Chapter B4: RUM Analysis

INTRODUCTION

This case study uses a random utility model (RUM) approach to estimate the benefits of improved fishing opportunities due to reduced impingement and entrainment (I&E) in the Northern and Southern California regions. The Northern and Southern California regions are defined based on National Marine Fisheries Service (NMFS) regional boundaries. Northern California includes all northern counties to, and including, San Luis Obispo County. Southern California includes all southern counties to, and including, Santa Barbara County.

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EPA included anglers intercepted at sites in both the Northern California region and the Southern California region in the RUM model. Thus, the model allows for substitution of sites across the two regions. When constructing each angler's choice set, EPA included all sites within 140 miles of the angler's home zip code. Thus, sites from the Southern California region were included for some Northern California anglers, and vice versa, to allow anglers to travel to all substitute sites located within a one day travel distance limit.

Cooling Water Intake Structures (CWIS) withdrawing water from California coastal waters and estuaries impinge and entrain many of the species sought by recreational anglers. These species include halibut, other flatfish, striped bass, sea basses, various bottom fish species, and other less prominent species. Accordingly, EPA included the following species and species groups in the model: flatfish, striped bass, sea basses, bottom fish, small game fish, salmon, sturgeon, other small fish, and other species. Some of these species inhabit a wide range of coastal waters, which can span the entire coast of California.

The study's main assumption is that, all else being equal, anglers will get greater satisfaction, and thus greater economic value, from sites with a higher catch rate. This benefit may occur in two ways: first, an angler may get greater enjoyment from a given fishing trip with higher catch rates, yielding a greater value per trip; second, anglers may take more fishing trips when catch rates are higher, resulting in greater overall value for fishing in the region.

The following sections focus on the data set used in the analysis and the analytic results. Chapter A-11 provides a detailed description of the RUM methodology used in this analysis.

B4-1 DATA SUMMARY

EPA's analysis of improvements in recreational fishing opportunities in California relies on data collected by the NMFS' Marine Recreational Fishery Statistics Survey (MRFSS) (NMFS, 2003b).[1] The model of recreational fishing behavior relies on a subset of the data that includes only single-day trips to sites located in California. In addition, the sample excludes respondents missing data on key variables (e.g., home town), and includes only private/rental boat and shore mode anglers. The Agency did not include charter boat anglers in the model. As explained below, the welfare gain to charter boat anglers from improved catch rates is approximated based on the regression coefficients developed for the boat anglers. Additionally,

[1] For general discussion of the MRFSS, see Chapter A11 of the Regional Study Report or Marine Recreational Fisheries Statistics: Data User's Manual, http://www.st.nmfs.gov/st1/recreational/pubs/data_users/index.html (NMFS, 1999a).

values for single-day trips were used to value each day of a multi-day trip. The final sample used to estimate the RUM model includes 11,367 boat and shore anglers.

B4-1.1 Summary of Anglers' Characteristics

a. Fishing modes and targeted species

Fifty-one percent of the anglers in the sample fish from either a private or a rental boat (see Table B4-1). Approximately 24 percent fish from the shore, and 24 percent fish from a party or charter boat. In Northern California, most anglers (61 percent) fish from a private or rental boat; 28 percent fish from shore, and only 11 percent fish from party or charter boats. In Southern California, 44 percent fish from private or rental boats, 34 percent fish from party or charter boats, and 22 percent fish from shore.

Table B4-1: Fishing Mode Choice, Northern and Southern California

Fishing Mode	All California		Northern California		Southern California	
	Frequency	Percent	Frequency	Percent by Mode	Frequency	Percent by Mode
Shore	4,007	24.48%	1,892	27.79%	2,115	22.12%
Private/Rental Boat	8,383	51.21%	4,158	61.07%	4,225	44.19%
Party/Charter Boat	3,979	24.31%	759	11.15%	3,220	33.68%
All Modes	16,369	100.00%	6,809	100.00%	9,560	100.00%

Source: NMFS, 2003b.

In addition to the mode of fishing, the MRFSS contains information on the specific species targeted on the current trip (see Tables B4-2 and B4-3). In Northern California, approximately 26 percent of anglers did not have a designated target species. The most popular targeted species, targeted by 25 percent of anglers, is salmon. The second most popular species group, targeted by 20 percent of anglers, is bottom fish. Of the remaining anglers, 9 percent target striped bass, 9 percent target flatfish (primarily California halibut), 6 percent target sturgeon, 2 percent target other species, 2 percent target small game fish, one percent target big game fish, and 0.5 percent target other small fish.[2]

In Southern California, 45 percent of anglers do not target a particular species. The most popular targeted species, targeted by 13 percent of anglers, is jacks. The second most popular species group, targeted by 12 percent of anglers, is flatfish (mostly California halibut). Of the remaining anglers, 10 percent target sea basses, 9 percent target bottom fish, 5 percent target small game, 4 percent target big game fish, and less than one percent target each of the following species/species groups: other species, salmon, other small fish, and striped bass.[3]

The distribution of target species is not uniform by fishing mode. In Northern California, for example, 34 percent of private/rental boat anglers and 28 percent of charter anglers target salmon, while less than 2 percent of shore anglers target salmon. Forty-six percent of shore anglers do not target a particular species, while only 20 percent of private/rental boat anglers and 13 percent of charter boat anglers do not target a particular species. Almost 58 percent of charter boat anglers target bottom fish species, while only 12 percent of private/rental boat anglers and 22 percent of shore anglers target bottom fish. Fourteen percent of private/rental boat anglers target flatfish (primarily halibut), while no charter anglers and less than two percent of shore anglers target flatfish. Twenty-two percent of shore anglers target striped bass, while only 6 percent of private/rental boat anglers and no charter boat anglers target striped bass.

[2] Bottom fish species include surfperches, seaperches, sheephead, croakers, rockfishes, scorpionfish, drums, hake, tomcod, opaleye, sargo, mullet, and queenfish. Small game fish include Pacific bonito, Pacific barracuda, and small tunas and mackerels. Flatfish include California halibut, sanddabs, starry flounder, and other flounders. Big game fish include sharks, dolphins, and tunas. Other small fish include the anchovy family, silverside family, pacific sardine, herrings, jacksmelt, and other smelts.

[3] Jacks include jack mackerel and yellowtail. Sea basses include kelp bass and sandbasses.

