Chapter B5: RUM Analysis

Introduction

This case study uses a random utility model (RUM) approach to estimate the effects of improved fishing opportunities due to reduced impingement and entrainment (I&E) in the Delaware River Estuary. The case study focuses on marine fishing sites in the Delaware River Estuary and the Atlantic coastal areas of Delaware and New Jersey. The study area was selected for consistency with the study area selected for the I&E analysis and does not include all recreational sites potentially affected by I&E in the Delaware Estuary.

Cooling Water Intake Structures (CWISs) withdrawing water from the Delaware Estuary impinge and entrain many of the species sought by recreational anglers. These species include striped bass, weakfish, croaker, spot, flounder, and other less prominent species. Some of these species (e.g., weakfish, flounder, and striped bass) inhabit a wide range (e.g., striped bass ranges from North Carolina to Maine). Therefore, increased fish mortality from I&E in the Delaware Estuary may affect recreational fishing from North Carolina to Maine.

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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 analytic results. Chapter A10 of Part A of this document provides a detailed description of the RUM methodology used in this analysis.

B5-1 Data Summary

EPA's analysis of improvements in recreational fishing opportunities in the Delaware Estuary relies on a subset of the Marine Recreational Fishery Statistics Survey (MRFSS) combined with the 1994 Add-on MRFSS Economic Survey (NMFS, 1999a; QuanTech, 1998).[1] The model of recreational fishing behavior relies on the subset that includes only single-day trips to sites located in the Delaware Bay or along the Atlantic coasts of Delaware and New Jersey.[2] In addition, the sample excludes respondents missing data on key variables (e.g., home town). This truncation resulted in a sample of 2,075 anglers.

The Agency included both single and multiple day trips in estimating the total economic gain from improvements in fishing site quality from reduced I&E. Details of this analysis are provided in Section B5-6 of this chapter.

[1] For general discussion of the MRFSS see Chapter A10 or "Marine Recreational Fisheries Statistics: Data user's Manual," NMFS 2001b.

[2] New Jersey included all sites located in counties bordering the Delaware Bay, but only those Atlantic coast sites located in the Cape May and Atlantic counties.

B5-1.1 Summary of Anglers' Characteristics

a. Fishing modes and targeted species

A majority of the interviewed anglers (63 percent) fish from either a private or a rental boat (see Table B5-1 below). Approximately 21 percent fish from the shore; the remaining 16 percent fish from a party or charter boat. In addition to the mode of fishing, the MRFSS contains information on the specific species targeted on the current trip. The most popular species, targeted by 29 percent of anglers, is summer/winter flounder. The second most popular species, targeted by 21 percent of anglers, is weakfish. Approximately 26 percent of anglers did not have a designated target species. Of the remaining anglers, six, five, two, and 11 percent target striped bass, bluefish, bottom fish (e.g., white perch, croaker and spot), and big game fish (e.g., yellowfin tuna), respectively.[3,4]

The distribution of target species is not uniform by fishing mode. For example, more than half the anglers fishing from private/rental boats target either flounder (35.3 percent) or weakfish (26.2 percent). The majority of shore anglers, on the other hand, either don't target any particular species (38.3 percent) or target bottom fish (18.8 percent). Flounder remains the most popular species among anglers fishing from party/charter boats (29.1 percent), followed by "no target" and bottom species (20 percent).[5] A relatively large percentage of charter boat anglers target big game species (10.8 percent) compared to a negligible percentage of anglers targeting big game species from either private or rental boats (0.7 percent) or shore (0 percent).

Anglers fishing from private or rental boats and anglers fishing from shore and charter boats target different species. EPA modeled recreational fishing behavior using anglers fishing from private or rental boats. The Agency could not extend the RUM to other fishing modes due to an insufficient number of observations for species of concern (i.e., striped bass and weakfish).

Table B5-1: Species Group Choice by Mode of Fishing

Species	All Modes		Private/Rental Boat		Party/Charter Boat		Shore	
	Frequency	Percent	Frequency	Percent by Mode	Frequency	Percent by Mode	Frequency	Percent by Mode
No target	535	25.67%	294	22.53%	70	21.02%	171	38.34%
Striped bass	134	6.43%	86	6.59%	17	5.11%	31	6.95%
Bluefish	99	4.75%	36	2.76%	11	3.30%	52	11.66%
Flounder	610	29.27%	461	35.33%	97	29.13%	52	11.66%
Weakfish	433	20.78%	342	26.21%	35	10.51%	56	12.56%
Big game fish	45	2.16%	9	0.69%	36	10.81%	0	0.00%
Bottom fish	219	10.51%	68	5.21%	67	20.12%	84	18.83%
All species	2,075	100.00%	1,305	100.00%	333	100.00%	446	100.00%

[3] Bottom fish includes dogfish sharks, catfish, white perch, white bass, black sea bass, scup, drums, spot, northern kingfish, Atlantic croaker, tautog, and Atlantic bonito.

[4] Big game fish includes mackerel, mako, and blue sharks, dolphin, tuna, bluefin tuna, and yellowfin tuna.

[5] Note that bottom species targeted by offshore anglers and charter boat anglers are different. Charter boat anglers usually target tautog, black sea bass, and drums, while offshore anglers target white perch, catfish, and dogfish sharks.

b. Anglers' characteristics

This section presents a summary of angler characteristics for the Delaware Bay region as defined above. For this data comparison the study uses both the observations valid for the site choice model and those valid for the trip participation model. Those valid for the trip participation model include only anglers who responded to the economic add-on survey. The following trip profile information relies on the 2,075 site choice observations, of which 239 responded to the economic add-on survey and therefore are valid also for the trip participation model. Table B5-2 summarizes characteristics of the sample anglers fishing the NMFS site in the Delaware Bay area.

