Chapter F4: 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 Gulf of Mexico region. The Gulf of Mexico region, as defined by the National Marine Fisheries Service (NMFS), includes NMFS fishing intercept sites along the Gulf of Mexico coasts of Florida, Alabama, Mississippi, and Louisiana. Because of data limitations for Texas, anglers from this state were not incorporated in the RUM analysis. Texas was included, however, in the benefits estimation.[1]

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Cooling Water Intake Structures (CWIS) withdrawing water in the Gulf of Mexico region impinge and entrain many of species sought by recreational anglers, including seatrout, mackerel, sea bass, sheepshead, black drum, silver perch, spot, and striped mullet. Accordingly, EPA included the following six species groups in the model: seatrout, bottom fish, small game, snapper-grouper, big game, and flatfish. Some of these species inhabit a wide range of coastal waters, spanning several states.

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 A-11 provides a detailed description of the RUM methodology used in this analysis.

F4-1 Data Summary

EPA's analysis of improvements in recreational fishing opportunities in the Gulf of Mexico region relies on the NMFS Marine Recreational Fishery Statistics Survey (MRFSS), combined with the 1997 Add-on MRFSS Economic Survey (NMFS, 2000, 2003b).[2] The model of recreational fishing behavior relies on the subset of the data that includes only single-day trips for boat and shore anglers. 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 analysis is based on a sample of 12,777 respondents to the MRFSS.

[1] For more detail, see sections F4-4.1 and F4-5.6.

[2] 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).

F4-1.1 Summary of Anglers' Characteristics

a. Fishing modes and targeted species

A majority of the interviewed anglers (70 percent) fish from either a private or a rental boat. Approximately 25 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 current trip (see Table F4-1). Approximately 47 percent of anglers did not have a designated target species. The most popular species group, targeted by 25 percent of anglers, is small game. The second most popular species group, targeted by 16 percent of anglers, is seatrout. Of the remaining anglers, 7, 2, 1, and almost 1 percent target snapper-grouper, bottom fish, big game, and flatfish, respectively.

For private/rental boat and shore anglers, small game is the most popular species group, targeted by 28 percent of private/rental boat anglers and 20 percent of shore anglers. The second most popular species group for private/rental boat and shore anglers is seatrout, targeted by 20 percent and 7 percent of anglers, respectively. Snapper-grouper is the third most popular species group, targeted by 8 percent of private/rental boat anglers and 4 percent of shore anglers. Small game is the most popular target species group for charter/party boat anglers (17 percent), followed by snapper-grouper (15 percent) and big game (11 percent).

Table F4-1: Species Group Choice by Mode of Fishing

Species Group	All Modes		Private/Rental Boat		Party/Charter Boat		Shore	
	Frequency	Percent	Frequency	Percent by Mode	Frequency	Percent by Mode	Frequency	Percent by Mode
Big Game	182	1.42%	114	1.28%	68	11.04%	N/A	0.00%
Bottom Fish	224	1.75%	132	1.48%	N/A	0.00%	92	2.82%
Flatfish	88	0.69%	54	0.61%	N/A	0.00%	34	1.04%
Seatrout	2,049	16.04%	1,809	20.34%	19	3.08%	221	6.76%
Small Game	3,239	25.35%	2,491	28.01%	103	16.72%	645	19.74%
Snapper-Grouper	930	7.28%	708	7.96%	93	15.10%	129	3.95%
No Target	6,065	47.47%	3,585	40.31%	333	54.06%	2,147	65.70%
All Species	12,777	100.00%	8,893	100.00%	616	100.00%	3,268	100.00%

Source: National Marine Fisheries Service, 2003b.

b. Anglers' characteristics

This section presents a summary of angler characteristics for private/rental boat and shore anglers included in the Gulf of Mexico region RUM model. The Agency did not include charter anglers in the model. Table F4-2 summarizes angler characteristics.

The average income of respondent anglers is $58,337 (1997$).[3] Ninety one percent of the anglers are white, with an average age of about 43 years. Fifteen percent of the anglers are retired, while 77 percent are employed. Less than 1 percent of anglers indicated that they lost income by taking the fishing trip.

