, northern puffer, smooth dogfish, striped cusk-eel, white catfish, and white mullet.

Sources: USFWS, 1978; Durbin et al., 1983; Ruppert et al., 1985; Able and Fahay, 1998; PSE&G, 1999; Entergy Nuclear Generation Company, 2000; and ASMFC, 2001b.

Table C1-45: Other Recreational and Commercial Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.08	0	0	0.000000716
Larvae	5.71	0	0	0.00000204
Juvenile 1	1.43	0	0	0.000746
Juvenile 2	1.43	0	0	0.0472
Age 1+	0.450	0	0	0.0937
Age 2+	0.450	0.80	0.50	0.356
Age 3+	0.450	0.80	1.0	0.679
Age 4+	0.450	0.80	1.0	0.974
Age 5+	0.450	0.80	1.0	1.21
Age 6+	0.450	0.80	1.0	1.38

[a] Includes American eel, black sea bass, conger eel, and piked dogfish.

Sources: USFWS, 1978; Durbin et al., 1983; Ruppert et al., 1985; Able and Fahay, 1998; PSE&G, 1999; Entergy Nuclear Generation Company, 2000; and ASMFC, 2001b.

Table C1-46: Other Forage Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.04	0	0	0.0000000186
Larvae	7.70	0	0	0.00000158
Juvenile	1.29	0	0	0.000480
Age 1+	1.62	0	0	0.00381
Age 2+	1.62	0	0	0.00496
Age 3+	1.62	0	0	0.00505

[a] See Table C1-47 for a list of species.

Sources: Derickson and Price, 1973; and PSE&G, 1999.

Table C1-47: Other Forage Species[a]

African pompano	Cornet fish	Northern shortfin squid	Sea lamprey
Alligatorfish	Crevalle jack	Ocean pout	Sheepshead minnow
Atlantic bigeye	Flying gurnard	Orange filefish	Short bigeye
Atlantic moonfish	Glasseye	Oyster toadfish	Silver rag
Atlantic seasnail	Gulf snailfish	Pearlside	Spotfin butterflyfish
Banded rudderfish	Long finned squid	Planehead filefish	Striped burrfish
Bigeye scad	Lookdown	Rough scad	Trumpetfish
Black ruff	Mackerel scad	Round scad	Wrymouth
Brown trout	Northern sennet	Sand tiger	

[a] Includes other organisms not identified to species.

Chapter C2: Evaluation of Impingement and Entrainment in the North Atlantic Region

Background: North Atlantic Marine Fisheries

Commercial and recreational fisheries of the North Atlantic region are managed by the New England Fisheries Management Council (NEFMC) according to Fishery Management Plans (FMPs) developed by NEFMC (NMFS, 2002a). The individual states control waters within three miles. NOAA Fisheries Northeast Fisheries Science Center provides scientific and technical support for management, conservation, and fisheries development.

The multispecies groundfish fishery is the most valuable commercial fishery of the North Atlantic region, followed by American lobster (*Homarus americanus*) (NMFS, 1999a). Important groundfish species include Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), yellowtail flounder (*Pleuronectes ferrugineus*), windowpane flounder (*Scophthalmus aquosus*), and winter flounder (*Pleuronectes americanus*). Atlantic pelagic fisheries are dominated by Atlantic mackerel (*Scomber scombrus*), Atlantic herring (*Clupea harengus*), bluefish (*Pomatomus saltatrix*), and butterfish (*Peprilus triacanthus*) (NMFS, 1999a). Important recreational fisheries of the region include Atlantic cod, winter flounder, Atlantic mackerel, striped bass (*Morone saxatilis*), bluefish, and bluefin tuna (*Thunnus thynnus*) (NMFS, 1999a).

Offshore fisheries for crustaceans and molluscs, particularly American lobster (*Homarus americanus*) and sea scallop (*Placopecten magellanicus*), are among the most valuable fisheries in the Northeast (NMFS, 1999a). Surfclams (*Spisula solidissima*), ocean quahogs (*Arctica islandica*), squids (*Loligo pealeii* and *Illex illecebrosus*), northern shrimp (*Pandalus borealis*), and red crab (*Chaceon quinquedens*) also provide important invertebrate fisheries.

The Northeast lobster fishery is second in commercial value after the multispecies groundfish fishery. The most recent comprehensive stock assessment, completed in 1996, indicated that lobster fishing mortality rates for both inshore and offshore populations greatly exceed the levels needed to provide maximum yields (NMFS, 1999a). Lobster fishing mortality in the Gulf of Maine was almost double the overfishing level. Inshore from Cape Cod through Long Island Sound, fishing mortality was three times the overfishing level.

C2-1 I&E Species/Species Groups Evaluated

Table C2-1 provides a list of species/species groups evaluated by EPA that are subject to impingement and entrainment (I&E) in the North Atlantic region. Appendix C1 provides the life history parameters that were used to express these losses as age-1 equivalents and foregone fishery yield.

Table C2-1: Species/Species Groups Evaluated by EPA that are Subject to I&E in the North Atlantic Region

Species/Species Group	Recreational	Commercial	Forage
Alewife			X
American plaice		X	
American sand lance			X
American shad		X	
Atlantic cod	X	X	
Atlantic herring		X	
Atlantic mackerel	X	X	
Atlantic menhaden		X	
Atlantic silverside			X
Atlantic tomcod			X
Bay anchovy			X
Blueback herring			X
Bluefish	X	X	
Butterfish		X	
Crabs (commercial)		X	
Cunner	X		
Fourbeard rockling			X
Grubby			X
Hogchoker			X
Lumpfish			X
Northern pipefish			X
Other (commercial)		X	
Other (forage)			X
Other (recreational)	X		
Other (recreational and commercial)	X	X	
Pollock	X	X	
Radiated shanny			X
Rainbow smelt			X
Red hake		X	
Rock gunnel			X
Sculpins	X	X	
Scup	X	X	
Seaboard goby			X
Searobin	X	X	
Silver hake		X	
Skate species		X	
Striped bass	X		
Striped killifish			X

Table C2-1: Species/Species Groups Evaluated by EPA that are Subject to I&E in the North Atlantic Region

Species/Species Group	Recreational	Commercial	Forage
Tautog	X	X	
Threespine stickleback			X
Weakfish	X	X	
White perch	X	X	
Windowpane		X	
Winter flounder	X	X	

C2-2 I&E Data Evaluated

Table C2-2 lists the facility I&E data evaluated by EPA to estimate current I&E rates at Phase III facilities in the North Atlantic Region. See Chapter A1 of Part A for a discussion of the methods used to evaluate the I&E data.

Table C2-2: Facility I&E Data Evaluated for the North Atlantic Analysis

Facility	Phase	Years of Data
Brayton Point (MA)	II	1974-1983
GE Company Aircraft Engines (MA)	III	1995-1996
Millstone (CT)	II	1973-2001
Pfizer Incorporated (CT)	III	1998
Pilgrim Nuclear (MA)	II	1990-1998
Seabrook Nuclear (NH)	II	1990-1998

C2-3 EPA's Estimate of Current I&E at Phase III Facilities in the North Atlantic Region Expressed as Age-1 Equivalents and Foregone Yield

Table C2-3 provides EPA's estimates of the annual age-1 equivalents and foregone fishery yield resulting from the impingement of aquatic species at Phase III facilities located in the North Atlantic region. Table C2-4 displays this information for entrainment. Note that in these tables, "total yield" includes direct losses of harvested species and the yield of harvested species that is lost due to losses of forage species (trophic transfer).

The lost yield estimates presented in Tables C2-3 and C2-4 are expressed as total pounds and include losses to both commercial and recreational catch. To estimate the economic value of these losses, total yield was partitioned between commercial and recreational fisheries based on the landings in each fishery. Table C2-6 presents the percentage impacts assumed for each species/species group.

Table C2-3: Estimated Current Annual Impingement at Phase III Facilities in the North Atlantic Region Expressed as Age-1 Equivalents and Foregone Fishery Yield

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
Alewife	483	<1
American plaice	<1	<1
American sand lance	913	<1
American shad	<1	<1
Atlantic cod	19	7
Atlantic herring	123	17
Atlantic mackerel	<1	<1
Atlantic menhaden	10	1
Atlantic silverside	13,900	<1
Atlantic tomcod	<1	<1
Bay anchovy	423	<1
Blueback herring	3	<1
Bluefish	<1	<1
Butterfish	206	6
Crabs (commercial)	790	7
Cunner	42	<1
Fourbeard rockling	1	<1
Grubby	666	<1
Hogchoker	720	<1
Lumpfish	90	13
Northern pipefish	233	<1
Other (commercial)	1	<1
Other (forage)	1,410	<1
Other (recreational and commercial)	9	2
Other (recreational)	10	2
Pollock	<1	1
Radiated shanny	9	<1
Rainbow smelt	1,200	<1
Red hake	4	1
Rock gunnel	105	<1
Sculpins	91	6
Scup	5	1
Seaboard goby	<1	<1
Searobin	34	1
Silver hake	47	6
Skate species	90	19
Striped bass	<1	<1
Striped killifish	85	<1

Table C2-3: Estimated Current Annual Impingement at Phase III Facilities in the North Atlantic Region Expressed as Age-1 Equivalents and Foregone Fishery Yield

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
Tautog	6	3
Threespine stickleback	509	<1
Trophic transfer[a]	<1	6
Weakfish	8	6
White perch	<1	<1
Windowpane	73	1
Winter flounder	743	90

[a] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

Table C2-4: Estimated Current Annual Entrainment at Phase III Facilities in the North Atlantic Region Expressed as Age-1 Equivalents and Foregone Fishery Yield

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
Alewife	54	<1
American plaice	154	27
American sand lance	170,000	<1
American shad	<1	<1
Atlantic cod	556	200
Atlantic herring	5,320	753
Atlantic mackerel	903	125
Atlantic menhaden	1,760	214
Atlantic silverside	889	<1
Atlantic tomcod	<1	<1
Bay anchovy	147,000	<1
Blueback herring	<1	<1
Bluefish	<1	<1
Butterfish	45	1
Cunner	184,000	1,000
Fourbeard rockling	56,800	<1
Grubby	165,000	<1
Hogchoker	1,540	<1
Lumpfish	8	1
Northern pipefish	1,660	<1
Other (commercial)	3	1
Other (forage)	1,640	<1
Other (recreational and commercial)	<1	<1
Other (recreational)	2	<1

Table C2-4: Estimated Current Annual Entrainment at Phase III Facilities in the North Atlantic Region Expressed as Age-1 Equivalents and Foregone Fishery Yield

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
Pollock	1	1
Radiated shanny	191,000	<1
Rainbow smelt	5,680	<1
Red hake	<1	<1
Rock gunnel	1,090,000	<1
Sculpins	83,800	5,630
Scup	63	10
Seaboard goby	168,000	<1
Searobin	488	19
Silver hake	180	24
Skate species	<1	<1
Striped bass	<1	<1
Striped killifish	51	<1
Tautog	4,810	2,690
Threespine stickleback	73	<1
Trophic transfer[a]	<1	9
Weakfish	53	42
White perch	<1	<1
Windowpane	901	17
Winter flounder	2,060	249

[a] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

C2-4   Reductions in I&E at Phase III Facilities in the North Atlantic Region Under Alternative Options

Table C2-5 presents estimated reductions in I&E under the "50 MGD for All Waterbodies" option, the "200 MGD for All Waterbodies" option, and the "100 MGD for Certain Waterbodies" option. Reductions under all other options are presented in Appendix C2.

Table C2-5: Estimated Reductions in I&E Under Alternative Options

Option	Age-1 Equivalents (#s)	Foregone Fishery Yield (lbs)
50 MGD All Option	908,000	4,380
200 MGD All Option	193,000	930
100 MGD Option	734,000	3,540

C2-5   Assumptions Used in Calculating Recreational and Commercial Losses

The lost yield estimates presented in Tables C2-3 and C2-4 are expressed as total pounds and include losses to both commercial and recreational catch. To estimate the economic value of these losses, total yield was partitioned between commercial and recreational fisheries based on the landings in each fishery. Table C2-6 presents the percentage impacts assumed for each species/species group.

Table C2-6: Percentage of Total Impacts Occurring to Commercial and Recreational Fisheries in the North Atlantic Region as a Result of I&E at Phase III Facilities

Species/Species Group	Percent Impact to Recreational Fishery[a,b]	Percent Impact to Commercial Fishery[a,b]
American plaice	0.0%	100.0%
American shad	0.0%	100.0%
Atlantic cod	50.0%	50.0%
Atlantic herring	0.0%	100.0%
Atlantic mackerel	22.2%	77.8%
Atlantic menhaden	0.0%	100.0%
Bluefish	89.1%	10.9%
Butterfish	0.0%	100.0%
Crabs (commercial)	0.0%	100.0%
Cunner	100.0%	0.0%
Other (commercial)	0.0%	100.0%
Other (recreational)	100.0%	0.0%
Other (recreational and commercial)	50.0%	50.0%
Pollock	50.0%	50.0%
Red hake	0.0%	100.0%
Sculpins	79.0%	21.0%
Scup	50.0%	50.0%
Searobin	83.9%	16.1%
Silver hake	0.0%	100.0%
Skate species	0.0%	100.0%
Striped bass	100.0%	0.0%
Tautog	92.2%	7.8%
Trophic transfer[c]	41.0%	59.0%
Weakfish	14.6%	85.4%
White perch	78.8%	21.2%
Windowpane	0.0%	100.0%
Winter flounder[d]	50.0%	50.0%

[a] Based on landings from 1993 to 2001.
[b] Calculated using recreational landings data from NMFS (2003b, http://www.st.nmfs.gov/recreational/queries/catch/snapshot.html) and commercial landings data from NMFS (2003a, http://www.st.nmfs.gov/commercial/landings/annual_landings.html).
[c] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).
[d] A 50%, 50% split was assumed because landings, which largely occur in the ocean, are not considered to be an accurate indicator of impact for these species, which are largely caught near-shore.

See Chapter C3 for results of the commercial fishing benefits analysis and Chapter C4 for recreational fishing results. As discussed in Chapter A8, benefits were discounted to account for (1) the time to achieve compliance once a Phase III final regulation for existing facilities would have become effective, and (2) the time it takes for fish spared from I&E to reach a harvestable age. For the North Atlantic region, EPA assumes the average compliance year will be 2010 for all options.

Appendix C2: Reductions in I&E Under Supplemental Policy Options

**Table C2-1: Estimated Reductions in I&E in the
North Atlantic Region Under Supplemental Options**

Option	Age-1 Equivalents (#s)	Foregone Fishery Yield (lbs)
Electric Generators 2-50 MGD		
I-only Everywhere	0	0
I&E like Phase II	0	0
I&E Everywhere	0	0
Manufacturers 2-50 MGD		
I-only Everywhere	0	0
I&E like Phase II	0	0
I&E Everywhere	0	0
Manufacturers 50+ MGD		
I-only Everywhere	0	0
I&E Everywhere	910,000	4,380

Chapter C3: Commercial Fishing Benefits

Introduction

This chapter presents the results of the commercial fishing benefits analysis for the North Atlantic region. The chapter presents EPA's estimates of baseline (i.e., current) annual commercial fishery losses from impingement and entrainment (I&E) at potentially regulated facilities in the North Atlantic region and annual reductions in these losses under the regulatory options for Phase III existing facilities[1]:

- ▸ the "50 MGD for All Waterbodies" option,
- ▸ the "200 MGD for All Waterbodies" option, and
- ▸ the "100 MGD for Certain Waterbodies" option.

The chapter then presents the estimated benefits to commercial fisheries from eliminating baseline losses from I&E, and the expected benefits under the regulatory options.

Chapter A4, "Methods for Estimating Commercial Fishing Benefits," details the methods used by EPA to estimate the commercial fishing benefits of reducing and eliminating I&E losses.

EPA considered a wide range of policy options in developing this regulation. In addition to the regulatory options, EPA evaluated several supplemental options. Appendix C3 presents results of the commercial fishing benefits analysis for the supplemental options. For additional information on the options, please see the TDD.

C3-1   Baseline Commercial Losses

Table C3-1 provides EPA's estimate of the value of gross revenues lost in commercial fisheries resulting from the impingement of aquatic species at facilities in the North Atlantic region. Table C3-2 displays this information for entrainment. Total annualized revenue losses are approximately $1,536 (undiscounted)

---

[1] See the Introduction to this report for a description of the regulatory options.

Table C3-1: Annualized Commercial Fishing Gross Revenues Lost due to Impingement at Facilities in the North Atlantic Region

Species[a]	Estimated Pounds of Harvest Lost	Commercial Value per Pound (2004$)	Estimated Value of Harvest Lost (2004$) Undiscounted
Atlantic cod	3	$1.05	$4
Atlantic herring	17	$0.06	$1
Butterfish	6	$0.62	$4
Commercial crabs	7	$0.57	$4
Sculpins	1	$0.62	$1
Silver hake	6	$0.40	$2
Skate species	19	$0.16	$3
Weakfish	5	$0.94	$5
Windowpane	1	$1.76	$2
Winter flounder	45	$1.30	$58
Trophic transfer[b]	4	$0.66	$3
Total	**114**		**$87**

[a] Species included are only those that have baseline losses greater than $1.
[b] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

Table C3-2: Annualized Commercial Fishing Gross Revenues Lost due to Entrainment at Facilities in the North Atlantic Region

Species[a]	Estimated Pounds of Harvest Lost	Commercial Value per Pound (2004$)	Estimated Value of Harvest Lost (2004$) Undiscounted
American plaice	27	$1.28	$34
Atlantic cod	100	$1.05	$105
Atlantic herring	753	$0.06	$48
Atlantic mackerel	97	$0.24	$23
Atlantic menhaden	214	$0.06	$13
Butterfish	1	$0.62	$1
Pollock	1	$0.78	$1
Sculpins	1,183	$0.62	$734
Scup	5	$1.12	$6
Silver hake	24	$0.40	$9
Tautog	210	$1.16	$245
Weakfish	36	$0.94	$34
Windowpane	17	$1.76	$30
Winter flounder	124	$1.30	$162
Trophic transfer[b]	5	$0.66	$3
Total	**2,797**		**$1,448**

[a] Species included are only those that have baseline losses greater than $1.
[b] Contribution of forage fish to yield based on trophic transfer (see Chapter

Table C3-2: Annualized Commercial Fishing Gross Revenues Lost due to Entrainment at Facilities in the North Atlantic Region

Species[a]	Estimated Pounds of Harvest Lost	Commercial Value per Pound (2004$)	Estimated Value of Harvest Lost (2004$) Undiscounted
A1).			

C3-2 Expected Benefits Under Regulatory Analysis Options

As described in Chapter A4, EPA estimates for North Atlantic that, depending on species, 0 to 82% of the gross revenue losses represent surplus losses to producers, assuming no change in prices or fishing costs. Earlier EPA analysis assumed a rate of 40%. The 0% estimate, of course, results in loss estimates of $0.

The expected reductions in I&E attributable to changes at facilities required by the "50 MGD for All Waterbodies" option (50 MGD All option) are 0% for impingement and 39.7% for entrainment; the expected reductions for the "200 MGD for All Waterbodies" option (200 MGD All option) are 0% for impingement and 8.4% for entrainment; and the expected reductions for the "100 MGD for Certain Waterbodies" option (100 MGD CWB option) are 0% for impingement and 32.1% for entrainment. Total annualized benefits are estimated by applying these estimated reductions to the annual baseline producer surplus loss. As presented in Tables C3-3, C3-4, and C3-5, this results in total annualized benefits of up to approximately $138 for the 50 MGD All option, $28 for the 200 MGD All option, and $113 for the 100 MGD CWB option, assuming a 3% discount rate and a species specific net benefits ratio.[2]

C3-2.1 Commercial Fishing Benefits of the "50 MGD for All Waterbodies" Option

Table C3-3 shows EPA's analysis of the commercial benefits of the "50 MGD for All Waterbodies" option for the North Atlantic region. The table shows that this option, assuming a species-specific net benefits ratio, will result in undiscounted total annualized commercial benefits of approximately $169. When evaluated at 3% and 7% discount rates, the annualized commercial benefits are $138 and $107, respectively.

Table C3-3: Annualized Commercial Fishing Benefits Attributable to the 50 MGD All Option at Facilities in the North Atlantic Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$89	$1,447	$1,536
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$57	$425	$482
Expected reduction due to rule	0%	39.7%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$169
3% discount rate			$138

[2] The net benefits ratio is the fractional share of gross revenue associated with net benefits, by gear and vessel type. See Chapter A4, section A4-10, for a description of the species-specific net benefits ratios and how they are calculated.

7% discount rate			$107

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

C3-2.2 Commercial Fishing Benefits of the "200 MGD for All Waterbodies" Option

Table C3-4 shows EPA's analysis of the commercial benefits of the "200 MGD for All Waterbodies" option for the North Atlantic region. The table shows that this option, assuming a species-specific net benefits ratio, will result in undiscounted total annualized commercial benefits of approximately $36. When evaluated at 3% and 7% discount rates, the annualized commercial benefits are $28 and $21, respectively.

Table C3-4: Annualized Commercial Fishing Benefits Attributable to the 200 MGD All Option at Facilities in the North Atlantic Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$89	$1,447	$1,536
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$57	$425	$482
Expected reduction due to rule	0	8.4%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$36
3% discount rate			$28
7% discount rate			$21

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

C3-2.3 Commercial Fishing Benefits of the "100 MGD for Certain Waterbodies" Option

Table C3-5 shows EPA's analysis of the commercial benefits of the "100 MGD for Certain Waterbodies" option for the North Atlantic region. The table shows that this option, assuming a species-specific net benefits ratio, will result in undiscounted total annualized commercial benefits of approximately $137. When evaluated at 3% and 7% discount rates, the annualized commercial benefits are $113 and $88, respectively.

**Table C3-5: Annualized Commercial Fishing Benefits Attributable to
the 100 MGD CWB Option at Facilities in the North Atlantic Region (2004$)[a]**

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$89	$1,447	$1,536
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$57	$425	$482
Expected reduction due to rule	0%	32.1%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$137
3% discount rate			$113
7% discount rate			$88

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Appendix C3: Commercial Fishing Benefits Under Supplemental Policy Options

Introduction

Chapter C3 presents EPA's estimates of the commercial benefits of the regulatory options for the section 316(b) rule for Phase III facilities in the North Atlantic region. To facilitate comparisons among the options, this appendix presents estimates of the commercial fishing benefits of several supplemental options that EPA evaluated in preparation for this rule:

- ▸ "Electric Generators 2-50 MGD I-only Everywhere" option;
- ▸ "Electric Generators 2-50 MGD I&E like Phase II" option;
- ▸ "Electric Generators 2-50 MGD I&E Everywhere" option;
- ▸ "Manufacturers 2-50 MGD I-only Everywhere" option;
- ▸ "Manufacturers 2-50 MGD I&E like Phase II" option;
- ▸ "Manufacturers 2-50 MGD I&E Everywhere" option;
- ▸ "Manufacturers 50+ MGD I-only Everywhere" option; and
- ▸ "Manufacturers 50+ MGD I&E Everywhere" option.

Commercial fishing benefits presented in this chapter were estimated using the benefit transfer approach discussed in Chapter C3 and in Chapter A4, "Methods for Estimating Commercial Fishing Benefits."

C3-1 Commercial Fishing Benefits of the Supplemental Options

No facilities located in the North Atlantic region are electric generators or manufacturers with design intake flows greater than 2 MGD and less than 50 MGD, so no facilities would have technology requirements under the "Electric Generators 2-50 MGD I-only Everywhere" option, the "Electric Generators 2-50 MGD I&E like Phase II" option, the "Electric Generators 2-50 MGD I&E Everywhere" option, the "Manufacturers 2-50 MGD I-only Everywhere" option, the "Manufacturers 2-50 MGD I&E like Phase II" option, or the "Manufacturers 2-50 MGD I&E Everywhere" option. Additionally, no facilities located in the North Atlantic region are manufacturers with design intake flows greater than 50 MGD that would have technology requirements under the "Manufacturers 50+ MGD I-only Everywhere" option. Thus no commercial benefits are expected under these options in the North Atlantic region.

Table C3-1 presents EPA's estimates of the annualized commercial benefits of the remaining supplemental option in the North Atlantic region.

Table C3-1: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 50+ MGD I&E Everywhere" Option at Facilities in the North Atlantic Region (2004$)[a]			
	Impingement	**Entrainment**	**Total**
Baseline loss — gross revenue			
Undiscounted	$89	$1,447	$1,536
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$57	$425	$482
Expected reduction due to rule	0%	40%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$169
3% discount rate			$138
7% discount rate			$107

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Chapter C4: Recreational Use Benefits

Introduction

This chapter presents the results of the recreational fishing benefits analysis for the North Atlantic region. The chapter presents EPA's estimates of baseline (i.e., current) annual recreational fishery losses from impingement and entrainment (I&E) at potentially regulated facilities in the North Atlantic region and annual reductions in these losses under the regulatory options for Phase III existing facilities[1]:

- ▸ the "50 MGD for All Waterbodies" option,
- ▸ the "200 MGD for All Waterbodies" option, and
- ▸ the "100 MGD for Certain Waterbodies" option.

The chapter then presents the estimated welfare gain to North Atlantic anglers from eliminating baseline recreational fishing losses from I&E and the expected benefits under the regulatory options.

EPA estimated the recreational benefits of reducing and eliminating I&E losses using a benefit transfer methodology based on a meta-analysis of the marginal value of catching different species of fish. This meta-analysis is discussed in detail in Chapter A5, "Recreational Fishing Benefits Methodology."

EPA considered a wide range of policy options in developing this regulation. In addition to the regulatory options, EPA evaluated several supplemental options. Appendix C4 presents results of the recreational fishing benefits analysis for the supplemental options. For more information on the options, please see the TDD.

C4-1 Benefit Transfer Approach Based on Meta-Analysis

EPA estimated the recreational welfare gain from the reduction in annual I&E losses expected under the policy options, and the welfare gain from eliminating I&E at potentially regulated facilities, using a benefit transfer approach. As discussed in Chapter A5, the Agency used a meta-analysis regression equation to estimate the marginal recreational value per additional fish caught by anglers, for different species in different regions. Since I&E at potentially regulated facilities affects a variety of species, EPA assigned each species with I&E losses to one of the general species groups used in the meta-analysis. The Agency then calculated the economic value of reducing or eliminating baseline I&E losses, for each species group, by multiplying the value per fish for that species group by the number of fish in the group that are lost in the baseline or saved under the policy options.[2]

---

[1] See the Introduction to this report for a description of the primary analysis options.

[2] The estimates of I&E presented in this chapter include only the fraction of impinged and entrained recreational fish that would be caught by anglers. The total amount of I&E of recreational species is actually much higher.

In general, the fit between the species with I&E losses and the species groups in the meta-analysis was good. However, EPA's estimates of baseline I&E losses and reductions in I&E under the policy options included losses of "unidentified" species. The "unidentified" group includes fish lost indirectly through trophic transfer, as well as species for which no species information was available.[3] Rather than using the meta-analysis regression to try to predict the value per fish for an "unidentified" species, EPA assumed that per-fish values for these species can be approximated by the weighted average value per fish for all species affected by I&E in the North Atlantic region.[4]

C4-1.1 Baseline Losses and Reductions in Recreational Fishery Losses Under the Regulatory Options

Table C4-1 presents EPA's estimates of baseline (i.e., current) annual recreational I&E losses at potentially regulated facilities, and annual reductions in these losses under each of the regulatory options, in the North Atlantic region. The table shows that total baseline losses to recreational fisheries are 20.8 thousand fish per year. In comparison, the "50 MGD for All Waterbodies" option prevents losses of 8.2 thousand fish per year, the "200 MGD for All Waterbodies" option prevents losses of 1.7 thousand fish per year, and the "100 MGD for Certain Waterbodies" option prevents losses of 6.7 thousand fish per year. Of all the affected species, sculpin and cunner have the highest losses in the baseline and the highest prevented losses under the regulatory options.

---

[3] In addition to recreational fish that are lost because they are impinged or entrained, some recreational fish are lost because the forage fish that they feed on are impinged or entrained, and thus removed from the food chain. These trophic transfer losses of recreational species are included in EPA's estimates of total I&E losses. Since it is difficult to predict which recreational species would be affected by losses of forage fish, these losses are classified as "unidentified" recreational species. Also included in the "unidentified" group are losses of fish that were reported by facilities without information about their exact species.

[4] EPA used the estimated level of baseline recreational losses for each species group as a weighting factor.

Table C4-1: Baseline Recreational Fishing Losses from I&E at Potentially Regulated Phase III Facilities and Reductions in Recreational Losses Under the Regulatory Options in the North Atlantic Region

Species[a]	Baseline Annual Recreational Fishing Losses (# of fish)	Annual Reductions in Recreational Fishing Losses (# of fish)		
		50 MGD All	200 MGD All	100 MGD CWB
Atlantic mackerel	39.0	15.5	3.3	12.5
Weakfish	5.7	2.0	0.4	1.6
Total (small game)	**44.7**	**17.5**	**3.7**	**14.1**
Winter flounder	136.5	39.9	8.5	32.2
Total (flatfish)	**136.5**	**39.9**	**8.5**	**32.2**
Atlantic cod	54.6	21.0	4.5	17.0
Cunner	4,635.4	1,842.4	391.1	1,490.0
Sculpin	15,233.1	6,049.4	1,284.2	4,892.3
Scup	5.4	2.0	0.4	1.6
Searobin	32.2	12.0	2.5	9.7
Tautog	618.4	245.5	52.1	198.6
Total (other saltwater)	**20,579.2**	**8,172.3**	**1,734.8**	**6,609.1**
Total (unidentified)	**10.0**	**1.6**	**0.3**	**1.3**
Total (all species)	**20,770.3**	**8,231.2**	**1,747.3**	**6,656.8**

[a] EPA assigned each species with I&E losses to one of the species groups used in the meta-analysis. The "other saltwater" group includes bottomfish and other miscellaneous species. The "unidentified" group includes fish lost indirectly through trophic transfer and fish reported lost without information about their species.