The average income of the respondent anglers was $44,109, with 87 percent having reported their household income. Ninety-four percent of the anglers are white, with an average age of about 47 years. Educational attainment information indicates that 14 percent of the anglers had not received a high school diploma, while only 15 percent had graduated from college. The average household size was 2.95 individuals. Nearly 20 percent of the anglers are retired, while 13 percent are self-employed. Forty-seven percent of the anglers indicated that they had flexible time when setting their work schedule.

Table B5-2 shows that on average anglers spent 28 days fishing during the past year. The average duration of a fishing trip was 4.2 hours per day. Anglers made an average of 2.2 trips to the current site, with an average trip cost of $25.73 ($1994).[6] Average travel time to and from the site was just under two hours. Fifty-eight percent of the Delaware Bay anglers own their own boat. Finally, the average number of years of fishing experience was 23. This analysis does not include anglers under the age of 16, which may result in overestimation of the average age of recreational anglers and years of experience.

[6] All costs are in $1994 because that was the MRFSS survey year. All costs/benefits will be updated to $2000 later in this analysis (i.e., for welfare estimation).

Table B5-2: Data Summary for Delaware Bay/Atlantic Coast Anglers

Variable	N	Mean[a]	Std Dev	Minimum	Maximum
Trip Cost	2075	24.47	21.62	0	224.73
Travel Time	2075	2.02	1.67	0	13.79
Visits	2075	2.20	5.55	1	88
Own a boat	239	0.58	0.49	0	1
High School	239	0.14	0.35	0	1
College Degree	239	0.15	0.36	0	1
Retired	239	0.20	0.40	0	1
Age	239	47.16	14.16	20	81
Years Fishing	239	23.30	14.34	1	63
Household Size	239	2.95	1.27	1	7
Flexible Time	239	0.47	0.50	0	1
Male	239	0.92	0.28	0	1
White	239	0.94	0.24	0	1
Household Income	239	$44,108.91	$23,767.07	$7,500.00	$150,000.00
Annual trips	239	28.34	39.83	1	200

a. For dummy variables such as "Own a Boat" that take the value of 0 or 1, the reported value represents a portion of the survey respondents possessing the relevant characteristic. For example, 58 percent of the surveyed anglers own a boat.