Table B4-2: Species Group Choice by Mode of Fishing, Northern California

Species Group	All Modes		Private/Rental Boat		Party/Charter Boat		Shore	
	Frequency	Percent	Frequency	Percent by Mode	Frequency	Percent by Mode	Frequency	Percent by Mode
Small Game	114	1.67%	102	2.45%	10	1.32%	2	0.11%
Striped Bass	641	9.41%	229	5.51%	0	0.00%	412	21.78%
Bottom Fish	1337	19.64%	490	11.78%	440	57.97%	407	21.51%
Flatfish	602	8.84%	566	13.61%	0	0.00%	36	1.90%
Big Game	95	1.40%	82	1.97%	0	0.00%	13	0.69%
Salmon	1669	24.51%	1,433	34.46%	209	27.54%	27	1.43%
Sturgeon	395	5.80%	371	8.92%	0	0.00%	24	1.27%
Other Species	130	1.91%	68	1.64%	0	0.00%	62	3.28%
Other Small Fish	34	0.50%	1	0.02%	0	0.00%	33	1.74%
No Target	1792	26.32%	816	19.62%	100	13.18%	876	46.30%
All Species	6,809	100.00%	4,158	100.00%	759	100.00%	1,892	100.00%

Source: NMFS, 2003b.

Table B4-3: Species Group Choice by Mode of Fishing, Southern California

Species Group	All Modes		Private/Rental Boat		Party/Charter Boat		Shore	
	Frequency	Percent	Frequency	Percent by Mode	Frequency	Percent by Mode	Frequency	Percent by Mode
Small Game	509	5.32%	251	5.94%	134	4.16%	124	5.86%
Other Small Fish	16	0.17%	0	0.00%	0	0.00%	16	0.76%
Striped Bass	1	0.01%	1	0.02%	0	0.00%	0	0.00%
Jacks	1,283	13.42%	748	17.70%	535	16.61%	0	0.00%
Sea Basses	964	10.08%	662	15.67%	204	6.34%	98	4.63%
Bottom Fish	852	8.91%	340	8.05%	369	11.46%	143	6.76%
Flatfish	1,153	12.06%	775	18.34%	176	5.47%	202	9.55%
Big Game	423	4.42%	247	5.85%	135	4.19%	41	1.94%
Salmon	24	0.25%	24	0.57%	0	0.00%	0	0.00%
Other	73	0.76%	21	0.50%	34	1.06%	18	0.85%
No Target	4,262	44.58%	1,156	27.36%	1,633	50.71%	1,473	69.65%
All Species	9,560	100.00%	4,225	100.00%	3220	100.00%	2,115	100.00%

Source: NMFS, 2003b.

In Southern California, no shore anglers target jacks, while 18 percent of private/rental boat anglers and 17 percent of charter anglers target jacks. Sixteen percent of private/rental boat anglers target sea basses, while only 6 percent of charter anglers and 5 percent of shore anglers target sea basses. Eighteen percent of private/rental boat anglers target flatfish, while 10 percent of shore anglers and 5 percent of charter anglers target flatfish. Seventy percent of shore anglers do not target a particular species, and 51 percent of charter anglers and 27 percent of boat anglers do not target a particular species.

b. Anglers' characteristics

This section presents a summary of angler characteristics for California, using the data included in the RUM model, i.e., only data for private/rental boat anglers and shore anglers. This data set includes 11,367 observations: 7,809 boat anglers and 3,558 shore anglers. Table B4-4 summarizes information on fishing trips and anglers.

The average income of the respondent anglers was $52,021. Because income was not reported by intercept survey respondents, EPA used median household income data by zip code, from the U.S. Census Bureau in 2000, to approximate income data for survey respondents.[4] Ninety-two percent of the anglers are male. The average angler spent 27 days fishing during the past year. The average trip cost for surveyed trips is $16 (2000$),[5] and the average one way travel time to the site was about 40 minutes.[6] The average duration of a fishing trip was four and a half hours. The California data did not include additional demographic statistics.

[4] Census data for median income by zip code are in census Summary File 3 (U.S. Census Bureau, 2002).

[5] All costs are in 2000$, which represent the MRFSS survey year. All costs/benefits will be updated to 2002$ later in this analysis (e.g., for welfare estimation).

[6] Calculation of trip cost and travel time is explained in section B4-1.4.

Table B4-4: Data Summary for California Anglers									
Variable	All Modes			Private/Rental Boat			Shore		
	N	Mean[a]	Std Dev	N	Mean[a]	Std Dev	N	Mean[a]	Std Dev
Travel Cost (2002$)	11,367	15.66	16.14	7,809	17.25	16.78	3,558	12.17	14.01
One Way Travel Time (hours)	11,367	0.60	0.62	7,809	0.66	0.65	3,558	0.47	0.54
Male	16,300	0.92	0.27	8,336	0.94	0.24	3,987	0.89	0.31
Annual Trips	16,117	27.13	41.34	8,261	26.36	33.67	3,918	36.80	57.24
Income	11,367	$52.021	$17.115	7,809	$53,353	$17,011	3,558	$49,096	$16,982
Average Trip Length (hours)	16,343	4.38	2.10	8,367	5.09	1.98	3,999	3.27	1.74

[a] For dummy variables such as "Male" that take the value of 0 or 1, the reported value represents a portion of the survey respondents possessing the relevant characteristic. For example, 92 percent of the surveyed anglers are males.

Sources: NMFS, 2003b; and U.S. Census Bureau, 2002.

B4-1.2 Recreational Fishing Choice Sets

The NMFS survey intercept sites included in the analysis are depicted in Figure B1-1 in Chapter B1 of this report. There are 126 fishing sites in the Northern California region total choice set, and 122 sites in the Southern California region choice set. Choice sets for individual anglers were generated based on NMFS sites located within 140 miles of the respondent's home zip code.[7] Distances from unique zip codes to each of the 248 NMFS sites located in California were estimated using ArcView 3.2a software. A maximum of 37 sites defines the choice set, inclusive of the site actually visited at the time of the survey. In cases where more than 37 additional sites per mode are within the 140 mile distance limit, 37 sites are randomly drawn from the available sites. Table B4-5 summarizes the number of sites available, and anglers intercepted, for each county in California.

Table B4-5: Number of California Sites and Anglers by County

County	Number of Sites	Number of Intercepted Anglers[a]
Northern CA		
Alameda	12	650
Contra Costa	5	409
Del Norte	6	119
Humboldt	11	379
Marin	11	388
Mendocino	10	233
Monterey	12	409
San Francisco	12	326
San Luis Obispo	10	239
San Mateo	15	602
Santa Clara	1	0
Santa Cruz	10	745
Solano	2	530
Sonoma	9	256
Total Northern CA	126	5,285
Southern CA		
Los Angeles	32	1,968
Orange	17	863
San Diego	35	2,595
Santa Barbara	18	166
Ventura	20	486
Total Southern CA	122	6,078

[a] Includes intercepted private/rental boat and shore mode anglers only. Charter boat anglers are not included as no specific charter boat model of site choice was estimated.