Source: U.S. EPA analysis for this report.

C4-1.2 Recreational Fishing Benefits from Eliminating Baseline I&E Losses

Table C4-2 shows the results of EPA's analysis of the welfare gain to recreational anglers from eliminating baseline recreational fishery losses at potentially regulated facilities in the North Atlantic region. The table presents baseline annual recreational I&E losses, the estimated value per fish, and the monetized annual welfare gain from eliminating recreational losses, for each species group. Total baseline recreational fishing losses for the North Atlantic region are 20.8 thousand fish per year. The undiscounted annual welfare gain to North Atlantic anglers from eliminating these losses is $52.6 thousand (2004$), with lower and upper bounds of $27.4 thousand and $101.0 thousand. Evaluated at 3% and 7% discount rates, the mean annualized welfare gain of eliminating these losses is $49.5 thousand and $45.9 thousand, respectively. The majority of monetized recreational losses from I&E under baseline conditions are attributable to losses of species in the "other saltwater" group, such as sculpin and cunner.

Table C4-2: Recreational Fishing Benefits from Eliminating Baseline I&E at Potentially Regulated Phase III Facilities in the North Atlantic Region (2004$)

Species Group	Baseline Annual Recreational Fishing Losses (thousands of fish)[a]	Value per Fish[b]			Annualized Benefits from Eliminating Recreational Fishing Losses (thousands)[c,d]		
		Low	Mean	High	Low	Mean	High
Small game	0.0[e]	$1.58	$5.00	$15.52	$0.1	$0.2	$0.7
Flatfish	0.1	$2.91	$5.02	$8.70	$0.4	$0.7	$1.2
Other saltwater	20.6	$1.31	$2.51	$4.82	$27.0	$51.7	$99.1
Unidentified	0.0[e]	$1.32	$2.53	$4.86	$0.0[f]	$0.0[f]	$0.0[f]
Total (undiscounted)	**20.8**				**$27.4**	**$52.6**	**$101.0**
Total (evaluated at 3% discount rate)	**20.8**				**$25.8**	**$49.5**	**$95.2**
Total (evaluated at 7% discount rate)	**20.8**				**$24.0**	**$45.9**	**$88.2**

[a] Recreational fishing losses include only the portion of impinged and entrained fish that would have been caught by recreational anglers.
[b] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[c] Monetized benefits are calculated by multiplying baseline losses by the estimated value per fish.
[d] Annualized values represent the total welfare gain over the time frame of the analysis from eliminating recreational losses, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting and annualization methodology, refer to Chapter A8.
[e] Denotes a positive value less than 50 fish.
[f] Denotes a positive value less than $50.

Source: U.S. EPA analysis for this report.

C4-1.3 Recreational Fishing Benefits of the "50 MGD for All Waterbodies" Option

Table C4-3 shows the results of EPA's analysis of the recreational benefits of the "50 MGD for All Waterbodies" option for the North Atlantic region. The table presents the annual reduction in recreational I&E losses expected under this option, the estimated value per fish, and annual monetized recreational welfare gain from this option, by species group. The table shows that this option reduces recreational losses by 8.2 thousand fish per year, resulting in an undiscounted welfare gain to recreational anglers of $20.8 thousand (2004$), with lower and upper bounds of $10.9 thousand and $40.0 thousand. Evaluated at 3% and 7% discount rates, the mean annualized welfare gain from this reduction in recreational losses is $17.0 thousand and $13.2 thousand, respectively. The majority of benefits result from reduced losses of species in the "other saltwater" group, such as sculpin and cunner.

**Table C4-3: Recreational Fishing Benefits of the "50 MGD for All Waterbodies" Option
in the North Atlantic Region (2004$)**

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)[a]	Value per Fish[b]			Annualized Recreational Fishing Benefits (thousands)[c,d]		
		Low	Mean	High	Low	Mean	High
Small game	0.0[e]	$1.58	$5.00	$15.52	$0.0[f]	$0.1	$0.3
Flatfish	0.0[e]	$2.91	$5.02	$8.70	$0.1	$0.2	$0.3
Other saltwater	8.2	$1.31	$2.51	$4.82	$10.7	$20.5	$39.4
Unidentified	0.0[e]	$1.32	$2.53	$4.86	$0.0[f]	$0.0[f]	$0.0[f]
Total (undiscounted)	8.2				$10.9	$20.8	$40.0
Total (evaluated at 3% discount rate)	8.2				$8.9	$17.0	$32.7
Total (evaluated at 7% discount rate)	8.2				$6.9	$13.2	$25.3

[a] Recreational fishing losses include only the portion of impinged and entrained fish that would have been caught by recreational anglers.
[b] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[c] Monetized benefits are calculated by multiplying the annual reduction in recreational losses by the estimated value per fish.
[d] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting and annualization methodology, refer to Chapter A8.
[e] Denotes a positive value less than 50 fish.
[f] Denotes a positive value less than $50.

Source: U.S. EPA analysis for this report.

C4-1.4 Recreational Fishing Benefits of the "200 MGD for All Waterbodies" Option

Table C4-4 shows the results of EPA's analysis of the recreational benefits of the "200 MGD for All Waterbodies" option for the North Atlantic region. The table presents the annual reduction in recreational I&E losses expected under this option, the estimated value per fish, and annual monetized recreational welfare gain from this option, by species group. The table shows that this option reduces recreational losses by 1.7 thousand fish per year, resulting in an undiscounted welfare gain to recreational anglers of $4.4 thousand (2004$), with lower and upper bounds of $2.3 thousand and $8.5 thousand. Evaluated at 3% and 7% discount rates, the mean annualized welfare gain from this reduction in recreational losses is $3.5 thousand and $2.6 thousand, respectively. The majority of benefits result from reduced losses of species in the "other saltwater" group, such as sculpin and cunner.

Table C4-4: Recreational Fishing Benefits of the "200 MGD for All Waterbodies"
Option in the North Atlantic Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)[a]	Value per Fish[b]			Annualized Recreational Fishing Benefits (thousands)[c,d]		
		Low	Mean	High	Low	Mean	High
Small game	0.0[e]	$1.58	$5.00	$15.52	$0.0[f]	$0.0[f]	$0.1
Flatfish	0.0[e]	$2.91	$5.02	$8.70	$0.0[f]	$0.0[f]	$0.1
Other saltwater	1.7	$1.31	$2.51	$4.82	$2.3	$4.4	$8.4
Unidentified	0.0[e]	$1.32	$2.53	$4.86	$0.0[f]	$0.0[f]	$0.0[f]
Total (undiscounted)	**1.7**				**$2.3**	**$4.4**	**$8.5**
Total (evaluated at 3% discount rate)	**1.7**				**$1.8**	**$3.5**	**$6.7**
Total (evaluated at 7% discount rate)	**1.7**				**$1.3**	**$2.6**	**$4.9**

[a] Recreational fishing losses include only the portion of impinged and entrained fish that would have been caught by recreational anglers.
[b] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[c] Monetized benefits are calculated by multiplying the annual reduction in recreational losses by the estimated value per fish.
[d] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting and annualization methodology, refer to Chapter A8.
[e] Denotes a positive value less than 50 fish.
[f] Denotes a positive value less than $50.

Source: U.S. EPA analysis for this report.

C4-1.5 Recreational Fishing Benefits of the "100 MGD for Certain Waterbodies" Option

Table C4-5 shows the results of EPA's analysis of the recreational benefits of the "100 MGD for Certain Waterbodies" option for the North Atlantic region. The table presents the annual reduction in recreational I&E losses expected under this option, the estimated value per fish, and annual monetized recreational welfare gain from this option, by species group. The table shows that this option reduces recreational losses by 6.7 thousand fish per year, resulting in an undiscounted welfare gain to recreational anglers of $16.8 thousand (2004$), with lower and upper bounds of $8.8 thousand and $32.3 thousand. Evaluated at 3% and 7% discount rates, the mean annualized welfare gain from this reduction in recreational losses is $13.9 thousand and $10.8 thousand, respectively. The majority of benefits result from reduced losses of species in the "other saltwater" group, such as sculpin and cunner.

**Table C4-5: Recreational Fishing Benefits of the "100 MGD for Certain Waterbodies"
Option in the North Atlantic Region (2004$)**

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)[a]	Value per Fish[b]			Annualized Recreational Fishing Benefits (thousands)[c,d]		
		Low	Mean	High	Low	Mean	High
Small game	0.0[e]	$1.58	$5.00	$15.52	$0.0[f]	$0.1	$0.2
Flatfish	0.0[e]	$2.91	$5.02	$8.70	$0.1	$0.2	$0.3
Other saltwater	6.6	$1.31	$2.51	$4.82	$8.7	$16.6	$31.8
Unidentified	0.0[e]	$1.32	$2.53	$4.86	$0.0[f]	$0.0[f]	$0.0[f]
Total (undiscounted)	**6.7**				**$8.8**	**$16.8**	**$32.3**
Total (evaluated at 3% discount rate)	**6.7**				**$7.2**	**$13.9**	**$26.6**
Total (evaluated at 7% discount rate)	**6.7**				**$5.7**	**$10.8**	**$20.8**

[a] Recreational fishing losses include only the portion of impinged and entrained fish that would have been caught by recreational anglers.
[b] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[c] Monetized benefits are calculated by multiplying the annual reduction in recreational losses by the estimated value per fish.
[d] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting and annualization methodology, refer to Chapter A8.
[e] Denotes a positive value less than 50 fish.
[f] Denotes a positive value less than $50.

Source: U.S. EPA analysis for this report.

C4-2 Limitations and Uncertainty

The results of the benefit transfer based on a meta-analysis represent EPA's best estimate of the recreational benefits of the regulatory options. Nonetheless, there are a number of limitations and uncertainties inherent in these estimates. General limitations pertaining to the development of the meta-analysis model, the use of the model to estimate per-fish values, and the validity of the benefit transfer are discussed in section A5-3.3e and section A5-5.3 of Chapter A5.

Appendix C4: Recreational Use Benefits Under Supplemental Policy Options

Introduction

Chapter C4 presents EPA's estimates of the recreational benefits of the regulatory options for the section 316(b) rule for Phase III facilities in the North Atlantic region. To facilitate comparisons among the options, this appendix presents estimates of the recreational fishing benefits of several supplemental options that EPA evaluated in preparation for this rule:

▸ "Electric Generators 2-50 MGD I-only Everywhere" option;
▸ "Electric Generators 2-50 MGD I&E like Phase II" option;
▸ "Electric Generators 2-50 MGD I&E Everywhere" option;
▸ "Manufacturers 2-50 MGD I-only Everywhere" option;
▸ "Manufacturers 2-50 MGD I&E like Phase II" option;
▸ "Manufacturers 2-50 MGD I&E Everywhere" option;
▸ "Manufacturers 50+ MGD I-only Everywhere" option; and
▸ "Manufacturers 50+ MGD I&E Everywhere" option.

Recreational fishing benefits presented in this chapter were estimated using the benefit transfer approach discussed in Chapter C4 and in Chapter A5, "Recreational Fishing Benefits Methodology."

C4-1 Recreational Fishing Benefits of the Supplemental Options

C4-1.1 Estimated Reductions in Recreational Fishing Losses Under the Supplemental Options

Table C4-1 presents EPA's estimates of the annual reduction in baseline (i.e., current) recreational fishing losses from impingement and entrainment (I&E) in the North Atlantic region under the supplemental options. For more information on the options, please see the TDD.

Table C4-1: Reductions in Recreational Fishing Losses from I&E Under the Supplemental Options in the North Atlantic Region

Species[a]	Annual Reduction in Recreational Losses (# of fish)							
	Electric Generators 2-50 MGD[b]			Manufacturers 2-50 MGD[b]			Manufacturers 50+ MGD	
	I-only Everywhere	I&E like Phase II	I&E Everywhere	I-only Everywhere	I&E like Phase II	I&E Everywhere	I-only Everywhere[c]	I&E Everywhere
Atlantic mackerel	0	0	0	0	0	0	0	15.5
Weakfish	0	0	0	0	0	0	0	2.0
Total (small game)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**17.5**
Winter flounder	0	0	0	0	0	0	0	39.9
Total (flatfish)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**39.9**
Atlantic cod	0	0	0	0	0	0	0	21.0
Cunner	0	0	0	0	0	0	0	1,842.4
Sculpin	0	0	0	0	0	0	0	6,049.4
Scup	0	0	0	0	0	0	0	2.0
Searobin	0	0	0	0	0	0	0	12.0
Tautog	0	0	0	0	0	0	0	245.5
Total (other saltwater)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**8,172.3**
Total (unidentified)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1.6**
Total (all species)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**8,231.2**

[a] EPA assigned each species with I&E losses to one of the species groups used in the meta-analysis. The "other saltwater" group includes bottomfish and other miscellaneous species. The "unidentified" group includes fish lost indirectly through trophic transfer and fish reported lost without information about their species.

[b] No facilities located in the North Atlantic region are electric generators or manufacturers with design intake flows greater than 2 MGD and less than 50 MGD. Thus no facilities would have technology requirements under the "Electric Generators 2-50 MGD I-only Everywhere" option, the "Electric Generators 2-50 MGD I&E like Phase II" option, the "Electric Generators 2-50 MGD I&E Everywhere" option, the "Manufacturers 2-50 MGD I-only Everywhere" option, the "Manufacturers 2-50 MGD I&E like Phase II" option, or the "Manufacturers 2-50 MGD I&E Everywhere" option.

[c] No facilities located in the North Atlantic region are manufacturers with design intake flows greater than 50 MGD that would have technology requirements under the "Manufacturers 50+ MGD I-only Everywhere" option.

Source: U.S. EPA analysis for this report.

C4-1.2 Recreational Fishing Benefits of the Supplemental Options

No facilities located in North Atlantic region are electric generators or manufacturers with design intake flows greater than 2 MGD and less than 50 MGD, so no facilities would have technology requirements under the "Electric Generators 2-50 MGD I-only Everywhere" option, the "Electric Generators 2-50 MGD I&E like Phase II" option, the "Electric Generators 2-50 MGD I&E Everywhere" option, the "Manufacturers 2-50 MGD I-only Everywhere" option, the "Manufacturers 2-50 MGD I&E like Phase II" option, or the "Manufacturers 2-50 MGD I&E Everywhere" option. Additionally, no facilities located in the North Atlantic region are manufacturers with design intake flows greater than 50 MGD that would have technology requirements under the "Manufacturers 50+ MGD I-only Everywhere" option. Thus no recreational benefits are expected under these options in the North Atlantic region.

Table C4-2 presents EPA's estimates of the annualized recreational benefits of the remaining supplemental option in the North Atlantic region.

Table C4-2: Recreational Fishing Benefits of the "Manufacturers 50+ MGD I&E Everywhere" Option in the North Atlantic Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	0.0[d]	$1.58	$5.00	$15.52	$0.0[e]	$0.1	$0.3
Flatfish	0.0[d]	$2.91	$5.02	$8.70	$0.1	$0.2	$0.3
Other saltwater	8.2	$1.31	$2.51	$4.82	$10.7	$20.5	$39.4
Unidentified	0.0[d]	$1.32	$2.53	$4.86	$0.0[e]	$0.0[e]	$0.0[e]
Total (undiscounted)	8.2				$10.9	$20.8	$40.0
Total (evaluated at 3% discount rate)	8.2				$8.9	$17.0	$32.7
Total (evaluated at 7% discount rate)	8.2				$6.9	$13.2	$25.3

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.
[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.
[d] Denotes a positive value less than 50 fish.
[e] Denotes a positive value less than $50.

Source: U.S. EPA analysis for this report.

C4-2   Comparison of Recreational Fishing Benefits by Option

Table C4-3 compares the recreational fishing benefits of the several supplemental options.

Table C4-3: Annual Recreational Benefits of the Supplemental Options in the North Atlantic Region				
Policy Option	**Annual Reduction in Recreational Fishing Losses from I&E (thousands of fish)**	**Undiscounted Recreational Fishing Benefits (thousands; 2004$)[a]**		
		Low	**Mean**	**High**
Electric Generators 2-50 MGD[b]				
I-only Everywhere	0.0	$0.0	$0.0	$0.0
I&E like Phase II	0.0	$0.0	$0.0	$0.0
I&E Everywhere	0.0	$0.0	$0.0	$0.0
Manufacturers 2-50 MGD[b]				
I-only Everywhere	0.0	$0.0	$0.0	$0.0
I&E like Phase II	0.0	$0.0	$0.0	$0.0
I&E Everywhere	0.0	$0.0	$0.0	$0.0
Manufacturers 50+ MGD				
I-only Everywhere[c]	0.0	$0.0	$0.0	$0.0
I&E Everywhere	8.2	$10.9	$20.8	$40.0

[a] These benefit estimates were calculated using the meta-analysis approach discussed in Chapter A5 and Chapter B4.
[b] No facilities located in the North Atlantic region are electric generators or manufacturers with design intake flows greater than 2 MGD and less than 50 MGD, so no facilities would have technology requirements under the "Electric Generators 2-50 MGD I-only Everywhere" option, the "Electric Generators 2-50 MGD I&E like Phase II" option, the "Electric Generators 2-50 MGD I&E Everywhere" option, the "Manufacturers 2-50 MGD I-only Everywhere" option, the "Manufacturers 2-50 MGD I&E like Phase II" option, or the "Manufacturers 2-50 MGD I&E Everywhere" option. Thus no recreational benefits are expected under these options in the North Atlantic region.
[c] No facilities located in the North Atlantic region are manufacturers with design intake flows greater than 50 MGD that would have technology requirements under the "Manufacturers 50+ MGD I-only Everywhere" option. Thus no recreational benefits are expected under this option in the North Atlantic region.

Source: U.S. EPA analysis for this report.

Chapter C5: Federally Listed T&E Species in the North Atlantic Region

This chapter lists current federally listed threatened and endangered (T&E) fish and shellfish species in the North Atlantic Region. This list does not address proposed or candidate species; In addition, fish and shellfish listed as cave species, marine mammals, reptiles, amphibians, and snails are not included in this chapter.

Table C5-1: Connecticut Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
E	*Acipenser brevirostrum*	Shortnose sturgeon
E	*Alasmidonta heterodon*	Dwarf wedgemussel

Source: USFWS, 2006a.

Table C5-2: Maine Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
E	*Acipenser brevirostrum*	Shortnose sturgeon
E	*Salmo salar*	Atlantic salmon (Gulf of Maine Atlantic salmon DPS)

Source: USFWS, 2006a.

Table C5-3: Massachusetts Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
E	*Acipenser brevirostrum*	Shortnose sturgeon
E	*Alasmidonta heterodon*	Dwarf wedgemussel

Source: USFWS, 2006a.

Table C5-4: New Hampshire Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
E	*Alasmidonta heterodon*	Dwarf wedgemussel

Source: USFWS, 2006a.

Part D: Mid-Atlantic Region

Part D: Mid-Atlantic Region

Chapter D1: Background

Introduction

This chapter presents an overview of the potential Phase III existing facilities in the Mid-Atlantic study region and summarizes their key cooling water and compliance characteristics. For further discussion of the technical and compliance characteristics of potential Phase III existing facilities, refer to the *Economic Analysis for the Final Section 316(b) Rule for Phase III Facilities* and the *Technical Development Document for the Final Section 316(b) Rule for Phase III Facilities* (U.S. EPA, 2006a,c).

Chapter Contents

D1-1   Facility Characteristics

The Mid-Atlantic Regional Study includes nine sample facilities that are potentially subject to the national standards for Phase III existing facilities. Figure D1-1 presents a map of these facilities. Five of them are manufacturing facilities and four are electric generators. Industry-wide, these nine sample facilities represent 15 facilities.[1]

---

[1] EPA applied sample weights to the survey respondents to account for non-sampled facilities and facilities that did not respond to the survey. For more information on EPA's 2000 Section 316(b) Industry Survey, please refer to the Information Collection Request (U.S. EPA, 2000b).

Figure D1-1: Potential Existing Phase III Facilities in the Mid-Atlantic Regional Study[a]

[a] The map includes locations of sample facilities only.

Source: U.S. EPA analysis for this report.

Table D1-1 summarizes key technical and compliance characteristics for all potentially regulated Phase III existing facilities in the Mid-Atlantic study region for the regulatory options considered by EPA for this rule (the "50 MGD for All Waterbodies" option, the "200 MGD for All Waterbodies" option, and the "100 MGD for Certain Waterbodies" option). Facilities with a design intake flow below the three applicability thresholds would be subject to permitting based on best professional judgment and are excluded from EPA's analyses.[2] Therefore, a different number of facilities is affected under each option.

Table D1-1 shows that 15 Phase III existing facilities in the Mid-Atlantic study region would potentially be subject to the national requirements. Under the "50 MGD for All Waterbodies" option, the most inclusive of the regulatory options, three facilities would be subject to the national requirements for Phase III existing facilities. Under the less inclusive "200 MGD for All Waterbodies" option and "100 MGD for Certain Waterbodies" option, two facilities would be subject to the national requirements. Two facilities in the Mid-Atlantic study region have a recirculating system in the baseline.

Table D1-1: Technical and Compliance Characteristics of Existing Phase III Facilities (sample-weighted)				
	All Potentially Regulated Facilities	**Regulatory Options**		
		50 MGD All	**200 MGD All**	**100 MGD CWB**
Total Number of Facilities (sample-weighted)	**15**	**3**	**2**	**2**
Number of Facilities with Recirculating System in Baseline	**2**	**-**	**-**	**-**
Design Intake Flow (MGD)	**982**	w.[a]	w.[a]	w.[a]
Number of Facilities by Compliance Response				
Fine mesh traveling screens with fish H&R	1	1	1	1
New larger intake structure with fine mesh and fish H&R	1	1	-	-
Passive fine mesh screens	2	1	1	1
None	11	-	-	-
Compliance Cost, Discounted at 3%[b]	$2.68	$1.22	$0.80	$0.80
Compliance Cost, Discounted at 7%[b]	$2.54	$1.18	$0.74	$0.74

[a] Data withheld because of confidentiality reasons.
[b] Annualized pre-tax compliance cost (2004$, millions).

Sources: U.S. EPA, 2000b; U.S. EPA analysis for this report.

---

[2] Also excluded are facilities that are estimated to be baseline closures. For additional information on EPA's baseline closure analyses, please refer to the *Economic Analysis for the Final Section 316(b) Rule for Phase III Facilities* (U.S. EPA, 2006a).

Appendix D1: Life History Parameter Values Used to Evaluate I&E in the Mid-Atlantic Region

The tables in this appendix present the life history parameter values used by EPA to calculate age-1 equivalents and fishery yields from impingement and entrainment (I&E) data for the Mid-Atlantic region. Because of differences in the number of life stages represented in the loss data, there are cases where more than one life stage sequence was needed for a given species or species group. Alternative parameter sets were developed for this purpose and are indicated with a number following the species or species group name (i.e., Alewife 1, Alewife 2).

Table D1-1: Alewife Life History Parameters 1				
Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.554	0	0	0.000000716
Yolksac larvae	1.81	0	0	0.000000728
Post-yolksac larvae	1.72	0	0	0.00000335
Juvenile 1	3.11	0	0	0.000746
Juvenile 2	3.11	0	0	0.0155
Age 1+	0.300	0	0	0.0303
Age 2+	0.300	0	0	0.125
Age 3+	0.300	0	0	0.254
Age 4+	0.900	0.1	0.45	0.379
Age 5+	1.50	0.1	0.9	0.485
Age 6+	1.50	0.1	1	0.565
Age 7+	1.50	0.1	1	0.625
Age 8+	1.50	0.1	1	0.666
Source: PSE&G, 1999.				

Table D1-2: Alewife Life History Parameters 2

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.554	0	0	0.000000716
Larvae	3.53	0	0	0.00000204
Juvenile	6.21	0	0	0.000746
Age 1+	0.300	0	0	0.0303
Age 2+	0.300	0	0	0.125
Age 3+	0.300	0	0	0.254
Age 4+	0.900	0.1	0.45	0.379
Age 5+	1.50	0.1	0.9	0.485
Age 6+	1.50	0.1	1.0	0.565
Age 7+	1.50	0.1	1.0	0.625
Age 8+	1.50	0.1	1.0	0.666

Source: PSE&G, 1999.

Table D1-3: American Shad Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.496	0	0	0.000000716
Yolksac larvae	0.496	0	0	0.000000728
Post-yolksac larvae	2.52	0	0	0.00000335
Juvenile	7.4	0	0	0.000746
Age 1+	0.3	0	0	0.309
Age 2+	0.3	0	0	1.17
Age 3+	0.3	0	0	2.32
Age 4+	0.54	0.21	0.45	3.51
Age 5+	1.02	0.21	0.90	4.56
Age 6+	1.5	0.21	1.0	5.47
Age 7+	1.5	0.21	1.0	6.20
Age 8+	1.5	0.21	1.0	6.77

Sources: USFWS, 1978; Able and Fahay, 1998; PSE&G, 1999; and Froese and Pauly, 2001.

Table D1-4: Atlantic Croaker Life History Parameters 1

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.817	0	0	0.0000000128
Yolksac larvae	3.27	0	0	0.0000000441
Post-yolksac larvae	4.90	0	0	0.000000246
Juvenile 1	1.18	0	0	0.0000120
Juvenile 2	2.20	0	0	0.000113
Age 1+	1.09	0.3	0.50	0.220
Age 2+	0.300	0.3	1.0	0.672
Age 3+	0.300	0.3	1.0	1.24
Age 4+	0.300	0.3	1.0	1.88
Age 5+	0.300	0.3	1.0	2.43
Age 6+	0.300	0.3	1.0	3.26
Age 7+	0.300	0.3	1.0	3.26
Age 8+	0.300	0.3	1.0	3.26

Source: PSE&G, 1999.

Table D1-5: Atlantic Croaker Life History Parameters 2

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.817	0	0	0.0000000128
Larvae	8.10	0	0	0.000000145
Juvenile	3.38	0	0	0.0000624
Age 1+	1.09	0.3	0.50	0.220
Age 2+	0.300	0.3	1.0	0.672
Age 3+	0.300	0.3	1.0	1.24
Age 4+	0.300	0.3	1.0	1.88
Age 5+	0.300	0.3	1.0	2.43
Age 6+	0.300	0.3	1.0	3.26
Age 7+	0.300	0.3	1.0	3.26
Age 8+	0.300	0.3	1.0	3.26

Source: PSE&G, 1999.

Table D1-6: Atlantic Menhaden Life History Parameters 1

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.08	0	0	0.000000716
Yolksac larvae	2.85	0	0	0.000000728
Post-yolksac larvae	2.85	0	0	0.00000335
Juvenile	2.85	0	0	0.000746
Age 1+	0.450	0	0	0.0937
Age 2+	0.450	0.8	0.50	0.356
Age 3+	0.450	0.8	1.0	0.679
Age 4+	0.450	0.8	1.0	0.974
Age 5+	0.450	0.8	1.0	1.21
Age 6+	0.450	0.8	1.0	1.38

Sources: USFWS, 1978; Durbin et al., 1983; Ruppert et al., 1985; Entergy Nuclear Generation Company, 2000; ASMFC, 2001b; and Froese and Pauly, 2001.

Table D1-7: Atlantic Menhaden Life History Parameters 2

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.07	0	0	0.000000716
Larvae	5.71	0	0	0.00000204
Juvenile	2.85	0	0	0.000746
Age 1+	0.45	0	0	0.0937
Age 2+	0.45	0.8	0.50	0.356
Age 3+	0.45	0.8	1.0	0.679
Age 4+	0.45	0.8	1.0	0.974
Age 5+	0.45	0.8	1.0	1.21
Age 6+	0.45	0.8	1.0	1.38

Sources: USFWS, 1978; Durbin et al., 1983; Ruppert et al., 1985; Entergy Nuclear Generation Company, 2000; ASMFC, 2001b; and Froese and Pauly, 2001.

Table D1-8: Atlantic Tomcod Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	8.46	0	0	0.00000126
Larvae	8.46	0	0	0.0000185
Juvenile	8.46	0	0	0.0145
Age 1+	8.46	0	0	0.080
Age 2+	2.83	0	0	0.270
Age 3+	2.83	0	0	0.486

Sources: Stewart and Auster, 1987; McLaren et al., 1988; Virginia Tech, 1998; and NMFS, 2003a.

Table D1-9: Bay Anchovy Life History Parameters 1

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.04	0	0	0.0000000186
Yolksac larvae	1.57	0	0	0.0000000441
Post-yolksac larvae 1	2.11	0	0	0.0000000929
Post-yolksac larvae 2	4.02	0	0	0.00000461
Juvenile 1	0.0822	0	0	0.0000495
Juvenile 2	0.0861	0	0	0.000199
Juvenile 3	0.129	0	0	0.000532
Juvenile 4	0.994	0	0	0.00114
Age 1+	1.62	0	0	0.00381
Age 2+	1.62	0	0	0.00496
Age 3+	1.62	0	0	0.00505

Sources: Derickson and Price, 1973; PSE&G, 1999; and NMFS, 2003a.