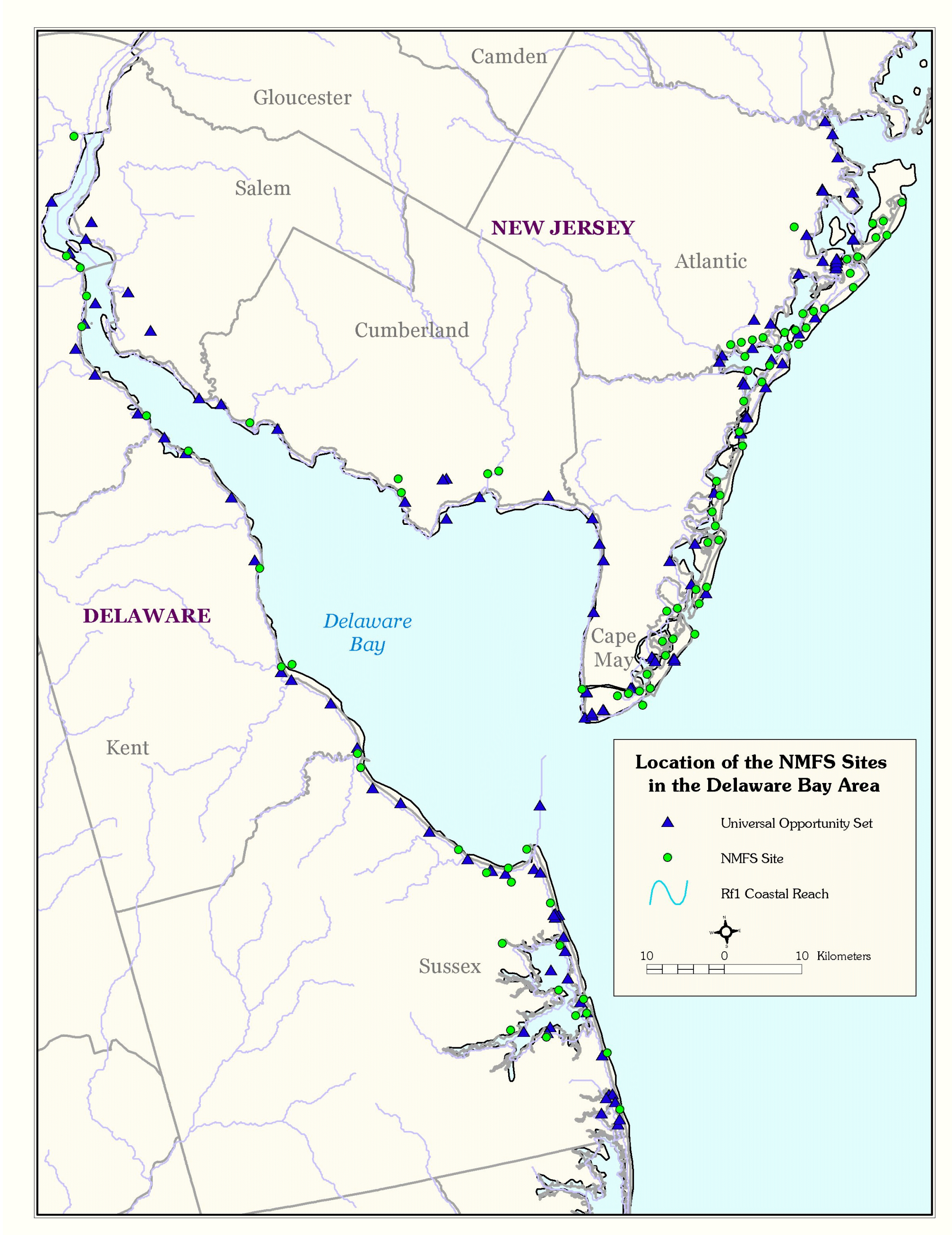
B5-1.2 Recreational Fishing Choice Sets

The National Marine Fisheries Service (NMFS) intercept sites included in the analysis are depicted in Figure B5-1. For tractability, the study aggregates NMFS intercept sites into 48 fishing zones based on Reach File version 1 (hereafter RF1) (Parsons and Needelman, 1992; McConnell and Strand, 1994). The 48 fishing zones (hereafter fishing sites), along with the angler's state of residence, define the individual's choice set. Based on the survey observations, residents of Delaware and Maryland almost exclusively visited sites within Delaware while New Jersey residents visited sites within New Jersey. Only two sampled anglers from Delaware visited New Jersey sites and one sampled person from New Jersey visited a fishing site located in Delaware. Pennsylvania residents, however, tended to visit sites located in both Delaware and New Jersey.

Based on these findings, EPA assumed that Delaware and Maryland anglers select their destination from 23 fishing zones located in the Delaware Bay and along Delaware's Atlantic coast. Similarly, EPA assumed that New Jersey residents select their destination among fishing zones located on the New Jersey side of the Delaware Bay or along New Jersey's Atlantic Coast. Given the size of the Delaware Bay, it is reasonable to assume that fishing zones on the opposite side of the bay are not included in anglers' choice set (Parsons and Hauber, 1997).[7] EPA assumed that all fishing zones on both sides of the Delaware Bay are included in the choice sets for Pennsylvania anglers. Table B5-3 summarizes choice sets available for recreational anglers residing in Delaware, Maryland, New Jersey, and Pennsylvania.

[7] EPA attempted a model in which individual choice sets for Delaware, Maryland, and New Jersey residents included fishing sites on both sides of the Delaware Bay. The Agency also attempted a nested structure, assuming that anglers first select a state and then a fishing site. Both model variations performed poorly.

Figure B5-1: NMFS Intercept Sites Included in RUM Analysis



Source: U.S. EPA, 1997.

Table B5-3: Number of Sites Available for Individual Choice Sets (by State)

Angler's State of Residence	Number of Anglers per State	State(s) Included in Choice Set	Number of Sites in Choice Set		
			Total Number of Sites	# of Delaware Bay Sites	# of Atlantic Coast Sites
Delaware	1176	Delaware	23	16	7
Maryland	173	Delaware	23	16	7
New Jersey	320	New Jersey	25	9	16
Pennsylvania	415	Delaware, New Jersey	48	25	23

B5-1.3 Site Attributes

This analysis assumes that the angler chooses between site alternatives based on several observable attributes. The attributes included in this analysis include catch rates for fish species of concern, presence of boat launching facilities, and the site's aesthetic quality.

Catch rate is the most important attribute of a fishing site from the anglers' 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 variable in the RUM therefore provides the means to measure baseline losses in I&E and changes in anglers' welfare attributed to changes from I&E due to the 316b rule.

To specify the fishing quality of the case study sites, EPA calculated historic catch rate based on the NMFS catch rate from 1994 to 1996 for recreationally important species, such as weakfish, striped bass, bluefish, and flounder (McConnell and Strand, 1994). Other species of interest (e.g., white perch, Atlantic croaker, American shad, and spot) did not produce enough observations to permit a RUM analysis. EPA therefore bundled all species other than weakfish, striped bass, bluefish, and flounder into two aggregate groups — big game fish and bottom fish — and calculated group-specific catch rates. No sample anglers targeted species in the "other fish" category (i.e., eel). The bottom fish and big game groups include the following species:[8]

- Big game: mako, blue, bluefin and yellowfin tuna, and dolphin; and
- Bottom fish: dogfish sharks, catfish, white perch, black sea bass, scup, drums, northern kingfish, tautog, Atlantic croaker, and spot.

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 in a given year over the three-year period. The big game and bottom fish catch rates are weighted average catch rates for all species in the group, weighted by sample proportion for each species.

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 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, striped bass catch rates include fish caught by striped bass anglers and anglers who don't target any particular species. This method may underestimate the average historic catch rate for a given site because anglers not targeting particular fish species are usually less experienced and may not have the appropriate fishing gear. EPA considered using targeted species catch rates for this analysis, but discovered that this approach did not provide a sufficient number of observations per fishing zone to allow estimation of catch rates for all fishing sites included in the analysis.

[8] None of the anglers included in the sample data set targeted small game species other than striped bass and bluefish.

EPA estimated the catch rate for each combination of recreational fishing zone in the study area and fish species of interest using a standard Inverse Distance Weighted (IDW) interpolation technique. The IDW technique estimates a value for any given location by assuming that each input value has an influence on that location. This influence diminishes with distance according to a predetermined power parameter. If available, EPA used observable catch rate values for a given site to estimate average catch rates for that site. If no observed catch rates were found, EPA used an inverse distance squared estimation technique to calculate an average catch rate for a given zone/species combination. The Agency first located any site visits within five kilometers from a given fishing zone and then used the catch rates of the nearest four sites visited as input values for calculating historic catch rates for the species in question.