Table F4-2 shows that, on average, anglers spent 43 days fishing during the past year. The average duration of a fishing trip was 4.2 hours, and anglers made an average of 4.3 trips to the current site. The average round trip travel cost was $21.25 (1997$), and the average travel time to and from the visited site was 1.6 hours. Sixty three percent of Gulf of Mexico anglers own their own boat. Finally, the average number of years of fishing experience is 22. This analysis does not include anglers under the age of 16, which may result in an overestimation of the average age and years of experience of recreational anglers.

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

Table F4-2: Data Summary for the Gulf of Mexico Anglers

Variable	All Modes					Private/Rental Boat					Shore				
	N	Mean[a]	Std Dev	Min	Max	N	Mean[a]	Std Dev	Min	Max	N	Mean[a]	Std Dev	Min	Max
Trip Cost	12,812	$21.25	$27.17	$0.12	$537.16	8,911	$19.97	$25.33	$0.43	$537.16	3,283	$21.99	$27.99	$0.19	$471.45
Travel Time	12,812	1.64	2.00	0	38.02	8,911	1.53	1.83	0	19.72	3,283	1.73	2.13	0	38.02
Visits	2,903	4.27	6.31	1	60	2,139	4.13	5.30	1	60	643	5.28	9.13	1	60
Hours Fished	12,785	4.16	2.08	0.5	23.5	8,889	4.30	1.89	0.5	20	3,278	3.60	2.43	0.5	23.5
Own a Boat	3,007	0.63	0.48	0	1	2,211	0.76	0.43	0	1	671	0.28	0.44	0	1
Retired	3,011	0.15	0.36	0	1	2,214	0.14	0.35	0	1	671	0.18	0.38	0	1
Employed	2,963	0.77	0.42	0	1	2,178	0.79	0.41	0	1	661	0.69	0.46	0	1
Age	2,938	43.19	14.17	14	96	2,157	43.09	13.95	14	96	657	43.41	14.97	14	93
Years Fishing	2,921	22.36	14.99	0	85	2,146	23.18	14.82	0	85	651	20.19	15.28	0	70
Wage Lost	2,301	0.08	0.27	0	1	1,737	0.08	0.27	0	1	464	0.07	0.26	0	1
Male	3,008	0.90	0.3	0	1	2,211	0.91	0.28	0	1	671	0.87	0.33	0	1
White	2,934	0.91	0.29	0	1	2,157	0.93	0.25	0	1	655	0.82	0.38	0	1
Household Income	1,732	$58,337	$33,136	$7,500	$122,500	1,277	$60,789	$32,944	$7,500	$122,500	387	$47,642	$31,263	$7,500	$122,500
Annual trips	2,971	43.14	45	0	364	2,184	40.65	48.16	0	360	663	56.37	70.43	0	364

[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.

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

F4-1.2 Recreational Fishing Choice Sets

There are 514 NMFS survey intercept sites (see Figure F1-1 in Chapter F1 for the survey intercept sites included in the analysis) in the Gulf of Mexico 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. 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 F4-1.4. EPA did not include sites on the Atlantic Coast of Florida or anglers from eastern Florida in the model, because the data indicated that Florida anglers do not generally cross to the opposite coast to fish.[4]

F4-1.3 Site Attributes

This analysis assumes that the angler chooses between site alternatives based on catch rates at the sites. Catch rates are the most important attribute of a fishing site from the angler's perspective (McConnell and Strand, 1994; Haab et al., 2000). This attribute is also a policy variable of concern because catch rate is a function of fish abundance, which is affected by fish mortality due to I&E. The catch variable in the RUM therefore provides the means to measure baseline losses from I&E, and changes in anglers' welfare due to reductions in I&E.

To specify the fishing quality of the case study sites, EPA calculated historical catch rates based on the NMFS catch rates for the years 1993 to 1997. EPA created six species groups: big game, bottom fish, small game, seatrout, snapper-grouper, and flatfish, and calculated group-specific catch rates. The six specific groups include the following species:

- ***Big game***: blackfin tuna, dolphin, sailfish, wahoo, bigeye tuna, billfish, blue shark, bluefin tuna, tiger shark, tuna, great hammerhead shark, smalleye hammerhead shark, skipjack tuna, blue marlin, and longbill spearfish.