Source: NMFS, 2003b.

[7] The distance limit was based on the 99th percentile for the distance traveled to a fishing site.

B4-1.3 Site Attributes

This analysis assumes that the angler chooses between site alternatives by comparing his/her utility for each alternative and choosing the one that maximizes his/her utility. Following McConnell and Strand (1994), we assume that the individual first chooses a mode and species and then, conditional on this choice, chooses the recreational site (Hicks et al., 1999).

To measure site quality, this analysis uses catch rates for the fish species of concern, as well as the presence of marinas and/or docks at each site, and the presence of piers or jetties at each site. Catch rate is the most important attribute of a fishing site from the angler's perspective (McConnell and Strand, 1994; Haab et al., 2000). This attribute is also a policy variable of concern because catch rate is a function of fish abundance, which is affected by fish mortality due to I&E. The catch rate variable in the RUM therefore provides the means to measure baseline losses in I&E and changes in anglers' welfare attributed to changes in I&E resulting from the final section 316(b) rule.

To specify the fishing quality of the case study sites, EPA calculated historic catch rate based on the NMFS catch rates from 1996 to 2000. Seven species or species groups were included in the model: sturgeon, salmon, flatfish, small game fish, big game fish, bottom fish, and other species. No-target anglers in California caught fish in all species groups included in the model. Thus, for no-target anglers, EPA calculated average catch for all species caught by anglers who did not target a specific species.

The catch rates represent the number of fish caught on a fishing trip divided by the number of hours spent fishing (i.e., the number of fish caught per hour per angler). The estimated catch rates are averages across all anglers by mode, target species, and site over the five-year period (1996-2000).

The catch rate variables include total catch, including fish caught and kept and fish released. Some NMFS studies use the catch-and-keep measure as the relevant catch rate. Although a greater error may be associated with the measured number of fish not kept, the total catch measure is most appropriate because a large number of anglers catch and release fish. The total catch rate variables include both targeted fish catch and incidental catch. For example, small game catch rates include fish caught by small game anglers, anglers targeting another species group but who actually caught a small game fish, and anglers who don't target any particular species. Anglers who target particular species generally catch more fish in the targeted category than anglers who do not target these species because of specialized equipment and skills. EPA considered using targeted species catch rates for this analysis, but discovered that this approach did not provide a sufficient number of observations to allow estimation of catch rates for all fishing sites included in the analysis. Tables B4-6 and B4-7 summarize average catch rates by species for Northern and Southern California sites.

- Northern California sites. Of the boat mode anglers who target particular species, bottom fish anglers catch the largest number of fish per hour (1.15), followed by anglers who target other small fish (0.71), those who target small game (0.62), those who target other species (0.56), those who target big game (0.45), those who target flatfish (0.40), those who target striped bass (0.36), those who target salmon (0.34), and those who target sturgeon (0.21). Of the shore mode anglers who target particular species, anglers who target other small fish catch the largest number of fish per hour (1.88), followed by anglers who target bottom fish (1.01), those who target small game (0.78), those who target flatfish (0.63), those who target other species (0.53), those who target sturgeon (0.52), those who target striped bass (0.47), and those who target salmon (0.28).

- Southern California sites. Of the boat mode anglers who target particular species, small game anglers catch the largest number of fish per hour (0.84), followed by anglers who target sea basses (0.76), those who target bottom fish (0.65), those who target other small fish (0.58), those who target salmon (0.52), those who target flatfish (0.45), those who target other species (0.44), those who target jacks (0.42), those who target big game (0.41), and those who target striped bass (0.20). Of the shore anglers who target particular species, anglers who target other small fish catch the largest number of fish per hour (1.50), followed by anglers who target small game (1.11), those who target bottom fish (1.05), those who target sea basses (0.65), those who target flatfish (0.55), and those who target other species (0.48).

Some RUM studies use predicted, rather than actual, catch rates (Haab et al., 2000; Hicks et al., 1999; McConnell and Strand, 1994). This practice allows for individual characteristics to affect catch rates; for example, anglers with different levels of experience may have different catch rates. Haab et al. (2000) compared historic catch-and-keep rates to predicted catch-and-keep rates and found that historic catch-and-keep rates were a better measure of site quality. Hicks et al. (1999) found that using historic catch rates resulted in more conservative welfare estimates than predicted catch rate models. Consequently, EPA favored this more conservative approach.

Table B4-6: Average Catch Rate by Species/Species Group for Northern California Sites by Mode of Fishing

Species/Species Group	Average Catch Rate (fish per angler per hour)			
	All Sites		Sites with Non Zero Catch Rates	
	Private/Rental Boat	Shore	Private/Rental Boat	Shore
Small Game	0.078	0.080	0.615	0.776
Striped Bass	0.060	0.160	0.360	0.469
Bottom Fish	0.420	0.697	1.152	1.009
Flatfish	0.116	0.140	0.404	0.628
Big Game	0.111	N/A	0.449	N/A
Salmon	0.085	0.020	0.336	0.280
Sturgeon	0.023	0.025	0.206	0.520
Other Species	0.186	0.248	0.557	0.530
Other Small Fish	0.107	0.731	0.713	1.880
No Target	0.294	0.645	0.881	0.992

Source: NMFS, 2002e.

Table B4-7: Average Catch Rate by Species/Species Group for Southern California Sites by Mode of Fishing

Species/Species Group	Average Catch Rate (fish per angler per hour)			
	All Sites		Sites with Non Zero Catch Rates	
	Private/Rental Boat	Shore	Private/Rental Boat	Shore
Small Game	0.192	0.418	0.837	1.109
Striped Bass	0.002	N/A	0.200	N/A
Bottom Fish	0.145	0.730	0.654	1.047
Flatfish	0.096	0.227	0.451	0.553
Big Game	0.057	N/A	0.408	N/A
Salmon	0.009	N/A	0.522	N/A
Sea Basses	0.231	0.353	0.761	0.652
Other Species	0.104	0.267	0.440	0.478
Other Small Fish	0.080	0.615	0.575	1.501
No Target	0.238	0.569	1.003	0.857
Jacks	0.065	N/A	0.415	N/A

Source: NMFS, 2002e.

B4-1.4 Travel Cost

EPA used ArcView 3.2a software to estimate distances from the household zip code to each NMFS fishing site in the individual opportunity sets. The Agency obtained fishing site locations from the Master Site Register supplied by NMFS. The Master Site Register includes both a unique identifier that corresponds to the visited site identifier used in the angler survey, and latitude and longitude coordinates. For some sites, the latitude and longitude coordinates were missing or demonstrably incorrect, in which case the town point, as identified in the U.S. Geological Survey (USGS) Geographic Names Information System, was used as the site location if a town was reported in the site address. The program measured the distance in miles of the shortest route, using state and U.S. highways, from the household zip code to each fishing site, then added the distances from the zip code location to the closest highway and from the site location to the closest highway. The average one-way distance to the visited site for all modes is 24.08 miles. Private/rental boat anglers traveled farther, on average, to the chosen site than shore anglers, going 26.53 miles versus 18.72 miles.