Table D1-10: Bay Anchovy Life History Parameters 2

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.04	0	0	0.0000000186
Larvae	7.70	0	0	0.00000158
Juvenile	1.29	0	0	0.000481
Age 1+	1.62	0	0	0.00381
Age 2+	1.62	0	0	0.00496
Age 3+	1.62	0	0	0.00505

Sources: Derickson and Price, 1973; PSE&G, 1999; and NMFS, 2003a.

Table D1-11: Bay Anchovy Life History Parameters 3

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.04	0	0	0.0000000186
Yolksac larvae	1.57	0	0	0.0000000441
Post-yolksac larvae	6.12	0	0	0.00000235
Juvenile	1.29	0	0	0.000481
Age 1+	1.62	0	0	0.00381
Age 2+	1.62	0	0	0.00496
Age 3+	1.62	0	0	0.00505

Sources: Derickson and Price, 1973; PSE&G, 1999; and NMFS, 2003a.

Table D1-12: Blue Crab Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Megalops	1.30	0	0	0.00000291
Juvenile	1.73	0.48	0.5	0.00000293
Age 1+	1.10	0.48	1	0.007
Age 2+	1.38	0.48	1	0.113
Age 3+	1.27	0.48	1	0.326

Sources: Hartman, 1993; and PSE&G, 1999.

Table D1-13: Blueback Herring Life History Parameters 1

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.558	0	0	0.000000716
Yolksac larvae	1.83	0	0	0.000000728
Post-yolksac larvae	1.74	0	0	0.00000335
Juvenile 1	3.13	0	0	0.000746
Juvenile 2	3.13	0	0	0.00836
Age 1+	0.300	0	0	0.0160
Age 2+	0.300	0	0	0.0905
Age 3+	0.300	0	0	0.204
Age 4+	0.900	0	0	0.318
Age 5+	1.50	0	0	0.414
Age 6+	1.50	0	0	0.488
Age 7+	1.50	0	0	0.540
Age 8+	1.50	0	0	0.576

Sources: PSE&G, 1999; and NMFS, 2003a.

Table D1-14: Blueback Herring Life History Parameters 2

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.558	0	0	0.000000716
Larvae	3.18	0	0	0.00000204
Juvenile	6.26	0	0	0.000746
Age 1+	0.300	0	0	0.0160
Age 2+	0.300	0	0	0.0905
Age 3+	0.300	0	0	0.204
Age 4+	0.900	0	0	0.318
Age 5+	1.50	0	0	0.414
Age 6+	1.50	0	0	0.488
Age 7+	1.50	0	0	0.540
Age 8+	1.50	0	0	0.576

Sources: PSE&G, 1999; and NMFS, 2003a.

Table D1-15: Hogchoker Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.04	0	0	0.000000487
Larvae	5.20	0	0	0.00110
Juvenile	2.31	0	0	0.00207
Age 1+	2.56	0	0	0.0113
Age 2+	0.705	0	0	0.0313
Age 3+	0.705	0	0	0.0610
Age 4+	0.705	0	0	0.0976
Age 5+	0.705	0	0	0.138
Age 6+	0.705	0	0	0.178

Sources: PG&E National Energy Group, 2001; Froese and Pauly, 2003; and NMFS, 2003a.

Table D1-16: Naked Goby Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.288	0	0	0.0000370
Larvae	4.09	0	0	0.000221
Juvenile	2.30	0	0	0.000485
Age 1+	2.55	0	0	0.00205

Sources: PG&E National Energy Group, 2001; and Froese and Pauly, 2003.

Table D1-17: Spot Life History Parameters 1

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.825	0	0	0.000000131
Yolksac larvae	3.30	0	0	0.000000154
Post-yolksac larvae	4.12	0	0	0.000000854
Juvenile 1	1.58	0	0	0.0000226
Juvenile 2	0.99	0.247	0.30	0.000220
Age 1+	0.463	0.40	1.0	0.0791
Age 2+	0.400	0.40	1.0	0.299
Age 3+	0.400	0.40	1.0	0.507
Age 4+	0.400	0.40	1.0	0.648
Age 5+	0.400	0.40	1.0	0.732
Age 6+	0.400	0.40	1.0	0.779
Age 7+	0.400	0.40	1.0	0.779
Age 8+	0.400	0.40	1.0	0.779
Age 9+	0.400	0.40	1.0	0.779
Age 10+	0.400	0.40	1.0	0.779
Age 11+	0.400	0.40	1.0	0.779
Age 12+	0.400	0.40	1.0	0.779
Age 13+	0.400	0.40	1.0	0.779
Age 14+	0.400	0.40	1.0	0.779
Age 15+	0.400	0.40	1.0	0.779

Sources: Schwartz et al., 1979; and PSE&G, 1984, 1999.

Table D1-18: Spot Life History Parameters 2

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.825	0	0	0.000000131
Larvae	7.40	0	0	0.000000504
Juvenile	2.57	0	0	0.000121
Age 1+	0.463	0.40	1.0	0.0791
Age 2+	0.400	0.40	1.0	0.299
Age 3+	0.400	0.40	1.0	0.507
Age 4+	0.400	0.40	1.0	0.648
Age 5+	0.400	0.40	1.0	0.732
Age 6+	0.400	0.40	1.0	0.779
Age 7+	0.400	0.40	1.0	0.779
Age 8+	0.400	0.40	1.0	0.779
Age 9+	0.400	0.40	1.0	0.779
Age 10+	0.400	0.40	1.0	0.779
Age 11+	0.400	0.40	1.0	0.779
Age 12+	0.400	0.40	1.0	0.779
Age 13+	0.400	0.40	1.0	0.779
Age 14+	0.400	0.40	1.0	0.779
Age 15+	0.400	0.40	1.0	0.779

Sources: Schwartz et al., 1979; and PSE&G, 1984, 1999.

Table D1-19: Striped Bass Life History Parameters 1

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.39	0	0	0.000000224
Yolksac larvae	2.22	0	0	0.000000243
Post-yolksac larvae	5.11	0	0	0.0000119
Juvenile 1	2.28	0	0	0.000154
Juvenile 2	1.00	0	0	0.0216
Age 1+	1.10	0	0	0.485
Age 2+	0.150	0.31	0.06	2.06
Age 3+	0.150	0.31	0.20	3.31
Age 4+	0.150	0.31	0.63	4.93
Age 5+	0.150	0.31	0.94	6.50
Age 6+	0.150	0.31	1.0	8.58
Age 7+	0.150	0.31	0.90	12.3
Age 8+	0.150	0.31	0.90	14.3
Age 9+	0.150	0.31	0.90	16.1
Age 10+	0.150	0.31	0.90	18.8
Age 11+	0.150	0.31	0.90	19.6
Age 12+	0.150	0.31	0.90	22.4
Age 13+	0.150	0.31	0.90	27.0
Age 14+	0.150	0.31	0.90	34.6
Age 15+	0.150	0.31	0.90	41.5

Sources: Bason, 1971; and PSE&G, 1999.

Table D1-20: Striped Bass Life History Parameters 2

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.39	0	0	0.000000224
Larvae	7.32	0	0	0.00000606
Juvenile	3.29	0	0	0.0109
Age 1+	1.10	0	0	0.485
Age 2+	0.150	0.31	0.06	2.06
Age 3+	0.150	0.31	0.20	3.31
Age 4+	0.150	0.31	0.63	4.93
Age 5+	0.150	0.31	0.94	6.5
Age 6+	0.150	0.31	1.0	8.58
Age 7+	0.150	0.31	0.90	12.3
Age 8+	0.150	0.31	0.90	14.3
Age 9+	0.150	0.31	0.90	16.1
Age 10+	0.150	0.31	0.90	18.8
Age 11+	0.150	0.31	0.90	19.6
Age 12+	0.150	0.31	0.90	22.4
Age 13+	0.150	0.31	0.90	27
Age 14+	0.150	0.31	0.90	34.6
Age 15+	0.150	0.31	0.90	41.5

Sources: Bason, 1971; and PSE&G, 1999.

Table D1-21: Striped Bass Life History Parameters 3

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.39	0	0	0.000000224
Yolksac larvae	2.22	0	0	0.000000243
Post-yolksac larvae	5.11	0	0	0.0000119
Juvenile	3.29	0	0	0.248
Age 1+	1.10	0	0	0.485
Age 2+	0.150	0.31	0.06	2.06
Age 3+	0.150	0.31	0.20	3.31
Age 4+	0.150	0.31	0.63	4.93
Age 5+	0.150	0.31	0.94	6.50
Age 6+	0.150	0.31	1.0	8.58
Age 7+	0.150	0.31	0.90	12.3
Age 8+	0.150	0.31	0.90	14.3
Age 9+	0.150	0.31	0.90	16.1
Age 10+	0.150	0.31	0.90	18.8
Age 11+	0.150	0.31	0.90	19.6
Age 12+	0.150	0.31	0.90	22.4
Age 13+	0.150	0.31	0.90	27
Age 14+	0.150	0.31	0.90	34.6
Age 15+	0.150	0.31	0.90	41.5

Sources: Bason, 1971; and PSE&G, 1999.

Table D1-22: Summer Flounder Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.288	0	0	0.00000109
Larvae	4.37	0	0	0.00000532
Juvenile	2.38	0	0	0.208
Age 1+	0.200	0.26	0.50	0.919
Age 2+	0.200	0.26	1.0	1.02
Age 3+	0.200	0.26	1.0	2.50
Age 4+	0.200	0.26	1.0	3.56
Age 5+	0.200	0.26	1.0	5.09
Age 6+	0.200	0.26	1.0	5.83
Age 7+	0.200	0.26	1.0	6.64
Age 8+	0.200	0.26	1.0	8.16
Age 9+	0.200	0.26	1.0	9.90
Age 10+	0.200	0.26	1.0	11.9
Age 11+	0.200	0.26	1.0	14.1
Age 12+	0.200	0.26	1.0	16.6
Age 13+	0.200	0.26	1.0	19.4
Age 14+	0.200	0.26	1.0	22.5

Sources: Wang and Kernehan, 1979; Grimes et al., 1989; Packer et al., 1999; Bolz et al., 2000; NOAA, 2001b; PG&E National Energy Group, 2001; and Froese and Pauly, 2003.

Table D1-23: Weakfish Life History Parameters 1

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.04	0	0	0.0000000787
Yolksac larvae	1.34	0	0	0.0000000882
Post-yolksac larvae	6.33	0	0	0.000000382
Juvenile 1	2.44	0	0	0.0000184
Juvenile 2	1.48	0	0	0.0502
Age 1+	0.349	0.25	0.10	0.260
Age 2+	0.250	0.25	0.50	0.680
Age 3+	0.250	0.25	1.0	1.12
Age 4+	0.250	0.25	1.0	1.79
Age 5+	0.250	0.25	1.0	2.91
Age 6+	0.250	0.25	1.0	6.21
Age 7+	0.250	0.25	1.0	7.14
Age 8+	0.250	0.25	1.0	9.16
Age 9+	0.250	0.25	1.0	10.8
Age 10+	0.250	0.25	1.0	12.5
Age 11+	0.250	0.25	1.0	12.5
Age 12+	0.250	0.25	1.0	12.5
Age 13+	0.250	0.25	1.0	12.5
Age 14+	0.250	0.25	1.0	12.5
Age 15+	0.250	0.25	1.0	12.5

Sources: Thomas, 1971; and PSE&G, 1999.

Table D1-24: Weakfish Life History Parameters 2

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.04	0	0	0.0000000787
Larvae	7.70	0	0	0.000000235
Juvenile	3.92	0	0	0.0251
Age 1+	0.349	0.25	0.10	0.260
Age 2+	0.250	0.25	0.50	0.680
Age 3+	0.250	0.25	1.0	1.12
Age 4+	0.250	0.25	1.0	1.79
Age 5+	0.250	0.25	1.0	2.91
Age 6+	0.250	0.25	1.0	6.21
Age 7+	0.250	0.25	1.0	7.14
Age 8+	0.250	0.25	1.0	9.16
Age 9+	0.250	0.25	1.0	10.8
Age 10+	0.250	0.25	1.0	12.5
Age 11+	0.250	0.25	1.0	12.5
Age 12+	0.250	0.25	1.0	12.5
Age 13+	0.250	0.25	1.0	12.5
Age 14+	0.250	0.25	1.0	12.5
Age 15+	0.250	0.25	1.0	12.5

Sources: Thomas, 1971; and PSE&G, 1999.

Table D1-25: White Perch Life History Parameters 1

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.75	0	0	0.000000330
Yolksac larvae	2.10	0	0	0.000000353
Post-yolksac larvae	3.27	0	0	0.00000507
Juvenile 1	0.947	0	0	0.000317
Juvenile 2	0.759	0	0	0.00486
Age 1+	0.693	0	0	0.0198
Age 2+	0.693	0	0	0.0567
Age 3+	0.693	0.15	0.00080	0.103
Age 4+	0.689	0.15	0.027	0.150
Age 5+	1.58	0.15	0.21	0.214
Age 6+	1.54	0.15	0.48	0.265
Age 7+	1.48	0.15	0.84	0.356
Age 8+	1.46	0.15	1.0	0.387
Age 9+	1.46	0.15	1.0	0.516
Age 10+	1.46	0.15	1.0	0.619

Sources: Horseman and Shirey, 1974; and PSE&G, 1999.

Table D1-26: White Perch Life History Parameters 2

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.75	0	0	0.000000330
Larvae	5.37	0	0	0.00000271
Juvenile	1.71	0	0	0.00259
Age 1+	0.693	0	0	0.0198
Age 2+	0.693	0	0	0.0567
Age 3+	0.693	0.15	0.00080	0.103
Age 4+	0.689	0.15	0.027	0.150
Age 5+	1.58	0.15	0.21	0.214
Age 6+	1.54	0.15	0.48	0.265
Age 7+	1.48	0.15	0.84	0.356
Age 8+	1.46	0.15	1.0	0.387
Age 9+	1.46	0.15	1.0	0.516
Age 10+	1.46	0.15	1.0	0.619

Sources: Horseman and Shirey, 1974; and PSE&G, 1999.

Table D1-27: White Perch Life History Parameters 3

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.75	0	0	0.000000330
Yolksac larvae	2.10	0	0	0.000000353
Post-yolksac larvae	3.27	0	0	0.00000507
Juvenile	1.71	0	0	0.00259
Age 1+	0.693	0	0	0.0198
Age 2+	0.693	0	0	0.0567
Age 3+	0.693	0.15	0.00080	0.103
Age 4+	0.689	0.15	0.027	0.150
Age 5+	1.58	0.15	0.21	0.214
Age 6+	1.54	0.15	0.48	0.265
Age 7+	1.48	0.15	0.84	0.356
Age 8+	1.46	0.15	1.0	0.387
Age 9+	1.46	0.15	1.0	0.516
Age 10+	1.46	0.15	1.0	0.619

Sources: Horseman and Shirey, 1974; and PSE&G, 1999.

Table D1-28: Windowpane Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.41	0	0	0.00000154
Larvae	6.99	0	0	0.00165
Juvenile	2.98	0	0	0.00223
Age 1+	0.420	0	0	0.0325
Age 2+	0.420	1.6	0.25	0.122
Age 3+	0.420	1.6	0.61	0.265
Age 4+	0.420	1.6	1.0	0.433
Age 5+	0.420	1.6	1.0	0.603
Age 6+	0.420	1.6	1.0	0.761
Age 7+	0.420	1.6	1.0	0.899
Age 8+	0.420	1.6	1.0	1.02
Age 9+	0.420	1.6	1.0	1.11
Age 10+	0.420	1.6	1.0	1.19

Sources: Hendrickson, 2000; PG&E National Energy Group, 2001; USGen New England, 2001; and Froese and Pauly, 2003.

Table D1-29: Winter Flounder Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.288	0	0	0.00000115
Larvae	4.37	0	0	0.0138
Juvenile	2.38	0	0	0.0330
Age 1+	1.10	0.24	0.01	0.208
Age 2+	0.924	0.24	0.29	0.562
Age 3+	0.200	0.24	0.80	0.997
Age 4+	0.200	0.24	0.92	1.42
Age 5+	0.200	0.24	0.83	1.78
Age 6+	0.200	0.24	0.89	2.07
Age 7+	0.200	0.24	0.89	2.29
Age 8+	0.200	0.24	0.89	2.45
Age 9+	0.200	0.24	0.89	2.57
Age 10+	0.200	0.24	0.89	2.65
Age 11+	0.200	0.24	0.89	2.71
Age 12+	0.200	0.24	0.89	2.75
Age 13+	0.200	0.24	0.89	2.78
Age 14+	0.200	0.24	0.89	2.80
Age 15+	0.200	0.24	0.89	2.82
Age 16+	0.200	0.24	0.89	2.83

Sources: Able and Fahay, 1998; Colarusso, 2000; Nitschke et al., 2000; and PG&E National Energy Group, 2001.

Table D1-30: Other Commercial Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.08	0	0	0.000000716
Larvae	5.71	0	0	0.00000204
Juvenile	2.85	0	0	0.000746
Age 1+	0.450	0	0	0.0937
Age 2+	0.450	0.80	0.5	0.356
Age 3+	0.450	0.80	1.0	0.679
Age 4+	0.450	0.80	1.0	0.974
Age 5+	0.450	0.80	1.0	1.21
Age 6+	0.450	0.80	1.0	1.38

[a] Includes American butterfish, American eel, brown bullhead, channel catfish, conger eel, gizzard shad, harvestfish, silver hake, white catfish, and yellow perch.

Sources: Durbin et al., 1983; Able and Fahay, 1998; and PSE&G, 1999.

Table D1-31: Other Recreational Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.08	0	0	0.000000716
Larvae	5.71	0	0	0.00000204
Juvenile	2.85	0	0	0.000746
Age 1+	0.450	0	0	0.0937
Age 2+	0.450	0.80	0.5	0.356
Age 3+	0.450	0.80	1.0	0.679
Age 4+	0.450	0.80	1.0	0.974
Age 5+	0.450	0.80	1.0	1.21
Age 6+	0.450	0.80	1.0	1.38

[a] Includes black drum, black sea bass, bluefish, northern puffer, northern searobin, orange filefish, oyster toadfish, sea lamprey, spotted hake, and spotted seatrout.

Sources: USFWS, 1978; Durbin et al., 1983; Ruppert et al., 1985; Able and Fahay, 1998; PSE&G, 1999; Entergy Nuclear Generation Company, 2000; and ASMFC, 2001b.

Table D1-32: Other Recreational and Commercial Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.08	0	0	0.000000716
Yolksac larvae	2.85	0	0	0.000000728
Post-yolksac larvae	2.85	0	0	0.00000335
Juvenile 1	1.43	0	0	0.000746
Juvenile 2	1.43	0	0	0.0472
Age 1+	0.450	0	0	0.0937
Age 2+	0.450	0.80	0.5	0.356
Age 3+	0.450	0.80	1.0	0.679
Age 4+	0.450	0.80	1.0	0.974
Age 5+	0.450	0.80	1.0	1.21
Age 6+	0.450	0.80	1.0	1.38

[a] Includes species designated as other commercial from Salem.

Sources: USFWS, 1978; Durbin et al., 1983; Ruppert et al., 1985; Able and Fahay, 1998; PSE&G, 1999; Entergy Nuclear Generation Company, 2000; and ASMFC, 2001b.

Table D1-33: Other Forage Species Life History Parameters 1[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.04	0	0	0.0000000186
Yolksac larvae	1.57	0	0	0.0000000441
Post-yolksac larvae 1	2.11	0	0	0.0000000929
Post-yolksac larvae 2	4.02	0	0	0.00000461
Juvenile 1	0.0822	0	0	0.0000495
Juvenile 2	0.0861	0	0	0.000199
Juvenile 3	0.129	0	0	0.000532
Juvenile 4	0.994	0	0	0.001161
Age 1+	1.62	0	0	0.00381
Age 2+	1.62	0	0	0.00496
Age 3+	1.62	0	0	0.00505

[a] Includes species designated as other forage from Salem.

Sources: Derickson and Price, 1973; and PSE&G, 1999.

Table D1-34: Other Forage Species Life History Parameters 2[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.04	0	0	0.0000000186
Larvae	7.70	0	0	0.00000158
Juvenile	1.29	0	0	0.000481
Age 1+	1.62	0	0	0.00381
Age 2+	1.62	0	0	0.00496
Age 3+	1.62	0	0	0.00505

[a] Includes Atlantic herring, Atlantic needlefish, Atlantic silverside, banded killifish, blackcheek tonguefish, bluegill, chain pickerel, fourspine stickleback, golden shiner, inland silverside, inshore lizardfish, lined seahorse, mississippi silvery minnow, mud minnow, mummichog, northern pipefish, northern stargazer, pumpkinseed, sheepshead minnow, skilletfish, spottail shiner, spotted codling, striped anchovy, striped blenny, striped killifish, threespine stickleback, and other organisms not identified to species.

Sources: Derickson and Price, 1973; and PSE&G, 1999.

Table D1-35: Other Forage Species Life History Parameters 3[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.04	0	0	0.0000000186
Yolksac larvae	1.57	0	0	0.0000000441
Post-yolksac larvae	6.10	0	0	0.00000662
Juvenile	1.29	0	0	0.000481
Age 1+	1.62	0	0	0.00381
Age 2+	1.62	0	0	0.00496
Age 3+	1.62	0	0	0.00505

[a] Includes inland silverside, river herring, and silversides not identified to species.

Sources: Derickson and Price, 1973; and PSE&G, 1999.

Chapter D2: Evaluation of Impingement and Entrainment in the Mid-Atlantic Region

Background: Mid-Atlantic Marine Fisheries

The Mid-Atlantic Fishery Management Council (MAFMC) manages fisheries in Federal waters off the Mid-Atlantic coast. The individual states control waters within three miles. States with voting representation on the MAFMC include New York, Pennsylvania, New Jersey, Delaware, Maryland, Virginia, and North Carolina. North Carolina is represented on both the MAFMC and the South Atlantic Fishery Management Council.

The MAFMC has fishery management plans in place for Atlantic mackerel (*Scomber scombrus*), squid (*Loligo pealeii* and *Illex illecebrosus*), butterfish (*Peprilus triacanthus*), Atlantic surf clam (*Spisula solidissima*), ocean quahog (*Arctica islandica*), Atlantic bluefish (*Pomatomus saltatrix*), summer flounder (*Paralichthys dentatus*), scup (*Stenotomus chrysops*), black sea bass (*Centropristis striata*), and monkfish (*Lophius americanus*). Mid-Atlantic groundfish fisheries are primarily for summer flounder, scup, goosefish (*Lophius americanus*), and black seabass (NMFS, 1999a). Summer flounder is one of the most valuable groundfish species in the region, and is targeted by both recreational and commercial fishers (NMFS, 1999a).

D2-1   I&E Species/Species Groups Evaluated

Table D2-1 provides a list of species/species groups in the Mid-Atlantic region that are subject to impingement and entrainment (I&E) and the species groups that were evaluated in EPA's analysis of regional I&E.

Table D2-1: Species/Species Groups Evaluated by EPA that are Subject to I&E in the Mid-Atlantic Region

Species/Species Group	Recreational	Commercial	Forage
Alewife		X	
American shad		X	
Atlantic croaker	X	X	
Atlantic herring	X	X	X
Atlantic menhaden		X	
Atlantic silverside			X
Atlantic tomcod			X
Bay anchovy			X
Black crappie	X	X	X
Black drum	X	X	

Table D2-1: Species/Species Groups Evaluated by EPA that are Subject to I&E in the Mid-Atlantic Region

Species/Species Group	Recreational	Commercial	Forage
Blue crab		X	
Blueback herring			X
Bluefish	X	X	X
Bluegill	X		
Bluntnose minnow	X	X	X
Brown bullhead	X		
Bullhead species	X		
Butterfish	X	X	X
Carp	X	X	X
Chain pipefish			X
Channel catfish	X		
Crabs (commercial)		X	
Crappie	X		
Cunner	X	X	X
Darter species	X		
Freshwater drum	X	X	X
Gizzard shad	X	X	X
Gobies	X	X	X
Grubby	X	X	X
Herrings	X	X	X
Hogchoker			X
Menhaden species	X		
Muskellunge	X		
Northern pipefish	X	X	X
Other (commercial)		X	
Other (forage)			X
Other (recreational and commercial)	X	X	
Other (recreational)	X		
Rainbow smelt	X	X	X
Red drum	X		
Red hake	X	X	X
Scup	X	X	X
Seaboard goby			X
Searobin	X	X	X
Shiner species			X
Silver hake	X	X	X
Silver perch	X	X	X
Silversides			X

Table D2-1: Species/Species Groups Evaluated by EPA that are Subject to I&E in the Mid-Atlantic Region

Species/Species Group	Recreational	Commercial	Forage
Smallmouth bass	X		
Spot	X	X	
Spotted seatrout	X		
Striped bass	X	X	
Striped killifish	X	X	X
Striped mullet	X	X	
Sucker species	X		
Summer flounder	X	X	
Sunfish	X	X	X
Tautog	X	X	X
Threespine stickleback	X	X	X
Weakfish	X	X	
White perch	X	X	
Whitefish	X		
Windowpane		X	
Winter flounder	X	X	
Yellow perch	X		

The life history data used in EPA's analysis and associated data sources are provided in Appendix D1 of this report.

D2-2 I&E Data Evaluated

Table D2-2 lists the facility I&E data evaluated by EPA to estimate current I&E rates for the Mid-Atlantic Region. See Chapter A1 of Part A for a discussion of methods used to extrapolate I&E data from these model facilities to Phase III facilities in the Mid-Atlantic without I&E data.

Table D2-2: Facility I&E Data Evaluated for the Mid-Atlantic Region Analysis

Facility	Phase	Years of Data
Baltimore Resco	II	1985
Bayway Refinery Company (NJ)	III	1975-1994
Calvert Cliffs Nuclear (MD)	II	1975-1995
Chalk Point (MD)	II	1976-1979
Gould Street	II	1979
Indian Point Nuclear (NY)	II	1981-1990
Indian River (DE)	II	1975-1976
Morgantown (MD)	II	1976

Table D2-2: Facility I&E Data Evaluated for the Mid-Atlantic Region Analysis

Facility	Phase	Years of Data
Motiva Enterprises LLC — Delaware City Refinery	III	1998-1999
Riverside	II	1979
Salem Nuclear (NJ)	II	1978-1998
Yorktown	II	1977

D2-3 EPA's Estimate of Current I&E at Phase III Facilities in the Mid-Atlantic Region Expressed as Age-1 Equivalents and Foregone Yield

Table D2-3 provides EPA's estimate of the annual age-1 equivalents and foregone fishery yield resulting from the impingement of aquatic species at facilities located in the Mid-Atlantic region. Table D2-4 displays this information for entrainment. Note that in these tables, "total yield" includes direct losses of harvested species and the yield of harvested species that is lost due to losses of forage species (trophic transfer).

Table D2-3: Estimated Current Annual Impingement at Phase III Facilities in the Mid-Atlantic Region Expressed as Age-1 Equivalents and Foregone Fishery Yield

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
Alewife	323	2
American shad	15	4
Atlantic croaker	25,400	5,230
Atlantic herring	1	<1
Atlantic menhaden	2,150,000	425,000
Atlantic silverside	26	<1
Atlantic tomcod	6	<1
Bay anchovy	967,000	<1
Black crappie	1	<1
Black drum	69	312
Blue crab	142,000	1,310
Blueback herring	1,270	<1
Bluefish	16	26
Bluegill	2	<1
Bluntnose minnow	1	<1
Brown bullhead	957	79
Bullhead species	957	79
Butterfish	160	5
Carp	7	<1
Chain pipefish	465	<1
Channel catfish	113	23
Crabs (commercial)	1,760	16

Table D2-3: Estimated Current Annual Impingement at Phase III Facilities in the Mid-Atlantic Region Expressed as Age-1 Equivalents and Foregone Fishery Yield

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
Crappie	<1	<1
Cunner	1	<1
Darter species	2	<1
Freshwater drum	<1	<1
Gizzard shad	39,400	<1
Gobies	19	<1
Grubby	26	<1
Herrings	1	<1
Hogchoker	49,700	<1
Menhaden species	<1	<1
Muskellunge	<1	<1
Northern pipefish	3,130	<1
Other (commercial)	38,400	7,590
Other (forage)	322,000	<1
Other (recreational and commercial)	29,000	5,720
Other (recreational)	2,750	542
Rainbow smelt	12	<1
Red drum	941	4,240
Red hake	245	75
Scup	1	<1
Seaboard goby	273	<1
Searobin	241	9
Shiner species	3,260	<1
Silver hake	78	10
Silver perch	329	<1
Silversides	27	<1
Smallmouth bass	117	5
Spot	274,000	30,600
Spotted seatrout	369	330
Striped bass	352	492
Striped killifish	25,900	<1
Striped mullet	73	35
Sucker species	1	<1
Summer flounder	2,200	3,110
Sunfish	193	<1
Tautog	<1	<1
Threespine stickleback	89	<1

Table D2-3: Estimated Current Annual Impingement at Phase III Facilities in the Mid-Atlantic Region Expressed as Age-1 Equivalents and Foregone Fishery Yield

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
Trophic transfer[a]	<1	619
Weakfish	23,400	18,400
White perch	184,000	81
Whitefish	69	62
Windowpane	156	3
Winter flounder	1,680	202
Yellow perch	166	2

[a] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

Table D2-4: Estimated Current Annual Entrainment at Phase III Facilities in the Mid-Atlantic Region Expressed as Age-1 Equivalents and Foregone Fishery Yield

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
Alewife	39	<1
American shad	148	36
Atlantic croaker	196,000	40,400
Atlantic herring	<1	<1
Atlantic menhaden	78,400	15,500
Atlantic silverside	<1	<1
Atlantic tomcod	<1	<1
Bay anchovy	77,100,000	<1
Black crappie	<1	<1
Black drum	<1	<1
Blue crab	2,690,000	24,900
Blueback herring	169	<1
Bluefish	<1	<1
Bluegill	<1	<1
Bluntnose minnow	<1	<1
Brown bullhead	<1	<1
Bullhead species	<1	<1
Butterfish	<1	<1
Carp	<1	<1
Chain pipefish	<1	<1
Channel catfish	<1	<1
Crabs (commercial)	<1	<1
Crappie	<1	<1

**Table D2-4: Estimated Current Annual Entrainment at Phase III
Facilities in the Mid-Atlantic Region Expressed as Age-1 Equivalents and
Foregone Fishery Yield**

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
Cunner	<1	<1
Darter species	<1	<1
Freshwater drum	<1	<1
Gizzard shad	<1	<1
Gobies	1,320	<1
Grubby	5	<1
Herrings	<1	<1
Hogchoker	30,400	<1
Menhaden species	79	16
Muskellunge	<1	<1
Northern pipefish	8,830	<1
Other (commercial)	1,450	287
Other (forage)	320,000	<1
Other (recreational and commercial)	73,500	14,500
Other (recreational)	<1	<1
Rainbow smelt	<1	<1
Red drum	<1	<1
Red hake	<1	<1
Scup	<1	<1
Seaboard goby	1,260,000	<1
Searobin	1	<1
Shiner species	113	<1
Silver hake	<1	<1
Silver perch	<1	<1
Silversides	<1	<1
Smallmouth bass	<1	<1
Spot	189,000	21,200
Spotted seatrout	<1	<1
Striped bass	20,300	28,300
Striped killifish	<1	<1
Striped mullet	<1	<1
Sucker species	<1	<1
Summer flounder	<1	<1
Sunfish	<1	<1
Tautog	<1	<1
Threespine stickleback	<1	<1
Trophic transfer[a]	<1	4,110

**Table D2-4: Estimated Current Annual Entrainment at Phase III
Facilities in the Mid-Atlantic Region Expressed as Age-1 Equivalents and
Foregone Fishery Yield**

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
Weakfish	36,400	28,700
White perch	115,000	51
Whitefish	<1	<1
Windowpane	<1	<1
Winter flounder	5,280	569
Yellow perch	32	<1

[a] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

D2-4   Reductions in I&E at Phase III Facilities in the Mid-Atlantic Region Under Alternative Options

Table D2-5 presents estimated reductions in I&E under the "50 MGD for All Waterbodies" option, the "200 MGD for All Waterbodies" option, and the "100 MGD for Certain Waterbodies" option. Reductions under all other options are presented in Appendix D2.

