Chapter E4: RUM Analysis

Introduction

Chapter Contents

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 South Atlantic region. The South Atlantic region, as defined by the National Marine Fisheries Service (NMFS), includes NMFS fishing intercept sites along the Atlantic coastal areas of North Carolina, South Carolina, Georgia, and East Florida.

Cooling Water Intake Structures (CWIS) withdrawing water from South Atlantic coastal waters impinge and entrain many of the species sought by recreational anglers. These species include black drum, Atlantic croaker, weakfish, spotted seatrout, spot, and others. Accordingly, EPA included the following species and species groups in the model: bottom fish, small game fish, snapper-grouper, big game fish, and flatfish. Some of these species inhabit a wide range of coastal waters spanning several states.

The main assumption of this analysis 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 used in the analysis and analytic results. Chapter A-11 provides a detailed description of the RUM methodology used in this analysis.

E4-1 Data Summary

EPA's analysis of improvements in recreational fishing opportunities in the South Atlantic region relies on a subset of the NMFS Marine Recreational Fishery Statistics Survey (MRFSS), combined with the 1997 Add-On MRFSS Economic Survey (NMFS 2000, 2003b).[1] The model of recreational fishing behavior developed in the study relies on a subset of the survey respondents that includes only single-day trips to sites located along the Atlantic Coast from North Carolina to Florida. The Agency did not include charter boat anglers in the model. As explained further 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, values for single-day trips were used to value each day of a multi-day trip. This section provides a summary of characteristics of anglers who took one-day trips to fishing sites in the four South Atlantic states. This analysis is based a sample of 11,219 respondents to the MRFSS survey.

[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).

E4-1.1 Summary of Anglers' Characteristics

a. Fishing modes and targeted species

Table E4-1 presents information on anglers' choices of mode and species. Based on the data set used in developing the RUM, a majority of the interviewed anglers (65 percent) fish from either a private or a rental boat. Approximately 30 percent fish from the shore; the remaining 5 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 surveyed trip. A majority of the interviewed anglers (62 percent) do not have a targeted species. The most popular species group, targeted by 20 percent of all anglers, is small game. The second and the third most popular species groups are big game and bottom fish, targeted by 7 and 4 percent of the anglers, respectively.

Table E4-1: Species Group Choice by Mode of Fishing in the South Atlantic Region

Species	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	2,212	19.73%	1,752	23.99%	50	9.45%	410	12.11%
Bottom Fish	494	4.40%	290	3.97%	2	0.38%	202	5.97%
Snapper-Grouper	348	3.10%	263	3.60%	3	0.57%	82	2.42%
Flatfish	417	3.72%	334	4.57%	N/A	N/A	83	2.45%
Big Game	801	7.14%	694	9.50%	103	19.47%	4	0.12%
No Target	6,947	61.91%	3,971	54.37%	371	70.13%	2,605	76.93%
All Species	11,219	100.00%	7,304	100.00%	529	100.00%	3,386	100.00%

Source: NMFS, 2003b.

The distribution of target species is not uniform by fishing mode. For example, approximately 54 percent of the anglers fishing from private/rental boats do not target a particular species, while 70 percent of charter boat anglers and 77 percent of shore anglers do not target a particular species. The majority of the anglers fishing from private/rental boats target small game fish (24 percent), while only 9 percent of charter boat anglers and 12 percent of shore anglers target small game. Big game is the second and third most popular species group targeted by 20 and 10 percent of charter and private/rental boat anglers, respectively.

b. Anglers' characteristics

This section presents a summary of angler characteristics for the South Atlantic region as defined above. Table E4-2 summarizes characteristics of the sample anglers fishing the NMFS sites in the South Atlantic region.

The average income of the respondent anglers was $60,113 (1997$).[2,3] Ninety-one percent of the anglers are white, with an average age of about 44 years. Nearly 16 percent of the anglers are retired, and 77 percent are employed. Table E4-2 shows that on average anglers spent 47 days fishing during the past year. The average time spent fishing was about 4 hours per day. Anglers made an average of 5.1 trips to the current site, with an average trip cost of $62.86 (1997$). Average round trip travel time was about five hours. Sixty-three percent of the South Atlantic anglers own their own boat. Finally, the average number of years of fishing experience was 22. 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.

[2] Income was not reported by most survey respondents. Median household income data by zip code, from the U.S. Census Bureau, was used to provide income information for respondents not reporting income.