EPA estimated trip "price" as the sum of travel costs plus the opportunity cost of time following the procedure described in Haab et al. (2000). Based on Parsons and Kealy (1992), this study assumed that time spent "on-site" is constant across sites and can be ignored in the price calculation. To estimate anglers' travel costs, EPA multiplied round trip distance by average motor vehicle cost per mile ($0.325, 2000 dollars).[8] To estimate the opportunity cost of travel time, EPA first divided round trip distance by 40 miles per hour to estimate trip time, and used one-third of the household's wage to yield the opportunity cost of time. EPA estimated household wage by dividing household income by 2,080 (i.e., the number of full time hours potentially worked).

EPA calculated visit price as:

$$Visit\ Price = (Round\ Trip\ Distance \times \$.325) + \left[\frac{Round\ Trip\ Distance}{40\ mph} \times (Wage) \times 0.33 \right] \qquad \text{(B4-1)}$$

B4-2 Site Choice Models

The nature of the MRFSS data leads to the RUM as a means of examining anglers' preferences (Haab et al., 2000). Anglers arrive at each NMFS site by choosing among a set of feasible sites. The RUM assumes that the individual angler makes a choice among mutually exclusive site alternatives based on the attributes of those alternatives (McFadden, 1981). The number of feasible choices (J) in each angler's choice set was set to 37 sites within 140 miles of the angler's home.

An angler's choice of sites relies on utility maximization. An angler will choose site j if the utility (u_j) from visiting site j is greater than that from vising other sites (h), such that:

$$u_j > u_h \ for\ h = 1, ... , J\ and\ h \neq j \qquad \text{(B4-2)}$$

Anglers choose the species to seek and the mode of fishing in addition to choosing a fishing site. Available fishing modes include shore fishing, fishing from charter boats, or fishing from private or rental boats. The target species or group of species include small game, striped bass, jacks, sea basses, bottom fish, flatfish, big game fish, salmon, sturgeon, and other fish. Anglers may also choose not to target any particular species.

Recreational fishing models generally assume that anglers first choose a mode and species, and then a site. The nested logit model is generally used for recreational demand models, as it avoids the independence of relevant alternatives (IIA) problem, in which sites with similar characteristics that are not included in the model have correlated error terms. However, the nested model did not work well for the California region, indicating that nesting may not be appropriate for the data. Consequently, EPA estimated separate logit models for boat and shore anglers. The Agency did not include the angler's choice of fishing

[8] EPA used the 2000 government rate ($0.325) for travel reimbursement to estimate travel costs per mile traveled. This estimate includes vehicle operating cost only.

mode and target species in the model, instead assuming that the mode/species choice is exogenous to the model and that the angler simply chooses the site. EPA used the following general model to specify the deterministic part of the utility function:[9]

$$v\ (site\ j) = f\,(TC_j,\ SITE\text{-}ATTRIBUTES_j,\ SQRT(Q_{js}) \times Flag(s)) \qquad \text{(B4-3)}$$

where:

v	=	the expected utility for site j (j=1,...37);
TC_j	=	travel cost for site j;
$SITE\text{-}ATTRIBUTES_j$	=	presence of marinas or docks; or piers or jetties at site j;
$SQRT(Q_{js})$	=	square root of the historic catch rate for species s at site j;[10] and
$Flag(s)$	=	1 if an angler is targeting this species; 0 otherwise.

The analysis assumes that each angler in the estimated model considers site quality based on the catch rate for the targeted species and site amenities such as the presence of marinas and/or docks and piers or jetties at each site. Theoretically, an angler may catch any of the available species at a given site (McFadden, 1981). If, however, an angler truly has a species preference, then including the catch variable for all species available at the site would inappropriately attribute utility to the angler for a species not pursued (Haab et al., 2000). To avoid this problem, the Agency used an interaction variable $SQRT(Q_{js}) \times Flag(s)$, such that the catch rate variable for a given species is turned on only if the angler targets a particular species [*Flag (s)* =1]. The Agency calculated a separate catch rate for no-target anglers, using the average of all species caught by no-target anglers. The final model presented here is a site choice model that includes all fish species. The analysis therefore assumes that each angler has chosen a mode/species combination followed by a site based on the catch rates for that site and species. EPA estimated all RUM models with LIMDEP™ software (Greene, 1995). Table B4-8 gives the parameter estimates for the boat and shore models.

One disadvantage of the specified model is that the model looks at site choice without regard to mode or species, whereas mode and species selection may be integral parts of the nested RUM. In the model presented here, once an angler chooses a target species and mode, no substitution is allowed across species or mode (i.e., the value of catching, or potentially catching, a different species, or fishing by a different mode, is not included in the calculation). Therefore, improvements in fishing circumstances related to species other than the target species will have no effect on angler's choices.

Table B4-8 shows that most coefficients have the expected signs and are statistically significant at the 95th percentile or better. The exceptions are the coefficients on sea basses and other small fish in the shore model. Trip cost has a negative effect on the probability of selecting a site, indicating that anglers prefer to visit sites closer to their homes (other things being equal). In the boat model, the positive coefficient on the marina/dock variable for Northern California and the negative coefficient on the pier/jetty variable indicates that anglers fishing from boats in Northern California are more likely to choose sites with marinas or docks, and less likely to choose sites with piers or jetties. The signs on these variables are reversed for shore anglers, for both Northern and Southern California, indicating that shore anglers prefer sites with piers or jetties, and are less likely to fish from marinas or docks. For the boat model, the Southern region has a negative coefficient on the marina/dock variable. This result is counter-intuitive, and is likely a result of insufficient data on site amenities in the Southern California region.

For all species, the probability of a site visit increases as the historic catch rate for fish species increases. EPA used historic catch rates averaged over all species caught by no-target anglers to characterize fishing site quality for no-target anglers. Many species can contribute to sites' perceived quality for no-target anglers because they catch whatever bites. In general, no-target anglers select sites with higher historic catch rates.

[9] See Chapter A-11 for details on model specification.

[10] The analysis used the square root of the catch rate to allow for decreasing marginal utility of catching fish (McConnell and Strand, 1994).