- ***Bottom fish***: striped mullet, black drum, gulf kingfish, mullet, largemouth bass, pinfish, southern kingfish, kingfish, Atlantic croaker, tripletail, sea catfish, drums, white mullet, spotted pinfish, silver perch, grunt, gafftopsail catfish, grass porgy, mullet, striped mullet, sand tiger shark, lizardfish, toadfish, leopard toadfish, reef squirrelfish, ribbonfishes, searobin, leopard searobin, sunfish, mojarra, silver jenny, tomtate, caesar grunt, French grunt, bluestriped grunt, pigfish, porgy, sea bream, spotted pinfish, slippery dick, blackear wrasse, parrotfish, Atlantic cutlassfish, and barrelfishes.

- ***Small game***: red drum, snook, Spanish mackerel, king mackerel, cobia, Atlantic tarpon, Florida pompano, bonefish, blue runner, bluefish, mackerels and tunas, permit, leatherjacket, ladyfish, pompano dolphin, jack, swordspine snook, striped bass, African pompano, Atlantic bumper, amberjack, banded rudderfish, round scad, cottonmouth jack, and cero.

- ***Seatrout***: spotted seatrout, sand seatrout, silver seatrout, and weakfish.

- ***Snapper-grouper***: gag, sheepshead, red snapper, grey snapper, snapper, sea bass, red grouper, white grunt, crevalle jack, hogfish, black sea bass, greater amberjack, mutton snapper, yellowtail snapper, Atlantic spadefish, gray triggerfish, black grouper, wenchman, hind red, lane snapper, mutton snapper, orange filefish, jewfish, rock hind, speckled hind, Nassau grouper, scamp, dwarf sandperch, sand tilefish, cubera snapper, schoolmaster, vermilion snapper, sailors choice, ocean triggerfish, and sargassum triggerfish.

- ***Flatfish***: left-eye flounder, southern flounder, gulf flounder, summer flounder, and hogchoker.

The catch rates measure 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 averaged across all anglers in a given year over the five-year period. EPA used total catch, including fish caught and kept and fish released. Some NMFS studies use the catch-and-keep measure as the relevant catch rate. Although a greater error may be associated with the measured number of fish not kept, the total catch measure is most appropriate because a large number of anglers catch and release fish. The total catch rate variables include both targeted fish catch and incidental catch. For example, king mackerel catch rates include fish

[4] According to the NMFS data, less than 0.01 percent of anglers from the Gulf Coast travel across Florida to fish at Atlantic coast sites.

caught by king mackerel anglers, and anglers who do not target any particular species or target something else. This method may underestimate the average historical 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.

About 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 and species groups caught by no-target anglers to characterize the fishing quality of a fishing site. The MRFSS provided information on species caught by 4,059 no-target anglers. Of those, 36 percent caught bottom fish; 32 percent caught snapper-grouper; 16 percent caught small game fish (i.e., king mackerel, Atlantic tarpon, Florida pompano, or other small game); 14 percent caught seatrout; and 2 percent caught flatfish.

Anglers who target particular species generally catch more fish in the targeted category than anglers who don't target any species mainly because of their skills and specialized equipment. Of the boat anglers who target particular species, bottom fish anglers catch the largest number of fish per hour, followed by anglers who target seatrout, snapper-grouper, small game, flatfish, and big game. Of the shore anglers who target particular species, bottom fish anglers catch the largest number of fish per hour, followed by anglers who target snapper-grouper, seatrout, flatfish, and small game. Table F4-3 summarizes average catch rates by species for all sites in the study area.

Table F4-3: Average Catch Rate by Species/Species Group for the Gulf of Mexico Sites by Mode of Fishing

Species Group	Average Catch Rate (fish per angler per hour)			
	All Sites		Sites with Zero Catch Rates	
	Private/Rental Boat	Shore	Private/Rental Boat	Shore
Big Game	0.02	N/A	0.27	N/A
Bottom Fish	0.25	0.28	0.98	1.27
Flatfish	0.05	0.04	0.38	0.42
Seatrout	0.18	0.07	0.82	0.45
Small Game	0.12	0.07	0.46	0.36
Snapper-Grouper	0.18	0.13	0.77	0.74
No Target	0.16	0.15	0.58	0.58

Source: National Marine Fisheries Service, 2002e.