Table D2-5: Estimated Reductions in I&E Under Alternative Options

Option	Age-One Equivalents (#s)	Foregone Fishery Yield (lbs)
50 MGD All Option	44,500,000	212,000
200 MGD All Option	39,400,000	163,000
100 MGD Option	39,400,000	163,000

D2-5   Assumptions Used in Calculating Recreational and Commercial Losses

The lost yield estimates presented in Tables D2-3 and D2-4 are expressed as total pounds and include losses to both commercial and recreational catch. To estimate the economic value of these losses, total yield was partitioned between commercial and recreational fisheries based on the landings in each fishery. Table D2-6 presents the percentage impacts assumed for each species/species group.

See Chapter D3 for results of the commercial fishing benefits analysis and Chapter D4 for recreational fishing results. As discussed in Chapter A8, benefits were discounted to account for (1) the time to achieve compliance once a Phase III final regulation for existing facilities would have become effective, and (2) the time it takes for fish spared from I&E to reach a harvestable age.

Table D2-6: Percentage of Total Impacts Occurring to the Commercial and Recreational Fisheries and Commercial Value per Pound for Species Impinged and Entrained at Mid-Atlantic Facilities

Species/Species Group	Percent Impact to Recreational Fishery[a,b]	Percent Impact to Commercial Fishery[a,b]
Alewife	0.0%	100.0%
American plaice	0.0%	100.0%
American shad	0.0%	100.0%
Atlantic cod	50.0%	50.0%
Atlantic croaker	66.4%	33.6%
Atlantic herring	19.0%	81.0%
Atlantic mackerel	22.2%	77.8%
Atlantic menhaden	0.0%	100.0%
Bigmouth buffalo	100.0%	0.0%
Black bullhead	100.0%	0.0%
Black crappie	100.0%	0.0%
Black drum	93.0%	7.0%
Blue crab	0.0%	100.0%
Bluefish	89.1%	10.9%
Bluegill	100.0%	0.0%
Brown bullhead	100.0%	0.0%
Bullhead species	100.0%	0.0%
Butterfish	0.0%	100.0%
Channel catfish	100.0%	0.0%
Crabs (commercial)	0.0%	100.0%
Crappie	100.0%	0.0%
Cunner	100.0%	0.0%
Darter species	100.0%	0.0%
Drums and croakers	69.1%	30.9%
Flounders	100.0%	0.0%
Freshwater drum	100.0%	0.0%
Golden redhorse	100.0%	0.0%
Leatherjacket	0.0%	100.0%
Logperch	100.0%	0.0%
Mackerels	73.5%	26.5%
Menhaden species	100.0%	0.0%
Muskellunge	100.0%	0.0%
Other (commercial)	0.0%	100.0%
Other (recreational and commercial)[c]	50.0%	50.0%
Other (recreational)	100.0%	0.0%
Paddlefish	100.0%	0.0%
Pinfish	100.0%	0.0%
Pink shrimp	100.0%	0.0%
Pollock	50.0%	50.0%

Table D2-6: Percentage of Total Impacts Occurring to the Commercial and Recreational Fisheries and Commercial Value per Pound for Species Impinged and Entrained at Mid-Atlantic Facilities

Species/Species Group	Percent Impact to Recreational Fishery[a,b]	Percent Impact to Commercial Fishery[a,b]
Red drum	100.0%	0.0%
Red hake	0.0%	100.0%
River carpsucker	100.0%	0.0%
Salmon	100.0%	0.0%
Sauger	100.0%	0.0%
Sculpins	79.0%	21.0%
Scup	50.0%	50.0%
Searobin	83.9%	16.1%
Sheepshead	67.0%	33.0%
Silver hake	0.0%	100.0%
Silver perch	100.0%	0.0%
Skate species	0.0%	100.0%
Smallmouth bass	100.0%	0.0%
Smelts	100.0%	0.0%
Spot	52.4%	47.6%
Spotted seatrout	100.0%	0.0%
Spotted sucker	100.0%	0.0%
Stone crab	0.0%	100.0%
Striped bass	95.5%	4.5%
Striped mullet	10.1%	89.9%
Sturgeon species	100.0%	0.0%
Sucker species	100.0%	0.0%
Summer flounder	88.0%	12.0%
Sunfish	100.0%	0.0%
Tautog	92.2%	7.8%
Trophic transfer[d]	69.0%	31.0%
Walleye	100.0%	0.0%
Weakfish	77.2%	22.8%
White bass	100.0%	0.0%
White perch	66.0%	34.0%
Whitefish	100.0%	0.0%
Windowpane	0.0%	100.0%
Winter flounder	63.0%	37.0%
Yellow perch	100.0%	0.0%

[a] Based on landings from 1993 to 2001.
[b] Calculated using recreational landings data from NMFS (2003b, http://www.st.nmfs.gov/recreational/queries/catch/snapshot.html) and commercial landings data from NMFS (2003a, http://www.st.nmfs.gov/commercial/landings/annual_landings.html).
[c] Assumed equally likely to be caught by recreational or commercial fishers. Commercial value calculated as overall average for region based on data from NMFS (2003a).
[d] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

Appendix D2: Reductions in I&E Under Supplemental Policy Options

Table D2-1: Estimated Reductions in I&E in the Mid-Atlantic Region Under Supplemental Options		
Option	Age-1 Equivalents (#s)	Foregone Fishery Yield (lbs)
Electric Generators 2-50 MGD		
I-only Everywhere	26,600	3,120
I&E like Phase II	26,600	3,120
I&E Everywhere	1,480,000	6,280
Manufacturers 2-50 MGD		
I-only Everywhere	150,000	17,700
I&E like Phase II	2,310,000	22,400
I&E Everywhere	2,310,000	22,400
Manufacturers 50+ MGD		
I-only Everywhere	1,000,000	118,000
I&E Everywhere	44,500,000	212,000

Chapter D3: Commercial Fishing Benefits

Introduction

This chapter presents the results of the commercial fishing benefits analysis for the Mid-Atlantic region. The chapter presents EPA's estimates of baseline (i.e., current) annual commercial fishery losses from impingement and entrainment (I&E) at potentially regulated facilities in the Mid-Atlantic region and annual reductions in these losses under the regulatory options for Phase III existing facilities[1]:

- ▸ the "50 MGD for All Waterbodies" option,
- ▸ the "200 MGD for All Waterbodies" option, and
- ▸ the "100 MGD for Certain Waterbodies" option.

The chapter then presents the estimated benefits to commercial fisheries from eliminating baseline losses from I&E, and the expected benefits under the regulatory options.

Chapter A4, "Methods for Estimating Commercial Fishing Benefits," details the methods used by EPA to estimate the commercial fishing benefits of reducing and eliminating I&E losses.

EPA considered a wide range of policy options in developing this regulation. In addition to the regulatory options, EPA evaluated several supplemental options. Appendix D3 presents results of the commercial fishing benefits analysis for the supplemental options. For more information on the options, please see the TDD.

D3-1   Baseline Commercial Losses

Table D3-1 provides EPA's estimate of the value of gross revenues lost in commercial fisheries resulting from the impingement of aquatic species at facilities in the Mid-Atlantic region. Table D3-2 displays this information for entrainment. Total annualized revenue losses are approximately $89,236 (undiscounted).

---

[1] See the Introduction to this report for a description of the primary analysis options.

Table D3-1: Annualized Commercial Fishing Gross Revenues Lost due to Impingement at Facilities in the Mid-Atlantic Region

Species[a]	Estimated Pounds of Harvest Lost	Commercial Value per Pound (2004$)	Estimated Value of Harvest Lost (2004$) Undiscounted
American shad	4	$0.64	$2
Atlantic croaker	1,759	$0.34	$602
Atlantic menhaden	424,650	$0.07	$29,444
Black drum	22	$0.70	$15
Blue crab	1,313	$0.80	$1,045
Bluefish	3	$0.30	$1
Butterfish	5	$0.62	$3
Commercial Crabs	16	$0.57	$9
Other[b]	7,592	$0.56	$4,238
Other[c]	2,859	$0.56	$1,596
Red hake	75	$0.23	$18
Silver hake	10	$0.40	$4
Spot	14,596	$0.45	$6,586
Striped bass	22	$1.78	$40
Striped mullet	31	$0.71	$22
Summer flounder	373	$1.62	$604
Weakfish	4,193	$0.69	$2,892
White perch	28	$0.63	$17
Windowpane	3	$0.39	$1
Winter flounder	75	$1.25	$94
Trophic transfer[d]	192	$0.42	$81
Total	**457,821**		**$47,314**

[a] Species included are only those that have baseline losses greater than $1.
[b] Includes only species that are commercially, but not recreationally, fished.
[c] Includes species that are both commercially and recreationally fished.
[d] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

Table D3-2: Annualized Commercial Fishing Gross Revenues Lost due to Entrainment at Facilities in the Mid-Atlantic Region

Species[a]	Estimated Pounds of Harvest Lost	Commercial Value per Pound (2004$)	Estimated Value of Harvest Lost (2004$) Undiscounted
American shad	36	$0.64	$23
Atlantic croaker	13,599	$0.34	$4,655
Atlantic menhaden	15,491	$0.07	$1,074
Blue crab	24,865	$0.80	$19,796
Other[b]	287	$0.56	$160
Other[c]	7,262	$0.56	$4,054
Spot	10,108	$0.45	$4,561
Striped bass	1,283	$1.78	$2,281
Weakfish	6,523	$0.69	$4,499
White perch	17	$0.63	$11
Winter flounder	211	$1.25	$264
Trophic transfer[d]	1,274	$0.42	$539
Total	**80,956**		**$41,917**

[a] Species included are only those that have baseline losses greater than $1.
[b] Includes only species that are commercially, but not recreationally, fished.
[c] Include species that are both commercially and recreationally fished.
[d] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

D3-2 Expected Benefits Under Regulatory Analysis Options

As described in Chapter A4, EPA estimates for Mid-Atlantic that, depending on species, 0 to 84% of the gross revenue losses represent surplus losses to producers, assuming no change in prices or fishing costs. Earlier EPA analysis assumed a rate of 40%. The 0% estimate, of course, results in loss estimates of $0.

The expected reductions in I&E attributable to changes at facilities required by the "50 MGD for All Waterbodies" option (50 MGD All option) are 23.4% for impingement and 52.9% for entrainment; the expected reductions for the "200 MGD for All Waterbodies" option (200 MGD All option) are 15.6% for impingement and 47.1% for entrainment; and the expected reductions for the "100 MGD for Certain Waterbodies" option (100 MGD CWB option) are 15.6% for impingement 47.1% for entrainment. Total annualized benefits are estimated by applying these estimated reductions to the annual baseline producer surplus loss. As presented in Tables D3-3, D3-4, and D3-5, this results in total annualized benefits of up to approximately $18,387 for the 50 MGD All option, $14,848 for the 200 MGD All option, and $14,848 for the 100 MGD CWB option, assuming a 3% discount rate and a species-specific net benefits ratio.[2]

---

[2] The net benefits ratio is the fractional share of gross revenue associated with net benefits, by gear and vessel type. See Chapter A4, section A4-10, for a description of the species-specific net benefits ratios and how they are calculated.

D3-2.1 Commercial Fishing Benefits of the "50 MGD for All Waterbodies" Option

Table D3-3 shows EPA's analysis of the commercial benefits of the "50 MGD for All Waterbodies" option for the Mid-Atlantic region. The table shows that this option, assuming a species-specific net benefits ratio, will result in undiscounted total annualized commercial benefits of approximately $22,630. When evaluated at 3% and 7% discount rates, the annualized commercial benefits are $18,387 and $14,105, respectively.

Table D3-3: Annualized Commercial Fishing Benefits Attributable to the 50 MGD All Option at Facilities in the Mid-Atlantic Region (2004$)[a]			
	Impingement	**Entrainment**	**Total**
Baseline loss — gross revenue			
Undiscounted	$47,318	$41,918	$89,236
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$33,502	$27,952	$61,454
Expected reduction due to rule	23.4%	52.9%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$22,630
3% discount rate			$18,387
7% discount rate			$14,105

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

D3-2.2 Commercial Fishing Benefits of the "200 MGD for All Waterbodies" Option

Table D3-4 shows EPA's analysis of the commercial benefits of the "200 MGD for All Waterbodies" option for the Mid-Atlantic region. The table shows that this option, assuming a species-specific net benefits ratio, will result in undiscounted total annualized commercial benefits of approximately $18,411. When evaluated at 3% and 7% discount rates, the annualized commercial benefits are $14,848 and $11,273, respectively.

**Table D3-4: Annualized Commercial Fishing Benefits Attributable to
the 200 MGD All Option at Facilities in the Mid-Atlantic Region (2004$)[a]**

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$47,318	$41,918	$89,236
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$33,502	$27,952	$61,454
Expected reduction due to rule	15.6%	47.1%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$18,411
3% discount rate			$14,848
7% discount rate			$11,273

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

D3-2.3 Commercial Fishing Benefits of the "100 MGD for Certain Waterbodies" Option

Table D3-5 shows EPA's analysis of the commercial benefits of the "100 MGD for Certain Waterbodies" option for the Mid-Atlantic region. The table shows that this option, assuming a species-specific net benefits ratio, will result in undiscounted total annualized commercial benefits of approximately $18,411. When evaluated at 3% and 7% discount rates, the annualized commercial benefits are $14,848 and $11,273, respectively.

**Table D3-5: Annualized Commercial Fishing Benefits Attributable to
the 100 MGD CWB Option at Facilities in the Mid-Atlantic Region (2004$)[a]**

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$47,318	$41,918	$89,236
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$33,502	$27,952	$61,454
Expected reduction due to rule	15.6%	47.1%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$18,411
3% discount rate			$14,848
7% discount rate			$11,273

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Appendix D3: Commercial Fishing Benefits Under Supplemental Policy Options

Introduction

Chapter D3 presents EPA's estimates of the commercial benefits of the regulatory options for the section 316(b) rule for Phase III facilities in the Mid-Atlantic region. To facilitate comparisons among the options, this appendix presents estimates of the

commercial fishing benefits of several supplemental options that EPA evaluated in preparation for this rule:

- ▸ "Electric Generators 2-50 MGD I-only Everywhere" option;
- ▸ "Electric Generators 2-50 MGD I&E like Phase II" option;
- ▸ "Electric Generators 2-50 MGD I&E Everywhere" option;
- ▸ "Manufacturers 2-50 MGD I-only Everywhere" option;
- ▸ "Manufacturers 2-50 MGD I&E like Phase II" option;
- ▸ "Manufacturers 2-50 MGD I&E Everywhere" option;
- ▸ "Manufacturers 50+ MGD I-only Everywhere" option; and
- ▸ "Manufacturers 50+ MGD I&E Everywhere" option.

Commercial fishing benefits presented in this chapter were estimated using the benefit transfer approach discussed in Chapter D3 and in Chapter A4, "Methods for Estimating Commercial Fishing Benefits."

D3-1   Commercial Fishing Benefits of the Supplemental Options

Tables D3-1 through D3-8 present EPA's estimates of the annualized commercial benefits of the supplemental options in the Mid-Atlantic region. For more information on the options, please see the TDD.

Table D3-1: Annualized Commercial Fishing Benefits Attributable to the "Electric Generators 2-50 MGD I-only Everywhere" Option at Facilities in the Mid-Atlantic Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$47,318	$41,918	$89,236
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$33,502	$27,952	$61,454
Expected reduction due to rule	1%	0%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$207
3% discount rate			$159
7% discount rate			$113

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table D3-2: Annualized Commercial Fishing Benefits Attributable to the "Electric Generators 2-50 MGD I&E like Phase II" Option at Facilities in the Mid-Atlantic Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$47,318	$41,918	$89,236
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$33,502	$27,952	$61,454
Expected reduction due to rule	1%	0%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$207
3% discount rate			$159
7% discount rate			$113

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table D3-3: Annualized Commercial Fishing Benefits Attributable to the "Electric Generators 2-50 MGD I&E Everywhere" Option at Facilities in the Mid-Atlantic Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$47,318	$41,918	$89,236
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$33,502	$27,952	$61,454
Expected reduction due to rule	1%	2%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$701
3% discount rate			$566
7% discount rate			$432

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table D3-4: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 2-50 MGD I-only Everywhere" Option at Facilities in the Mid-Atlantic Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$47,318	$41,918	$89,236
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$33,502	$27,952	$61,454
Expected reduction due to rule	4%	0%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$1,174
3% discount rate			$982
7% discount rate			$782

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table D3-5: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 2-50 MGD I&E like Phase II" Option at Facilities in the Mid-Atlantic Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$47,318	$41,918	$89,236
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$33,502	$27,952	$61,454
Expected reduction due to rule	4%	3%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$1,909
3% discount rate			$1,597
7% discount rate			$1,271

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table D3-6: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 2-50 MGD I&E Everywhere" Option at Facilities in the Mid-Atlantic Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$47,318	$41,918	$89,236
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$33,502	$27,952	$61,454
Expected reduction due to rule	4%	3%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$1,909
3% discount rate			$1,597
7% discount rate			$1,271

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table D3-7: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 50+ MGD I-only Everywhere" Option at Facilities in the Mid-Atlantic Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$47,318	$41,918	$89,236
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$33,502	$27,952	$61,454
Expected reduction due to rule	23%	0%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$7,835
3% discount rate			$6,369
7% discount rate			$4,897

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table D3-8: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 50+ MGD I&E Everywhere" Option at Facilities in the Mid-Atlantic Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$47,318	$41,918	$89,236
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$33,502	$27,952	$61,454
Expected reduction due to rule	23%	53%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$22,630
3% discount rate			$18,387
7% discount rate			$14,105

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Chapter D4: Recreational Use Benefits

Introduction

This chapter presents the results of the recreational fishing benefits analysis for the Mid-Atlantic region. The chapter presents EPA's estimates of baseline (i.e., current) annual recreational fishery losses from impingement and entrainment (I&E) at potentially regulated facilities in the Mid-Atlantic region and annual reductions in these losses under the regulatory options for Phase III existing facilities[1]:

- ► the "50 MGD for All Waterbodies" option,
- ► the "200 MGD for All Waterbodies" option, and
- ► the "100 MGD for Certain Waterbodies" option.

The chapter then presents the estimated welfare gain to Mid-Atlantic anglers from eliminating baseline recreational fishing losses from I&E and the expected benefits under the regulatory options.

EPA estimated the recreational benefits of reducing and eliminating I&E losses using a benefit transfer methodology based on a meta-analysis of the marginal value of catching different species of fish. This meta-analysis is discussed in detail in Chapter A5, "Recreational Fishing Benefits Methodology."

EPA considered a wide range of policy options in developing this regulation. In addition to the regulatory options, EPA evaluated several supplemental options. Appendix D4 presents results of the recreational fishing benefits analysis for the supplemental options. For additional information on the options, please see the TDD.

D4-1   Benefit Transfer Approach Based on Meta-Analysis

EPA estimated the recreational welfare gain from the reduction in annual I&E losses expected under the policy options, and the welfare gain from eliminating I&E at potentially regulated facilities, using a benefit transfer approach. As discussed in Chapter A5, the Agency used a meta-analysis regression equation to estimate the marginal recreational value per additional fish caught by anglers, for different species in different regions. Since I&E at potentially regulated facilities affects a variety of species, EPA assigned each species with I&E losses to one of the general species groups used in the meta-analysis. The Agency then calculated the economic value of reducing or eliminating baseline I&E losses, for each species group, by multiplying the value per fish for that species group by the number of fish in the group that are lost in the baseline or saved under the policy options.[2]

---

[1] See the Introduction to this report for a description of the regulatory options.

[2] The estimates of I&E presented in this chapter include only the fraction of impinged and entrained recreational fish that would be caught by anglers. The total amount of I&E of recreational species is actually much higher.

In general, the fit between the species with I&E losses and the species groups in the meta-analysis was good. However, EPA's estimates of baseline I&E losses and reductions in I&E under the policy options included losses of "unidentified" species. The "unidentified" group includes fish lost indirectly through trophic transfer, as well as species for which no species information was available.[3] Rather than using the meta-analysis regression to try to predict the value per fish for an "unidentified" species, EPA assumed that per-fish values for these species can be approximated by the weighted average value per fish for all species affected by I&E in the Mid-Atlantic region.[4]

D4-1.1 Baseline Losses and Reductions in Recreational Fishery Losses Under the Regulatory Options

Table D4-1 presents EPA's estimates of baseline (i.e., current) annual recreational I&E losses at potentially regulated facilities, and annual reductions in these losses under each of the regulatory options, in the Mid-Atlantic region. The table shows that total baseline losses to recreational fisheries are 108.7 thousand fish per year. In comparison, the "50 MGD for All Waterbodies" option prevents losses of 43.0 thousand fish per year, and the "200 MGD for All Waterbodies" option and the "100 MGD for Certain Waterbodies" option both prevent losses of 35.8 thousand fish per year. Of all the affected species, spot and Atlantic croaker have the highest losses in the baseline and the highest prevented losses under the regulatory options.

---

[3] In addition to recreational fish that are lost because they are impinged or entrained, some recreational fish are lost because the forage fish that they feed on are impinged or entrained, and thus removed from the food chain. These trophic transfer losses of recreational species are included in EPA's estimates of total I&E losses. Since it is difficult to predict which recreational species would be affected by losses of forage fish, these losses are classified as "unidentified" recreational species. Also included in the "unidentified" group are losses of fish that were reported by facilities without information about their exact species.

[4] EPA used the estimated level of baseline recreational losses for each species group as a weighting factor.

Table D4-1: Baseline Recreational Fishing Losses from I&E at Potentially Regulated Phase III Facilities and Reductions in Recreational Losses Under the Regulatory Options in the Mid-Atlantic Region

Species[a]	Annual Baseline Recreational Fishing Losses (# of fish)	Annual Reductions in Recreational Fishing Losses (# of fish)		
		50 MGD All	200 MGD All[b]	100 MGD CWB[b]
Bluefish	3.1	0.7	0.5	0.5
Red drum	262.8	61.5	41.1	41.1
Spotted seatrout	134.3	31.4	21.0	21.0
Striped bass	2,460.5	1,289.9	1,146.2	1,146.2
Weakfish	6,639.0	2,746.6	2,310.6	2,310.6
Total (small game)	**9,499.8**	**4,130.1**	**3,519.4**	**3,519.4**
Summer flounder	525.8	123.0	82.2	82.2
Winter flounder	288.3	130.1	111.9	111.9
Total (flatfish)	**814.1**	**253.1**	**194.1**	**194.1**
Atlantic croaker	18,023.4	8,930.1	7,843.1	7,843.1
Black drum	18.0	4.2	2.8	2.8
Searobin	14.9	3.5	2.3	2.3
Smallmouth bass[c]	5.7	1.3	0.9	0.9
Spot	65,471.5	23,225.6	18,673.1	18,673.1
Striped mullet	1.2	0.3	0.2	0.2
White perch	374.1	129.9	103.7	103.7
Whitefish[c]	41.9	9.8	6.6	6.6
Total (other saltwater)	**83,951.0**	**32,304.8**	**26,632.9**	**26,632.9**
Brown bullhead	203.4	47.6	31.8	31.8
Bullhead	165.6	38.7	25.9	25.9
Channel catfish	19.0	4.4	3.0	3.0
Menhaden	24.0	12.7	11.3	11.3
Sunfish	2.2	0.5	0.4	0.4
Yellow perch	21.8	6.1	4.5	4.5
Total (panfish)	**436.7**	**110.2**	**77.0**	**77.0**
Total (unidentified)	**13,952.6**	**6,250.7**	**5,365.8**	**5,365.8**
Total (all species)	**108,654.2**	**43,049.0**	**35,789.2**	**35,789.2**

[a] EPA assigned each species with I&E losses to one of the species groups used in the meta-analysis. The "other saltwater" group includes bottomfish and other miscellaneous species. The "unidentified" group includes fish lost indirectly through trophic transfer and fish reported lost without information about their species.

[b] Annual reductions in recreational I&E losses are the same in the Mid-Atlantic region for the "200 MGD for All Waterbodies" and "100 MGD for Certain Waterbodies" options.

[c] The "other saltwater" species group includes two freshwater species, smallmouth bass and whitefish, which can be found in estuarine environments.

Source: U.S. EPA analysis for this report.

D4-1.2 Recreational Fishing Benefits from Eliminating Baseline I&E Losses

Table D4-2 shows the results of EPA's analysis of the welfare gain to recreational anglers from eliminating baseline recreational fishery losses at potentially regulated facilities in the Mid-Atlantic region. The table presents baseline annual recreational I&E losses, the estimated value per fish, and the monetized annual welfare gain from eliminating recreational losses, for each species group. Total baseline recreational fishing losses for the Mid-Atlantic region are 108.7 thousand fish per year. The undiscounted annual welfare gain to Mid-Atlantic anglers from eliminating these losses is $295.9 thousand (2004$), with lower and upper bounds of $150.3 thousand and $604.2 thousand. Evaluated at 3% and 7% discount rates, the mean annualized welfare gain of eliminating these losses is $278.7 thousand and $258.3 thousand, respectively. The majority of monetized recreational losses from I&E under baseline conditions are attributable to losses of species in the "other saltwater" group, including spot and Atlantic croaker.

Table D4-2: Recreational Fishing Benefits from Eliminating Baseline I&E at Potentially Regulated Phase III Facilities in the Mid-Atlantic Region (2004$)

Species Group	Baseline Annual Recreational Fishing Losses (thousands of fish)[a]	Value per Fish[b]			Annualized Benefits from Eliminating Recreational Fishing Losses (thousands)[c,d]		
		Low	Mean	High	Low	Mean	High
Small game	9.5	$1.67	$4.97	$14.55	$15.8	$47.2	$138.2
Flatfish	0.8	$2.80	$4.73	$8.07	$2.3	$3.9	$6.6
Other saltwater [e]	84.0	$1.34	$2.46	$4.54	$112.6	$206.4	$380.8
Panfish	0.4	$0.48	$0.89	$1.63	$0.2	$0.4	$0.7
Unidentified	14.0	$1.39	$2.73	$5.58	$19.3	$38.1	$77.8
Total (undiscounted)	**108.7**				**$150.3**	**$295.9**	**$604.2**
Total (evaluated at 3% discount rate)	**108.7**				**$141.5**	**$278.7**	**$568.9**
Total (evaluated at 7% discount rate)	**108.7**				**$131.2**	**$258.3**	**$527.4**

[a] Recreational fishing losses include only the portion of impinged and entrained fish that would have been caught by recreational anglers.
[b] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[c] Monetized benefits are calculated by multiplying baseline losses by the estimated value per fish.
[d] Annualized values represent the total welfare gain over the time frame of the analysis from eliminating recreational losses, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting and annualization methodology, refer to Chapter A8.
[e] The "other saltwater" species group includes two freshwater species, smallmouth bass and whitefish, which can be found in estuarine environments.
Source: U.S. EPA analysis for this report.