[3] All costs are in 1997$, which represent the MRFSS year. All costs/benefits will be updated to 2002$ later in this analysis (e.g., for welfare estimation).

Table E4-2: Data Summary for the South Atlantic Coast Anglers

Variable	All Modes			Private/Rental Boat			Party/Charter Boat			Shore		
	N	Mean[a]	Std Dev	N	Mean[a]	Std Dev	N	Mean[a]	Std Dev	N	Mean[a]	Std Dev
Trip Cost	9,600	62.86	39.42	6,371	61.30	39.07	411	74.82	50.48	2,818	64.70	37.98
Travel Time	9,600	4.89	2.58	6,371	4.74	2.56	411	5.61	2.33	2,818	5.11	2.62
Visits	3,018	5.10	7.30	2,086	4.69	5.60	125	1.66	2.25	807	6.71	10.63
Own a Boat	3,128	0.63	0.48	2,160	0.77	0.42	127	0.47	0.50	841	0.27	0.45
Retired	3,130	0.16	0.37	2,160	0.15	0.35	127	0.11	0.31	843	0.22	0.41
Employed	3,078	0.77	0.42	2,120	0.81	0.39	126	0.84	0.37	832	0.66	0.47
Age	3,060	43.96	13.85	2,108	43.67	13.23	126	43.56	12.80	826	44.77	15.43
Years Fishing	3,044	22.08	15.18	2,094	22.62	14.92	126	18.80	15.53	824	21.22	15.68
Hours Fished	3,126	4.34	1.99	2,157	4.44	1.86	127	6.19	1.70	842	3.85	2.13
Wage Lost	2,390	0.10	0.30	1,738	0.10	0.30	103	0.17	0.37	549	0.10	0.30
Male	3,129	0.89	0.31	2,159	0.92	0.28	127	0.91	0.29	843	0.82	0.38
White	3,055	0.91	0.29	2,101	0.94	0.23	125	0.91	0.28	829	0.83	0.38
Household Income	1,862	$60,113	$33,712	1,289	$63,993	$33,625	66	$73,788	$33,790	507	$48,466	$30,927
Average trip length in hours	9,600	5.00	2.49	9,600	4.85	2.47	411	5.77	2.18	2,818	5.20	2.55
Annual trips	3,056	47.21	57.51	2,105	46.45	52.14	124	9.76	19.05	827	54.74	70.60

[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, 63 percent of the surveyed anglers own a boat.

Source: NMFS, 2003b.

E4-1.2 Recreational Fishing Choice Sets

There are 657 NMFS survey intercept sites (see Figure E1-1 in Chapter E1 for the survey intercept sites included in the analysis) in the South Atlantic region total choice set. Each angler's choice set included his/her chosen site, plus a randomly selected set of up to 73 additional sites within 150 miles of his/her home zip code.[4] EPA used ArcView 3.2a software to determine the distance from an angler's residence to each NMFS intercept site. Further discussion of distance estimation is presented in Section E4-1.4. EPA did not include sites on the Gulf coast of Florida, or anglers from western Florida, in the model, because the data indicated that Florida anglers do not generally cross to the opposite coast to fish.

E4-1.3 Site Attributes

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 as catch rate is a function of fish abundance, which is affected by fish mortality due to I&E. The catch rate variable in the model provides a means to measure baseline losses from I&E and changes in anglers' welfare attributed to changes from I&E due to the final section 316(b) rule.

To specify the fishing quality of the case study sites, EPA calculated historic catch rates based on the NMFS intercept survey data from 1992 to 1996 for recreationally important species, such as red drum, mackerel, spotted seatrout, striped bass, snook, spot, and left-eye flounder (McConnell and Strand, 1994; Hicks et al., 1999). EPA aggregated all species into 5 species groups — big game fish, bottom fish, snapper-grouper, flatfish, and small game fish — and calculated the average group-specific historic catch rates. The five specific groups include the following species:

- ***Big game:*** billfishes, blackfin tuna, blue marlin, cobia, dolphin, great hammerhead shark, sailfish, tuna, wahoo, yellowfin tuna.

- ***Bottom fish:*** Atlantic croaker, black drum, bonnetmouth, banded drum false pilchard, grunt, gulf kingfish, kingfish, mullet, pigfish, pinfish, sea catfish, southern kingfish, spot, spotted pinfish, tripletail, white mullet, crevalle jack.

