Chapter 21
Sampling the Recreational Fishery

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21.1 INTRODUCTION

This chapter discusses the collection of recreational fishery information using direct interview, on-site, survey sampling techniques. (Mail and telephone surveys will be treated in chapter 23.) Emphasis is placed on marine and large impoundment recreational fisheries, although basic aspects of the sampling techniques apply to all situations. Discussion will center around estimating the traditional fishery descriptors of fishing effort (pressure) and fish harvest. In addition, the chapter will describe the commonly used methods of determining the economic benefit associated with recreational fisheries.

The basic unit of fishing effort is the fisherman-hour or angler-hour, which is one hour of active fishing by a single angler. In certain situations it may be difficult to obtain reasonable estimates of the number of hours spent fishing, and other units of effort, such as the boat-trip or party-trip must be used; boat-trips or party-trips can be converted to angler-trips by knowing the mean number of anglers per boat or party. An angler-trip and an angler-day are equivalent units of effort. Effort over a given time period (usually a year) on a given resource can be expressed on a per unit of surface area basis for comparative purposes. Lambou (1966) gives an overview of the most appropriate ways to express creel survey results for reservoirs.

Benefit derived from recreational fisheries has traditionally been measured as harvest of fishes in number or weight. In the past, the terms harvest and catch have been used synonymously; however, given that recreational benefit may be derived from catching fish and returning them to the water, it is more appropriate to treat harvest as a component of catch and define catch as fish harvested plus fish released. Yield incorporates catch as well as all other benefits derived from the recreational experience (Anderson 1975). Relative comparisons of catch, independent of the magnitude of effort or the size of the water body, are possible by expressing catch on a per unit of effort or on a per unit of surface area basis, respectively. Catch per unit of fishing effort (CPUE), usually measured as harvest per unit of effort, is typically used as an index of stock density (Ricker 1975) where the stock comprises harvestable-sized individuals.

Ultimately, it is desirable to measure the economic value of angling so that it can be related to other segments of the economy. Economic (and social attitude) information can be derived through interviews and, when integrated with catch and effort data, can enhance understanding of the clientele and guide management.

The commonly used expression "creel census" will not be used in this chapter. A census implies a total enumeration of the angling population which is virtually impossible for large recreational fisheries. A survey refers to a sample of the population and is the correct terminology. Given that the creel survey, for cost effectiveness, should be directed at more than just creel data, a more appropriate expression describing this kind of data collection effort is "recreational fishery survey."

21.2 THEORETICAL FRAMEWORK: SAMPLING THE ANGLING POPULATION

There are two basic considerations concerning the collection of recreational fishery information: (1) what statistical survey design provides the best quantitative estimates of the fishery characteristics of interest; and (2) what is the most effective way to contact the anglers to obtain the needed information. This section will address commonly used survey sampling designs and the following section will treat angler contact methods.

Before deciding on a particular sampling design, you must clearly formulate the objectives of the survey. The objectives should identify the anglers of concern (target population), define the temporal and spatial dimensions of sampling, and specify the kind of information to be collected. Objectives may be very broad, for example, if the aim is to describe annual fishing for a state, or quite specific, for example, if information is desired on anglers who fish for one species in one lake for one week a year.

The fishery biologist must divide the time and/or space dimensions of fishing into sampling units (SUs) that should be chosen at random. The primary objective is to give all anglers in the target population some probability of being sampled; although anglers cannot be chosen directly at random, the SUs within which they fish can be (*see* chapter 1). Sampling design concepts are covered in detail in survey technique books; Bazigos (1974) presents these concepts specifically for fisheries surveys in inland waters with emphasis on artisanal fisheries in developing countries. The designs outlined here are simple random sampling, stratified random sampling, and stratified two-stage probability sampling.

21.2.1 Simple Random Sampling

In simple random sampling, the temporal/spatial framework is divided into non-overlapping SUs, a given number of which are then chosen for the sample randomly and with equal probability. Box 21.1 outlines a simple random sampling process used to choose sampling days over a 59-day period. The specific objective of such sampling could be to describe a fishery over the period indicated, on a particular body of water that can be canvassed entirely during one fishing day (for example, 6 A.M. to 6 P.M.), when monetary restrictions permit sampling on only 10 of the 59 possible days.

The random sampling process begins by numbering the SUs (fishing days) from one to 59. Next, 10 random numbers are chosen from a random numbers table by looking at random digits two at a time, for example, and choosing the first 10 between 01 and 59. Sampling days should be chosen without replacement so that once a particular day has been chosen, it cannot be sampled again; therefore, its number is ignored if it appears again in the random numbers table.

21.2.2 Stratified Random Sampling

Stratified random sampling is a technique which reduces sampling variance by controlling variability in the parameter being estimated. A heterogeneous population

Box 21.1 Simple Random Sampling

Outline of a simple random sampling procedure where 10 sampling units (fishing days) were chosen from 59 possible units over a two-month survey period. Randomly chosen days are circled on the calendar.