Table B4-8: Estimated Coefficients for the Conditional Site Choice

Variable	Private/Rental Boat Model		Shore Model	
	Estimated Coefficient	t-statistic	Estimated Coefficient	t-statistic
Travel Cost	-0.0524	-73.39	-0.0827	-49.67
SQRT ($Q_{small\ game}$)	1.5578	12.10	1.9067	7.33
SQRT ($Q_{striped\ bass\ -\ North}$)	3.3437	7.82	1.9558	9.89
SQRT ($Q_{jacks\ -\ South}$)	11.9676	25.00	N/A	N/A
SQRT ($Q_{sea\ basses\ -\ South}$)	0.5443	5.51	0.1873	0.57
SQRT (Q_{bottom})	1.8420	15.58	0.7824	5.24
SQRT ($Q_{flatfish\ -\ North}$)	2.7179	12.71	2.4743	5.00
SQRT ($Q_{flatfish\ -\ South}$)	4.4960	21.81	1.6156	6.98
SQRT ($Q_{big\ game\ -\ North}$)	2.9221	5.51	N/A	N/A
SQRT ($Q_{big\ game\ -\ South}$)	1.5820	10.27	N/A	N/A
SQRT ($Q_{salmon\ -\ North}$)	5.5201	23.88	N/A	N/A
SQRT ($Q_{salmon\ -\ South}$)	4.2645	5.63	N/A	N/A
SQRT ($Q_{sturgeon\ -\ North}$)	17.3385	10.21	N/A	N/A
SQRT ($Q_{other\ -\ North}$)	N/A	N/A	3.0937	5.28
SQRT ($Q_{other\ -\ South}$)	1.4604	2.30	1.7437	1.50
SQRT ($Q_{other\ small\ fish)}$	N/A	N/A	1.1416	6.63
SQRT ($Q_{no\ target}$)	0.4074	10.22	0.5255	8.23
Marina/Dock	N/A	N/A	-0.2206	-3.86
Marina/Dock - North	0.4235	10.17	N/A	N/A
Marina/Dock - South	-1.1688	-17.40	N/A	N/A
Pier/Jetty	-0.7106	-23.30	0.4777	12.81

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

B4-3 WELFARE ESTIMATES

This section presents estimates of welfare losses to recreational anglers from fish mortality due to I&E, and potential welfare gains from improvements in fishing opportunities due to reduced fish mortality stemming from the final section 316(b) rule.

B4-3.1 Estimating Changes in the Quality of Fishing Sites

To estimate changes in the quality of fishing sites under different policy scenarios, EPA relied on the recreational fishery landings data by state and the estimates of recreational losses from I&E corresponding to different technology options. The NMFS provided recreational fishery landings data for the Northern and Southern California regions. EPA estimated the losses to recreational fisheries using the physical impacts of I&E on the relevant fish species, and the percentage of total fishery landings attributed to recreational fishing, as described in Chapter B2 of this document. I&E affects recreational species in two ways: by directly killing recreational species, and by killing forage species, thus indirectly affecting recreational species through the food chain. The indirect effects on recreational species were calculated in two steps. First, EPA estimated the total number of fish lost due to forage fish losses. Second, EPA allocated this total number of fish among recreational species according to each species' percent of total recreational landings.

The Agency estimated changes in the quality of recreational fishing sites under different policy scenarios in terms of the percentage change in the historic catch rate. EPA estimated changes in catch rates for each NMFS region, Northern and Southern California, separately. The Agency assumed that catch rates will change uniformly across all marine fishing sites in each NMFS region (i.e., Northern and Southern California), because species considered in the analysis inhabit the entire coast of each NMFS region.[11] For each species included in the model, EPA used five-year recreational landing data (1996 through 2000) for state waters to calculate an average landing per year for a given NMFS region in California.[12] EPA then divided losses to the recreational fishery from I&E by the total recreational landings for a given NMFS region to calculate the percent change in historic catch rate from eliminating I&E completely. Table B4-9 presents results of this analysis for Northern California, and Table B4-10 presents results for Southern California. EPA estimated that compliance with the Phase II rule would reduce impingement by 32.1 percent in Northern California and 30 percent in Southern California, and would reduce entrainment by 35.93 percent in Northern California and 9.5 percent in Southern California (see Chapter B2 for details). Tables B4-11 and B4-12 present estimated improvements in catch rates, over baseline losses, for the final section 316(b) rule in each region.

Table B4-9: Estimated Changes in Catch Rates from Eliminating All I&E of Affected Species in Northern California

Estimated Fishery I&E		Total Recreational Landings for Northern California (fish per year)[a]	Percent Increase in Recreational Catch from Elimination of I&E
Species by Species Group	**Total I&E**		
Flatfish	135,092	238,394	56.67%
Striped Bass	50,023	220,345	22.70%
Bottom Fish	3,093,249	3,245,932	95.23%
Small Game Fish	40,723	250,634[b]	16.25%
Other Fish	875,665	691,382	126.65%
Other Small Fish	234,466	1,442,356	16.26%
Total for All Species[c]	**4,429,218**	**6,089,043**	**72.71%**

[a] Total recreational Landings are calculated as a five year average (1996-2000) for state waters.
[b] Small game fish landings include landings of jacks and all other small game fish except striped bass.
[c] The "all species" totals are used to calculate I&E losses for no-target anglers.

Source: NMFS, 2002e; and U.S. EPA analysis for this report.

[11] Fish lost to I&E are most often very small fish, which are too small to catch. Because of the migratory nature of most affected species, by the time these fish have grown to catchable size, they may have traveled some distance from the facility where I&E occurs. Without collecting extensive data on migratory patterns of all affected fish, it is not possible to evaluate whether catch rates will change uniformly or in some other pattern. Thus, EPA assumed that catch rates will change uniformly across the entire region.

[12] State waters include sounds, inlets, tidal portions of rivers, bay, estuaries, and other areas of salt or brackish water, plus ocean waters to three nautical miles from shore, http://www.st.nmfs.gov/st1/recreational/queries/catch/snapshot.html (NMFS, 2003b).

Table B4-10: Estimated Changes in Catch Rates from Eliminating All I&E of Affected Species in Southern California

Estimated Fishery I&E		Total Recreational Landings for Southern California (fish per year)[a]	Percent Increase in Recreational Catch from Elimination of I&E
Species by Species Group	Total I&E		
Flatfish	3,487	730,812	0.48%
Sea Basses	835,299	3,298,540	25.32%
Bottom Fish	466,316	2,089,320	22.32%
Small Game Fish	11,766	3,541,997[b]	0.33%
Other Fish	39,995	1,461,775	2.74%
Other Small Fish	1,580	475,689	0.33%
Total for All Species[c]	**1,358,442**	**8,056,136**	**11.71%**

[a] Total recreational landings are calculated as a five year average (1996-2000) for state waters.
[b] Small game fish landings include landings of jacks, striped bass, and all other small game fish.
[c] The "all species" totals are used to calculate I&E losses for no-target anglers.