- ***Snapper-grouper:*** Atlantic spadefish, black margate, black sea basses, blue runner, cubera snapper, gag, gray snapper, hind red, hogfish, lane snapper, mutton snapper, red snapper, sea basses, sheepshead, vermilion snapper, yellowtail snapper.

- ***Flatfish:*** gulf flounder, left-eye flounder, southern flounder.

- ***Small game:*** Atlantic bonito, Atlantic tarpon, Florida pompano, Spanish mackerel, amberjack, bluefish, bonefish, cero, crevalle jack, greater amberjack, Irish pompano, king mackerel, ladyfish, permit, pompano dolphin, red drum, seatrout, shad, snook, spotted seatrout, striped bass, tarpon snook, weakfish.

The catch rates represent the number of fish caught on a fishing trip per angler by aggregated species group. The estimated catch rates are averaged across all anglers by wave, mode, target species group, and site over the five-year period (1992-1996).[5] Catch rates for earlier years were not included in the analysis because of significant changes in species populations for recreational fisheries.

The catch rate variables include total catch, which includes both fish caught and kept and fish released. Several NMFS studies use only 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 more 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 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 site to allow estimation of catch rates for all fishing sites included in the analysis.

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[4] Based on the 99th percentile for the distance traveled to a fishing site.

[5] "Wave" is a two month period (e.g., May-June). Fishing conditions such as catch rates may differ significantly across six waves.

More than half of the anglers do not target any particular species, and therefore are treated in the analysis as 'no-target' anglers. For anglers who don't target any species, EPA used catch rates for all species caught by no-target anglers 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 5,799 no-target anglers. Of those, 56 percent caught bottom fish, 20 percent caught small game fish, 16 percent caught snapper-grouper, and 8 percent caught flatfish.

Anglers who target particular species generally catch more fish in the targeted category than anglers who do not target any species, mainly because of their skills and specialized equipment. Of the anglers who target particular species groups, bottom fish anglers catch the largest number of fish per hour, followed by anglers who catch snapper-grouper, and then followed by anglers who catch small game. Anglers who target big game fish catch fewer fish than anglers targeting any other species group. Table E4-3 summarizes average catch rates by species for all sites in the study area.

Table E4-3: Average Catch Rate by Species/Species Group for the South Atlantic Sites by Mode of Fishing

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
Big Game	0.03	N/A	0.18	N/A
Bottom Fish	0.38	0.40	1.02	0.93
Flatfish	0.07	0.08	0.29	0.33
Small Game	0.16	0.16	0.43	0.43
Snapper-Grouper	0.20	0.15	0.72	0.51
No Target	0.16	0.17	0.50	0.40

Source: NMFS, 2002e.

E4-1.4 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 the NMFS. The Master Site Register includes both a unique identifier that corresponds to the visited site 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 ArcView 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 is 29.3 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 anglers' travel costs, EPA multiplied round-trip distance by average motor vehicle cost per mile ($0.31, 1997 dollars).[6] To estimate the opportunity cost of travel time, EPA divided round trip distance by 40 miles per hour to estimate trip time, and multiplied by 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).

[6] EPA used the 1997 government rate ($0.31) for travel reimbursement to estimate travel costs per mile traveled. This estimate includes vehicle operating cost only.
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Only those respondents who reported that they lost income during the trip (*WAGELOST=1*) are assigned a time cost in the trip cost variable. Information on the *WAGELOST* variable was available only for a subset of survey respondents who participated in the follow-up telephone interviews. Only 350 out of 3,130 respondents reported that they lost income. Given that only a small number of survey respondents reported lost income, EPA assumed that the remaining 10,869 anglers did not lose income during the trip. EPA calculated visit price as:

$$Visit\ Price = \begin{cases} Round\ Trip\ Distance \times \$.31 + \dfrac{Round\ Trip\ Distance}{40\ mph} \times (Wage) & If\ WAGELOST = 1 \\ Round\ Trip\ Distance \times \$.31 & If\ WAGELOST = 0 \end{cases} \quad \text{(E4-1)}$$

For those respondents who cannot work extra hours for extra pay, 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:

$$Travel\ Time = \begin{cases} Round\ Trip\ Distance/40 & If\ WAGELOST = 0 \\ 0 & If\ WAGELOST = 1 \end{cases} \quad \text{(E4-2)}$$