D4-1.3 Recreational Fishing Benefits of the "50 MGD for All Waterbodies" Option

Table D4-3 shows the results of EPA's analysis of the recreational benefits of the "50 MGD for All Waterbodies" option for the Mid-Atlantic region. The table presents the annual reduction in recreational I&E losses expected under this option, the estimated value per fish, and annual monetized recreational welfare gain from this option, by species group. The table shows that this option reduces recreational losses by 43.0 thousand fish per year, resulting in an undiscounted welfare gain to recreational anglers of $118.3 thousand (2004$), with lower and

upper bounds of $59.6 thousand and $243.7 thousand. Evaluated at 3% and 7% discount rates, the mean annualized welfare gain from this reduction in recreational losses is $96.1 thousand and $73.7 thousand, respectively. The majority of benefits result from reduced losses of species in the "other saltwater" group, including spot and Atlantic croaker.

Table D4-3: Recreational Fishing Benefits of the "50 MGD for All Waterbodies" Option in the Mid-Atlantic Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)[a]	Value per Fish[b]			Annualized Recreational Fishing Benefits (thousands)[c,d]		
		Low	Mean	High	Low	Mean	High
Small game	4.1	$1.67	$4.97	$14.55	$6.9	$20.5	$60.1
Flatfish	0.3	$2.80	$4.73	$8.07	$0.7	$1.2	$2.0
Other saltwater[e]	32.3	$1.34	$2.46	$4.54	$43.3	$79.4	$146.5
Panfish	0.1	$0.48	$0.89	$1.63	$0.1	$0.1	$0.2
Unidentified	6.3	$1.39	$2.73	$5.58	$8.7	$17.1	$34.9
Total (undiscounted)	**43.0**				**$59.6**	**$118.3**	**$243.7**
Total (evaluated at 3% discount rate)	**43.0**				**$48.5**	**$96.1**	**$198.0**
Total (evaluated at 7% discount rate)	**43.0**				**$37.2**	**$73.7**	**$151.9**

[a] Recreational fishing losses include only the portion of impinged and entrained fish that would have been caught by recreational anglers.
[b] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[c] Monetized benefits are calculated by multiplying the annual reduction in recreational losses by the estimated value per fish.
[d] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting and annualization methodology, refer to Chapter A8.
[e] The "other saltwater" species group includes two freshwater species, smallmouth bass and whitefish, which can be found in estuarine environments.

Source: U.S. EPA analysis for this report.

D4-1.4 Recreational Fishing Benefits of the "200 MGD for All Waterbodies" Option

Table D4-4 shows the results of EPA's analysis of the recreational benefits of the "200 MGD for All Waterbodies" option for the Mid-Atlantic region. The table presents the annual reduction in recreational I&E losses expected under this option, the estimated value per fish, and annual monetized recreational welfare gain from this option, by species group. The table shows that this option reduces recreational losses by 35.8 thousand fish per year, resulting in an undiscounted welfare gain to recreational anglers of $98.6 thousand (2004$), with lower and upper bounds of $49.6 thousand and $203.6 thousand. Evaluated at 3% and 7% discount rates, the mean annualized welfare gain from this reduction in recreational losses is $79.5 thousand and $60.4 thousand, respectively. The majority of benefits result from reduced losses of species in the "other saltwater" group, including spot and Atlantic croaker.

Table D4-4: Recreational Fishing Benefits of the "200 MGD for All Waterbodies" Option in the Mid-Atlantic Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)[a]	Value per Fish[b]			Annualized Recreational Fishing Benefits (thousands)[c,d]		
		Low	Mean	High	Low	Mean	High
Small game	3.5	$1.67	$4.97	$14.55	$5.9	$17.5	$51.2
Flatfish	0.2	$2.80	$4.73	$8.07	$0.5	$0.9	$1.6
Other saltwater[e]	26.6	$1.34	$2.46	$4.54	$35.7	$65.5	$120.8
Panfish	0.1	$0.48	$0.89	$1.63	$0.0[f]	$0.1	$0.1
Unidentified	5.4	$1.39	$2.73	$5.58	$7.4	$14.7	$29.9
Total (undiscounted)	**35.8**				**$49.6**	**$98.6**	**$203.6**
Total (evaluated at 3% discount rate)	**35.8**				**$40.0**	**$79.5**	**$164.2**
Total (evaluated at 7% discount rate)	**35.8**				**$30.4**	**$60.4**	**$124.7**

[a] Recreational fishing losses include only the portion of impinged and entrained fish that would have been caught by recreational anglers.

[b] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.

[c] Monetized benefits are calculated by multiplying the annual reduction in recreational losses by the estimated value per fish.

[d] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting and annualization methodology, refer to Chapter A8.

[e] The "other saltwater" species group includes two freshwater species, smallmouth bass and whitefish, which can be found in estuarine environments.

[f] Denotes a positive value less than $50.

Source: U.S. EPA analysis for this report.

D4-1.5 Recreational Fishing Benefits of the "100 MGD for Certain Waterbodies" Option

In the Mid-Atlantic region, all Phase III facilities that would have to install technology under the "200 MGD for All Waterbodies" option or the "100 MGD for Certain Waterbodies" option have design intake flows that are greater than 200 million gallons per day (MGD) and are located on coastal waterbodies. Because the requirements under these two options are identical for this class of facilities, the I&E reductions and welfare gain resulting from these two options are also identical. Thus, the benefits estimates presented for the "200 MGD for All Waterbodies" option in Table D4-4 also apply to the "100 MGD for Certain Waterbodies" option. The table shows that this option reduces recreational losses by 35.8 thousand fish per year, resulting in an undiscounted welfare gain to recreational anglers of $98.6 thousand (2004$), with lower and upper bounds of $49.6 thousand and $203.6 thousand. Evaluated at 3% and 7% discount rates, the mean annualized welfare gain from this reduction in recreational losses is $79.5 thousand and $60.4 thousand, respectively.

D4-2 Limitations and Uncertainty

The results of the benefit transfer based on a meta-analysis represent EPA's best estimate of the recreational benefits of the regulatory options. Nonetheless, there are a number of limitations and uncertainties inherent in these estimates. General limitations pertaining to the development of the meta-analysis model, the use of the model to estimate per-fish values, and the validity of the benefit transfer are discussed in section A5-3.3e and section A5-5.3 of Chapter A5.

Appendix D4: Recreational Use Benefits Under Supplemental Policy Options

Introduction

Chapter D4 presents EPA's estimates of the recreational benefits of the regulatory options for the section 316(b) rule for Phase III facilities in the Mid-Atlantic region. To facilitate comparisons among the options, this appendix presents estimates of the recreational fishing benefits of several supplemental options that EPA evaluated in preparation for this rule:

  ▸ "Electric Generators 2-50 MGD I-only Everywhere" option;
  ▸ "Electric Generators 2-50 MGD I&E like Phase II" option;
  ▸ "Electric Generators 2-50 MGD I&E Everywhere" option;
  ▸ "Manufacturers 2-50 MGD I-only Everywhere" option;
  ▸ "Manufacturers 2-50 MGD I&E like Phase II" option;
  ▸ "Manufacturers 2-50 MGD I&E Everywhere" option;
  ▸ "Manufacturers 50+ MGD I-only Everywhere" option; and
  ▸ "Manufacturers 50+ MGD I&E Everywhere" option.

Recreational fishing benefits presented in this chapter were estimated using the benefit transfer approach discussed in Chapter D4 and in Chapter A5, "Recreational Fishing Benefits Methodology."

D4-1   Recreational Fishing Benefits of the Supplemental Options

D4-1.1 Estimated Reductions in Recreational Fishing Losses Under the Supplemental Options

Table D4-1 presents EPA's estimates of the annual reduction in baseline (i.e., current) recreational fishing losses from impingement and entrainment (I&E) in the Mid-Atlantic region under the supplemental options. For additional information on the options, please see the TDD.

Table D4-1: Reductions in Recreational Fishing Losses from I&E Under the Supplemental Options in the Mid-Atlantic Region

	Annual Reduction in Recreational Losses (# of fish)							
	Electric Generators 2-50 MGD			Manufacturers 2-50 MGD			Manufacturers 50+ MGD	
Species[a]	I-only Everywhere[b]	I&E like Phase II[b]	I&E Everywhere	I-only Everywhere	I&E like Phase II[c]	I&E Everywhere[c]	I-only Everywhere	I&E Everywhere
Bluefish	0.0	0.0	0.0	0.1	0.1	0.1	0.7	0.7
Red drum	1.6	1.6	1.6	9.2	9.2	9.2	61.5	61.5
Spotted seatrout	0.8	0.8	0.8	4.7	4.7	4.7	31.4	31.4
Striped bass	0.3	0.3	43.0	1.5	65.1	65.1	9.8	1,289.9
Weakfish	16.1	16.1	87.5	91.1	197.3	197.3	607.5	2,746.6
Total (small game)	**18.8**	**18.8**	**133.0**	**106.6**	**276.4**	**276.4**	**710.9**	**4,130.1**
Summer flounder	3.3	3.3	3.3	18.4	18.4	18.4	123.0	123.0
Winter flounder	0.5	0.5	4.2	2.7	8.2	8.2	17.8	130.1
Total (flatfish)	**3.7**	**3.7**	**7.5**	**21.1**	**26.7**	**26.7**	**140.7**	**253.1**
Atlantic croaker	12.8	12.8	294.9	72.3	491.9	491.9	482.6	8,930.1
Black drum	0.1	0.1	0.1	0.6	0.6	0.6	4.2	4.2
Searobin	0.1	0.1	0.1	0.5	0.5	0.5	3.5	3.5
Smallmouth bass[d]	0.0	0.0	0.0	0.2	0.2	0.2	1.3	1.3
Spot	239.8	239.8	713.4	1,355.9	2,060.1	2,060.1	9,046.3	23,225.6
Striped mullet	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3
White perch	1.4	1.4	4.0	8.1	11.9	11.9	53.9	129.9
Whitefish[d]	0.3	0.3	0.3	1.5	1.5	1.5	9.8	9.8
Total (other saltwater)	**254.5**	**254.5**	**1,012.8**	**1,439.1**	**2,566.7**	**2,566.7**	**9,602.1**	**32,304.8**
Brown bullhead	1.3	1.3	1.3	7.1	7.1	7.1	47.6	47.6
Bullhead	1.0	1.0	1.0	5.8	5.8	5.8	38.7	38.7
Channel catfish	0.1	0.1	0.1	0.7	0.7	0.7	4.4	4.4
Menhaden	0.0	0.0	0.4	0.0	0.6	0.6	0.0	12.7
Sunfish	0.0	0.0	0.0	0.1	0.1	0.1	0.5	0.5
Yellow perch	0.1	0.1	0.2	0.6	0.7	0.7	4.3	6.1

Table D4-1: Reductions in Recreational Fishing Losses from I&E Under the Supplemental Options in the Mid-Atlantic Region

Species[a]	Annual Reduction in Recreational Losses (# of fish)							
	Electric Generators 2-50 MGD			**Manufacturers 2-50 MGD**			**Manufacturers 50+ MGD**	
	I-only Everywhere[b]	**I&E like Phase II[b]**	**I&E Everywhere**	**I-only Everywhere**	**I&E like Phase II[c]**	**I&E Everywhere[c]**	**I-only Everywhere**	**I&E Everywhere**
Total (panfish)	2.5	2.5	3.0	14.3	15.1	15.1	95.7	110.2
Total (unidentified)	23.8	23.8	202.6	134.6	400.4	400.4	898.0	6,250.7
Total (all species)	303.5	303.5	1,358.9	1,715.7	3,285.2	3,285.2	11,447.4	43,049.0

[a] EPA assigned each species with I&E losses to one of the species groups used in the meta-analysis. The "other saltwater" group includes bottomfish and other miscellaneous species. The "unidentified" group includes fish lost indirectly through trophic transfer and fish reported lost without information about their species.
[b] Annual reductions in recreational I&E losses are the same in the Mid-Atlantic region for the "Electric Generators 2-50 MGD I-only Everywhere" and "Electric Generators 2-50 MGD I&E like Phase II" options.
[c] Annual reductions in recreational I&E losses are the same in the Mid-Atlantic region for the "Manufacturers 2-50 MGD I&E like Phase II" and "Manufacturers 2-50 MGD I&E Everywhere" options.
[d] The "other saltwater" species group includes two freshwater species, smallmouth bass and whitefish, which can be found in estuarine environments.

Source: U.S. EPA analysis for this report.

D4-1.2 Recreational Fishing Benefits of the Supplemental Options

Tables D4-2 through D4-7 present EPA's estimates of the annualized recreational benefits of the supplemental options in the Mid-Atlantic region.

Annual reductions in recreational I&E losses are the same in the Mid-Atlantic region for the "Electric Generators 2-50 MGD I&E like Phase II" option as for the "Electric Generators 2-50 MGD I-only Everywhere" option. Therefore, the annualized recreational fishing benefits for these two options are the same and are presented together in Table D4-2.

Table D4-2: Recreational Fishing Benefits of the "Electric Generators 2-50 MGD I-only Everywhere" Option or the "Electric Generators 2-50 MGD like Phase II" Option in the Mid-Atlantic Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	0.0[e]	$1.67	$4.97	$14.55	$0.0[f]	$0.1	$0.3
Flatfish	0.0[e]	$2.80	$4.73	$8.07	$0.0[f]	$0.0[f]	$0.0[f]
Other saltwater[d]	0.3	$1.34	$2.46	$4.54	$0.3	$0.6	$1.2
Panfish	0.0[e]	$0.48	$0.89	$1.63	$0.0[f]	$0.0[f]	$0.0[f]
Unidentified	0.0[e]	$1.39	$2.73	$5.58	$0.0[f]	$0.1	$0.1
Total (undiscounted)	**0.3**				**$0.4**	**$0.8**	**$1.6**
Total (evaluated at 3% discount rate)	**0.3**				**$0.3**	**$0.6**	**$1.2**
Total (evaluated at 7% discount rate)	**0.3**				**$0.2**	**$0.4**	**$0.9**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.
[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.
[d] The "other saltwater" species group includes two freshwater species, smallmouth bass and whitefish, which can be found in estuarine environments.
[e] Denotes a non-zero value less than 50 fish.
[f] Denotes a non-zero value less than $50.

Source: U.S. EPA analysis for this report.

Table D4-3: Recreational Fishing Benefits of the "Electric Generators 2-50 MGD I&E Everywhere" Option in the Mid-Atlantic Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	0.1	$1.67	$4.97	$14.55	$0.2	$0.7	$1.9
Flatfish	0.0[e]	$2.80	$4.73	$8.07	$0.0[f]	$0.0[f]	$0.1
Other saltwater[d]	1.0	$1.34	$2.46	$4.54	$1.4	$2.5	$4.6
Panfish	0.0[e]	$0.48	$0.89	$1.63	$0.0[f]	$0.0[f]	$0.0[f]
Unidentified	0.2	$1.39	$2.73	$5.58	$0.3	$0.6	$1.1
Total (undiscounted)	**1.4**				**$1.9**	**$3.7**	**$7.7**
Total (evaluated at 3% discount rate)	**1.4**				**$1.5**	**$3.0**	**$6.2**
Total (evaluated at 7% discount rate)	**1.4**				**$1.2**	**$2.3**	**$4.8**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.

[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.

[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.

[d] The "other saltwater" species group includes two freshwater species, smallmouth bass and whitefish, which can be found in estuarine environments.

[e] Denotes a non-zero value less than 50 fish.

[f] Denotes a non-zero value less than $50.

Source: U.S. EPA analysis for this report.

Table D4-4: Recreational Fishing Benefits of the "Manufacturers 2-50 MGD I-only Everywhere" Option in the Mid-Atlantic Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	0.1	$1.67	$4.97	$14.55	$0.2	$0.5	$1.6
Flatfish	0.0[e]	$2.80	$4.73	$8.07	$0.1	$0.1	$0.2
Other saltwater[d]	1.4	$1.34	$2.46	$4.54	$1.9	$3.5	$6.5
Panfish	0.0[e]	$0.48	$0.89	$1.63	$0.0[f]	$0.0[f]	$0.0[f]
Unidentified	0.1	$1.39	$2.73	$5.58	$0.2	$0.4	$0.8
Total (undiscounted)	**1.7**				**$2.4**	**$4.5**	**$9.0**
Total (evaluated at 3% discount rate)	**1.7**				**$2.0**	**$3.8**	**$7.5**
Total (evaluated at 7% discount rate)	**1.7**				**$1.6**	**$3.0**	**$6.0**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.
[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.
[d] The "other saltwater" species group includes two freshwater species, smallmouth bass and whitefish, which can be found in estuarine environments.
[e] Denotes a non-zero value less than 50 fish.
[f] Denotes a non-zero value less than $50.

Source: U.S. EPA analysis for this report.

Annual reductions in recreational I&E losses are the same in the Mid-Atlantic region for the "Manufacturers 2-50 MGD I&E Everywhere" option as for the "Manufacturers 2-50 MGD I&E like Phase II" option. Therefore, the annualized recreational fishing benefits for these two options are the same, and are presented together in Table D4-5.

Table D4-5: Recreational Fishing Benefits of the "Manufacturers 2-50 MGD I&E like Phase II" Option and the "Manufacturers 2-50 MGD I&E Everywhere" Option in the Mid-Atlantic Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	0.3	$1.67	$4.97	$14.55	$0.5	$1.4	$4.0
Flatfish	0.0[e]	$2.80	$4.73	$8.07	$0.1	$0.1	$0.2
Other saltwater[d]	2.6	$1.34	$2.46	$4.54	$3.4	$6.3	$11.6
Panfish	0.0[e]	$0.48	$0.89	$1.63	$0.0[f]	$0.0[f]	$0.0[f]
Unidentified	0.4	$1.39	$2.73	$5.58	$0.6	$1.1	$2.2
Total (undiscounted)	**3.3**				**$4.5**	**$8.9**	**$18.1**
Total (evaluated at 3% discount rate)	**3.3**				**$3.8**	**$7.5**	**$15.2**
Total (evaluated at 7% discount rate)	**3.3**				**$3.0**	**$5.9**	**$12.1**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.
[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.
[d] The "other saltwater" species group includes two freshwater species, smallmouth bass and whitefish, which can be found in estuarine environments.
[e] Denotes a non-zero value less than 50 fish.
[f] Denotes a non-zero value less than $50.

Source: U.S. EPA analysis for this report.

Table D4-6: Recreational Fishing Benefits of the "Manufacturers 50+ MGD I-only Everywhere" Option in the Mid-Atlantic Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	0.7	$1.67	$4.97	$14.55	$1.2	$3.5	$10.3
Flatfish	0.1	$2.80	$4.73	$8.07	$0.4	$0.7	$1.1
Other saltwater[d]	9.6	$1.34	$2.46	$4.54	$12.9	$23.6	$43.6
Panfish	0.1	$0.48	$0.89	$1.63	$0.0[e]	$0.1	$0.2
Unidentified	0.9	$1.39	$2.73	$5.58	$1.2	$2.5	$5.0
Total (undiscounted)	**11.4**				**$15.7**	**$30.3**	**$60.2**
Total (evaluated at 3% discount rate)	**11.4**				**$12.8**	**$24.7**	**$48.9**
Total (evaluated at 7% discount rate)	**11.4**				**$9.8**	**$19.0**	**$37.6**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.
[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.
[d] The "other saltwater" species group includes two freshwater species, smallmouth bass and whitefish, which can be found in estuarine environments.
[e] Denotes a non-zero value less than $50.

Source: U.S. EPA analysis for this report.

Table D4-7: Recreational Fishing Benefits of the "Manufacturers 50+ MGD I&E Everywhere" Option in the Mid-Atlantic Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	4.1	$1.67	$4.97	$14.55	$6.9	$20.5	$60.1
Flatfish	0.3	$2.80	$4.73	$8.07	$0.7	$1.2	$2.0
Other saltwater[d]	32.3	$1.34	$2.46	$4.54	$43.3	$79.4	$146.5
Panfish	0.1	$0.48	$0.89	$1.63	$0.1	$0.1	$0.2
Unidentified	6.3	$1.39	$2.73	$5.58	$8.7	$17.1	$34.9
Total (undiscounted)	**43.0**				**$59.6**	**$118.3**	**$243.7**
Total (evaluated at 3% discount rate)	**43.0**				**$48.5**	**$96.1**	**$198.0**
Total (evaluated at 7% discount rate)	**43.0**				**$37.2**	**$73.7**	**$151.9**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.

[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.

[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.

[d] The "other saltwater" species group includes two freshwater species, smallmouth bass and whitefish, which can be found in estuarine environments.

Source: U.S. EPA analysis for this report.

D4-2   Comparison of Recreational Fishing Benefits by Option

Table D4-8 compares the recreational fishing benefits of several supplemental options.

Table D4-8: Annual Recreational Benefits of the Supplemental Options in the Mid-Atlantic Region				
Policy Option	**Annual Reduction in Recreational Fishing Losses from I&E (thousands of fish)**	**Undiscounted Recreational Fishing Benefits (thousands; 2004$)[a]**		
		Low	**Mean**	**High**
Electric Generators 2-50 MGD				
I-only Everywhere[b]	0.3	$0.4	$0.8	$1.6
I&E like Phase II[b]	0.3	$0.4	$0.8	$1.6
I&E Everywhere	1.4	$1.9	$3.7	$7.7
Manufacturers 2-50 MGD				
I-only Everywhere	1.7	$2.4	$4.5	$9.0
I&E like Phase II[c]	3.3	$4.5	$8.9	$18.1
I&E Everywhere[c]	3.3	$4.5	$8.9	$18.1
Manufacturers 50+ MGD				
I-only Everywhere	11.4	$15.7	$30.3	$60.2
I&E Everywhere	43.0	$59.6	$118.3	$243.7

[a] These benefit estimates were calculated using the meta-analysis approach discussed in Chapter A5 and Chapter B4.
[b] Annual reductions in recreational I&E losses and undiscounted recreational fishing benefits are the same in the Mid-Atlantic region for the "Electric Generators 2-50 MGD I-only Everywhere" and "Electric Generators 2-50 MGD I&E like Phase II" options.
[c] Annual reductions in recreational I&E losses and undiscounted recreational fishing benefits are the same in the Mid-Atlantic region for the "Manufacturers 2-50 MGD I&E like Phase II" and "Manufacturers 2-50 MGD I&E Everywhere" options.

Source: U.S. EPA analysis for this report.

Chapter D5: Federally Listed T&E Species in the Mid-Atlantic Region

This chapter lists current federally listed threatened and endangered (T&E) fish and shellfish species in the Mid-Atlantic Region. This list does not address proposed or candidate species; In addition, fish and shellfish listed as cave species, marine mammals, reptiles, amphibians, and snails are not included in this chapter.

Table D5-1: Delaware Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
E	*Acipenser brevirostrum*	Shortnose sturgeon
E	*Alasmidonta heterodon*	Dwarf wedgemussel

Source: USFWS, 2006a.

Table D5-2: District of Columbia Federally Listed T&E fish and Shellfish

Status	Scientific Name	Common Name
E	*Alasmidonta heterodon*	Dwarf wedgemussel

Source: USFWS, 2006a.

Table D5-3: Maryland Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
E	*Acipenser brevirostrum*	Shortnose sturgeon
E	*Alasmidonta heterodon*	Dwarf wedgemussel
E	*Etheostoma sellare*	Maryland darter

Source: USFWS, 2006a.

Table D5-4: New Jersey Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
E	*Acipenser brevirostrum*	Shortnose sturgeon
E	*Alasmidonta heterodon*	Dwarf wedgemussel

Source: USFWS, 2006a.

Table D5-5: New York Federally Listed T&E Fish and Shellfish

E	*Alasmidonta heterodon*	Dwarf wedgemussel
E	*Acipenser brevirostrum*	Shortnose sturgeon

Source: USFWS, 2006a.

Table D5-6: Pennsylvania Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
E	Pleurobema clava	Clubshell mussel: entire range except where listed as experimental populations
E	*Cyprogenia stegaria*	Fanshell mussel
E	*Lampsilis abrupta*	Pink mucket pearlymussel
E	*Pleurobema plenum*	Rough pigtoe pearlymussel
E	*Plethobasus cooperianus*	Orange-foot pimpleback pearlymussel
E	*Epioblasma torulosa rangiana*	Northern riffleshell mussel
E	*Obovaria retusa*	Ring pink mussel
E	*Alasmidonta heterodon*	Dwarf wedgemussel

Source: USFWS, 2006a.

Table D5-7: Virginia Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
E	*Acipenser brevirostrum*	Shortnose sturgeon
E	*Alasmidonta heterodon*	Dwarf wedgemussel
E	*Conradilla caelata*	Birdwing pearlymussel: entire range except where listed as experimental populations
T	*Cyprinella monacha*	Spotfin chub
E	*Cyprogenia stegaria*	Fanshell mussel
E	*Dromus dromas*	Dromedary pearlymussel: entire range except where listed as experimental populations
E	*Epioblasma brevidens*	Cumberlandian combshell mussel: entire range except where listed as experimental populations
E	*Epioblasma capsaeformis*	Oyster mussel: entire range except where listed as experimental populations
E	*Epioblasma florentina walker (= E. walkeri)*	Tan riffleshell mussel
T	*Erimystax cahni*	Slender chub
E	*Etheostoma percnurum*	Duskytail darter
E	*Fusconaia cor*	Shiny pigtoe mussel: entire range except where listed as experimental populations
E	*Fusconaia cuneolus*	Fine-rayed pigtoe mussel: entire range except where listed as experimental populations
E	*Hemistena lata*	Cracking pearlymussel: entire range except where listed as experimental populations
T	*Noturus flavipinnis*	Yellowfin madtom

Table D5-7: Virginia Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
E	*Pegias fabula*	Little-wing pearlymussel
E	*Percina rex*	Roanoke logperch
E	*Pleurobema collina*	James spinymussel
E	*Pleurobema plenum*	Rough pigtoe mussel
E	*Quadrula cylindrica strigillata*	Rough rabbitsfoot mussel
E	*Quadrula intermedia*	Cumberland monkeyface pearlymussel: entire range except where listed as experimental populations
E	*Quadrula sparsa*	Appalachian monkeyface pearlymussel
E	*Villosa trabalis*	Cumberland bean pearlymussel: entire range except where listed as experimental populations
E	*Epioblasma torulosa gubernaculum*	Green blossom pearlymussel: entire range except where listed as experimental populations
E	*Villosa perpurpurea*	Purple bean mussel

Source: USFWS, 2006a.

Part E: Gulf of Mexico

Chapter E1: Background

Introduction

This chapter presents an overview of the potential Phase III existing facilities in the Gulf of Mexico study region and summarizes their key cooling water and compliance characteristics. For further

discussion of the technical and compliance characteristics of potential Phase III existing facilities, refer to the *Economic Analysis for the Final Section 316(b) Rule for Phase III Facilities* and the *Technical Development Document for the Final Section 316(b) Rule for Phase III Facilities* (U.S. EPA, 2006a,c).

E1-1   Facility Characteristics

The Gulf of Mexico Regional Study includes five sample facilities that are potentially subject to the national standards for Phase III existing facilities. Figure E1-1 presents a map of these facilities. All five facilities are manufacturing facilities. Industry-wide, these five sample facilities represent 12 manufacturing facilities.[1]

---

[1] EPA applied sample weights to the survey respondents to account for non-sampled facilities and facilities that did not respond to the survey. For more information on EPA's 2000 Section 316(b) Industry Survey, please refer to the Information Collection Request (U.S. EPA, 2000b).

Figure E1-1: Potential Existing Phase III Facilities in the Gulf of Mexico Regional Study[a]
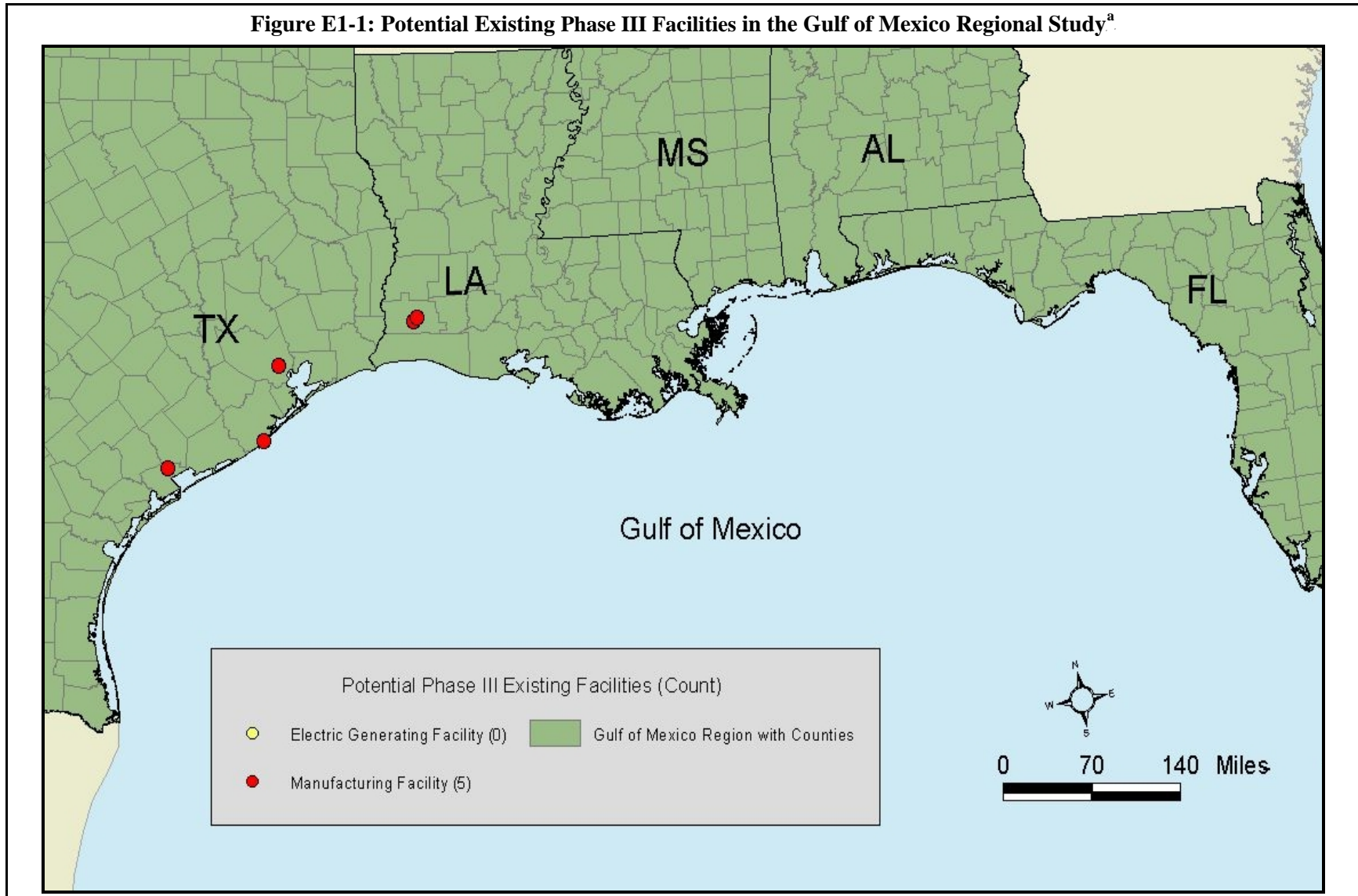
[a] The map includes locations of sample facilities only.