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 historical catch-and-keep rates to predicted catch-and-keep rates and found that historical 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 historical catch rates resulted in more conservative welfare estimates than predicted catch rate models. Consequently, EPA favored this more conservative approach.

F4-1.4 Travel Cost

EPA used ArcView 3.2a software to estimate distances from each angler's zip code to each NMFS fishing site in the angler's opportunity set. The Agency obtained fishing site locations from the Master Site Register supplied by NMFS. The Master Site Register includes both a unique identifier that corresponds to the visited site 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. EPA measured the distance in miles of the shortest route, using state and U.S. highways, from the household zip code to each fishing site, then added the distances from the zip code location to the closest highway and from the site location to the closest highway. The average one-way distance to the visited site for boat and shore anglers is 33.4 miles. Private/rental boat anglers traveled an average of 31.2 miles to the chosen site, while shore anglers traveled an average of 35.0 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 ($0.31, 1997$).[5] 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).

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. Only 181 out of the 2,731respondents reported that they lost income. Given that only a small number of survey respondents reported lost income, EPA assumed that the remaining 10,081 anglers did not lose income during the trip. EPA calculated visit price as:

$$Visit\ Price = \begin{cases} Round\ Trip\ Distance \times \$.29 + \dfrac{Round\ Trip\ Distance}{40\ mph} \times (Wage) & If\ LOSEINC = 1 \\ Round\ Trip\ Distance \times \$.29 & If\ LOSEINC = 0 \end{cases} \quad \text{(F4-1)}$$

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 traveling. EPA estimated time cost as the round trip distance divided by 40 mph:

$$Travel\ Time = \begin{cases} Round\ Trip\ Distance/40 & If\ LOSEINC = 0 \\ 0 & If\ LOSEINC = 1 \end{cases} \quad \text{(F4-2)}$$

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 :

$$Ln(Income) = 0.14 \times male + 0.10 \times age - 0.0017 \times age^2 + 0.32 \times employed + 0.147 \times boatown + 0.818 \log (stinc) \quad \text{(F4-3)}$$

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 $30,058 per year, and the corresponding hourly wage is $14.73.

[5] 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.

F4-2 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 Gulf of Mexico Coast 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 each angler's choice set was set to 74 sites within 150 miles of the angler's home.[6]

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

$$u_j > u_h \; for \; h = 1, \ldots, J \; and \; h \neq j \tag{F4-4}$$

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, seatrout, 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 Gulf of Mexico 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]

$$v \; (site \; j) = f \; (TC_j, \; TT_j, \; SQRT(Q_{js}) \times Flag(s)) \tag{F4-5}$$

where:

v	=	the expected utility for site *j* (*j*=1,...37);
TC_j	=	travel cost for site *j*;
TT_j	=	travel time for site *j*;
$SQRT(Q_{js})$	=	square root of the historical 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 LIMDEPTM software (Greene, 1995). Table F4-4 gives the parameter estimates for this model.

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

[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 F4-4: Estimated Coefficients for the Flat Logit Site Choice Model

Variable	Private/Rental Boat		Shore	
	Estimated Coefficient	T-statistic	Estimated Coefficient	T-statistic
TRAVCOST	-0.030	-10.315	-0.031	-4.690
TRAVTIME	-1.129	-28.906	-0.705	-8.466
SQRT ($Q_{seatrout}$)	2.225	27.850	2.755	15.273
SQRT ($Q_{bottom\ fish}$)	1.662	6.690	0.595	6.046
SQRT ($Q_{small\ game}$)	2.660	32.797	2..117	21.944
SQRT ($Q_{snapper\text{-}grouper}$)	2.442	20.304	2.420	9.462
SQRT ($Q_{big\ game}$)	5.531	11.074	N/A	N/A
SQRT ($Q_{flatfish}$)	3.159	4.683	2.006	4.105
SQRT ($Q_{no\ target}$)	1.417	34.045	1.149	28.564

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

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 species will have no effect on anglers' choices.

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 historical catch rate for fish species increases.

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 F4-1.3, 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.

F4-3 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 Gulf of Mexico and South Atlantic 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 more than 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

[9] EPA combined data for the Gulf of Mexico and South Atlantic regions 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.