EPA used a log-linear ordinary least square regression model to estimate wage rates for anglers who did not report their income. The estimated regression equation used in the wage calculation is :

$$\begin{aligned} Ln(Income) = & -0.64 + 0.28 \times white + 0.07 \times male + 0.11 \times age + 0.0018 \times age^2 \\ & + 0.0018 \times age^3 + 0.45 \times employed + 0.15 \times boatown + 0.81 \ln(stinc) \end{aligned} \quad \text{(E4-3)}$$

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 at better than the 99th percentile. The average imputed household income for anglers who do not report income is \$45,775 per year and the corresponding hourly wage is \$22.

E4-2 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 South Atlantic coast and collect data on the anglers' home location 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 each angler's choice set was set to 74 sites within 150 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:

$$u_j > u_h \text{ for } h = 1, \ldots, J \text{ and } h \neq j \qquad \text{(E4-4)}$$

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 big game, bottom fish, small game, snapper-grouper, and flatfish. 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 South Atlantic 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 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:[7]

$$v\ (site\ j) = f\ (TC_j,\ TT_j,\ SQRT(Q_{js}) \times Flag(s)) \qquad \text{(E4-5)}$$

where:

v	=	the expected utility for site j (j=1,...37);
TC_j	=	travel cost for site j;
TT_j	=	travel time to site j;
$SQRT(Q_{js})$	=	square root of the historic catch rate for species s at site j;[8] 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. 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 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 E4-4 gives the parameter estimates for this model.

One disadvantage of the specified model is that the model looks at site and mode choice without regard to species. 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 modes or species will have no effect on anglers' choices.

Two variables present in the boat model were not included in the shore model: catch rates for big game and snapper grouper. EPA did not estimate a coefficient for big game based on the assumption that shore anglers would not target or catch big game species. The Agency combined species falling under snapper-grouper category with bottom fish species due to a small number of shore anglers targeting snapper-grouper fish.

All model coefficients have the expected signs and are statistically significant at the 99th 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). The probability of a site visit increases as the historic catch rate for fish species increases.

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[7] See Chapter A-11 for detail on model specification.

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

Table E4-4: Estimated Coefficients for the Flat Logit Site Choice Model

Variable	Private/Rental Boat		Shore	
	Estimated Coefficient	t-statistic	Estimated Coefficient	t-statistic
TRAVCOST	-0.045	-12.646	-0.022	-5.821
TRAVTIME	-1.301	-25.839	-1.067	-19.938
SQRT ($Q_{bottom\ fish}$)	1.715	13.356	1.321	8.738
SQRT ($Q_{small\ game}$)	2.570	28.693	1.550	10.862
SQRT ($Q_{snapper\text{-}grouper}$)	1.841	8.53	N/A	N/A
SQRT ($Q_{big\ game}$)	6.950	25.239	N/A	N/A
SQRT ($Q_{flatfish}$)	5.658	17.166	2.928	7.255
SQRT ($Q_{no\ target}$)	1.976	41.178	1.965	27.688

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

On average, no-target anglers place a lower value on the catch rate of particular species than anglers targeting a species. This result is not surprising. In general, species caught by no-target anglers are not as valuable as those caught by target anglers because of lack of special gear and skills. As discussed in Section E4-1.3, no-target anglers mostly catch bottom fish and therefore, the estimated coefficient for the no-target catch rate is close to the coefficient for the bottom fish catch rate.

E4-3 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 socio-economic data and estimates of individual utility (the inclusive value) derived from the site choice model (Parsons et al., 1999; Feather et al., 1995). EPA estimated a combined participation model for the South Atlantic and Gulf of Mexico regions.[9] 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 A11 of this report.

The dependent variable, the number of recreational trips within the past 12 months, is an integer value ranging from 1 to 365. To avoid over-prediction of the number of fishing trips, EPA set the number of trips for anglers reporting over 151 trips per year to 151 in the model estimation.[10] The Agency first tested the data on the number of fishing trips for overdispersion to determine whether to use the Poisson model or 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 gender, hourly wage, whether the angler targets a species, whether the angler fishes from shore or from a boat, whether the angler is retired, and whether the angler owns a boat. The model also includes a dummy variable to indicate whether the angler is from the Gulf of Mexico region. Variable definitions for the trip participation model are:

[9] EPA combined data for the South Atlantic and Gulf of Mexico regions, as these regions are part of a single NMFS data set, to estimate the model. The Agency calculated separate estimates of participation and changes in participation for each region, based on average values of variables for that region.