Source: NMFS, 2002e; and U.S. EPA analysis for this report.

Table B4-11: Estimated Changes in Catch Rates from Reducing I&E of Affected Species in Northern California Under the Final Section 316(b) Rule

Estimated Fishery I&E		Total Recreational Landings for Northern California (fish per year)[a]	Percent Increase in Recreational Catch from Reduction of I&E
Species by Species Group	Total Reduced I&E		
Flatfish	48,524	238,394	20.35%
Striped Bass	17,802	220,345	8.08%
Bottom Fish	1,105,461	3,245,932	34.03%
Small Game Fish	14,626	250,634[b]	5.84%
Other Fish	313,921	691,382	45.40%
Other Small Fish	84,204	1,442,356	5.84%
Total for All Species[c]	**1,584,538**	**6,089,043**	**26.01%**

[a] Total recreational landings are calculated as a five year average (1996-2000) for state waters.
[b] Small game fish landings include landings of jacks and all other small game fish except striped bass.
[c] The "all species" totals are used to calculate I&E losses for no-target anglers.

Source: NMFS, 2002e; and U.S. EPA analysis for this report.

Table B4-12: Estimated Changes in Catch Rates from Reducing I&E of Affected Species in Southern California Under the Final Section 316(b) Rule

Estimated Fishery I&E		Total Recreational Landings for Southern California (fish per year)[a]	Percent Increase in Recreational Catch from Reduction of I&E
Species by Species Group	Total Reduced I&E		
Flatfish	648	730,812	0.09%
Sea Basses	80,258	3,298,540	2.43%
Bottom Fish	63,934	2,089,320	3.06%
Small Game Fish	1,878	3,541,997[b]	0.05%
Other Fish	4,159	1,461,775	0.28%
Other Small Fish	252	475,689	0.05%
Total for All Species[c]	**151,129**	**11,598,133**	**1.30%**

[a] Total recreational landings are calculated as a five year average (1996-2000) for state waters.
[b] Small game fish landings include landings of jacks, striped bass, and all other small game fish.
[c] The "all species" totals are used to calculate I&E losses for no-target anglers.

Source: NMFS, 2002e.

B4-3.2 Estimating Losses from I&E in Northern and Southern California

The recreational behavior model described in the preceding sections provides a means for estimating the economic effects of changes in recreational fishery losses from I&E in California. First, EPA estimated welfare gain to recreational anglers from eliminating fishery losses due to I&E. This estimate represents economic damages to recreational anglers from I&E of recreational fish species in California under the baseline scenario. EPA then estimated benefits to recreational anglers from implementing the preferred CWIS technologies.

EPA estimated anglers' willingness-to-pay (WTP) for improvements in the quality of recreational fishing due to I&E elimination by first calculating an average per-day welfare gain based on the expected changes in catch rates from eliminating I&E. Table B4-13 presents the compensating variation per fishing day (averaged over all anglers in the sample) associated with reduced fish mortality from eliminating I&E for each fish species group of concern. Table B4-13 also shows the per-day welfare gain attributable to reduced I&E resulting from the final section 316(b) rule.[13,14]

Table B4-13 shows that shore anglers in Northern California targeting species in the "other" category have the largest per-day gain ($15.51) from eliminating I&E, followed by boat anglers targeting bottom fish in Northern California ($13.04). Anglers in Northern California targeting flatfish also have a relatively high per-day welfare gain of $6.98 for boat anglers and $6.66 for shore anglers. The high value for "other" species is due to the large predicted change in catch rates for these species.

Table B4-13 also reports the willingness-to-pay for a one-unit increase in historic catch rate by species. The value of increasing the historic catch rate varies significantly by species and by fishing mode. For boat anglers in Northern California who target specific species, sturgeon are the most highly valued fish, followed by salmon, striped bass, big game fish, flatfish, bottom fish, and small game fish. For boat anglers in Southern California who target specific species, jacks are the most highly valued fish, followed by flatfish, salmon, bottom fish, small game fish, other fish, big game fish, and sea basses. For shore anglers in Northern California who target specific species, other fish are the most highly valued, followed by flatfish, striped bass, small game fish, bottom fish, and other small fish. For shore anglers in Southern California who target specific species, other fish (includes unidentified sharks, greenling, and sculpins) are the most highly valued, followed by flatfish, small game fish, bottom fish, other small fish, and sea basses. Boat anglers have higher values than shore anglers for flatfish, striped bass, and bottom fish.

[13] A compensating variation equates the expected value of realized utility under the baseline and post-compliance conditions.

[14] As the RUM model estimated values for single-day trips, the per-day value is equal to a per-trip value.

Table B4-13: Per-Day Welfare Gain from Eliminating I&E and From I&E Reductions with the Preferred Technology in Northern and Southern California

Targeted Species Group	Per-Day Welfare Gain (2002$)				WTP for an Additional Fish per Trip (2002$)	
	Eliminating I&E		Reduced I&E with Preferred Technology		Boat Anglers	Shore Anglers
	Boat Anglers	Shore Anglers	Boat Anglers	Shore Anglers		
Flatfish - N. CA	$6.98	$6.66	$2.59	$2.47	$6.21	$4.41
Flatfish - S. CA	$0.13	$0.03	$0.02	$0.01	$10.83	$3.12
Sea Basses - S. CA	$0.69	$0.20	$0.07	$0.02	$0.71	$0.35
Striped Bass - N. CA	$3.87	$1.70	$1.40	$0.62	$8.23	$4.22
Bottom Fish - N. CA	$13.04	$3.35	$4.90	$1.30	$2.70	$1.35
Bottom Fish - S. CA	$2.00	$1.06	$0.28	$0.17	$2.70	$1.35
Small Game Fish - N. CA	$0.98	$1.25	$0.35	$0.46	$2.21	$3.02
Small Game Fish - S. CA	$0.04	$0.04	$0.01	$0.01	$2.21	$3.02
Other Fish - N. CA[a]	N/A	$15.51	N/A	$6.11	N/A	$6.54
Other Fish - S. CA	$0.14	$0.31	$0.02	$0.06	$2.11	$4.21
Other Small Fish-N. CA[a]	N/A	$2.16	N/A	$0.78	N/A	$1.18
Other Small Fish - S. CA[a]	N/A	$0.13	N/A	$0.04	N/A	$1.18
No Target - N. CA [b]	$0.93	$1.79	$0.36	$0.46	$0.45	$0.92
No Target - S. CA [b]	$0.22	$0.34	$0.03	$0.05	$0.45	$0.92
Jacks - S. CA[c,d]	N/A	N/A	N/A	N/A	$28.54	N/A
Salmon - N. CA[c,d]	N/A	N/A	N/A	N/A	$15.23	N/A
Salmon - S. CA [e]	N/A	N/A	N/A	N/A	$8.28	N/A
Sturgeon - N. CA	N/A	N/A	N/A	N/A	$60.14	N/A
Big Game Fish - N. CA[d,e]	N/A	N/A	N/A	N/A	$6.33	N/A
Big Game Fish - S. CA[d,e]	N/A	N/A	N/A	N/A	$2.10	N/A

[a] Not targeted by boat anglers in the sample.
[b] The value is based on all species caught by no-target anglers.
[c] Not targeted by shore anglers in the sample.
[d] Values for jacks are included in small game values.