Source: U.S. EPA analysis for this report.

Table E1-1 summarizes key technical and compliance characteristics for all potentially regulated Phase III existing facilities in the Gulf of Mexico study region for the regulatory options considered by EPA for this rule (the "50 MGD for All Waterbodies" option, the "200 MGD for All Waterbodies" option, and the "100 MGD for Certain Waterbodies" option). Facilities with a design intake flow below the three applicability thresholds would be subject to permitting based on best professional judgment and are excluded from EPA's analyses.[2] Therefore, a different number of facilities is affected under each option.

Table E1-1 shows that 11 Phase III existing facilities in the Gulf of Mexico study region would potentially be subject to the national requirements. Under the "50 MGD for All Waterbodies" option, the most inclusive of the regulatory options, seven facilities would be subject to the national requirements for Phase III existing facilities. Under the less inclusive "200 MGD for All Waterbodies" option, three facilities would be subject to the national requirements. Seven facilities would also be subject to the national requirements under the "100 MGD for Certain Waterbodies" option. No facility in the Gulf of Mexico study region has a recirculating system in the baseline.

Table E1-1: Technical and Compliance Characteristics of Existing Phase III Facilities (sample-weighted)

	All Potentially Regulated Facilities	Regulatory Options		
		50 MGD All	200 MGD All	100 MGD CWB
Total Number of Facilities (sample-weighted)[a]	**12**	**7**	**3**	**7**
Number of Facilities with Recirculating System in Baseline	-	**-**	**-**	**-**
Design Intake Flow (MGD)	**2,501**	**w**[b]	**w**[b]	**w**[b]
Number of Facilities by Compliance Response				
New larger intake structure with fine mesh and fish H&R	6	6	2	6
Double-entry, single-exit with fine mesh, and fish H&R	1	1	1	1
None	4	-	-	-
Compliance Cost, Discounted at 3%[c]	$10.12	$6.74	$3.52	$6.72
Compliance Cost, Discounted at 7%[c]	$11.18	$6.67	$3.44	$6.67

[a] Total may not equal compliance response subtotals due to rounding.
[b] Data withheld because of confidentiality reasons.
[c] Annualized pre-tax compliance cost (2004$, millions).

Sources: U.S. EPA, 2000b; U.S. EPA analysis for this report.

---

[2] Also excluded are facilities that are estimated to be baseline closures. For additional information on EPA's baseline closure analyses, please refer to the *Economic Analysis for the Final Section 316(b) Rule for Phase III Facilities* (U.S. EPA, 2006a).

Appendix E1: Life History Parameter Values Used to Evaluate I&E in the Gulf of Mexico Region

The tables in this appendix are those life history parameter values used by EPA to calculate age-1 equivalents and fishery yield from impingement and entrainment (I&E) data for the Gulf of Mexico region. Because of differences in the number of life stages represented in the loss data, there are cases where more than one life stage sequence was needed for a given species or species group. Alternative parameter sets were developed for this purpose and are indicated with a number following the species or species group name (i.e., Anchovies 1, Anchovies 2).

| | **Table E1-1: Atlantic Croaker Life History Parameters** | | | |
Stage Name	**Instantaneous Natural Mortality (M)**	**Instantaneous Fishing Mortality (F)**	**Fraction Vulnerable to Fishery**	**Weight (lbs)**
Eggs	0.817	0	0	0.0000000128
Larvae	8.10	0	0	0.000000145
Juvenile	3.38	0	0	0.0000624
Age 1+	1.09	0.30	0.50	0.220
Age 2+	0.300	0.30	1.0	0.672
Age 3+	0.300	0.30	1.0	1.24
Age 4+	0.300	0.30	1.0	1.88
Age 5+	0.300	0.30	1.0	2.43
Age 6+	0.300	0.30	1.0	3.26
Age 7+	0.300	0.30	1.0	3.26
Age 8+	0.300	0.30	1.0	3.26
Source: PSE&G, 1999.				

Table E1-2: Anchovies Parameters 1[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.94	0	0	0.0000000186
Prolarvae	1.57	0	0	0.0000000441
Post larvae	6.12	0	0	0.00000235
Juvenile	1.29	0	0	0.000481
Age 1+	1.62	0	0	0.00381
Age 2+	1.62	0	0	0.00496
Age 3+	1.62	0	0	0.00505

[a] Includes bay anchovy, striped anchovy, and other anchovies not identified to species.

Sources: Derickson and Price, 1973; Leak and Houde, 1987; PSE&G, 1999; and NMFS, 2003a.

Table E1-3: Anchovies Parameters 2[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.94	0	0	0.0000000186
Larvae	7.70	0	0	0.00000158
Juvenile 1	0.0822	0	0	0.0000495
Juvenile 2	0.0861	0	0	0.000199
Juvenile 3	0.129	0	0	0.000532
Juvenile 4	0.994	0	0	0.00114
Age 1+	1.62	0	0	0.00381
Age 2+	1.62	0	0	0.00496
Age 3+	1.62	0	0	0.00505

[a] Includes bay anchovy.

Sources: Derickson and Price, 1973; Leak and Houde, 1987; PSE&G, 1999; and NMFS, 2003a.

	Table E1-4: Black Drum Life History Parameters 1			
Stage Name	**Instantaneous Natural Mortality (M)**	**Instantaneous Fishing Mortality (F)**	**Fraction Vulnerable to Fishery**	**Weight (lbs)**
Egg	2.27	0	0	0.000000842
Prolarvae	3.06	0	0	0.000000926
Postlarvae	3.06	0	0	0.0000176
Juvenile	1.15	0.15	0.50	0.0327
Age 1+	0.0977	0.15	1.0	0.671
Age 2+	0.0977	0.15	1.0	1.70
Age 3+	0.0977	0.15	1.0	3.21
Age 4+	0.0977	0.15	1.0	5.15
Age 5+	0.0977	0.15	1.0	7.43
Age 6+	0.0977	0.15	1.0	9.93
Age 7+	0.0977	0.15	1.0	12.6
Age 8+	0.0977	0.15	1.0	15.3
Age 9+	0.0977	0.15	1.0	18.0
Age 10+	0.0977	0.15	1.0	20.7
Age 11+	0.0977	0.15	1.0	23.3
Age 12+	0.0977	0.15	1.0	25.7
Age 13+	0.0977	0.15	1.0	28.1
Age 14+	0.0977	0.15	1.0	30.2
Age 15+	0.0977	0.15	1.0	32.3
Age 16+	0.0977	0.15	1.0	34.1
Age 17+	0.0977	0.15	1.0	35.8
Age 18+	0.0977	0.15	1.0	37.4
Age 19+	0.0977	0.15	1.0	38.8
Age 20+	0.0977	0.15	1.0	40.1
Age 21+	0.0977	0.15	1.0	41.3
Age 22+	0.0977	0.15	1.0	42.4
Age 23+	0.0977	0.15	1.0	43.3
Age 24+	0.0977	0.15	1.0	44.2
Age 25+	0.0977	0.15	1.0	45.0
Age 26+	0.0977	0.15	1.0	45.7
Age 27+	0.0977	0.15	1.0	46.3
Age 28+	0.0977	0.15	1.0	46.8
Age 29+	0.0977	0.15	1.0	47.3
Age 30+	0.0977	0.15	1.0	47.8
Age 31+	0.0977	0.15	1.0	48.2
Age 32+	0.0977	0.15	1.0	48.5
Age 33+	0.0977	0.15	1.0	48.8
Age 34+	0.0977	0.15	1.0	49.1

Table E1-4: Black Drum Life History Parameters 1

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Age 35+	0.0977	0.15	1.0	49.4
Age 36+	0.0977	0.15	1.0	49.6
Age 37+	0.0977	0.15	1.0	49.8
Age 38+	0.0977	0.15	1.0	50.0
Age 39+	0.0977	0.15	1.0	50.1
Age 40+	0.0977	0.15	1.0	50.3

Sources: Sutter et al., 1986; Scott and Scott, 1988; Murphy and Taylor, 1989; Leard et al., 1993; Bartell and Campbell, 2000; Froese and Pauly, 2001; and personal communication with Michael D. Murphy, Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute, January 23, 2002.

Table E1-5: Black Drum Life History Parameters 2

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Egg	2.27	0	0	0.000000842
Larvae	6.13	0	0	0.00000453
Juvenile	1.15	0.15	0.50	0.0327
Age 1+	0.0977	0.15	1.0	0.671
Age 2+	0.0977	0.15	1.0	1.70
Age 3+	0.0977	0.15	1.0	3.21
Age 4+	0.0977	0.15	1.0	5.15
Age 5+	0.0977	0.15	1.0	7.43
Age 6+	0.0977	0.15	1.0	9.93
Age 7+	0.0977	0.15	1.0	12.6
Age 8+	0.0977	0.15	1.0	15.3
Age 9+	0.0977	0.15	1.0	18.0
Age 10+	0.0977	0.15	1.0	20.7
Age 11+	0.0977	0.15	1.0	23.3
Age 12+	0.0977	0.15	1.0	25.7
Age 13+	0.0977	0.15	1.0	28.1
Age 14+	0.0977	0.15	1.0	30.2
Age 15+	0.0977	0.15	1.0	32.3
Age 16+	0.0977	0.15	1.0	34.1
Age 17+	0.0977	0.15	1.0	35.8
Age 18+	0.0977	0.15	1.0	37.4
Age 19+	0.0977	0.15	1.0	38.8
Age 20+	0.0977	0.15	1.0	40.1

Table E1-5: Black Drum Life History Parameters 2

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Age 21+	0.0977	0.15	1.0	41.3
Age 22+	0.0977	0.15	1.0	42.4
Age 23+	0.0977	0.15	1.0	43.3
Age 24+	0.0977	0.15	1.0	44.2
Age 25+	0.0977	0.15	1.0	45.0
Age 26+	0.0977	0.15	1.0	45.7
Age 27+	0.0977	0.15	1.0	46.3
Age 28+	0.0977	0.15	1.0	46.8
Age 29+	0.0977	0.15	1.0	47.3
Age 30+	0.0977	0.15	1.0	47.8
Age 31+	0.0977	0.15	1.0	48.2
Age 32+	0.0977	0.15	1.0	48.5
Age 33+	0.0977	0.15	1.0	48.8
Age 34+	0.0977	0.15	1.0	49.1
Age 35+	0.0977	0.15	1.0	49.4
Age 36+	0.0977	0.15	1.0	49.6
Age 37+	0.0977	0.15	1.0	49.8
Age 38+	0.0977	0.15	1.0	50.0
Age 39+	0.0977	0.15	1.0	50.1
Age 40+	0.0977	0.15	1.0	50.3

Sources: Sutter et al., 1986; Scott and Scott, 1988; Murphy and Taylor, 1989; Leard et al., 1993; Able and Fahay, 1998; Bartell and Campbell, 2000; Froese and Pauly, 2001; and personal communication with Michael D. Murphy, Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute, January 23, 2002.

Table E1-6: Blue Crab Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Zoeae	13.8	0	0	0.000000211
Megalops	1.30	0	0	0.00000291
Juvenile	1.73	0.48	0.50	0.00000293
Age 1+	1.00	1.0	1.0	0.00719
Age 2+	1.00	1.0	1.0	0.113
Age 3+	1.00	1.0	1.0	0.326

Sources: Hartman, 1993; PSE&G, 1999; and Murphy et al., 2000.

Table E1-7: Commercial Shrimp Life History Parameters 1[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	3.22	0	0	0.0000000253
Prolarvae	1.70	0	0	0.00000274
Postlarvae	1.70	0	0	0.0000268
Juvenile	0.140	0.14	1.0	0.0473
Age 1+	0.140	0.14	1.0	0.0770

[a] Includes pink shrimp, brown shrimp, white shrimp, and other commercial shrimp not identified to species.

Sources: Costello and Allen, 1970; Stone & Webster Engineering Corporation, 1980; Bielsa et al., 1983; and TBNEP, 1992.

Table E1-8: Commercial Shrimp Life History Parameters 2[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	3.22	0	0	0.0000000253
Larvae	3.40	0	0	0.00000274
Juvenile	0.140	0.14	1.0	0.0473
Age 1+	0.140	0.14	1.0	0.0770

[a] Includes pink shrimp.

Sources: Costello and Allen, 1970; Stone & Webster Engineering Corporation, 1980; Bielsa et al., 1983; and TBNEP, 1992.

Table E1-9: Goby Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.288	0	0	0.00000200
Larvae	4.09	0	0	0.00000219
Juvenile	2.30	0	0	0.00049
Age 1+	2.55	0	0	0.00205

[a] Includes clown goby, code goby, frillfin goby, green goby, naked goby, sharptail goby, skilletfish, violet goby, and other goby species not identified to species.

Sources: PSE&G, 1999; Froese and Pauly, 2003; and NMFS, 2003a.

Table E1-10: Hogchoker Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.24	0	0	0.000000487
Larvae	6.73	0	0	0.00110
Juvenile	0.916	0	0	0.00207
Age 1+	0.250	0	0	0.0113
Age 2+	0.250	0	0	0.0313
Age 3+	0.250	0	0	0.0610
Age 4+	0.250	0	0	0.0976
Age 5+	0.250	0	0	0.138
Age 6+	0.250	0	0	0.178

Sources: New England Power Company and Marine Research Inc., 1995; Able and Fahay, 1998; PG&E National Energy Group, 2001; and NMFS, 2003a.

Table E1-11: Jack/Pompano Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.817	0	0	0.00000115
Larvae	8.61	0	0	0.00000127
Juvenile	0.916	0	0	0.0222
Age 1+	0.340	0.25	0.50	0.168
Age 2+	0.340	0.25	1.0	0.460
Age 3+	0.340	0.25	1.0	0.511
Age 4+	0.340	0.25	1.0	0.565

[a] Includes Atlantic bumper, Atlantic moonfish, bluntnose jack, crevalle jack, leatherjacket, lookdown, and permit.

Sources: PSE&G, 1999; Florida Fish and Wildlife Conservation Commission, 2001; Overholtz, 2002b; and Froese and Pauly, 2003.

Table E1-12: Killifish Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.0000180
Larvae	3.00	0	0	0.0000182
Juvenile	0.916	0	0	0.000157
Age 1+	0.777	0	0	0.0121
Age 2+	0.777	0	0	0.0327
Age 3+	0.777	0	0	0.0551
Age 4+	0.777	0	0	0.0778
Age 5+	0.777	0	0	0.0967
Age 6+	0.777	0	0	0.113
Age 7+	0.777	0	0	0.158

[a] Includes gulf killifish, longnose killifish, bayou killifish, and other killifish species not identified to species.

Sources: Carlander, 1969; Stone & Webster Engineering Corporation, 1977; Meredith and Lotrich, 1979; Able and Fahay, 1998; and NMFS, 2003a.

Table E1-13: Mackerel Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.39	0	0	0.00000176
Larvae	10.6	0	0	0.00000193
Juvenile	0.916	0	0	0.0000368
Age 1+	0.520	0	0	0.309
Age 2+	0.370	0.25	0.50	0.510
Age 3+	0.370	0.25	1.0	0.639
Age 4+	0.370	0.25	1.0	0.752
Age 5+	0.370	0.25	1.0	0.825
Age 6+	0.370	0.25	1.0	0.918
Age 7+	0.370	0.25	1.0	1.02
Age 8+	0.370	0.25	1.0	1.10
Age 9+	0.370	0.25	1.0	1.13
Age 10+	0.370	0.25	1.0	1.15
Age 11+	0.370	0.25	1.0	1.22
Age 12+	0.370	0.25	1.0	1.22
Age 13+	0.370	0.25	1.0	1.22
Age 14+	0.370	0.25	1.0	1.22

[a] Includes Spanish mackerel.

Sources: Scott and Scott, 1988; Overholtz et al., 1991; Studholme et al., 1999; Entergy Nuclear Generation Company, 2000; and Froese and Pauly, 2001, 2003.

Table E1-14: Menhaden Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.08	0	0	0.000000716
Larvae	5.71	0	0	0.00000203
Juvenile	2.85	0	0	0.000746
Age 1+	0.450	0	0	0.0937
Age 2+	0.450	0.8	0.50	0.356
Age 3+	0.450	0.8	1.0	0.679
Age 4+	0.450	0.8	1.0	0.974
Age 5+	0.450	0.8	1.0	1.21
Age 6+	0.450	0.8	1.0	1.38

[a] Includes Alabama shad, Atlantic thread herring, finescale menhaden, gizzard shad, gulf menhaden, skipjack herring, yellowfin menhaden, and other closely related herrings not identified to species.

Sources: USFWS, 1978; Durbin et al., 1983; Ruppert et al., 1985; Able and Fahay, 1998; Entergy Nuclear Generation Company, 2000; ASMFC, 2001b; and Froese and Pauly, 2001.

Table E1-15: Pinfish Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000107
Larvae	7.39	0	0	0.0000238
Juvenile	1.91	0	0	0.00669
Age 1+	0.340	0.34	0.50	0.0791
Age 2+	0.340	0.34	1.0	0.218

[a] Includes pinfish, spottail pinfish, and other porgies not identified to species.

Sources: Muncy, 1984; Nelson, 1998; and Froese and Pauly, 2001.

Table E1-16: Pipefish Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.000000842
Larvae	2.40	0	0	0.0000122
Juvenile	0.916	0	0	0.00785
Age 1+	0.750	0	0	0.0195
Age 2+	0.750	0	0	0.0384
Age 3+	0.750	0	0	0.0658
Age 4+	0.750	0	0	0.103
Age 5+	0.750	0	0	0.151

[a] Includes chain pipefish, dusky pipefish, gulf pipefish, and other pipefish not identified to species.

Sources: Stone & Webster Engineering Corporation, 1977; Scott and Scott, 1988; Able and Fahay, 1998; Froese and Pauly, 2001, 2003; and NMFS, 2003a.

Table E1-17: Red Drum Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Egg	2.27	0	0	0.000000842
Prolarvae	3.06	0	0	0.000000926
Postlarvae	3.06	0	0	0.0000176
Juvenile	1.15	0.15	0.50	0.0327
Age 1+	0.0977	0.15	1.0	0.671
Age 2+	0.0977	0.15	1.0	1.70
Age 3+	0.0977	0.15	1.0	3.21
Age 4+	0.0977	0.15	1.0	5.15
Age 5+	0.0977	0.15	1.0	7.43
Age 6+	0.0977	0.15	1.0	9.93
Age 7+	0.0977	0.15	1.0	12.6
Age 8+	0.0977	0.15	1.0	15.3
Age 9+	0.0977	0.15	1.0	18.0
Age 10+	0.0977	0.15	1.0	20.7
Age 11+	0.0977	0.15	1.0	23.3
Age 12+	0.0977	0.15	1.0	25.7
Age 13+	0.0977	0.15	1.0	28.1
Age 14+	0.0977	0.15	1.0	30.2
Age 15+	0.0977	0.15	1.0	32.3
Age 16+	0.0977	0.15	1.0	34.1
Age 17+	0.0977	0.15	1.0	35.8
Age 18+	0.0977	0.15	1.0	37.4

Table E1-17: Red Drum Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Age 19+	0.0977	0.15	1.0	38.8
Age 20+	0.0977	0.15	1.0	40.1
Age 21+	0.0977	0.15	1.0	41.3
Age 22+	0.0977	0.15	1.0	42.4
Age 23+	0.0977	0.15	1.0	43.3
Age 24+	0.0977	0.15	1.0	44.2
Age 25+	0.0977	0.15	1.0	45.0
Age 26+	0.0977	0.15	1.0	45.7
Age 27+	0.0977	0.15	1.0	46.3
Age 28+	0.0977	0.15	1.0	46.8
Age 29+	0.0977	0.15	1.0	47.3
Age 30+	0.0977	0.15	1.0	47.8
Age 31+	0.0977	0.15	1.0	48.2
Age 32+	0.0977	0.15	1.0	48.5
Age 33+	0.0977	0.15	1.0	48.8
Age 34+	0.0977	0.15	1.0	49.1
Age 35+	0.0977	0.15	1.0	49.4
Age 36+	0.0977	0.15	1.0	49.6
Age 37+	0.0977	0.15	1.0	49.8
Age 38+	0.0977	0.15	1.0	50.0
Age 39+	0.0977	0.15	1.0	50.1
Age 40+	0.0977	0.15	1.0	50.3

Sources: Sutter et al., 1986; Scott and Scott, 1988; Murphy and Taylor, 1989; Leard et al., 1993; Bartell and Campbell, 2000; Froese and Pauly, 2001; and personal communication with Michael D. Murphy, Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute, January 23, 2002.

Table E1-18: Scaled Sardine Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.12	0	0	0.00000533
Prolarvae	0.560	0	0	0.00000586
Postlarvae	6.53	0	0	0.0000247
Juvenile	0.916	0	0	0.000483
Age 1+	1.02	0	0	0.275

[a] Includes Brazilian sardinella, scaled sardine, threadfin shad, and other clupeids not identified to species.

Sources: Houde et al., 1974; Stone & Webster Engineering Corporation, 1980; Pierce et al., 2001; Froese and Pauly, 2003; and NMFS, 2003a.

Table E1-19: Sea Bass Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Egg	0.288	0	0	0.00000101
Larvae	6.00	0	0	0.00000111
Juvenile	0.190	0	0	0.000581
Age 1+	0.190	0	0	0.0313
Age 2+	0.190	0	0	0.0625
Age 3+	0.190	0	0	0.125
Age 4+	0.190	0	0	0.312
Age 5+	0.190	0.26	0.50	0.531
Age 6+	0.190	0.26	1.0	0.813
Age 7+	0.287	0.26	1.0	1.13
Age 8+	0.287	0.26	1.0	1.50
Age 9+	0.287	0.26	1.0	1.88
Age 10+	0.287	0.26	1.0	2.19

[a] Includes black sea bass.

Sources: Cailliet, 2000; California Department of Fish and Game, 2000b; Leet et al., 2001; and Froese and Pauly, 2002.

Table E1-20: Searobin Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.00000132
Larvae	3.66	0	0	0.00000145
Juvenile	0.916	0	0	0.000341
Age 1+	0.420	0.10	0.50	0.0602
Age 2+	0.420	0.10	1.0	0.176
Age 3+	0.420	0.10	1.0	0.267
Age 4+	0.420	0.10	1.0	0.386
Age 5+	0.420	0.10	1.0	0.537
Age 6+	0.420	0.10	1.0	0.721
Age 7+	0.420	0.10	1.0	0.944
Age 8+	0.420	0.10	1.0	1.21

[a] Includes bighead searobin, leopard searobin, and other searobins not identified to species.

Sources: Saila et al., 1997; Virginia Tech, 1998; and Froese and Pauly, 2001, 2003.

Table E1-21: Sheepshead Seabream Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.000000591
Larvae	7.39	0	0	0.0000241
Juvenile	1.91	0	0	0.00167
Age 1+	1.98	0	0	0.981
Age 2+	1.98	0	0	1.22
Age 3+	1.98	0.45	0.50	1.56
Age 4+	1.98	0.45	1.0	2.33
Age 5+	1.98	0.45	1.0	2.43
Age 6+	1.98	0.45	1.0	2.45
Age 7+	1.98	0.45	1.0	2.47
Age 8+	1.98	0.45	1.0	2.49
Age 9+	1.98	0.45	1.0	2.51
Age 10+	1.98	0.45	1.0	2.53
Age 11+	1.98	0.45	1.0	2.55
Age 12+	1.98	0.45	1.0	2.57
Age 13+	1.98	0.45	1.0	2.59
Age 14+	1.98	0.45	1.0	2.61
Age 15+	1.98	0.45	1.0	2.63
Age 16+	1.98	0.45	1.0	2.65

Sources: Pattillo et al., 1997; Nelson, 1998; Murphy and MacDonald, 2000; Murphy et al., 2000; Froese and Pauly, 2002; and personal communication with Michael D. Murphy, Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute, January 23, 2002.

Table E1-22: Silver Perch Life History Parameters 1[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.75	0	0	0.000000527
Prolarvae	2.10	0	0	0.000000580
Postlarvae	3.27	0	0	0.0000379
Juvenile	1.71	0	0	0.0445
Age 1+	3.84	0	0	0.273
Age 2+	3.84	0.10	0.50	4.15
Age 3+	3.84	0.10	1.0	0.607

[a] Includes banded drum, silver perch, silver seatrout, southern kingfish, and star drum.

Sources: Able and Fahay, 1998; PSE&G, 1999; Florida Fish and Wildlife Conservation Commission, 2001; Froese and Pauly, 2001, 2003; and personal communication with Michael D. Murphy, Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute, January 23, 2002.

Table E1-23: Silver Perch Life History Parameters 2[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.75	0	0	0.000000527
Larvae	5.37	0	0	0.00000771
Juvenile	1.71	0	0	0.0445
Age 1+	3.84	0	0	0.273
Age 2+	3.84	0.10	0.50	0.415
Age 3+	3.84	0.10	1.0	0.607

[a] Includes silver perch, northern kingfish, and southern kingfish.

Sources: Able and Fahay, 1998; PSE&G, 1999; Florida Fish and Wildlife Conservation Commission, 2001; Froese and Pauly, 2001, 2003; and personal communication with Michael D. Murphy, Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute, January 23, 2002.

Table E1-24: Silverside Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.000000487
Prolarvae	1.45	0	0	0.000000554
Postlarvae	1.45	0	0	0.00000554
Juvenile	0.916	0	0	0.0000292
Age 1+	2.10	0	0	0.0119
Age 2+	2.10	0	0	0.0224

[a] Includes California grunion, inland silverside, rough silverside, tidewater silverside, and other silversides not identified to the species.

Sources: Hildebrand, 1922; Garwood, 1968; Stone & Webster Engineering Corporation, 1977, 1980; Scott and Scott, 1988; Froese and Pauly, 2001; and NMFS, 2003a.

Table E1-25: Spot Life History Parameters 1

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.825	0	0	0.000000131
Prolarvae	3.30	0	0	0.000000154
Postlarvae	4.12	0	0	0.000000854
Juvenile	2.57	0	0	0.000121
Age 1+	0.463	0.4	1.0	0.0791
Age 2+	0.400	0.4	1.0	0.299
Age 3+	0.400	0.4	1.0	0.507
Age 4+	0.400	0.4	1.0	0.648
Age 5+	0.400	0.4	1.0	0.732
Age 6+	0.400	0.4	1.0	0.779
Age 7+	0.400	0.4	1.0	0.779
Age 8+	0.400	0.4	1.0	0.779
Age 9+	0.400	0.4	1.0	0.779
Age 10+	0.400	0.4	1.0	0.779
Age 11+	0.400	0.4	1.0	0.779
Age 12+	0.400	0.4	1.0	0.779
Age 13+	0.400	0.4	1.0	0.779
Age 14+	0.400	0.4	1.0	0.779
Age 15+	0.400	0.4	1.0	0.779

Sources: Warlen et al., 1980; and PSE&G, 1984, 1999.

Table E1-26: Spot Life History Parameters 2

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	0.825	0	0	0.000000131
Larvae	7.42	0	0	0.000000504
Juvenile	2.57	0	0	0.000121
Age 1+	0.463	0.4	1.0	0.0791
Age 2+	0.400	0.4	1.0	0.299
Age 3+	0.400	0.4	1.0	0.507
Age 4+	0.400	0.4	1.0	0.648
Age 5+	0.400	0.4	1.0	0.732
Age 6+	0.400	0.4	1.0	0.779
Age 7+	0.400	0.4	1.0	0.779
Age 8+	0.400	0.4	1.0	0.779
Age 9+	0.400	0.4	1.0	0.779
Age 10+	0.400	0.4	1.0	0.779
Age 11+	0.400	0.4	1.0	0.779
Age 12+	0.400	0.4	1.0	0.779
Age 13+	0.400	0.4	1.0	0.779
Age 14+	0.400	0.4	1.0	0.779
Age 15+	0.400	0.4	1.0	0.779

Sources: Warlen et al., 1980; and PSE&G, 1984, 1999.