[10] The number of trips was truncated at the 95th percentile, 151 trips per year.

- Constant: a constant term;
- IVBASE: the inclusive value estimated using the coefficients from the site choice model;
- RETIRED: equals 1 if the individual is retired; 0 otherwise;
- MALE: equals 1 if the individual is male; 0 if female;
- OWNBT: equals 1 if individual owns a boat, 0 otherwise;
- NOTARG: equals 1 if the individual did not target a particular species; 0 otherwise;
- SHORE: equals 1 if the individual fished from shore; 0 if the individual fished from a boat;
- WAGE: household hourly wage (household income divided by 2,080);
- GULF: equals 1 if the angler fishes in the Gulf of Mexico region; 0 if the angler fishes in the South Atlantic region; and
- α (alpha): overdispersion parameter estimated by the negative binomial model.

Table E4-5 presents the results of the trip participation model. Where a particular sign is expected, all estimated parameters have the expected signs. The model shows that the most significant determinants of the number of fishing trips taken by an angler are gender (MALE), region (GULF), boat ownership (OWNBT), whether the angler fishes from shore (SHORE), and whether the angler targets a species (NOTARG).

Table E4-5: Trip Participation Model (Negative Binomial Model)

Variable	Coefficient	t-statistic
Constant	3.284	49.69
IVBASE	0.106	16.48
RETIRED	0.102	2.24
MALE	0.266	5.33
OWNBT	0.191	5.15
NOTARG	-0.159	-4.71
SHORE	0.185	3.88
WAGE	-0.003	-2.13
GULF	-0.253	-7.16
α (alpha)	1.03	41.38

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

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 anglers in the Gulf region take less fishing trips than those in the South Atlantic region. Anglers who are retired take more trips than those who are not retired, and male anglers fish more frequently than female anglers. Anglers who own boats, those who target a specific species, and those who fish from shore take more trips each year, while those with higher incomes take less trips.

E4-4 Welfare Estimates

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

E4-4.1 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 corresponding to different technology options. The NMFS provided recreational fishery landings data for the South Atlantic region. 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 E2 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 measured changes in the quality of recreational fishing sites in terms of a percentage change applied to the historic catch rate. EPA assumed that catch rates will change uniformly across all marine fishing sites along the South Atlantic coast because species considered in this analysis inhabit a wide range of states.[11] To estimate the expected change in catch rates, EPA used the most recent data on total recreational landings in the South Atlantic region. EPA used a five-year average of recreational landing data (1997 through 2001) for sites within state waters to calculate an average number of landings per year.[12] EPA then divided losses to the recreational fishery from I&E by the total recreational landings for the region to calculate the percent change in historic catch rate from eliminating I&E completely. EPA estimated that compliance with the Phase II rule would reduce impingement by 43.65 percent, and entrainment by 17.05 percent. EPA estimates the complete elimination of I&E losses to increase small game catch rates by 4 percent, bottom fish catch rates by 13 percent, snapper-grouper catch rates by 1 percent, flatfish catch rates by 2 percent, and no target catch rates by 7 percent.

EPA also estimated percentage changes to species group historic catch rates resulting from reduced I&E losses resulting from the final rule. Dividing the reduced I&E losses by the 5-year average recreational landings leads to an increase in small game catch rates of 1.1 percent, bottom fish catch rates of 2.8 percent, snapper-grouper catch rates by 0.3 percent, flatfish catch rates of 0.4 percent, and no target catch rates of 1.5 percent. Table E4-6 presents the recreational landings, I&E loss estimates, and percentage changes in historic catch rates.

[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, bays, estuaries, and other areas of salt or brackish water; and ocean waters to three nautical miles offshore (NMFS, 2001a).