For anglers who don't target any species, EPA used weakfish, flounder, and bottom fish catch rates to characterize the fishing quality of a fishing site. EPA based its assessment on the analysis of fish species caught by no-target anglers. The MRFSS provided information on species caught for 78 percent of the 532 no-target anglers. Of those, 48 percent caught bottom fish, 10 percent caught small game (i.e., either striped bass or bluefish), 13 percent caught weakfish, and ten percent caught flounder. The remaining 19 percent caught other fish species.

Anglers who target particular species generally catch more fish in the targeted category because of specialized equipment and skills than anglers who don't target these species. Of the anglers who target particular species, bottom fish anglers catch the largest number of fish per hour (0.95), followed by anglers who catch weakfish (0.89) and flounder (0.86). Anglers who target big game fish catch fewer fish than anglers targeting any other species or species group. Table B5-4 summarizes average catch rates by species for all sites in the study area.

Table B5-4: Average Catch Rate by Species/Species Group for the Delaware Bay and Coastal Sites

Species/Species Group	Average Catch Rate (fish per angler per hour)
Striped bass	0.608
Weakfish	0.894
Flounder	0.860
Bluefish	0.498
Bottom fish	0.947
Big game fish	0.275

Some RUM studies have used 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. The authors also found that the choice of catch rate had little effect on the travel cost parameters. 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

EPA included two additional site attributes in the model: presence of boat launching facilities and fishing site aesthetic quality.

- **Presence of boat launching facilities**. Anglers who own a boat view the presence of a boat ramp as an important factor that may affect site choice. EPA therefore obtained information on the presence of boat ramps at the study sites from the Delaware and New Jersey Atlas and Gazetteer (DeLorme, 1999; DeLorme, 1993). The Agency also used information provided in the MRFSS to supplement information from the Atlas and Gazetteer. EPA used a dummy variable (Boat_Ramp=1) for whether or not a site has a boat ramp.

- **Fishing site aesthetic quality**. Visual appearance of the site may play an important role in an angler's decision to visit a particular site because the site's aesthetic quality will likely affect the angler's recreational trip enjoyment. EPA used ambient concentrations of Total Kjeldahl Nitrogen (TKN) as a proxy for visual water quality at the fishing sites.[9] Nitrogen is the major limiting nutrient regulating primary productivity in coastal ecosystems (U.S. EPA, 1991). Excessive nitrogen loading in coastal waters can stimulate or enhance the impact of microscopic algal species and lead to algal blooms. Such blooms, sometimes referred to as brown or red tides, result in unattractive site appearance. Such algal blooms can also release potent neurotoxins to surface water that may affect higher forms of life, including humans.[10]

B5-1.4 Travel Cost

EPA used ZipFip software to estimate distances from the household Zip code to each fishing zone in the individual opportunity sets.[11] As noted above, a fishing zone is defined as a tidal river or a coastal reach. If a fishing zone has designated fishing areas, EPA assumed that anglers visited the fishing area nearest to their homes. Otherwise, EPA measured the distance between the household Zip code and the reach midpoint. The program used the closest valid Zip code to match unknown Zip codes. The average one-way distance to the visited site is 40.3 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 consumers' travel costs, EPA multiplied round-trip distance by average motor vehicle cost per mile ($0.29, 1994 dollars).[12] 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 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).

Only those respondents who reported that they lost income during the trip (LOSEINC=1) are assigned a time cost in the trip cost variable. Information on the LOSEINC variable was available only for a subset of survey respondents who participated in the follow-up telephone interviews. Approximately three percent of the 239 telephone interview participants reported that they lost income. Given that only a small number of survey respondents reported lost income, EPA assumed that the remaining 1836 anglers who did not participate in the telephone interview did not lose income during the trip. EPA calculated visit price as:

$$\text{Visit Price} = \begin{cases} \text{Round Trip Distance} \times \$.29 + \dfrac{\text{Round Trip Distance}}{40\ mph} \times (\text{Wage}) & \text{If } LOSEINC = 1 \\ \text{Round Trip Distance} \times \$.29 & \text{If } LOSEINC = 0 \end{cases} \tag{5-1}$$

For those respondents who do not lose income, the time cost is accounted for in an additional variable equal to the amount of time spent on travel. EPA therefore estimated time cost as the round-trip distance divided by 40 mph:

$$\text{Travel Time} = \begin{cases} \text{Round Trip Distance}/40 & \text{If } LOSEINC = 0 \\ 0 & \text{If } LOSEINC = 1 \end{cases} \tag{5-2}$$

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[9] The relevant data on TKN concentrations come from EPA's water quality database (STORET).

[10] Humans who eat seafood contaminated by toxic algae can experience shellfish poisoning, including Ciguatera Fish Poisoning, Amnesic Shellfish Poisoning, or Paralytic Shellfish Poisoning.

[11] The program was created by Daniel Hellerstam and is available through the USDA at http://usda.maunlib.cornell.edu/datasets/general/93014.

[12] EPA used the 1994 government rate ($0.29) for travel reimbursement to estimate travel costs per mile traveled. This estimate includes vehicle operating cost only.

EPA used a log-linear ordinary least square regression model to estimate wage rates for the 13 percent of the 239 survey respondents who participated in the telephone interview but did not report their income. The estimated regression equation used in wage calculation is :

$$Ln(Income) = 0.14 \times male + 0.10 \times age - 0.0017 \times age^2 + 0.32 \times employed + 0.147 \times boatown + 0.818 \log(stinc) \tag{5-3}$$

where:

INCOME	=	the reported household income;
MALE	=	1 for males;
AGE	=	age in years;
EMPLOYED	=	1 if the respondent is currently employed and 0 otherwise;
BOATOWN	=	1 if the respondent owns a boat; and
STINC	=	the average income of residents in the corresponding states.