Table E1-27: Spotted Seatrout Life History Parameters 1[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.000000842
Prolarvae	1.50	0	0	0.000000926
Postlarvae	6.92	0	0	0.00000568
Juvenile	0.272	0.27	0.50	0.571
Age 1+	0.272	0.27	1.0	0.914
Age 2+	0.272	0.27	1.0	1.55
Age 3+	0.272	0.27	1.0	2.50
Age 4+	0.272	0.27	1.0	3.15
Age 5+	0.272	0.27	1.0	3.54
Age 6+	0.272	0.27	1.0	4.41
Age 7+	0.272	0.27	1.0	4.97
Age 8+	0.272	0.27	1.0	4.99

[a] Includes sand seatrout, sand weakfish, spotted seatrout, and other drums not identified to species.

Sources: Stone & Webster Engineering Corporation, 1980; Johnson and Seaman, 1986; Sutter et al., 1986; and Murphy and Taylor, 1994.

Table E1-28: Spotted Seatrout Life History Parameters 2[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.30	0	0	0.000000842
Larvae	8.42	0	0	0.000000926
Juvenile	0.272	0.27	0.50	0.571
Age 1+	0.272	0.27	1.0	0.914
Age 2+	0.272	0.27	1.0	1.55
Age 3+	0.272	0.27	1.0	2.50
Age 4+	0.272	0.27	1.0	3.15
Age 5+	0.272	0.27	1.0	3.54
Age 6+	0.272	0.27	1.0	4.41
Age 7+	0.272	0.27	1.0	4.97
Age 8+	0.272	0.27	1.0	4.99

[a] Includes sand seatrout and spotted seatrout.

Sources: Stone & Webster Engineering Corporation, 1980; Johnson and Seaman, 1986; Sutter et al., 1986; and Murphy and Taylor, 1994.

Table E1-29: Stone Crab Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Stage 1	1.97	0	0	0.000000101
Stage 2	1.97	0	0	0.000000417
Stage 3	1.97	0	0	0.00000109
Stage 4	1.97	0	0	0.00000226
Stage 5	1.97	0	0	0.00000405
Megalops	1.97	0	0	0.00000662
Juvenile	1.97	0	0	0.0000182
Age 1+	0.939	0.75	0.50	1.02
Age 2+	0.939	0.75	1.0	3.63
Age 3+	0.939	0.75	1.0	7.12
Age 4+	0.939	0.75	1.0	10.0

Sources: Bert et al., 1978; Sullivan, 1979; Lindberg and Marshall, 1984; Van den Avyle and Fowler, 1984; and Ehrhardt et al., 1990.

Table E1-30: Striped Mullet Life History Parameters

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.90	0	0	0.000000537
Larvae	4.61	0	0	0.0000110
Juvenile	0.916	0	0	0.131
Age 1+	0.230	0.30	0.50	0.187
Age 2+	0.230	0.30	1.0	0.379
Age 3+	0.230	0.30	1.0	0.774
Age 4+	0.230	0.30	1.0	1.58
Age 5+	0.230	0.30	1.0	3.21
Age 6+	0.230	0.30	1.0	6.53

Sources: Collins, 1985; Wang, 1986; PSE&G, 1999; and Froese and Pauly, 2003.

Table E1-31: Other Commercial Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.08	0	0	0.000000716
Larvae	5.71	0	0	0.00000204
Juvenile	2.85	0	0	0.000746
Age 1+	0.450	0	0	0.0937
Age 2+	0.450	0.80	0.50	0.356
Age 3+	0.450	0.80	1.0	0.679
Age 4+	0.450	0.80	1.0	0.974
Age 5+	0.450	0.80	1.0	1.21
Age 6+	0.450	0.80	1.0	1.38

[a] Includes Atlantic cutlassfish, black bullhead, cobia, grey snapper, gulf butterfish, ladyfish, largehead hairtail, mojarra spp., silver jenny, spotfin mojarra, tripletail, and yellow bullhead.

Sources: USFWS, 1978; Durbin et al., 1983; Ruppert et al., 1985; Able and Fahay, 1998; PSE&G, 1999; Entergy Nuclear Generation Company, 2000; and ASMFC, 2001b.

Table E1-32: Other Recreational Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	2.08	0	0	0.000000716
Larvae	5.71	0	0	0.00000204
Juvenile	2.85	0	0	0.000746
Age 1+	0.450	0	0	0.0937
Age 2+	0.450	0.80	0.50	0.356
Age 3+	0.450	0.80	1.0	0.679
Age 4+	0.450	0.80	1.0	0.974
Age 5+	0.450	0.80	1.0	1.21
Age 6+	0.450	0.80	1.0	1.38

[a] See Table E1-34 for a list of species.

Sources: USFWS, 1978; Durbin et al., 1983; Ruppert et al., 1985; Able and Fahay, 1998; PSE&G, 1999; Entergy Nuclear Generation Company, 2000; and ASMFC, 2001b.

Table E1-33: Other Forage Species Life History Parameters[a]

Stage Name	Instantaneous Natural Mortality (M)	Instantaneous Fishing Mortality (F)	Fraction Vulnerable to Fishery	Weight (lbs)
Eggs	1.04	0	0	0.0000000186
Larvae	7.70	0	0	0.00000158
Juvenile	1.29	0	0	0.000481
Age 1+	1.62	0	0	0.00381
Age 2+	1.62	0	0	0.00496
Age 3+	1.62	0	0	0.00505

[a] See Table E1-35 for a list of species.

Sources: Derickson and Price, 1973; and PSE&G, 1999.

Table E1-34: Other Recreational Species[a]

Atlantic sharpnose shark	Bonnethead	Hardhead sea catfish	Smooth butterfly ray
Atlantic stingray	Channel catfish	Least puffer	Smooth puffer
Bandtail puffer	Dwarf sandperch	Pigfish	Southern flounder
Belted sandfish	Gafftopsail catfish	Rock sea bass	Southern puffer
Blackear bass	Gag grouper	Sand perch	Tomtate
Bluefish	Gulf toadfish	Sea catfish	

[a] Includes other organisms not identified to species.

Table E1-35: Other Forage Species[a]

Atlantic midshipman	Dwarf seahorse	Jawfish	Seahorse
Atlantic needlefish	Fat sleeper	Lined seahorse	Sheepshead minnow
Atlantic spadefish	Feather blenny	Live sharksucker	Snakefish
Atlantic threadfin	Florida blenny	Longear sunfish	Southern codling
Barbfish	Freckled blenny	Mottled jawfish	Southern hake
Bay whiff	Fringed filefish	Needlefish	Southern stargazer
Blackcheek tonguefish	Fringed flounder	Orange filefish	Spotted whiff
Blackwing flyingfish	Golden shiner	Planehead filefish	Striped blenny
Bluegill	Green sunfish	Polka dot batfish	Striped burrfish
Bridle cardinalfish	Gulf of Mexico ocellated flounder	Redfin needlefish	Warmouth
Carp	Halfbeak	Roughback batfish	Yellowhead jawfish
Common halfbeak	Harvestfish	Sailfin molly	
Diamond lizardfish	Inshore lizardfish	Scrawled cowfish	

[a] Includes other organisms not identified to species.

Chapter E2: Evaluation of Impingement and Entrainment in the Gulf of Mexico

Background: Gulf of Mexico Marine Fisheries

Important marine fisheries of the Gulf of Mexico include both migratory pelagic species and reef fishes. Coastal pelagic fishes include king mackerel, Spanish mackerel, cero, dolphinfish, and cobia. These species range from the northeastern U.S. through the Gulf of Mexico and Caribbean Sea, and as far south as Brazil (NMFS, 1999a). They are managed under the Coastal Migratory Pelagic Resources Fishery Management Plan and regulations of the South Atlantic and Gulf of Mexico Fishery Management Councils, which are implemented by the NOAA Fisheries. King and Spanish mackerel make up nearly 95% of harvested coastal pelagic species, and are managed as two separate groups, the Gulf group and the Atlantic group (NMFS, 1999a). Most of the commercial catch of Spanish mackerel is landed in Florida. Up to 40% of the Gulf stock is also recreationally fished. Dolphinfish and cobia are also important recreational species, but the status of these stocks is uncertain (NMFS, 1999a).

Reef fishes include over 100 species ranging from North Carolina through the Gulf of Mexico and the Caribbean Sea that are important for commercial and recreational anglers (NMFS, 1999a). Many reef fisheries are closely associated with other managed reef animals, including spiny lobster and stone crab. In the Gulf of Mexico, reef fisheries include snapper and grouper species as well as grunts, amberjacks, and seabasses. Although landings of individual species aren't large, collectively reef fisheries have significant landings and value (NMFS, 1999a). However, stock status of many of these species remains unknown. Red snapper, the most important Gulf reef fish, is considered overutilized, in part because it is caught incidentally by the shrimp fishery (NMFS, 1999a).

E2-1   I&E Species/Species Groups Evaluated

Table E2-1 provides a list of species/species groups that were evaluated in EPA's analysis of impingement and entrainment (I&E) in the Gulf region.

Table E2-1: Species/Species Groups Evaluated by EPA that are Subject to I&E in the Gulf of Mexico

Species/Species Group	Recreational	Commercial	Forage
Atlantic croaker	X	X	
Bay anchovy			X
Black drum	X	X	
Blue crab		X	
Chain pipefish			X
Gobies			X

Table E2-1: Species/Species Groups Evaluated by EPA that are Subject to I&E in the Gulf of Mexico

Species/Species Group	Recreational	Commercial	Forage
Gulf killifish			X
Hogchoker			X
Leatherjacket		X	
Mackerel	X	X	
Menhaden species		X	
Other (commercial)		X	
Other (forage)			X
Other (recreational)	X		
Pinfish	X		
Pink shrimp		X	
Red drum	X		
Scaled sardine			X
Sea basses	X	X	
Searobin	X		
Sheepshead	X	X	
Silver perch	X		
Spot	X	X	
Spotted seatrout	X		
Stone crab		X	
Striped mullet	X	X	
Tidewater silverside			X

The life history data used in EPA's analysis and associated data sources are provided in Appendix E1 of this report.

E2-2   I&E Data Evaluated

Table E2-2 lists the facility I&E data evaluated by EPA to estimate current I&E rates for the region. See Chapter A1 of Part A for a discussion of the methods used to evaluate the I&E data.

Table E2-2: Phase II Facility I&E Data Evaluated for the Gulf of Mexico Analysis

Facilities	Years of Data
Big Bend (FL)	1976-1979
Crystal River (FL)	1984
P H Robinson (TX)	1978
Webster (TX)	1978

E2-3 EPA's Estimate of Current I&E at Phase III Facilities in the Gulf Region Expressed as Age-1 Equivalents and Foregone Yield

Table E2-3 provides EPA's estimate of the annual age-1 equivalents and foregone fishery yield resulting from the impingement of aquatic species at facilities located in the Gulf region. Table E2-4 displays this information for entrainment. Note that in these tables, "total yield" includes direct losses of harvested species and the yield of harvested species that is lost due to losses of forage species (trophic transfer).

Table E2-3: Estimated Current Annual Impingement at Phase III Facilities in the Gulf Region Expressed as Age-1 Equivalents and Foregone Fishery Yield

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
Atlantic croaker	752,000	155,000
Bay anchovy	1,350,000	<1
Black drum	5,900	26,600
Blue crab	2,460,000	30,300
Chain pipefish	28,300	<1
Gobies	10,400	<1
Gulf killifish	16,500	<1
Hogchoker	39,000	<1
Leatherjacket	314,000	39,400
Mackerels	3,690	511
Menhaden species	2,260,000	446,000
Other (commercial)	493,000	97,400
Other (forage)	819,000	<1
Other (recreational)	183,000	36,200
Pinfish	13,100	557
Pink shrimp	9,770,000	91,900
Red drum	37,000	167,000
Scaled sardine	62,000	<1
Sea basses	329	76
Searobin	426,000	17,600
Sheepshead	192	1
Silver perch	128,000	15
Spot	173,000	19,400
Spotted seatrout	574,000	513,000
Stone crab	84,600	61,800
Striped mullet	169,000	80,400
Tidewater silverside	100,000	<1
Trophic transfer[a]	<1	352

[a] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

Table E2-4: Estimated Current Annual Entrainment at Phase III Facilities in the Gulf Region Expressed as Age-1 Equivalents and Foregone Fishery Yield

Species/Species Group	Age-1 Equivalents (#s)	Total Yield (lbs)
Atlantic croaker	339	70
Bay anchovy	2,490,000	<1
Black drum	1,180,000	5,300,000
Blue crab	3,660,000	45,100
Chain pipefish	14,300	<1
Gobies	1,130,000	<1
Gulf killifish	<1	<1
Hogchoker	10,700	<1
Leatherjacket	6,800	852
Mackerels	<1	<1
Menhaden species	10,400	2,050
Other (commercial)	6,920	1,370
Other (forage)	3,730,000	<1
Other (recreational)	25,000	4,950
Pinfish	216,000	9,200
Pink shrimp	1,070,000	10,100
Red drum	142	642
Scaled sardine	142,000	<1
Sea basses	<1	<1
Searobin	73,700	3,040
Sheepshead	7,030	24
Silver perch	1,020,000	118
Spot	12,100	1,360
Spotted seatrout	26,000	23,300
Stone crab	5,800	4,240
Striped mullet	529,000	252,000
Tidewater silverside	144,000	<1
Trophic transfer[a]	<1	9,340

[a] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

E2-4   Reductions in I&E at Phase III Facilities in the Gulf of Mexico Region Under Alternative Options

Table E2-5 presents estimated reductions in I&E under the "50 MGD for All Waterbodies" option, the "200 MGD for All Waterbodies" option, and the "100 MGD for Certain Waterbodies" option. Reductions under all other options are presented in Appendix E2.

Table E2-5: Estimated Reductions in I&E Under Alternative Options		
Option	Age-1 Equivalents (#s)	Foregone Fishery Yield (lbs)
50 MGD All Option	19,400,000	4,200,000
200 MGD All Option	12,500,000	2,900,000
100 MGD Option	19,400,000	4,200,000

E2-5   Assumptions Used in Calculating Recreational and Commercial Losses

The lost yield estimates presented in Tables E2-3 and E2-4 are expressed as total pounds and include losses to both commercial and recreational catch. To estimate the economic value of these losses, total yield was partitioned between commercial and recreational fisheries based on the landings in each fishery. Table E2-6 presents the percentage impacts assumed for each species/species group. Commercial and recreational fishing benefits are presented in Chapters E3 and E4.

Table E2-6: Percentage of Total Impacts Occurring to the Commercial and Recreational Fisheries and Commercial Value per Pound for Species Impinged and Entrained at Gulf of Mexico Facilities		
Species/Species Group	Percent Impact to Recreational Fishery[a,b]	Percent Impact to Commercial Fishery[c]
Atlantic croaker	88.2%	11.8%
Black drum	93.0%	7.0%
Blue crab	0.0%	100.0%
Leatherjacket	0.0%	100.0%
Mackerels	73.5%	26.5%
Menhaden species	0.0%	100.0%
Other (commercial)	0.0%	100.0%
Other (recreational)	100.0%	0.0%
Pinfish	100.0%	0.0%
Pink shrimp	0.0%	100.0%
Red drum	100.0%	0.0%
Sea basses	86.0%	14.0%
Searobin	100.0%	0.0%
Sheepshead	67.0%	33.0%
Silver perch	100.0%	0.0%
Spot	23.9%	76.1%
Spotted seatrout	100.0%	0.0%
Stone crab	0.0%	100.0%
Striped mullet	10.1%	89.9%
Trophic transfer[d]	58.0%	42.0%

[a] Based on landings from 1993 to 2001 in Alabama, Florida (west coast), Louisiana, and Mississippi. Recreational landings data for Texas are not collected by NOAA Fisheries.
[b] Calculated using recreational landings data from NMFS (2003b, http://www.st.nmfs.gov/recreational/queries/catch/snapshot.html) and commercial landings data from NMFS (2003a, http://www.st.nmfs.gov/commercial/landings/annual_landings.html).
[c] Calculated using commercial landings data from NMFS (2003a).
[d] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

See Chapter E3 for results of the commercial fishing benefits analysis and Chapter E4 for recreational fishing results. As discussed in Chapter A8, benefits were discounted to account for (1) the time to achieve compliance once a Phase III final regulation for existing facilities would have become effective, and (2) the time it takes for fish spared from I&E to reach a harvestable age.

Appendix E2: Reductions in I&E Under Supplemental Policy Options

Option	Age-1 Equivalents (#s)	Foregone Fishery Yield (lbs)
Table E2-1: Estimated Reductions in I&E in the Gulf of Mexico Region Under Eight Supplemental Options		
Electric Generators 2-50 MGD		
I-only Everywhere	0	0
I&E like Phase II	0	0
I&E Everywhere	0	0
Manufacturers 2-50 MGD		
I-only Everywhere	543,000	47,800
I&E like Phase II	855,000	162,000
I&E Everywhere	855,000	162,000
Manufacturers 50+ MGD		
I-only Everywhere	10,400,000	917,000
I&E Everywhere	19,400,000	4,200,000

Chapter E3: Commercial Fishing Benefits

Introduction

This chapter presents the results of the commercial fishing benefits analysis for the Gulf of Mexico region. The chapter presents EPA's estimates of baseline (i.e., current) annual commercial fishery losses from impingement and entrainment (I&E) at potentially regulated facilities in the Gulf of Mexico region and annual reductions in these losses under the regulatory options for Phase III existing facilities[1]:

- ▸ the "50 MGD for All Waterbodies" option,
- ▸ the "200 MGD for All Waterbodies" option, and
- ▸ the "100 MGD for Certain Waterbodies" option.

The chapter then presents the estimated benefits to commercial fisheries from eliminating baseline losses from I&E, and the expected benefits under the regulatory options.

Chapter A4, "Methods for Estimating Commercial Fishing Benefits," details the methods used by EPA to estimate the commercial fishing benefits of reducing and eliminating I&E losses.

EPA considered a wide range of policy options in developing this regulation. In addition to the regulatory options, EPA evaluated several supplemental options. Appendix E3 presents results of the commercial fishing benefits analysis for the supplemental options. For additional information on the options, please see the TDD.

E3-1   Baseline Commercial Losses

Table E3-1 provides EPA's estimate of the value of gross revenues lost in commercial fisheries resulting from the impingement of aquatic species at facilities in the Gulf of Mexico region. Table E3-2 displays this information for entrainment. Total annualized revenue losses are approximately $1,020,218 (undiscounted).

---

[1] See the Introduction to this report for a description of the primary analysis options.

Table E3-1: Annualized Commercial Fishing Gross Revenues Lost due to Impingement at Facilities in the Gulf of Mexico Region

Species[a]	Estimated Pounds of Harvest Lost	Commercial Value per Pound (2004$)	Estimated Value of Harvest Lost (2004$) Undiscounted
Atlantic croaker	18,278	$0.25	$4,525
Black drum	1,873	$0.70	$1,315
Blue crab	30,298	$0.69	$20,842
Leatherjacket	39,401	$1.13	$44,584
Mackerels	135	$0.48	$65
Menhaden	445,871	$0.06	$25,326
Other[b]	97,415	$0.56	$54,388
Pink shrimp	91,899	$2.49	$228,779
Sea basses	11	$0.57	$6
Spot	14,736	$0.29	$4,240
Stone crab	61,812	$1.54	$95,264
Striped mullet	72,276	$0.71	$51,195
Trophic transfer[c]	148	$0.65	$97
Total	**874,153**		**$530,626**

[a] Species included are only those that have baseline losses greater than $1.
[b] Includes only species that are commercially, but not recreationally, fished.
[c] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

Table E3-2: Annualized Commercial Fishing Gross Revenues Lost due to Entrainment at Facilities in the Gulf of Mexico Region

Species[a]	Estimated Pounds of Harvest Lost	Commercial Value per Pound (2004$)	Estimated Value of Harvest Lost (2004$) Undiscounted
Atlantic croaker	8	$0.25	$2
Black drum	373,428	$0.70	$262,100
Blue crab	45,092	$0.69	$31,018
Leatherjacket	852	$1.13	$965
Menhaden	2,045	$0.06	$116
Other[b]	1,367	$0.56	$763
Pink shrimp	10,060	$2.49	$25,045
Sheepshead	8	$0.34	$3
Spot	1,032	$0.29	$297
Stone crab	4,236	$1.54	$6,528
Striped mullet	226,160	$0.71	$160,194
Trophic transfer[c]	3,923	$0.65	$2,562
Total	**668,211**		**$489,593**

[a] Species included are only those that have baseline losses greater than $1.
[b] Includes only species that are commercially, but not recreationally, fished.

Table E3-2: Annualized Commercial Fishing Gross Revenues Lost due to Entrainment at Facilities in the Gulf of Mexico Region

Species[a]	Estimated Pounds of Harvest Lost	Commercial Value per Pound (2004$)	Estimated Value of Harvest Lost (2004$) Undiscounted

[c] Contribution of forage fish to yield based on trophic transfer (see Chapter A1).

E3-2 Expected Benefits Under Regulatory Analysis Options

As described in Chapter A4, EPA estimates for Gulf of Mexico that, depending on species, 0 to 79% of the gross revenue losses represent surplus losses to producers, assuming no change in prices or fishing costs. Earlier EPA analysis assumed a rate of 40%. The 0% estimate, of course, results in loss estimates of $0.

The expected reductions in I&E attributable to changes at facilities required by the "50 MGD for All Waterbodies" option (50 MGD All option) are 51.4% for impingement and 57.9% for entrainment; the expected reductions for the "200 MGD for All Waterbodies" option (200 MGD All option) are 29.9% for impingement and 41.8% for entrainment; and the expected reductions for the "100 MGD for Certain Waterbodies" option (100 MGD CWB option) are 51.4% for impingement and 57.9% for entrainment. Total annualized benefits are estimated by applying these estimated reductions to the annual baseline producer surplus loss. As presented in Tables E3-3, E3-4, and E3-5, this results in total annualized benefits of up to approximately $283,218 for the 50 MGD All option, $188,205 for the 200 MGD All option, and $283,218 for the 100 MGD CWB option, assuming a 3% discount rate and a species-specific net benefits ratio.[2]

E3-2.1 Commercial Fishing Benefits of the "50 MGD for All Waterbodies" Option

Table E3-3 shows EPA's analysis of the commercial benefits of the "50 MGD for All Waterbodies" option for the Gulf of Mexico region. The table shows that this option, assuming a species-specific net benefits ratio, will result in undiscounted total annualized commercial benefits of approximately $338,493. When evaluated at 3% and 7% discount rates, the annualized commercial benefits are $283,218 and $225,425, respectively.

Table E3-3: Annualized Commercial Fishing Benefits Attributable to the 50 MGD All Option at Facilities in the Gulf of Mexico Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$530,625	$489,593	$1,020,218
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$267,680	$346,483	$614,163
Expected reduction due to rule	51.4%	57.9%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$338,493
3% discount rate			$283,218

[2] The net benefits ratio is the fractional share of gross revenue associated with net benefits, by gear and vessel type. See Chapter A4, section A4-10, for a description of the species-specific net benefits ratios and how they are calculated.

7% discount rate	$225,425

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

E3-2.2 Commercial Fishing Benefits of the "200 MGD for All Waterbodies" Option

Table E3-4 shows EPA's analysis of the commercial benefits of the "200 MGD for All Waterbodies" option for the Gulf of Mexico region. The table shows that this option, assuming a species-specific net benefits ratio, will result in undiscounted total annualized commercial benefits of approximately $224,937. When evaluated at 3% and 7% discount rates, the annualized commercial benefits are $188,205 and $149,800, respectively.

Table E3-4: Annualized Commercial Fishing Benefits Attributable to The 200 MGD All Option at Facilities in the Gulf of Mexico Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$530,625	$489,593	$1,020,218
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$267,680	$346,483	$614,163
Expected reduction due to rule	29.9%	41.8%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$224,937
3% discount rate			$188,205
7% discount rate			$149,800

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

E3-2.3 Commercial Fishing Benefits of the "100 MGD for Certain Waterbodies" Option

Table E3-5 shows EPA's analysis of the commercial benefits of the "100 MGD for Certain Waterbodies" option for the Gulf of Mexico region. The table shows that this option, assuming a species-specific net benefits ratio, will result in undiscounted total annualized commercial benefits of approximately $338,493. When evaluated at 3% and 7% discount rates, the annualized commercial benefits are $283,218 and $225,425, respectively.

**Table E3-5: Annualized Commercial Fishing Benefits Attributable to
the 100 MGD CWB Option at Facilities in the Gulf of Mexico Region (2004$)[a]**

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$530,625	$489,593	$1,020,218
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$267,680	$346,483	$614,163
Expected reduction due to rule	51.4%	57.9%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$338,493
3% discount rate			$283,218
7% discount rate			$225,425

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Appendix E3: Commercial Fishing Benefits Under Supplemental Policy Options

Introduction

Chapter E3 presents EPA's estimates of the commercial benefits of the regulatory options for the section 316(b) rule for Phase III facilities in the Gulf of Mexico region. To facilitate comparisons among the options, this appendix presents estimates of the commercial fishing benefits of several supplemental options that EPA evaluated in preparation for this rule:

- ▸ "Electric Generators 2-50 MGD I-only Everywhere" option;
- ▸ "Electric Generators 2-50 MGD I&E like Phase II" option;
- ▸ "Electric Generators 2-50 MGD I&E Everywhere" option;
- ▸ "Manufacturers 2-50 MGD I-only Everywhere" option;
- ▸ "Manufacturers 2-50 MGD I&E like Phase II" option;
- ▸ "Manufacturers 2-50 MGD I&E Everywhere" option;
- ▸ "Manufacturers 50+ MGD I-only Everywhere" option; and
- ▸ "Manufacturers 50+ MGD I&E Everywhere" option.

Commercial fishing benefits presented in this chapter were estimated using the benefit transfer approach discussed in Chapter E3 and in Chapter A4, "Methods for Estimating Commercial Fishing Benefits." For additional information on the options, please see the TDD.

E3-1   Commercial Fishing Benefits of the Supplemental Options

No facilities located in the Gulf of Mexico region are electric generators with design intake flows greater than 2 MGD and less than 50 MGD, so no facilities would have technology requirements under the "Electric Generators 2-50 MGD I-only Everywhere" option, the "Electric Generators 2-50 MGD I&E like Phase II" option, or the "Electric Generators 2-50 MGD I&E Everywhere" option. Thus no commercial benefits are expected under these options in the Gulf of Mexico region.

Tables E3-1 through E3-5 present EPA's estimates of the annualized commercial benefits of the remaining supplemental options in the Gulf of Mexico region.

Table E3-1: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 2-50 MGD I-only Everywhere" Option at Facilities in the Gulf of Mexico Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$530,625	$489,593	$1,020,218
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$267,680	$346,483	$614,163
Expected reduction due to rule	3%	0%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$7,174
3% discount rate			$6,002
7% discount rate			$4,778

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table E3-2: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 2-50 MGD I&E like Phase II" Option at Facilities in the Gulf of Mexico Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$530,625	$489,593	$1,020,218
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$267,680	$346,483	$614,163
Expected reduction due to rule	3%	2%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$14,138
3% discount rate			$11,829
7% discount rate			$9,416

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table E3-3: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 2-50 MGD I&E Everywhere" Option at Facilities in the Gulf of Mexico Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$530,625	$489,593	$1,020,218
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$267,680	$346,483	$614,163
Expected reduction due to rule	3%	2%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$14,138
3% discount rate			$11,829
7% discount rate			$9,416

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table E3-4: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 50+ MGD I-only Everywhere" Option at Facilities in the Gulf of Mexico Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$530,625	$489,593	$1,020,218
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$267,680	$346,483	$614,163
Expected reduction due to rule	51%	0%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$137,568
3% discount rate			$115,103
7% discount rate			$91,616

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Table E3-5: Annualized Commercial Fishing Benefits Attributable to the "Manufacturers 50+ MGD I&E Everywhere" Option at Facilities in the Gulf of Mexico Region (2004$)[a]

	Impingement	Entrainment	Total
Baseline loss — gross revenue			
Undiscounted	$530,625	$489,593	$1,020,218
Producer surplus lost — 0%	$0	$0	$0
Producer surplus lost — (gross revenue * species-specific net benefits ratio)			
Undiscounted	$267,680	$346,483	$614,163
Expected reduction due to rule	51%	58%	
Benefits attributable to rule — 0%	$0	$0	$0
Benefits attributable to rule — species-specific net benefits ratio			
Undiscounted			$338,493
3% discount rate			$283,218
7% discount rate			$225,425

[a] Annualized benefits represent the value of all commercial benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a 30 year period. For a more detailed discussion of the discounting methodology, refer to Chapter A8, and see Chapter I1 for a timeline of benefits.

Chapter E4: Recreational Use Benefits

Introduction

This chapter presents the results of the recreational fishing benefits analysis for the Gulf of Mexico region. The chapter presents EPA's estimates of baseline (i.e., current) annual recreational fishery losses from impingement and entrainment (I&E) at potentially regulated facilities in the Gulf of Mexico region and annual reductions in these losses under the regulatory options for Phase III existing facilities[1]:

> ▸ the "50 MGD for All Waterbodies" option,
> ▸ the "200 MGD for All Waterbodies" option, and
> ▸ the "100 MGD for Certain Waterbodies" option.

The chapter then presents the estimated welfare gain to Gulf of Mexico anglers from eliminating baseline recreational fishing losses from I&E and the expected benefits under the regulatory options.