Table E4-6: Estimated Changes in Historic Catch Rates from Eliminating and Reducing I&E in the South-Atlantic Region					
Species Group	Total Recreational Landings for Four States Combined (fish per year)[a]	Baseline Losses		Reduced Losses Under the Final Section 316(b) Rule	
		Total Recreational Losses from I&E	Percent Increase in Recreational Catch from Elimination of I&E	Combined I&E	Percent Increase in Recreational Catch from Reduction of I&E
Small game	14,642,212	526,377	3.59%	156,257	1.07%
Bottom fish	28,320,721	3,666,453	12.95%	802,529	2.83%
Snapper-Grouper	5,760,638	80,912	1.40%	17,075	0.30%
Flatfish	2,555,799	41,241	1.61%	9,908	0.39%
No target[b]	64,243,209	4,314,983	6.72%	985,769	1.53%

[a] Total recreational landings are calculated as a five-year average (1997-2001) for state waters.
[b] No target includes small game, bottom fish, snapper-grouper, and flatfish.

Source: NMFS, 2002e.

E4-4.2 Estimating Losses from I&E in the South Atlantic Region

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 South Atlantic region. 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 under the baseline scenario. EPA then estimated benefits to recreational anglers from the final section 316(b) rule.

EPA estimated anglers' willingness-to-pay (WTP) for improvements in the quality of recreational fishing due to changes in I&E by calculating an average per-day welfare gain based on the expected changes in catch rates from eliminating and reducing I&E. Table E4-7 presents the compensating variation per day (averaged over all anglers in the sample) associated with reduced fish mortality from changes in I&E for each fish species of concern.[13,14]

Table E4-7: Per-Day Welfare Gain from Eliminating and Reducing I&E in the South Atlantic Region (2002$)						
Species Group	Baseline Per-Day Welfare Gain		Reduced Losses Under the Final Section 316(b) Rule Per-Day Welfare Gain		WTP for an Additional Fish per Day	
	Boat Anglers	Shore Anglers	Boat Anglers	Shore Anglers	Boat Anglers	Shore Anglers
Big Game	N/A	N/A	N/A	N/A	$37.09	N/A
Bottom Fish	$3.01	$4.40	$0.68	$0.83	$4.81	$9.19
Snapper-Grouper	$0.31	N/A	$0.07	N/A	$5.30	N/A
Flatfish	$0.61	$0.63	$0.15	$0.15	$27.05	$30.52
Small Game	$0.83	$1.09	$0.25	$0.33	$10.19	$13.43
No Target	$1.35	$2.14	$0.31	$0.49	$7.25	$19.31

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

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 E4-7 shows that shore anglers in the South Atlantic region targeting bottom fish have the largest per-day gain ($4.40) from eliminating I&E. Boat anglers targeting bottom fish also have a relatively high per-day welfare gain of $3.01. Table E4-7 also reports the willingness-to-pay for a one fish per trip increase in catch. The more desirable the fish, the greater the per-day welfare gain, as evidenced by the willingness-to-pay for catching one additional fish per trip. Of the species groups affected by I&E reductions, anglers value flatfish the most ($27.05 and $30.52 for an additional fish by boat and shore anglers, respectively), followed by small game ($10.19 and $13.43). Anglers targeting big game, not surprisingly, place the highest value on catching an additional fish ($37.09).

EPA calculated the total economic value of eliminating and reducing I&E in the South Atlantic region by combining the estimated per-day welfare gain with the total number of fishing days at coastal sites in the South Atlantic region. NMFS provided information on the total number of fishing trips by state and 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 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 E4-8 shows the calculation results for the South Atlantic states.

Table E4-8: Recreational Fishing Participation by Species and Fishing Mode

Species	Number of Fishing Days			
	Private/Rental Boat	Shore	Charter Boat	Total for all Modes[a]
Small Game	1,576,370	1,367,917	9,043	2,953,330
Bottom Fish	242,576	470,582	81	713,238
Snapper-Grouper	200,778	109,572	419	310,769
Flatfish	485,152	355,243	113	840,508
Big Game	683,691	N/A	86,349	770,040
No Target	4,275,306	9,230,555	65,185	13,571,045
Total[a]	7,463,872	11,533,868	161,190	19,158,930

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

Sources: NMFS,2002b; and U.S. EPA analysis for this report.

No-target anglers account for the largest number of fishing days at South Atlantic NMFS sites (13.6 million). Anglers targeting small game rank second, fishing almost 3 million days per year. Flatfish anglers, big game anglers, and bottom fish anglers rank third, fourth, and fifth, fishing 840 thousand, 770 thousand, and 713 thousand days per year, respectively. Anglers targeting snapper-grouper species have the lowest number of fishing days per year (311 thousand).