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.[11] The model also includes a dummy variable to indicate whether the angler fishes in the Gulf of Mexico region. Variable definitions for the trip participation model are:

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 F4-5 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), boat ownership (OWNBT), region (GULF), whether the angler targets a species (NOTARG), and whether the angler fishes from shore (SHORE).

Table F4-5: Trip Participation Model (Negative Binomial Model)

Variable	Coefficient	t-statistic
Constant	3.284	49.69
IVBASE	0.106	16.48
RETIRED	0.101	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	-0.254	-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.

[11] It would be desirable to include additional socio-economic variables such as age, education, and household size in the participation model. However, those data are not available in the MRFSS Economic Survey.

The model shows that anglers in the Gulf of Mexico 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.

F4-4 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 final section 316(b) rule. While Texas was not included in the RUM because of data limitations, EPA estimated welfare effects for Texas.

F4-4.1 Estimating Changes in the Quality of Fishing Sites

To estimate changes in the quality of fishing sites under different policy scenarios, EPA relied on recreational fishery landings data by state and the estimates of recreational losses from I&E corresponding to different technology options. The NMFS provided the recreational fishery landings data for all the states in the Gulf of Mexico region except for Texas.[12] 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 F2 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 historical catch rate. EPA assumed that catch rates will change uniformly across all marine fishing sites in the Gulf of Mexico region, because species considered in this analysis (e.g., black drum, seatrout, sea bass) are found throughout waters of the Gulf. EPA used five-year recreational landing data (1997 through 2001) for state waters to calculate an average landing per year for all species groups.[13] Since landing data for Texas were limited, EPA assumed that Texas anglers have similar catch rates to those in the other Gulf states and therefore would have the same per-day welfare gain. 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 historical catch rate from eliminating I&E completely. EPA estimated I&E losses for West Florida, Alabama, Mississippi, and Louisiana by applying an adjustment factor of 0.6683 to the I&E losses estimated for all five states in the Gulf of Mexico region. This adjustment factor reflects the fact that Texas facilities account for 33.17 percent of CWIS flow in the region. Table F4-6 presents the results of this analysis.

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[12] EPA obtained landing data for Texas from the Texas Parks and Wildlife Department, Marine Sport-Harvest Monitoring Program, but found that landing data for the shore mode were not available, and data for private/rental and charter boat modes were very limited (e.g., landing data for the bottom fish group included only 3 species, whereas NMFS data for other Gulf states included 20 species in this group) (TPWD, 2003).

[13] State waters include sounds, inlets, tidal portions of rivers, bay, estuaries, and other areas of salt or brackish water plus ocean waters to three nautical miles from shore (NMFS, 2003a).

Table F4-6: Estimated Changes in Historical Catch Rates from Eliminating and Reducing I&E in the Gulf of Mexico Region

Species Group[a]	Baseline Losses				Reduced Losses under Preferred Option		
	Total Recreational Landings for Four States (fish per year)[b,c]	Baseline I&E for Five States[d]	Baseline I&E for Four States[c,e]	Percent Increase in Recreational Catch from Elimination of I&E, for Four States[b]	Reduced I&E for Five States[d]	For Four States: Reduced I&E for Four States[c,e]	For Four States: Percent Increase in Recreational Catch from Elimination of I&E, for Four States[b]
Bottom Fish	33,608,792	2,461,061	1,644,727	4.89%	997,789	666,822	1.98%
Seatrout	27,822,999	1,196,527	799,639	2.87%	689,698	460,925	1.66%
Small Game	15,004,373	108,072	72,225	0.48%	61,145	40,863	0.27%
Snapper-Grouper	17,132,522	55,421	37,038	0.22%	30,866	20,627	0.12%
Flatfish	1,077,195	3,465	2,316	0.22%	1,930	1,290	0.12%
No Target	104,064,982	3,854,850	2,576,196	2.48%	1,798,304	1,201,806	1.15%

[a] I&E losses to species that were not identified and those attributed to I&E forage fish were distributed to the species in the same proportions found in the MRFSS landing data.
[b] Includes Western Florida, Alabama, Mississippi, and Louisiana; does not include Texas.
[c] Total recreational landings are calculated as a five-year average (1997-2001) for state waters.
[d] Includes Western Florida, Alabama, Mississippi, Louisiana, and Texas.
[b] I&E losses for four states were calculated based on the intake flow in the region; the four states account for 66.83 percent of the region flow.