All variables in the estimated income regression are statistically significant from zero at 99th percentile. The average imputed household income for anglers who do not report income is $61,894 per year and the corresponding hourly wage is $29.76.

B5-2 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. Interviewers intercept individual anglers at marine fishing sites along the Atlantic coast, including the Delaware Bay area, and collect data on the anglers' origins and catch (including number and weight of species caught).

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 the study area is 48. For anglers residing in Delaware or New Jersey, the feasible choice set is restricted to the sites located in the home state. The study assumes that anglers from other states can choose from all 48 fishing zones.

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:

$$u_j > u_h \text{ for } h = 1, \ldots, J \text{ and } h \neq j \tag{5-4}$$

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 weakfish, striped bass, bluefish, flounder, bottom fish, and big game 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 generally 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. The nested structure based on mode/species and then site choice therefore assumes that sites selected for certain modes and/or species have similar characteristics.[13]

Fishing modes and species do not clearly define differences among Delaware Bay area sites. The same sites feature several fishing mode/species combinations. The likely differences among all sites in the study area makes the IIA problem insignificant. The Agency did not include the angler's choice of fishing 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:[14]

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[13] See Chapter A10 of Part A of this document for greater detail.

[14] See Chapter A10 of Part A of this document for details on model specification.

$$v\ (site\ j) = f\,(TC_j,\ TT_j,\ BOAT\_RAMP_j,\ Ln(NMFS)_j,\ SQRT(Q_{js}) \times Flag(s),\ TKN_j) \qquad (5\text{-}5)$$

where:

v	=	the expected utility for site *j* (j=1,...48);
TC_j	=	travel cost at site j;
TT_j	=	travel time for survey respondents who cannot value the extra time according to the wage rate;
$BOAT\_RAMP_j$	=	presence of a boat ramp at site *j*; and
$Ln(NMFS)_j$	=	the log of the number of sites within a reach;
$SQRT(Q_{js})$	=	square root of the historic catch rate for species *s* at site *j*;[15]
Flag(s)	=	1 if an angler is targeting this species; 0 otherwise;
TKN_j	=	ambient concentrations of TKN at site j

The analysis assumes that each angler in the estimated model considers site quality based only on the catch rate for the targeted species. 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 (Qjs) × 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). Because a large number of no-target anglers catch either weakfish or flounder, and because these two species are the most frequently targeted in the Delaware Bay area, EPA used both weakfish and flounder catch rates to characterize a site's fishing quality for the no-target angler group.

The analysis tested various alternative model specifications, but the model presented here was the most successful at explaining the probability of selecting a site. For example, a model that included catch rates for bottom species, striped bass, and bluefish for no-target anglers did not produce meaningful results. The additional catch rate variables either had a wrong sign or were insignificant for no-target anglers. The analysis also ran separate models for anglers targeting each species or group of species (i.e., flounder, striped bass, weakfish, and no-target). The presented model and species-specific models produced very similar results.

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. The model examines only private/rental boat anglers because anglers using different fishing modes target different species. The single model is appropriate for this case study because the most important valuation question is how different catch rates for the species of interest will affect recreational fishing values in the case study area. EPA estimated all RUM and Poisson models with LIMDEP™ software (Greene, 1995). Table B5-5 gives the parameter estimates for this model.

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

Table B5-5 shows that most coefficients have the expected signs and are statistically significant at the 95th percentile. Travel cost and travel time have 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). A positive sign on the boat ramp indicates that anglers owning a boat are more likely to choose sites with a boat ramp. The more interview locations within a reach, the more likely that anglers visited the reach.

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

Table B5-5: Estimated Coefficients for the Conditional Site Choice

Variable	Estimated Coefficient	t-statistics
TRIPCST	-0.024	-3.355
TIMECST	-0.893	-10.211
BT_RAMP	1.131	13.306
ln(NMFS)	1.924	56.035
SQRT ($Q_{weakfish}$)	2.811	18.219
SQRT ($Q_{striped\ bass}$)	3.551	9.880
SQRT ($Q_{bluefish}$)	2.868	3.764
SQRT ($Q_{flounder}$)	1.363	9.186
SQRT (Q_{bottom})	-0.554	-2.036
SQRT ($Q_{big\ game}$)	0.724	0.160
SQRT ($Q_{weakfish}$) x No_Target	1.256	6.515
SQRT ($Q_{flounder}$) x No_Target	1.627	7.064
TKN	-0.994	-20.593

The probability of a site visit increases as the historic catch rate for fish species increases, but bottom species and big game species form two notable exceptions. As shown in the model, the catch rate for bottom species has a negative impact on site selection. The catch rate for big game species, while positive, has an insignificant effect on site selection. These results are likely to be due to the relatively small number of anglers in the sample who actually target big game and bottom species from private or rental boats. Finally, higher ambient concentrations of nitrogen in coastal water are indicative of potential eutrophication problems and negatively affect the probability of site selection. In other words, anglers prefer sites with more fish and cleaner water, all else being equal.

EPA used historic catch rates for the two most popular species in the area, weakfish and flounder, to characterize fishing site quality for no-target anglers. The models presented in Table B5-5 show that no-target anglers seem to place a lower value on the catch rate of particular species such as weakfish than anglers targeting this species. This result is not surprising. Many species can contribute to sites' perceived quality for no-target anglers because they catch whatever bites. As indicated by similar coefficient values on the historic catch of weakfish and flounder, no-target anglers would almost equally enjoy catching either of these two species.

B5-3 Trip Frequency Model

EPA also examined effects of changes in fishing circumstances on an individual's choice concerning the number of trips to take during a recreation season. EPA used the negative binomial form of the Poisson regression model to estimate the number of fishing trips per recreational season. The participation model relies on socioeconomic data and estimates of individual utility (the inclusive value) derived from the site choice model (Parsons et al., 1999; Feather et al, 1995). This section discusses results from the Poisson model of recreational fishing participation, including statistical and theoretical implications of the model. A detailed discussion of the Poisson model is presented in Chapter A10 of Part A.