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 trip participation model to estimate the percentage increase in the number of trips due to the elimination and reduction of I&E. These changes are reported in Table E4-9. For baseline I&E, the estimated percentage increase ranges from 0.13 percent for anglers who target snapper-grouper fish to 1.15 percent for anglers targeting bottom fish. EPA calculated the number of recreational fishing trips under each I&E scenario by applying the estimated percentage increase to the baseline number of trips.

[15] See section E4-5.3 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 E4-9: Increased Recreational Fishing Participation by Species and Fishing Mode From Eliminating or Reducing I&E in the South Atlantic Region

Species	Predicted Percent Change in Annual Fishing Trips		Number of Fishing Days					
			Private/Rental Boat		Shore		Charter Boat	
	Baseline I&E	Reduced I&E	Baseline I&E	Reduced I&E	Baseline I&E	Reduced I&E	Baseline I&E	Reduced I&E
Small Game	0.34%	0.10%	1,581,772	1,577,985	1,372,604	1,369,318	9,074	9,052
Bottom Fish	1.15%	0.26%	245,367	243,206	475,997	471,804	82	81
Snapper-Grouper	0.13%	0.03%	201,043	200,835	109,572	109,572	420	419
Flatfish	0.25%	0.06%	486,359	485,444	356,127	355,458	113	113
No Target	0.54%	0.12%	4,298,182	4,280,542	9,279,945	9,241,859	65,534	65,265
Total [a]			6,812,723	6,788,012	11,594,246	11,548,011	75,222	74,930

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

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

Table E4-10 provides total welfare estimates for two policy scenarios. It presents losses to recreational anglers from baseline I&E and the welfare gains that would result from installing the preferred CWIS technology at all plants in the South Atlantic region. EPA calculated the total welfare estimates by multiplying the estimated values per day (Table E4-7) by the number of fishing days (Tables E4-8 and E4-9).[17] 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 impingement and entrainment of each species. To estimate discounted total benefits for the South Atlantic, EPA calculated weighted averages of these discount factors, and applied them to estimated willingness-to-pay values. Discount factors were calculated for both a 3 percent discount rate and a 7 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 E4-10: Estimated Total Welfare Gain to Recreational Anglers From Eliminating and Reducing I&E in the South Atlantic Region (2002$)

Species Group	Eliminating Recreational Fishery Losses From I&E			Reduced Losses Under the the Final Section 316(b) Rule		
	Undiscounted	3% Discount Factor	7% Discount Factor	Undiscounted	3% Discount Factor	7% Discount Factor
Small Game	$2,806,549	$2,666,222	$2,497,829	$838,552	$773,418	$697,487
Bottom Fish	$2,818,284	$2,677,370	$2,480,090	$624,860	$576,325	$513,904
Snapper-Grouper	$62,432	$59,311	$54,941	$13,402	$12,361	$11,022
Flatfish	$520,244	$489,030	$452,613	$126,103	$115,084	$102,532
No Target	$25,673,146	$24,132,757	$22,592,369	$5,887,280	$5,372,837	$4,841,878
All Species	$31,880,656	$30,024,690	$28,077,841	$7,490,196	$6,850,024	$6,166,823

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

[17] EPA averaged the initial number of days (Table E4-8) and the predicted increased number of days (Table E4-9) to estimate total welfare (Bockstael et al., 1987).

Table E4-10 presents annual losses to recreational anglers from baseline I&E effects in the South Atlantic region. The total value of recreational losses for all species impinged and entrained at the cooling water intake structures in the South Atlantic is $32 million per year (2002$), before discounting. The discounted recreational losses are $30 million and $28 million (2002$) per year, discounted at 3 and 7 percent, respectively.

Total welfare gain from reducing I&E from cooling water intake structures was also estimated. Multiplying the per-day welfare changes from reduced I&E under the final rule by the total number of fishing trips in 2001 yielded an undiscounted value of $7 million. Discounting the welfare gain by 3 and 7 percent results in total welfare gains of $7 million and $6 million, respectively.

E4-5 Limitations and Uncertainties

E4-5.1 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), non-use values, etc., are also likely to be important.

E4-5.2 Including Welfare for Only Target Anglers

Due to the inability to estimate a statistically significant coefficient for no-target anglers, this study is likely to underestimate total welfare gains for the South Atlantic region.

E4-5.3 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)."

E4-5.4 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, 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).