EPA estimated the recreational benefits of reducing and eliminating I&E losses using a benefit transfer methodology based on a meta-analysis of the marginal value of catching different species of fish. This meta-analysis is discussed in detail in Chapter A5, "Recreational Fishing Benefits Methodology."

EPA considered a wide range of policy options in developing this regulation. In addition to the regulatory options, EPA evaluated several supplemental options. Appendix E4 presents results of the recreational fishing benefits analysis for the supplemental options. For additional information on the options, please see the TDD.

E4-1 Benefit Transfer Approach Based on Meta-Analysis

EPA estimated the recreational welfare gain from the reduction in annual I&E losses expected under the policy options, and the welfare gain from eliminating I&E at potentially regulated facilities, using a benefit transfer approach. As discussed in Chapter A5, the Agency used a meta-analysis regression equation to estimate the marginal recreational value per additional fish caught by anglers, for different species in different regions. Since I&E at potentially regulated facilities affects a variety of species, EPA assigned each species with I&E losses to one of the general species groups used in the meta-analysis. The Agency then calculated the economic value of reducing or eliminating baseline I&E losses, for each species group, by multiplying the value per fish for that species group by the number of fish in the group that are lost in the baseline or saved under the policy options.[2]

---

[1] See the Introduction to this report for a description of the regulatory options.

[2] The estimates of I&E presented in this chapter include only the fraction of impinged and entrained recreational fish that would be caught by anglers. The total amount of I&E of recreational species is actually much higher.

In general, the fit between the species with I&E losses and the species groups in the meta-analysis was good. However, EPA's estimates of baseline I&E losses and reductions in I&E under the policy options included losses of "unidentified" species. The "unidentified" group includes fish lost indirectly through trophic transfer, as well as species for which no species information was available.[3] Rather than using the meta-analysis regression to try to predict the value per fish for an "unidentified" species, EPA assumed that per-fish values for these species can be approximated by the weighted average value per fish for all species affected by I&E in the Gulf of Mexico region.[4]

E4-1.1 Baseline Losses and Reductions in Recreational Fishery Losses Under the Regulatory Options

Table E4-1 presents EPA's estimates of baseline (i.e., current) annual recreational I&E losses at potentially regulated facilities, and annual reductions in these losses under each of the regulatory options, in the Gulf of Mexico region. The table shows that total baseline losses to recreational fisheries are 788.0 thousand fish per year. In comparison, the "50 MGD for All Waterbodies" and "100 MGD for Certain Waterbodies" options prevent losses of 430.9 thousand fish per year, and the "200 MGD for All Waterbodies" option prevents losses of 282.4 thousand fish per year. Of all the affected species, black drum and spotted seatrout have the highest losses in the baseline and the highest prevented losses under the regulatory options.

---

[3] In addition to recreational fish that are lost because they are impinged or entrained, some recreational fish are lost because the forage fish that they feed on are impinged or entrained, and thus removed from the food chain. These trophic transfer losses of recreational species are included in EPA's estimates of total I&E losses. Since it is difficult to predict which recreational species would be affected by losses of forage fish, these losses are classified as "unidentified" recreational species. Also included in the "unidentified" group are losses of fish that were reported by facilities without information about their exact species.

[4] EPA used the estimated level of baseline recreational losses for each species group as a weighting factor.

Table E4-1: Baseline Recreational Fishing Losses from I&E at Potentially Regulated Phase III Facilities and Reductions in Recreational Losses Under the Regulatory Options in the Gulf of Mexico Region

Species[a]	Baseline Annual Recreational Fishing Losses (# of fish)	Annual Reductions in Recreational Fishing Losses (# of fish)		
		50 MGD All[b]	200 MGD All	100 MGD CWB[b]
Mackerels	526.7	270.7	157.3	270.7
Red drum	10,374.9	5,334.6	3,103.4	5,334.6
Spotted seatrout	218,691.7	113,018.0	66,454.1	113,018.0
Total (small game)	**229,593.3**	**118,623.2**	**69,714.9**	**118,623.2**
Atlantic croaker	81,331.5	41,800.9	24,295.7	41,800.9
Black drum	307,109.6	177,991.7	128,328.8	177,991.7
Pinfish	53,772.5	30,980.1	22,133.6	30,980.1
Sea bass	54.4	28.0	16.2	28.0
Searobin	45,435.6	23,792.5	14,372.7	23,792.5
Sheepshead	9.3	5.4	3.9	5.4
Silver perch	313.3	179.4	126.9	179.4
Spot	11,962.2	6,199.3	3,666.5	6,199.3
Striped mullet	11,627.7	6,557.1	4,528.4	6,557.1
Total (other saltwater)	**511,616.2**	**287,534.4**	**197,472.8**	**287,534.4**
Total (unidentified)	**46,818.1**	**24,745.7**	**15,226.3**	**24,745.7**
Total (all species)	**788,027.6**	**430,903.4**	**282,414.1**	**430,903.4**

[a] EPA assigned each species with I&E losses to one of the species groups used in the meta-analysis. The "other saltwater" group includes bottomfish and other miscellaneous species. The "unidentified" group includes fish lost indirectly through trophic transfer and fish reported lost without information about their species.

[b] Annual reductions in recreational I&E losses are the same in the Gulf of Mexico region for the "50 MGD for All Waterbodies" and "100 MGD for Certain Waterbodies" options.

Source: U.S. EPA analysis for this report.

E4-1.2 Recreational Fishing Benefits from Eliminating Baseline I&E Losses

Table E4-2 shows the results of EPA's analysis of the welfare gain to recreational anglers from eliminating baseline recreational fishery losses at potentially regulated facilities in the Gulf of Mexico region. The table presents baseline annual recreational I&E losses, the estimated value per fish, and the monetized annual welfare gain from eliminating recreational losses, for each species group. Total baseline recreational fishing losses for the Gulf of Mexico region are 788.0 thousand fish per year. The undiscounted annual welfare gain to Gulf of Mexico anglers from eliminating these losses is $2.43 million (2004$), with lower and upper bounds of $1.29 million and $4.68 million. Evaluated at 3% and 7% discount rates, the mean annualized welfare gain of eliminating these losses is $2.36 million and $2.27 million, respectively. The majority of monetized recreational losses from I&E under baseline conditions are attributable to losses of black drum and spotted seatrout.

Table E4-2: Recreational Fishing Benefits from Eliminating Baseline I&E at Potentially Regulated Phase III Facilities in the Gulf of Mexico Region (2004$)

Species Group	Baseline Annual Recreational Fishing Losses (thousands of fish)[a]	Value per Fish[b]			Annualized Benefits from Eliminating Recreational Fishing Losses (thousands)[c,d]		
		Low	Mean	High	Low	Mean	High
Small game	229.6	$2.05	$4.74	$10.79	$470.8	$1,088.3	$2,476.7
Other saltwater	511.6	$1.46	$2.34	$3.77	$746.4	$1,196.4	$1,929.5
Unidentified	46.8	$1.64	$3.08	$5.94	$76.9	$144.3	$278.3
Total (undiscounted)	**788.0**				**$1,294.1**	**$2,429.0**	**$4,684.5**
Total (evaluated at 3% discount rate)[c]	**788.0**				**$1,255.3**	**$2,356.0**	**$4,543.8**
Total (evaluated at 7% discount rate)[c]	**788.0**				**$1,208.8**	**$2,268.8**	**$4,375.6**

[a] Recreational fishing losses include only the portion of impinged and entrained fish that would have been caught by recreational anglers.

[b] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.

[c] Monetized benefits are calculated by multiplying baseline losses by the estimated value per fish.

[d] Annualized values represent the total welfare gain over the time frame of the analysis from eliminating recreational losses, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting and annualization methodology, refer to Chapter A8.

Source: U.S. EPA analysis for this report.

E4-1.3 Recreational Fishing Benefits of the "50 MGD for All Waterbodies" Option

Table E4-3 shows the results of EPA's analysis of the recreational benefits of the "50 MGD for All Waterbodies" option for the Gulf of Mexico region. The table presents the annual reduction in recreational I&E losses expected under this option, the estimated value per fish, and annual monetized recreational welfare gain from this option, by species group. The table shows that this option reduces recreational losses by 430.9 thousand fish per year, resulting in an undiscounted welfare gain to recreational anglers of $1.31 million (2004$), with lower and upper bounds of $0.70 million and $2.51 million. Evaluated at 3% and 7% discount rates, the mean annualized welfare gain from this reduction in recreational losses is $1.10 million and $0.87 million, respectively. The majority of benefits result from reduced losses of black drum and spotted seatrout.

**Table E4-3: Recreational Fishing Benefits of the "50 MGD for All Waterbodies" Option
in the Gulf of Mexico Region (2004$)**

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)[a]	Value per Fish[b]			Annualized Recreational Fishing Benefits (thousands)[c,d]		
		Low	Mean	High	Low	Mean	High
Small game	118.6	$2.05	$4.74	$10.79	$243.3	$562.3	$1,279.6
Other saltwater	287.5	$1.46	$2.34	$3.77	$419.5	$672.4	$1,084.4
Unidentified	24.7	$1.64	$3.08	$5.94	$40.6	$76.3	$147.1
Total (undiscounted)	**430.9**				**$703.4**	**$1,310.9**	**$2,511.1**
Total (evaluated at 3% discount rate)[c]	**430.9**				**$588.5**	**$1,096.9**	**$2,101.1**
Total (evaluated at 7% discount rate)[c]	**430.9**				**$468.4**	**$873.0**	**$1,672.3**

[a] Recreational fishing losses include only the portion of impinged and entrained fish that would have been caught by recreational anglers.

[b] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.

[c] Monetized benefits are calculated by multiplying the annual reduction in recreational losses by the estimated value per fish.

[d] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting and annualization methodology, refer to Chapter A8.

Source: U.S. EPA analysis for this report.

E4-1.4 Recreational Fishing Benefits of the "200 MGD for All Waterbodies" Option

Table E4-4 shows the results of EPA's analysis of the recreational benefits of the "200 MGD for All Waterbodies" option for the Gulf of Mexico region. The table presents the annual reduction in recreational I&E losses expected under this option, the estimated value per fish, and annual monetized recreational welfare gain from this option, by species group. The table shows that this option reduces recreational losses by 282.4 thousand fish per year, resulting in an undiscounted welfare gain to recreational anglers of $0.84 million (2004$), with lower and upper bounds of $0.46 million and $1.59 million. Evaluated at 3% and 7% discount rates, the mean annualized welfare gain from this reduction in recreational losses is $0.70 million and $0.56 million, respectively. The majority of benefits result from reduced losses of black drum and spotted seatrout.

Table E4-4: Recreational Fishing Benefits of the "200 MGD for All Waterbodies" Option in the Gulf of Mexico Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)[a]	Value per Fish[b]			Annualized Recreational Fishing Benefits (thousands)[c,d]		
		Low	Mean	High	Low	Mean	High
Small game	69.7	$2.05	$4.74	$10.79	$143.0	$330.4	$752.0
Other saltwater	197.5	$1.46	$2.34	$3.77	$288.1	$461.8	$744.7
Unidentified	15.2	$1.64	$3.08	$5.94	$25.0	$46.9	$90.5
Total (undiscounted)	**282.4**				**$456.1**	**$839.2**	**$1,587.3**
Total (evaluated at 3% discount rate)[c]	**282.4**				**$381.6**	**$702.1**	**$1,328.1**
Total (evaluated at 7% discount rate)[c]	**282.4**				**$303.7**	**$558.9**	**$1,057.1**

[a] Recreational fishing losses include only the portion of impinged and entrained fish that would have been caught by recreational anglers.

[b] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.

[c] Monetized benefits are calculated by multiplying the annual reduction in recreational losses by the estimated value per fish.

[d] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting and annualization methodology, refer to Chapter A8.

Source: U.S. EPA analysis for this report.

E4-1.5 Recreational Fishing Benefits of the "100 MGD for Certain Waterbodies" Option

All potentially regulated facilities in the Gulf of Mexico region that would have to install new technology under the "50 MGD for All Waterbodies" option and "100 MGD for Certain Waterbodies" option have design intake flows that are greater than 100 MGD and are located on coastal waterbodies. Because the requirements under the 50 MGD option and the 100 MGD option are identical for this class of facilities, the estimated I&E reductions and recreational fishing benefits from these two options are identical. Thus, the estimated recreational fishing benefits presented in Table E4-3 also apply to the "100 MGD for Certain Waterbodies" option. The table shows that this option reduces recreational losses by 430.9 thousand fish per year, resulting in an undiscounted welfare gain to recreational anglers of $1.31 million (2004$), with lower and upper bounds of $0.70 million and $2.51 million. Evaluated at 3% and 7% discount rates, the mean annualized welfare gain from this reduction in recreational losses is $1.10 million and $0.87 million, respectively. The majority of benefits result from reduced losses of black drum and spotted seatrout.

E4-2 Limitations and Uncertainty

The results of the benefit transfer based on a meta-analysis represent EPA's best estimate of the recreational benefits of the regulatory options. Nonetheless, there are a number of limitations and uncertainties inherent in these estimates. General limitations pertaining to the development of the meta-analysis model, the use of the model to estimate per-fish values, and the validity of the benefit transfer are discussed in section A5-3.3e and section A5-5.3 of Chapter A5.

Appendix E4: Recreational Use Benefits Under Supplemental Policy Options

Introduction

Chapter E4 presents EPA's estimates of the recreational benefits of the regulatory options for the section 316(b) rule for Phase III facilities in the Gulf of Mexico region. To facilitate comparisons among the options, this appendix presents estimates of the recreational fishing benefits of several supplemental options that EPA evaluated in preparation for this rule:

- ▸ "Electric Generators 2-50 MGD I-only Everywhere" option,
- ▸ "Electric Generators 2-50 MGD I&E like Phase II" option;
- ▸ "Electric Generators 2-50 MGD I&E Everywhere" option;
- ▸ "Manufacturers 2-50 MGD I-only Everywhere" option;
- ▸ "Manufacturers 2-50 MGD I&E like Phase II" option;
- ▸ "Manufacturers 2-50 MGD I&E Everywhere" option;
- ▸ "Manufacturers 50+ MGD I-only Everywhere" option; and
- ▸ "Manufacturers 50+ MGD I&E Everywhere" option.

Recreational fishing benefits presented in this chapter were estimated using the benefit transfer approach discussed in Chapter E4 and in Chapter A5, "Recreational Fishing Benefits Methodology."

E4-1   Recreational Fishing Benefits of the Supplemental Options

E4-1.1 Estimated Reductions in Recreational Fishing Losses Under the Supplemental Options

Table E4-1 presents EPA's estimates of the annual reduction in baseline (i.e., current) recreational fishing losses from impingement and entrainment (I&E) in the Gulf of Mexico region under the supplemental options. For more information on the options, please see the TDD.

Table E4-1: Reductions in Recreational Fishing Losses from I&E Under the Supplemental Options in the Gulf of Mexico Region

	Annual Reduction in Recreational Losses (# of fish)							
	Electric Generators 2-50 MGD[b]			Manufacturers 2-50 MGD			Manufacturers 50+ MGD	
Species[a]	I-only Everywhere	I&E like Phase II	I&E Everywhere	I-only Everywhere	I&E like Phase II[c]	I&E Everywhere[c]	I-only Everywhere	I&E Everywhere
Mackerels	0	0	0	14.1	14.1	14.1	270.7	270.7
Red drum	0	0	0	277.0	277.8	277.8	5,311.5	5,334.6
Spotted seatrout	0	0	0	5,606.5	5,797.3	5,797.3	107,512.2	113,018.0
Total (small game)	**0**	**0**	**0**	**5,897.6**	**6,089.2**	**6,089.2**	**113,094.4**	**118,623.2**
Atlantic croaker	0	0	0	2,178.7	2,179.4	2,179.4	41,779.6	41,800.9
Black drum	0	0	0	41.1	6,183.2	6,183.2	787.7	177,991.7
Pinfish	0	0	0	82.3	1,101.4	1,101.4	1,578.4	30,980.1
Sea bass	0	0	0	1.5	1.5	1.5	28.0	28.0
Searobin	0	0	0	1,038.2	1,172.8	1,172.8	19,907.9	23,792.5
Sheepshead	0	0	0	0.0	0.2	0.2	0.1	5.4
Silver perch	0	0	0	0.9	6.5	6.5	18.0	179.4
Spot	0	0	0	299.6	315.3	315.3	5,745.3	6,199.3
Striped mullet	0	0	0	75.5	252.6	252.6	1,447.2	6,557.1
Total (other saltwater)	**0**	**0**	**0**	**3,717.7**	**11,212.9**	**11,212.9**	**71,292.2**	**287,534.4**
Total (unidentified)	**0**	**0**	**0**	**976.6**	**1,185.2**	**1,185.2**	**18,727.7**	**24,745.7**
Total (all species)	**0**	**0**	**0**	**10,591.9**	**18,487.4**	**18,487.4**	**203,114.3**	**430,903.4**

[a] EPA assigned each species with I&E losses to one of the species groups used in the meta-analysis. The "other saltwater" group includes bottomfish and other miscellaneous species. The "unidentified" group includes fish lost indirectly through trophic transfer and fish reported lost without information about their species.
[b] No facilities located in the Gulf of Mexico region are electric generators with design intake flows greater than 2 MGD and less than 50 MGD. Thus no facilities would have technology requirements under the "Electric Generators 2-50 MGD I-only Everywhere" option, the "Electric Generators 2-50 MGD I&E like Phase II" option, or the "Electric Generators 2-50 MGD I&E Everywhere" option.
[c] Annual reductions in recreational I&E losses are the same in the Gulf of Mexico region for the "Manufacturers 2-50 MGD I&E like Phase II" and "Manufacturers 2-50 MGD I&E Everywhere" options.

Source: U.S. EPA analysis for this report.

E4-1.2 Recreational Fishing Benefits of the Supplemental Options

Tables E4-2 through E4-5 present EPA's estimates of the annualized recreational benefits of the supplemental options in the Gulf of Mexico region.

No facilities located in the Gulf of Mexico region are electric generators with design intake flows greater than 2 MGD and less than 50 MGD, so no facilities would have technology requirements under the "Electric Generators 2-50 MGD I-only Everywhere" option, the "Electric Generators 2-50 MGD I&E like Phase II" option, or the "Electric Generators 2-50 MGD I&E Everywhere" option. Thus no recreational benefits are expected under these options in the Gulf of Mexico region.

Table E4-2: Recreational Fishing Benefits of the "Manufacturers 2-50 MGD I-only Everywhere" Option in the Gulf of Mexico Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	5.9	$2.05	$4.74	$10.79	$12.1	$28.0	$63.6
Other saltwater	3.7	$1.46	$2.34	$3.77	$5.4	$8.7	$14.0
Unidentified	1.0	$1.64	$3.08	$5.94	$1.6	$3.0	$5.8
Total (undiscounted)	**10.6**				**$19.1**	**$39.7**	**$83.4**
Total (evaluated at 3% discount rate)	**10.6**				**$16.0**	**$33.2**	**$69.8**
Total (evaluated at 7% discount rate)	**10.6**				**$12.7**	**$26.4**	**$55.6**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.
[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.

Source: U.S. EPA analysis for this report.

Annual reductions in recreational I&E losses are the same in the Gulf of Mexico region for the "Manufacturers 2-50 MGD I&E Everywhere" option as for the "Manufacturers 2-50 MGD I&E like Phase II" option. Therefore, the annualized recreational fishing benefits for these two options are the same, and are presented together in Table E4-3.

Table E4-3: Recreational Fishing Benefits of the "Manufacturers 2-50 MGD I&E like Phase II" Option and the "Manufacturers 2-50 MGD I&E Everywhere" Option in the Gulf of Mexico Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	6.1	$2.05	$4.74	$10.79	$12.5	$28.9	$65.7
Other saltwater	11.2	$1.46	$2.34	$3.77	$16.4	$26.2	$42.3
Unidentified	1.2	$1.64	$3.08	$5.94	$1.9	$3.7	$7.0
Total (undiscounted)	**18.5**				**$30.8**	**$58.7**	**$115.0**
Total (evaluated at 3% discount rate)	**18.5**				**$25.8**	**$49.1**	**$96.2**
Total (evaluated at 7% discount rate)	**18.5**				**$20.5**	**$39.1**	**$76.6**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.
[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.

Source: U.S. EPA analysis for this report.

Table E4-4: Recreational Fishing Benefits of the "Manufacturers 50+ MGD I-only Everywhere" Option in the Gulf of Mexico Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	113.1	$2.05	$4.74	$10.79	$231.9	$536.1	$1,220.0
Other saltwater	71.3	$1.46	$2.34	$3.77	$104.0	$166.7	$268.9
Unidentified	18.7	$1.64	$3.08	$5.94	$30.8	$57.7	$111.3
Total (undiscounted)	**203.1**				**$366.7**	**$760.5**	**$1,600.2**
Total (evaluated at 3% discount rate)	**203.1**				**$306.8**	**$636.3**	**$1,338.9**
Total (evaluated at 7% discount rate)	**203.1**				**$244.2**	**$506.5**	**$1,065.7**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.
[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.

Source: U.S. EPA analysis for this report.

Table E4-5: Recreational Fishing Benefits of the "Manufacturers 50+ MGD I&E Everywhere" Option in the Gulf of Mexico Region (2004$)

Species Group	Annual Reduction in Recreational Fishing Losses (thousands of fish)	Value per Fish[a]			Annualized Recreational Fishing Benefits (thousands)[b,c]		
		Low	Mean	High	Low	Mean	High
Small game	118.6	$2.05	$4.74	$10.79	$243.3	$562.3	$1,279.6
Other saltwater	287.5	$1.46	$2.34	$3.77	$419.5	$672.4	$1,084.4
Unidentified	24.7	$1.64	$3.08	$5.94	$40.6	$76.3	$147.1
Total (undiscounted)	**430.9**				**$703.4**	**$1,310.9**	**$2,511.1**
Total (evaluated at 3% discount rate)	**430.9**				**$588.5**	**$1,096.9**	**$2,101.1**
Total (evaluated at 7% discount rate)	**430.9**				**$468.4**	**$873.0**	**$1,672.3**

[a] Lower and upper bounds on per-fish values are based on the 5% and 95% confidence bounds predicted by the Krinsky and Robb approach. See section A5-5.1 of Chapter A5 for more details on this approach.
[b] Monetized benefits are calculated by multiplying the reduction in losses by the estimated value per fish.
[c] Annualized benefits represent the value of all recreational benefits generated over the time frame of the analysis, discounted to 2007, and then annualized over a thirty year period. For a detailed discussion of the discounting methodology, refer to Chapter A8.

Source: U.S. EPA analysis for this report.

E4-2 Comparison of Recreational Fishing Benefits by Option

Table E4-6 compares the recreational fishing benefits of several supplemental options.

	Annual Reduction in Recreational Fishing Losses from I&E (thousands of fish)	Undiscounted Recreational Fishing Benefits (thousands; 2004$)[a]		
Policy Option		**Low**	**Mean**	**High**
Electric Generators 2-50 MGD[b]				
I-only Everywhere	0.0	$0.0	$0.0	$0.0
I&E like Phase II	0.0	$0.0	$0.0	$0.0
I&E Everywhere	0.0	$0.0	$0.0	$0.0
Manufacturers 2-50 MGD				
I-only Everywhere	10.6	$19.1	$39.7	$83.4
I&E like Phase II[c]	18.5	$30.8	$58.7	$115.0
I&E Everywhere[c]	18.5	$30.8	$58.7	$115.0
Manufacturers 50+ MGD				
I-only Everywhere	203.1	$366.7	$760.5	$1,600.2
I&E Everywhere	430.9	$703.4	$1,310.9	$2,511.1

Table E4-6: Annual Recreational Benefits of the Supplemental Options in the Gulf of Mexico Region

[a] These benefit estimates were calculated using the meta-analysis approach discussed in Chapter A5 and Chapter B4.

[b] No facilities located in the Gulf of Mexico region are electric generators with design intake flows greater than 2 MGD and less than 50 MGD, so no facilities would have technology requirements under the "Electric Generators 2-50 MGD I-only Everywhere" option, the "Electric Generators 2-50 MGD I&E like Phase II" option, or the "Electric Generators 2-50 MGD I&E Everywhere" option. Thus no recreational benefits are expected under these options in the Gulf of Mexico region.

[c] Annual reductions in recreational I&E losses and undiscounted recreational fishing benefits are the same in the Gulf of Mexico region for the "Manufacturers 2-50 MGD I&E like Phase II" and "Manufacturers 2-50 MGD I&E Everywhere" options.

Source: U.S. EPA analysis for this report.

Chapter E5: Federally Listed T&E Species in the Gulf of Mexico Region

This chapter lists current federally listed threatened and endangered (T&E) fish and shellfish species in the Gulf of Mexico Region. This list does not address proposed or candidate species; In addition, fish and shellfish listed as cave species, marine mammals, reptiles, amphibians, and snails are not included in this chapter.

	Table E5-1: Alabama Federally Listed T&E Fish and Shellfish	
Status	**Scientific Name**	**Common Name**
T	*Acipenser oxyrinchus desotoi*	Gulf sturgeon
E	*Dromus dromas*	Dromedary pearlymussel: entire range except where listed as experimental populations
T	*Elliptoideus sloatianus*	Purple bankclimber mussel
E	*Epioblasma florentina walkeri (= E. walkeri)*	Tan riffleshell mussel
E	*Epioblasma othcaloogensis*	Southern acornshell mussel
E	*Epioblasma torulosa torulosa*	Tubercled blossom pearlymussel: entire range except where listed as experimental populations
E	*Leptodea leptodon*	Scaleshell mussel
E	*Medionidus parvulus*	Moccasinshell mussel
E	*Medionidus penicillatus*	Gulf moccasinshell mussel
E	*Pegias fabula*	Littlewing pearlymussel
E	*Percina antesella*	Amber darter
E	*Pleurobema clava*	Clubshell mussel: entire range except where listed as experimental populations
E	*Pleurobema curtum*	Black clubshell mussel
E	*Pleurobema pyriforme*	Oval pigtoe mussel
E	*Pristis pectinata*	Smalltooth sawfish
E	*Quadrula fragosa*	Winged mapleleaf mussel: entire range except where listed as experimental populations
E	*Villosa trabalis*	Cumberland bean pearlymussel: entire range except where listed as experimental populations

Source: USFWS, 2006a.

Table E5-2: Florida Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
E	*Acipenser brevirostrum*	Shortnose sturgeon
T	*Acipenser oxyrinchus desotoi*	Gulf sturgeon
E	*Amblema neislerii*	Fat three-ridge mussel
T	*Elliptio chipolaensis*	Chipola slabshell mussel
T	*Elliptoideus sloatianus*	Purple bankclimber mussel
E	*Etheostoma okaloosae*	Okaloosa darter
E	*Lampsilis subangulata*	Shinyrayed pocketbook mussel
E	*Medionidus penicillatus*	Gulf moccasinshell
E	*Medionidus simpsonianus*	Ochlockonee moccasinshell
E	*Pleurobema pyriforme*	Oval pigtoe mussel
E	*Pristis pectinata*	Smalltooth sawfish

Source: USFWS, 2006a.

Table E5-3: Louisiana Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
T	*Acipenser oxyrinchus desotoi*	Gulf sturgeon
E	*Lampsilis abrupta*	Pink mucket pearlymussel
T	*Margaritifera hembeli*	Louisiana pearlshell mussel
T	*Potamilus inflatus*	Alabama heelsplitter (= inflated) mussel
E	*Pristis pectinata*	Smalltooth sawfish
E	*Scaphirhynchus albus*	Pallid sturgeon

Source: USFWS, 2006a.

Table E5-4: Mississippi Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
T	*Lampsilis perovalis*	Orangenacre mucket mussel
T	*Acipenser oxyrinchus desotoi*	Gulf sturgeon
E	*Epioblasma brevidens*	Cumberlandian combshell mussel: entire range except where listed as experimental populations
E	*Epioblasma penita*	Southern combshell mussel
T	*Etheostoma rubrum*	Bayou darter
T	*Medionidus acutissimus*	Alabama moccasinshell
E	*Pleurobema curtum*	Black clubshell mussel
E	*Pleurobema decisum*	Southern clubshell mussel
E	*Pleurobema marshalli*	Flat pigtoe mussel
E	*Pleurobema perovatum*	Ovate clubshell mussel
E	*Pleurobema taitianum*	Heavy pigtoe mussel
E	*Potamilus capax*	Fat pocketbook mussel

Table E5-4: Mississippi Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
T	*Potamilus inflatus*	Alabama heelsplitter (= inflated) mussel
E	*Pristis pectinata*	Smalltooth sawfish
E	*Quadrula stapes*	Stirrupshell mussel
E	*Scaphirhynchus albus*	Pallid sturgeon
E	*Scaphirhynchus suttkusi*	Alabama sturgeon

Source: USFWS, 2006a.

Table E5-5: Texas Federally Listed T&E Fish and Shellfish

Status	Scientific Name	Common Name
E	*Cyprinodon bovinus*	Leon Springs pupfish
E	*Cyprinodon elegans*	Comanche Springs pupfish
T	*Dionda diaboli*	Devils River minnow
E	*Etheostoma fonticola*	Fountain darter
E	*Gambusia gaigei*	Big Bend gambusia
E	*Gambusia georgei*	San Marcos gambusia
E	*Gambusia heterochir*	Clear Creek gambusia
E	*Gambusia nobilis*	Pecos gambusia
E	*Hybognathus amarus*	Rio Grande silvery minnow
T	*Notropis girardi*	Arkansas River shiner (Arkansas River basin)
E	*Pristis pectinata*	Smalltooth sawfish

Source: USFWS, 2006a.