The dependent variable, the number of recreational trips within past 12 months, is an integer value ranging from one to 200. The Agency first tested the Delaware and New Jersey data on the number of fishing trips for overdispersion to determine whether to use the Poisson model of the negative binomial model. If the dispersion parameter is equal to zero, then the Poisson model is appropriate; otherwise the negative binomial is more appropriate. The analysis found that the overdispersion parameter is significantly different from zero and therefore the negative binomial model is the most appropriate for this case study.

Independent variables of importance include age, ethnicity, gender, education, household size, whether or not the individual has a flexible work schedule, and whether he (or she) owns a boat. Variable definitions for the trip participation model are:

- IVBASE: an inclusive value estimated using the coefficients obtained from the site choice model;
- NOHS: equals 1 if the individual did not complete high school, 0 otherwise;
- COLLEGE: equals 1 if the individual completed college, 0 otherwise;
- RETIRED: equals 1 if the individual is retired, 0 otherwise;
- AGE: individual's age in years. If not reported, the individual's age is set to the sample mean;
- YRSFISH: number of years participating in recreational fishing. If the individual did not report years of fishing experience, this variable is set to the sample mean;
- HOUSE_SZ: household size;
- OWNBT: equals 1 if individual owns a boat, 0 otherwise;
- FLEXTIM: equals 1 if the individual can set a flexible work schedule; 0 otherwise;
- Constant: a constant term
- α (alpha): overdispersion parameter estimated by the negative binomial model.

Table B5-6 presents the results of the trip participation model. All but one parameter estimate in the participation model have the expected signs. The model shows that the most significant determinants of the number of fishing trips taken by an angler are the quality of the fishing sites (IVBASE), fishing experience (YRSFISH), and boat ownership (OWN_BOAT).

Table B5-6: Trip Participation Model (Negative Binomial Model)

Variable	Coefficient	t-statistics
Constant	2.22	4.267
IVBASE	.146	2.727
NOHS	.326	1.359
COLLEGE	-0.221	-1.212
RETIRED	-0.071	-0.284
AGE	-0.012	-1.577
YRSFISH	0.012	2.129
HOUSE_SZ	-0.040	-0.626
OWN_BOAT	.565	3.500
FLEXTIM	.051	0.313
α (alpha)	2.976	10.596

The positive coefficient on the inclusive value index (IVBASE) indicates that the quality of recreational fishing sites has a positive effect on the number of fishing trips per recreational season. EPA therefore expects improvements in recreational fishing opportunities, such as an increase in fish abundance and catch rate, to result in an increase in the number fishing trips to the affected sites.

The model shows that education also influences trip frequency. People who did not complete high school (NOHS=1) tend to take more fishing trips than those with a high school diploma. Respondents who attended college are less likely to participate in fishing than those who have only a high school education.

Both the AGE and RETIRED variables are negative, meaning that .younger people are more likely to go fishing. A negative sign on the retired variable is counterintuitive because retirees have more leisure time to pursue their interests. A negative sign on the household size variable (HOUSE_SZ) indicates that anglers who have larger families tend to take fewer recreational trips.

A flexible work schedule (FLEXTIM=1) and boat ownership (OWN_BOAT) have a positive effect on an individuals' decision to take a fishing trip. Finally, more experienced anglers (YRSFSH) take more recreational fishing trips than less experienced anglers.

B5-4 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 316b rule.

B5-4.1 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 on the relevant species corresponding to different technology options. The National Marine Fisheries Service provided the recreational fishery landings data for the states of Delaware and New Jersey. 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 fishery, as described in Chapter B4 of this document.

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 assumed that catch rates will change uniformly across all marine fishing sites along the Delaware and New Jersey coast because species considered in this analysis (i.e., weakfish, striped bass, and flounder) inhabit a wide range of states (e.g., from North Carolina to Massachusetts). EPA used five-year recreational landing data (1994 through 1998) for inland sites to calculate an average landing per year for weakfish and striped bass.[16] EPA then divided losses to the recreational fishery from I&E by the total recreational landings for the states of Delaware and New Jersey to calculate the percent change in historic catch rate from eliminating I&E completely. Table B5-7 presents results of this analysis for the Salem NGS facility only, for all Phase 2 facilities in the transitional estuary, and for all facilities in the Transitional Estuary.[17]

Estimates were not provided for other species because of data limitations. For example, flounder was not included as a representative important species (RIS) in the I&E monitoring performed by Salem NGS, therefore, the Agency was not able to estimate baseline losses of benefits due to the regulation of this species. For other species such as Atlantic croaker and spot, EPA was unable to estimate an empirical model of anglers' behavior due to insufficient number of observations.

[16] Inland sites include sounds, inlets, tidal portions of rivers, bay, estuaries, and other areas of salt or brackish water (NMFS, 2001b).

[17] Other facilities include Hope Creek, Dupont Nemours, Edge Moor, Motiva, Deepwater.