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

EPA calculated the total economic value of eliminating I&E in Northern California by combining the estimated per-day welfare gain with the total number of fishing days in the Northern California region. NMFS provided information on the total number of fishing trips by state and by fishing mode; this total number of fishing days includes both single- and multiple-day trips. Table B4-14 presents the NMFS number of fishing days by fishing mode.

The Agency assumed that the welfare gain per day of fishing is independent of the number of days fished per trip and therefore equivalent for both single- and multiple-day trips. Each day of a multiple-day trip is valued the same as a single-day trip.[15] Per-day welfare gain differs across recreational species and fishing mode.[16] EPA therefore estimated the number of fishing days associated with each species of concern and the number of days fished by no-target anglers. EPA used the MRFSS sample to calculate the proportion of recreational fishing trips taken by no-target anglers and anglers targeting each species of concern and applied these percentages to the total number of trips to estimate species-specific participation. Tables B4-15 and B4-16 show the calculation results.

[15] See section B4-4.1 for limitations and uncertainties associated with ths assumption.

[16] EPA used the per-day values for private/rental boat anglers to estimate welfare gains for charter boat anglers.

Table B4-14: Recreational Fishing Participation in 2001 by Fishing Mode for Northern and Southern California

Fishing Mode	Total Number of Fishing Days per Year, Northern CA[a]	Total Number of Fishing Days per Year, Southern CA[a]
Private Rental Boat	1,065,009	1,742,369
Shore	864,178	1,315,430
Charter Boat	278,447	994,353
Total	2,207,634	4,052,152

[a] Total days includes each day of a multiple-day fishing trip.

Source: *http://www.st.nmfs.gov/recreational/queries/participation/par_time_series.html (NMFS, 2002d).*

Table B4-15: Recreational Fishing Participation by Species and Fishing Mode, Northern California

Species	Mode: Private Rental Boats Number of Fishing Days	Mode: Shore Number of Fishing Days	Mode: Charter Boat Number of Fishing Days	Total for All Modes [a]
Flatfish	144,948	16,419	0	161,367
Striped Bass	58,682	188,218	0	246,900
Bottom Fish	125,458	185,885	161,416	472,759
Other Small Fish	0	15,037	0	15,037
No Target	208,955	400,114	36,699	645,768
Total [a]	538,043	805,673	198,115	1,541,831

[a] Sum of individual values may not add up to totals due to rounding error.

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

Table B4-16: Recreational Fishing Participation by Species and Fishing Mode, Southern California

Species	Mode: Private Rental Boats Number of Fishing Days	Mode: Shore Number of Fishing Days	Mode: Charter Boat Number of Fishing Days	Total for All Modes [a]
Flatfish	319,550	125,624	54,391	499,565
Sea Basses	273,029	60,904	63,042	396,975
Bottom Fish	140,261	88,923	113,953	343,137
Other Small Fish	0	9,997	0	9,997
No Target	476,712	916,197	504,236	1,897,145
Total [a]	1,209,552	1,201,645	735,622	3,146,819

[a] Sum of individual values may not add up to totals due to rounding error.

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

In Northern California, no-target anglers account for the largest number of fishing days, followed by anglers targeting bottom fish, striped bass, flatfish, and other small fish. In Southern California, no-target anglers account for the largest number of fishing days, followed by anglers targeting flatfish, sea basses, bottom fish, and other small fish.

The estimated number of fishing days represents the baseline level of participation. Anglers may fish more when recreational fishing circumstances improve. However, EPA was unable to estimate a trip participation model for California, because the required data were not available. Therefore, the welfare estimates presented here do not account for likely increases in the number of trips due to elimination or reduction of I&E, and thus understate total welfare effects.

Tables B4-17 and B4-18 provide total annual welfare estimates for two policy scenarios. These values were discounted, to reflect the fact that fish must grow to a certain size before they will be caught by recreational anglers. EPA calculated discount factors separately for I&E of each species. To estimate discounted total benefits, EPA calculated weighted averages of these discount factors for each species group, and applied them to estimated willingness-to-pay values. Discount factors were calculated for both a three percent discount rate and a seven percent discount rate. For the final section 316(b) rule, an additional discount factor was applied to account for the one-year lag between the date when installation costs are incurred and the installation of the required cooling water technology is completed.

Table B4-17 presents annual losses to recreational anglers from baseline I&E effects in California. Total recreational losses from I&E to California anglers, before discounting, are $8.9 million per year (2002$). Total discounted baseline losses are $7.5 million, discounted using a three percent discount rate; and $6.1 million, discounted using a seven percent discount rate.

Table B4-18 presents the annual welfare gain to recreational anglers resulting from the final section 316(b) rule. Total gain to recreational anglers before discounting is $3 million under the final section 316(b) rule. Total discounted gain is $2.5 million and $1.9 million using a three and seven percent discount rate, respectively.

Table B4-17: Total Estimated Annual Baseline Losses From I&E for California Anglers (2002$)												
Species	**Total Losses Before Discounting**				**Total Losses with 3% Discounting**				**Total Losses with 7% Discounting**			
	Boat	**Shore**	**Charter**	**Totals**	**Boat**	**Shore**	**Charter**	**Totals**	**Boat**	**Shore**	**Charter**	**Totals**
Flatfish	$1,052,504	$113,509	$6,968	$1,172,981	$867,417	$93,509	$6,279	$967,205	$687,022	$74,021	$5,546	$766,589
Striped Bass	$226,994	$320,117	$0	$547,111	$205,350	$289,593	$0	$494,943	$181,660	$256,184	$0	$437,844
Sea Basses	$187,937	$11,886	$43,367	$243,190	$153,850	$9,730	$35,501	$199,081	$119,395	$7,551	$27,551	$154,497
Bottom Fish	$1,916,883	$716,181	$2,332,755	$4,965,819	$1,580,960	$590,084	$1,917,757	$4,088,801	$1,252,856	$467,074	$1,514,014	$3,233,944
Small Game Fish	$40,914	$4,461	$11,261	$56,636	$37,707	$4,123	$10,403	$52,233	$34,141	$3,745	$9,444	$47,330
Other Fish	$1,244	$442,515	$1,508	$445,267	$1,181	$417,450	$1,432	$420,063	$1,107	$388,231	$1,342	$390,680
Other Small	$0	$33,850	$0	$33,850	$0	$31,119	$0	$31,119	$0	$28,095	$0	$28,095
No Target	$297,670	$1,028,627	$143,603	$1,469,900	$252,037	$871,272	$121,150	$1,244,459	$206,319	$713,934	$98,253	$1,018,506
Total Recreational Use Losses	$3,724,146	$2,671,146	$2,539,462	$8,934,754	$3,098,502	$2,306,880	$2,092,522	$7,497,904	$2,482,500	$1,938,835	$1,656,150	$6,077,485