Sources: National Marine Fisheries Service, 2002e; and U.S. EPA analysis for this report.

F4-4.2 Estimating Losses from I&E in the Gulf of Mexico 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 Gulf of Mexico region. The total welfare gain for the five Gulf states is calculated by estimating the per-day welfare gain for the four states included in the RUM, and then multiplying the per day welfare gain by the predicted total number of fishing days by residents of all five Gulf states. Welfare gains to recreational anglers are estimated under two scenarios. The baseline scenario represents economic damages from I&E to recreational anglers in the region. Under the second scenario, EPA estimated reduced damages to recreational anglers from implementing the CWIS technologies under the final section 316(b) rule.

EPA estimated anglers' willingness-to-pay (WTP) for improvements in the quality of recreational fishing due to I&E elimination by first calculating an average per-day welfare gain based on the expected changes in catch rates from eliminating I&E. Table F4-7 presents the compensating variation per day (averaged over all anglers in the sample) associated with reduced fish mortality from eliminating I&E for each fish species of concern.[14] Table F4-7 also shows the per-day welfare gain attributable to reduced I&E resulting from the final section 316(b) rule.[15]

[14] A compensating variation equates the expected value of realized utility under the baseline and post-compliance conditions. For more detail, see Chapter A11 of this report.

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

Table F4-7: Per-Trip Welfare Gain from Eliminating and Reducing I&E in the Gulf of Mexico Region (2002$)

Species Group	Baseline Per-Trip Welfare Gain		Reduced Losses Under the Proposed Rule Per-Trip Welfare Gain		WTP for an Additional Fish per Trip	
	Boat Anglers	Shore Anglers	Boat Anglers	Shore Anglers	Boat Anglers	Shore Anglers
Big Game[a]	N/A	N/A	N/A	N/A	$29.84	N/A
Bottom Fish	$1.53	$0.62	$0.62	$0.25	$7.08	$2.16
Flatfish	$0.09	$0.16	$0.05	$0.09	$16.27	$9.21
Seatrout	$1.13	$1.36	$0.66	$0.78	$9.93	$13.56
Small Game	$0.17	$0.13	$0.10	$0.07	$15.31	$12.57
Snapper-Grouper	$0.09	$0.08	$0.05	$0.04	$11.03	$11.23
No Target	$0.54	$0.40	$0.25	$0.19	$6.23	$5.24

[a] Shore anglers do not target Big Game.

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

Table F4-7 shows that boat anglers in the Gulf of Mexico region targeting bottom fish have the largest per-day gain ($1.53) from eliminating I&E. Seatrout anglers have the largest per-day gain ($1.36) of those who fish from the shore. Shore anglers targeting bottom fish also have a relatively high per-day welfare gain of $0.62. Table F4-7 also reports the WTP for a one fish per day increase in catch. The more desirable the fish, the greater the per-day welfare gain, as evidenced by the WTP for catching one additional fish per trip. Of the species groups affected by I&E reductions, boat anglers value flatfish the most ($16.27 for an additional fish) followed by small game ($15.31) and snapper-grouper ($11.03). Shore anglers value seatrout the most ($13.56) followed by small game ($12.57) and snapper-grouper ($11.23). Both boat and shore anglers place the lowest value on bottom fish, $7.08 and $2.16, respectively. Anglers targeting big game, not surprisingly, place the highest value on catching an additional fish ($29.84).

EPA calculated the total economic value of eliminating I&E in the Gulf of Mexico region by combining the estimated per-day welfare gain with the total number of fishing days at Gulf of Mexico sites. NMFS provided information on the total number of fishing trips by state and by fishing mode for West Florida, Alabama, Mississippi, and Louisiana. The Agency utilized data from the U.S. Department of the Interior's *2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* (U.S. Fish and Wildlife Service, 2001) to estimate fishing days in Texas.[16]

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.[17] Per-day welfare gain differs across recreational species and fishing mode.[18] EPA therefore estimated the number of fishing days associated with each species of concern and the number of days taken by no-target anglers. EPA used the MRFSS sample to calculate the proportion of recreational fishing days taken by no-target anglers and anglers targeting each species of concern and applied these percentages to the total number of days to estimate species-specific participation. Table F4-8 shows the calculation results for the Gulf states.