Table B5-7: Estimated Changes in Catch Rates from Eliminating all I&E of Weakfish and Striped Bass in the Transitional Estuary

Species	Estimated Fishery I&E						Total Recreational Landings for DE and NJ Combined (fish per year)[a]	Percent Increase in Recreational Catch from Elimination of I&E		
	Number of Fish Impinged			Number of Fish Entrained				Salem Only	All Phase 2 Facilities[b]	All Facilities[c]
	Salem Only	Phase 2	All	Salem Only	Phase 2	All				
Weakfish	2,486	4,990	6,196	54,104	83,904	98,253	2,790,234	2.03%	3.19%	3.74%
Striped bass	721	1,201	1,432	50,624	78,508	91,933	395,744	12.97%	20.14%	23.59%

a. *Source:* The Marine Recreational Fishery Statistics Survey, 1994-1998. Total recreational Landings are calculated as a five year average (1994-1998) for inland sites.
b. Facilities included in this analysis are: Salem, Hope Creek, Edge Moor, Deepwater (without Chambers Cogen).
c. Facilities included in this analysis are: Salem, Hope Creek, DuPont, Edge Moor, Delaware City Refinery, Deepwater (without Chambers Cogen), Chambers Cogen, Gen Chem Corporation, SPI Polyols, Sun Refining, Logan Generating Co., and Hay Road.

B5-4.2 Estimating Losses from I&E in the Delaware Estuary

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 the Delaware Bay Estuary. 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 the Delaware Estuary under the baseline scenario. EPA then estimated benefits to recreational anglers from implementing various CWIS technologies (see Section B5-4.3 and Chapter B6).

EPA estimated anglers' willingness to pay for improvements in the quality of recreational fishing due to I&E elimination by first calculating an average per trip welfare gain based on the expected changes in catch rates from eliminating I&E. Table B5-8 presents the compensating variation per trip (averaged over all anglers in the sample) associated with reduced fish mortality from eliminating I&E for each fish species of concern.[18]

Results shown in Table B5-8 are not surprising. The more desirable the fish, the greater the per trip welfare gain. Anglers targeting striped bass have the largest per trip gain ($9.77) from eliminating I&E in the Delaware Estuary. Striped bass is a small game species prized for both its fighting skills and taste. In contrast, the per trip welfare gain for anglers targeting weakfish is much smaller ($2.00). Because weakfish is smaller and more abundant in the Delaware Estuary than striped bass, it is less valued by recreational anglers. Finally, no-target anglers, who don't have well-defined preferences and who derive satisfaction from catching a variety of fish species, have the lowest welfare gain ($0.74) from eliminating I&E of the affected species.

Table B5-8 also reports the willingness to pay for a one-unit increase in historic catch rate by species. The estimated values are consistent with those available from previous studies (see Table B4-2 in this document). The value of increasing the historic catch rate varies significantly by species and by angler type. Target anglers value the increase of one additional striped bass the most, followed by weakfish, with bluefish and flounder following. The value of increasing the historic catch rate for a given species is generally lower for no-target anglers.

[18] A compensating variation equates the expected value of realized utility under the baseline and post-compliance conditions. For more detail see Chapter A10 of Part A of this document.

Table B5-8: Per Trip Welfare Gain from Eliminating I&E of Weakfish and Striped Bass in the Transitional Estuary

Targeted Species	Per Trip Welfare Gain (2000$)			WTP for an Additional Fish per Trip (2000$)
	Salem Only	All Phase 2 Facilities	All Facilities in the Delaware River Estuary	
Weakfish	$1.08	$1.71	$2.00	$11.50
Striped bass	$5.38	$8.35	$9.77	$18.14
Bluefish[a]	N/A	N/A	N/A	$3.94
Bottom fish[b]	N/A	N/A	N/A	N/A
Flounder[a]	N/A	N/A	N/A	$3.92
No target[c]	$0.41	$0.64	$0.74	$5.02

a. Not estimated due to limitations of I&E data.
b. Not estimated due to a wrong sign on the catch rate variable for bottom fish.
c. The value is based on weakfish caught by no-target anglers.

EPA calculated the total economic value of eliminating I&E in the Delaware estuary by combining the estimated per trip welfare gain with the total number of fishing days at the Delaware and New Jersey coastal sites. 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 B5-9 presents the NMFS number of fishing days by state and fishing mode

Table B5-9: Recreational Fishing Participation by Fishing Mode and by State

State	Fishing Mode	Total Number of Fishing Days per Year
DE	Private Rental Boat	390,578
DE	Shore	367,402
DE	Charter Boat	43,339
NJ	Private Rental Boat	2,596,380
NJ	Shore	1,596,531
NJ	Charter Boat	403,523
	Total	5,397,753

Source: NMFS, 2001b.

The Agency assumed that the welfare gain per day of fishing is independent of the fishing mode and the number of days fished per trip and therefore equivalent for all modes (i.e., private or rental boat, shore, and charter boat) for both single- and multiple-day trips. However, per trip welfare gain differs across recreational species. EPA therefore estimated the number of fishing trips associated with each species of concern and the number of trips taken 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. Table B5-10 shows the calculation results. Anglers targeting flounder account for the largest number of fishing days at the Delaware and New Jersey NMFS sites (2,044,291). No-target anglers and anglers targeting weakfish rank second and third, fishing 1,133,742 and 969,714 days per year, respectively. Anglers targeting big game species have the lowest number of fishing days per year (49,747).

The estimated number of trips represents the baseline level of participation. Anglers may take more fishing trips as recreational fishing circumstances change. EPA used the estimated trip participation model to estimate the percentage increase in the number of trips due to I&E elimination. The estimated percentage increase ranges from 0.2 percent for no-target anglers to 3.3 percent for anglers targeting striped bass. This result is not surprising because anglers historically respond slowly to demographic trends, circumstances in the fisheries, and competing opportunities for anglers. EPA calculated the number of recreational fishing trips under the eliminated I&E scenario by applying the estimated percentage increase to the baseline number of trips. The estimated increase in the total number of recreational fishing days ranges from 2,608 days for no target anglers to 5,915 trips for anglers seeking weakfish (see Table B5-10). The estimated aggregate increase in the number of fishing days for no target anglers and anglers targeting weakfish and striped bass is 10,870.