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

Table B4-18: Total Estimated Annual Welfare Gain to California Anglers Under the Final Section 316(b) Rule (2002$)

Species	Total Gain Before Discounting				Total Gain with 3% Discounting				Total Gain with 7% Discounting			
	Boat	Shore	Charter	Totals	Boat	Shore	Charter	Totals	Boat	Shore	Charter	Totals
Flatfish	$382,876	$41,435	$1,310	$425,621	$305,687	$33,075	$1,129	$339,891	$232,373	$25,137	$944	$258,454
Striped Bass	$82,398	$116,617	$0	$199,015	$72,388	$102,450	$0	$174,838	$61,663	$87,271	$0	$148,934
Sea Basses	$18,755	$1,201	$4,328	$24,284	$14,928	$956	$3,445	$19,329	$11,175	$715	$2,579	$14,469
Bottom Fish	$653,649	$256,811	$822,157	$1,732,617	$520,528	$204,473	$653,566	$1,378,567	$394,583	$154,965	$494,348	$1,043,896
Small Game Fish	$11,551	$948	$2,499	$14,998	$10,337	$852	$2,245	$13,434	$9,012	$747	$1,966	$11,725
Other Fish	$130	$173,668	$157	$173,955	$120	$159,040	$145	$159,305	$108	$142,358	$131	$142,597
Other Small	$0	$12,212	$0	$12,212	$0	$10,902	$0	$10,902	$0	$9,476	$0	$9,476
No Target	$86,253	$318,265	$25,444	$429,962	$71,128	$262,456	$21,014	$354,598	$56,416	$208,167	$16,639	$281,222
Total Recreational Use Gain	$1,235,612	$921,157	$855,895	$3,012,664	$995,116	$774,204	$681,544	$2,450,864	$765,330	$628,836	$516,607	$1,910,773

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

B4-4 Limitations and Uncertainties

B4-4.1 Extrapolating Single-Day Trip Results to Estimate Benefits from Multiple-Day Trips

Use of per-day welfare gain estimated for single-day trips to estimate per-day welfare gain associated with multiple-day trips can either understate or overstate benefits to anglers taking multiple-day trips. Inclusion of multi-day trips in the model of recreational anglers' behavior can be problematic because multi-day trips are frequently multi-activity trips. An individual might travel a substantial distance and participate in several recreational activities such as shopping and sightseeing, all as part of one trip. Recreational benefits from improved recreational opportunities for the primary activity are overstated if all travel costs are treated as though they apply to the one recreational activity of interest. EPA therefore limited the recreational behavior model to single-day trips only and then extrapolated single-day trip results to estimate benefits to anglers taking multiple-day trips.

There is evidence that multi-day trips are more valuable than single-day trips. McConnell and Strand (1994) estimated a RUM using the NMFS data for New England and the Mid-Atlantic. Their study was intended to supplement the RUM study of single-day trips for the same region conducted by Hicks et al. (1999). The reported values for a catch rate increase of one fish are consistently higher for overnight trips than for single-day trips. Lupi and Hoehn (1998) compared values for single- and multi-day fishing trips. Their comparison is based on a RUM for the Great Lakes, with single and multiple-day trips treated as distinct alternatives in the choice set, with separate parameters for different length trips. They found that multiple-day trips are less responsive to changes in travel cost, and thus relatively more valuable than single-day trips. Their case study results found that "over half the value of an across the board marginal change in catch rates was due to multiple-day trips even though multiple-day trips represent less than one fourth of the trips in the sample" (p. 45).

B4-4.2 Considering Only Recreational Values

This study understates the total benefits of improvements in fishing site quality because estimates are limited to recreational use benefits. Many other forms of benefits, such as habitat values for a variety of species (in addition to recreational fish), non-use values, etc., are also likely to be important.

B4-4.3 Species and Mode Substitution

EPA's estimated RUM model does not allow for anglers to substitute between modes or species. The analysis therefore assumes that each angler has chosen a mode/species combination followed by a site based on the catch rates for that site and species. One disadvantage of the specified model is that the model looks at site choice without regard to mode or species. Once an angler chooses a target species and mode, no substitution is allowed across species or mode (i.e., the value of catching, or potentially catching, a different species or fishing using a different mode is not included in the calculation). Therefore, improvements in fishing circumstances related to other species or modes will have no effect on anglers' choices, and thus will not be accounted for in the welfare estimates.

B4-4.4 Charter Anglers

EPA's model does not include charter boat anglers. Instead, the Agency used values for private/rental boat anglers to estimate values for charter anglers. It is not clear whether this will result in an overestimate or underestimate of per-day values for charter boat anglers.

B4-4.5 Potential Sources of Survey Bias

The survey results could suffer from bias, such as recall bias and sampling effects.

a. Recall bias

Recall bias can occur when respondents are asked, such as in the MRFSS, the number of their recreation days over the previous season. Some researchers believe that recall bias tends to lead to an overstatement of the number of recreation days, particularly by more avid participants. Avid participants tend to overstate the number of recreation days because they count days in a "typical" week and then multiply them by the number of weeks in the recreation season. They often neglect to consider days missed due to bad weather, illness, travel, or when fulfilling "atypical" obligations. Some studies also found that the more salient the activity, the more "optimistic" the respondent tends to be in estimating the number of recreation days.

Individuals also have a tendency to overstate the number of days they participate in activities that they enjoy and value. Taken together, these sources of recall bias may result in an overstatement of the actual number of recreation days.

b. Sampling effects

Recreational demand studies frequently face observations that do not fit general recreation patterns, such as observations of avid participants. These participants can be problematic because they claim to participate in an activity an inordinate number of times. This reported level of activity is sometimes correct but often overstated, perhaps due to recall bias. Even where the reports are correct, these observations tend to be overly influential (Thomson, 1991).