No-target anglers account for the largest number of fishing days at Gulf of Mexico NMFS sites (11 million). Anglers targeting small game and seatrout rank second and third, fishing 5 million and 2.9 million days per year, respectively. Anglers targeting other species have the lowest number of fishing days per year (59,110).

[16] EPA assumed Texas anglers chose their mode of fishing and target species in the same proportions as in the other Gulf states.

[17] See section F4-5.1 for limitations and uncertainties associated with this assumption.

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

Table F4-8: Recreational Fishing Participation by Species for the Gulf of Mexico Region

Species Group	Number of Fishing Days		
	Four States[a]	Texas	All Gulf States
Big Game	181,944	65,280	247,224
Bottom Fish	434,177	155,778	589,955
Flatfish	167,801	60,205	228,006
Seatrout	2,870,680	1,029,968	3,900,648
Small Game	5,016,475	1,799,854	6,816,329
Snapper-Grouper	1,305,131	468,266	1,773,397
Other	59,110	21,208	80,318
No Target	10,974,261	3,937,441	14,911,702
Total[b]	21,009,580	7,538,000	28,547,580

[a] Includes Western Florida, Alabama, Mississippi, and Louisiana.
[b] Sum of individual values may not add up to totals due to rounding.

Source: National Marine Fisheries Service, 2002d.

The estimated number of days presented in Table F4-8 represents the baseline level of participation. However, anglers may take more trips if recreational fishing conditions improve. EPA used the trip frequency model described in section F4-3 to estimate the predicted number of fishing days due to the elimination and reduction of I&E. These changes are reported in Table F4-9. For baseline I&E elimination, the estimated percentage increase ranges from 0.43 percent for boat anglers targeting bottom fish to 0.02 percent for shore anglers targeting snapper-grouper. For I&E reduction under the final section 316(b) rule, the increase ranges from 0.23 per cent for shore anglers targeting seatrout to 0.01 percent for boat anglers targeting flatfish and all anglers targeting snapper-grouper. The total increase for the region is 37,385 fishing days under the baseline elimination of I&E and 19,022 days under the final section 316(b) rule reduced I&E, an increase of 0.13 and 0.07 percent, respectively.

Table F4-9: Increased Recreational Fishing Participation by Species and Fishing Mode from Eliminating or Reducing I&E in the Gulf of Mexico Region

Species	Predicted Percent Change in Annual Fishing Trips				Boat Mode		Shore Mode		Party/Charter Mode	
	Boat Mode		Shore Mode							
	Baseline	Reduced	Baseline	Reduced	Baseline	Reduced	Baseline	Reduced	Baseline	Reduced
Bottom Fish	0.43%	0.18%	0.18%	0.07%	218,952	218,394	372,610	372,216	-	-
Flatfish	0.03%	0.01%	0.05%	0.03%	89,878	89,868	138,215	138,186	-	-
Seatrout	0.32%	0.18%	0.39%	0.23%	2,999,831	2,995,793	897,513	896,026	16,406	16,375
Small Game	0.05%	0.03%	0.04%	0.02%	4,119,123	4,118,268	2,611,203	2,610,793	88,942	88,918
Snapper-Grouper	0.03%	0.01%	0.02%	0.01%	1,171,379	1,171,241	522,165	522,115	80,289	80,277
No Target	0.15%	0.07%	0.11%	0.05%	5,935,061	5,930,261	8,708,202	8,702,878	287,665	287,450
Total					14,534,224	14,523,825	13,249,908	13,242,214	473,302	473,020

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

Table F4-10 provides welfare estimates for two policy scenarios: welfare losses to recreational anglers from baseline I&E and welfare gains that will result from installing the technology required under the final section 316(b) rule at the Gulf of Mexico region facilities. EPA calculated the total welfare estimates by multiplying the estimated values per day (Table F4-7) by the number of fishing days (Tables F4-8 and F4-9).[19] These values were discounted to reflect the fact that fish must grow to a certain size before they can be caught by recreational anglers. EPA calculated discount factors separately for I&E of each species(See Chapter F2 for details). To estimate discounted total benefits, EPA calculated weighted averages of these discount factors for each species group, and applied them to estimated WTP values. Discount factors were calculated for both a 3 percent discount rate and a 7 percent discount rate. For the welfare estimates of the final section 316(b) rule, an additional discount factor was applied to account for the 1-year lag between the date when installation costs are incurred and the installation of the required cooling water technology is completed.