Tables B5-11, B5-12, and B5-13 provide welfare estimates for three policy scenarios. First, Table B5-11 presents losses to recreational anglers from baseline I&E of weakfish and striped bass from Salem NGS. Estimates presented in Table B5-12 represent the welfare gain to recreational anglers from the elimination of I&E of weakfish and striped bass from all Phase 2 CWIS, and Table B5-13 details the losses that occur from baseline I&E of weakfish and striped bass by all facilities in the transitional estuary. Recreational losses (2000$) to Delaware and New Jersey anglers from I&E of 2 species at Salem NGS, at all Phase 2 facilities in the transitional estuary, and all facilities in the transitional estuary range from $2.69to $2.70 million, from $4.23 to $ 4.26 and from $4.95 to $ 4.99 million, respectively.

B5-5 Limitations and Uncertainty

B5-5.1 Geographic Area of the Case Study

Limiting the case study area to the Delaware River Estuary and the Atlantic coastal sites of Delaware and New Jersey may result in missed benefits. Many popular target species that spawn in the Delaware River Estuary inhabit a wide range of areas. For example, weakfish, flounder, and striped bass that together attract 56 percent of all anglers in the area can be found from North Carolina to Massachusetts (flounder and weakfish) or to Maine (striped bass). A watershed-based approach that restricts its analysis to recreation activities within the watershed boundary state misses benefits that occur at more remote locations. This omission will likely be more significant for species that spawn mainly in the Delaware Estuary (i.e., weakfish).

B5-5.2 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, participate in several recreation activities including shopping and sightseeing, all as part of one trip. Recreational benefits from improved recreational opportunities for the primary activity are overstated if all travel 1costs 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.

Table B5-10: Recreational Fishing Participation by Species and Fishing Mode

Species	Mode: Private Rental Boats Number of Fishing Days				Mode: Off Shore Number of Fishing Days				Mode: Charter Boat Number of Fishing Days				Total Number of Fishing Days per Year			
		With Improved Fishing Quality				With Improved Fishing Quality				With Improved Fishing Quality				With Improved Fishing Quality		
	Baseline	Salem	In-scope Facilities	All Facilities	Baseline	Salem	In-scope Facilities	All Facilities	Baseline	Salem	In-scope Facilities	All Facilities	Baseline	Salem	In-scope Facilities	All Facilities
Weakfish	651,942	653,735	654,765	655,267	294,744	295,554	296,020	296,247	23,029	23,092	23,129	23,146	969,714	972,381	973,913	974,660
Striped bass	36,949	37,229	37,385	37,459	60,681	61,323	61,579	61,700	3,909	3,939	3,955	3,963	101,718	102,491	102,919	103,122
Bluefish	233,171	NA	NA	NA	105,322	NA	NA	NA	1,630	NA	NA	NA	340,122	NA	NA	NA
Flounder	1,483,921	NA	NA	NA	438,381	NA	NA	NA	121,990	NA	NA	NA	2,044,291	NA	NA	NA
Bottom fish	116,442	NA	NA	NA	462,776	NA	NA	NA	177,249	NA	NA	NA	756,467	NA	NA	NA
Big game fish	47,468	NA	NA	NA	0	NA	NA	NA	2,280	NA	NA	NA	49,747	NA	NA	NA
No target	414,957	415,372	415,625	415,741	602,010	602,612	602,979	603,147	116,776	116,893	116,964	116,997	1,133,742	1,134,876	1,135,568	1,135,885
Total [a]	2,986,958				1,963,933				446,862				5,397,753			

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

Table B5-11: Total Estimated Baseline Losses from I&E of Weakfish and Striped Bass from Salem NGS (2000$)

Species	Total Losses	
	Low Value	High Value
Weakfish	$1,046,127	$1,049,580
Striped bass	$4.16,873	$423,751
No target	$1,223,081	$1,224,548
Total recreational use	$2,686,082	$2,697,880

Table B5-12: Total Estimated Baseline Losses from I&E of Weakfish and Striped Bass in the Transitional Estuary by In-Scope Phase 2 Facilities[a] (2000$)

Species	Total Losses	
	Low Value	High Value
Weakfish	$1,653,557	$1,662,156
Striped bass	$646,872	$663,561
No target	$1,933,257	$1,936,931
Total recreational use	$4,233,686	$4,262,647

a. Facilities included in this analysis are: Salem, Hope Creek, Edge Moor, Deepwater (without Chambers Cogen).

Table B5-13: Total Estimated Baseline Losses from I&E of Weakfish and Striped Bass in the Transitional Estuary by All Facilities[a]

Species	Total Losses	
	Low Value	High Value
Weakfish	$1,934,774	$1,946,756
Striped bass	$756,480	$776,401
No target	$2,262,043	$2,267,246
Total recreational use	$4,953,295	$4,993,223

a. Facilities included in this analysis are: Salem, Hope Creek, DuPont, Edge Moor, Delaware City Refinery, Deepwater (without Chambers Cogen), Chambers Cogen, Gen Chem Corporation, SPI Polyols, Sun Refining, Logan Generating Co., and Hay Road.

B5-5.3 Considering Only Recreational Values

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

B5-5.4 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 survey, the number of their recreation days over the previous season. Some researchers believe that recall bias tends to lead to the number of recreation days being overstated, 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 (Haab et al., 2000). EPA set the upper limit of the number of fishing trips per year to 180 days to correct for potential bias caused by these observations when estimating trip participation models. Instead of dropping four survey observations with the number of annual trips reported as greater than 180, the Agency set the number of annual trips to the upper bound (i.e., 180 trips).