Table F4-10: Total Estimated Annual Welfare Gain to Recreational Anglers from Eliminating and Reducing I&E Under the Final Section 316(b) Rule in the Gulf of Mexico Region (2002$)

Species Group	Eliminating Recreational Fishery Losses from I&E			Reduced I&E Losses Under the Final Section 316(b) Rule		
	Undiscounted	3% Discount Factor	7% Discount Factor	Undiscounted	3% Discount Factor	7% Discount Factor
Big Game	N/A	N/A	N/A	N/A	N/A	N/A
Bottom Fish	$565,039	$514,186	$463,332	$230,230	$203,407	$176,438
Flatfish	$30,064	$28,260	$26,156	$16,744	$15,281	$13,614
Seatrout	$4,631,381	$4,446,125	$4,260,870	$2,673,690	$2,491,974	$2,298,875
Small Game	$1,041,644	$947,896	$854,148	$589,764	$521,052	$451,969
Snapper-Grouper	$157,082	$135,090	$111,528	$89,703	$74,897	$59,523
No Target	$6,817,301	$6,340,090	$5,794,706	$3,186,871	$2,877,455	$2,531,628
All Species	$13,242,511	$12,411,647	$11,510,740	$6,787,002	$6,184,066	$5,532,047

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

The total value of recreational losses for all species impinged and entrained at the cooling water intake structures in the region is $13.2 million per year (2002$), for all anglers in all five Gulf states, before discounting. The discounted recreational losses are $12.4 million and $11.5 million (2002$) per year, discounted at 3 and 7 percent, respectively. The last three columns of Table F4-10 present the annual reduction in losses resulting from installation of the CWIS technology for each facility subject to the final section 316(b) regulation. Total recreational losses under the final section 316(b) rule are reduced by $6.8 million. Discounting the welfare gain by 3 and 7 percent results in total welfare gains of $6.2 million and $5.5 million, respectively.

[19] EPA averaged the baseline number of days (Table F4-8) and predicted increased number of days (Table F4-9) to estimate total welfare (Bockstael et al., 1987).

F4-5 Limitations and Uncertainties

F4-5.1 Extrapolating Single-Day Trip Results to Estimate Benefits from Multiple-Day Trips

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

There is evidence that multi-day trips are more valuable than single-day trips. McConnell and Strand (1999) 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).

F4-5.2 Considering Only Recreational Values

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

F4-5.3 Species Substitution

EPA's estimated RUM model does not allow for anglers to substitute between modes or species. The analysis therefore assumes that each angler has chosen a mode/species combination followed by a site based on the catch rates for that site and species. One disadvantage of the specified model is that the model looks at site choice without regard to mode or species. Once an angler chooses a target species and mode, no substitution is allowed across species or mode (i.e., the value of catching, or potentially catching, a different species or fishing using a different mode is not included in the calculation). Therefore, improvements in fishing circumstances related to other species or modes will have no effect on anglers' choices, and thus will not be accounted for in the welfare estimates. This limitation, however, is unlikely to have a significant effect on welfare estimates, because most anglers tend to fish for the same target species on most of their trips (Haab et al., 2000).

F4-5.4 Charter Anglers

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

F4-5.5 Potential Sources of Survey Bias

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

a. Recall bias

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

b. Sampling effects

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

F4-5.6 Extrapolation to Texas

The per-trip welfare calculations used angler data from the four Gulf states, excluding Texas. However, the I&E data pertained to all five states and was reduced by 33.17 percent to reflect Texas' share of CWIS flow in the region. To estimate angling days by mode and target species for Texas from total angling days, EPA assumed Texas anglers chose their mode of fishing and target species in the same proportions as in the other Gulf states. EPA also assumed that per-trip welfare for Texas anglers would be the same as the other Gulf states anglers. This may introduce an unknown bias if the changes in fishing site quality in Texas differ from the changes estimated for other the Gulf states or if Texas anglers prefer different species and fishing modes than anglers in their neighboring states.