SAMPLING UNIT DEFINITIONS

SU	DATE
1	1 Feb
2	2 Feb
3	3 Feb
4	4 Feb
|	|
57	29 Mar
58	30 Mar
59	31 Mar

RANDOM CHOICES

SU	DATE
51	23 Mar
24	24 Feb
09	09 Feb
57	29 Mar
30	02 Mar
39	11 Mar
21	21 Feb
36	08 Mar
37	09 Mar
26	26 Feb

FEBRUARY

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28						

MARCH

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

is divided into homogeneous sub-populations (strata) which are then subjected to simple random sampling. In order to reduce variability associated with estimates of fishing effort, for example, the days within the survey period are often grouped into weekdays and weekend days. The usual situation is that weekend days receive consistently higher levels of fishing effort than do weekdays. A simple random sample of days would probably include both day-types and would give a highly variable estimate of daily fishing effort. Taking a simple random sample of weekdays and another simple random sample of weekend days, however, would provide two relatively precise estimates of fishing effort that could then be combined to estimate effort for the entire study period.

A stratified random sampling plan is presented in Box 21.2 using the same time period identified in the simple random sampling example. Days within the weekday stratum are enclosed by the dark squares on the calendar. The stratified random sampling plan requires that the sampling units for each stratum be chosen separately. The weekday stratum contains 43 SUs, and the weekend stratum contains 16;

weekdays thus are consecutively numbered from 01 to 43 and weekend days from 01 to 16 so that two separate random samples can be chosen. In the example, 10 sampling days are allocated equally between strata, five days each.

The gain in precision because of stratification depends on the degree of heterogeneity in the total population and the extent to which this heterogeneity is alleviated by the stratification scheme. Thus, if most of the variability (heterogeneity) in daily fishing effort is caused by differences between weekdays and weekend days, then stratification by day-type should decrease sampling variance; if, however, variation in daily fishing effort is caused primarily by other factors (weather, for example), stratification by day-type will do little to improve the precision of the estimate. Also, whereas this stratification would be expected to improve the precision of estimates of fishing effort and probably of catch (since catch is highly correlated with effort), it would not result in a more precise CPUE estimate unless CPUE was found to vary consistently according to day-type.

In Box 21.2, the 10 sampling days were allocated equally between strata. Equal allocation of SUs among strata usually will not be the best design. Cochran (1977) gives the general rule that more samples should be taken within a stratum if: (1) the stratum is larger than others being sampled (more fishing days); (2) the characteristic being measured is more variable in the stratum; and (3) the stratum costs less to sample. These three considerations can be interrelated mathematically (Cochran 1977, section 5.5) to provide optimum allocation of sampling units. Malvestuto et al. (1979), using months as strata with constant cost requirements, showed that for West Point Reservoir, Alabama-Georgia, the sampling variation associated with monthly estimates of fishing effort was highly correlated with fluctuations in air temperature and rainfall; the authors offer a method of more optimally allocating monthly sampling effort based on this information.

Apart from potential gains in precision through stratification, this technique must be used if independent estimates are desired for particular subsets of the total population. Common subsets are geographical regions, habitat types, months or seasons of the year, and fishing methods (bank versus boat, for example). Sometimes multiple stratification is desirable (seasons x day-type x habitat), but given that each stratum must be independently sampled, the number of SUs, and thus the expense, quickly can become too large for practical purposes.

21.2.3 Stratified Two-Stage Probability Sampling

Because of time, cost, and logistical constraints, the fishery may be divided into smaller units for sampling purposes. The stratified random sampling scheme presented earlier, for example, requires the creel clerk to cover the entire body of water and to remain on the water for the entire fishing day; frequently this is impossible. The solution is to subdivide each fishing day into secondary or subsampling units. The stratified sampling procedure is conducted in two stages: (1) fishing days or primary SUs (PSUs) are chosen; (2) within each randomly chosen PSU, one or more secondary sampling units (SSUs) are randomly chosen. Box 21.3 shows a subsampling design where each fishing day is divided into six SSUs (two time periods x three lake sections), and one of these SSUs is chosen from each PSU. The box shows a random sample of SSUs (marked with an X) from the five weekdays and five weekend days previously chosen using stratified random sampling. Note that the time periods are labeled A.M. and P.M. and may realistically represent a morning sampling period of six hours (6 A.M. to 12 noon) and an afternoon sampling period of six hours (12 noon

Box 21.2 Stratified Random Sampling

Outline of a stratified random sampling procedure where five sampling units (fishing days) were chosen from each of two strata, one composed of weekdays, the other of weekend days. The strata are separated by the dark outline on the calendar; randomly chosen days are circled.

SAMPLING UNIT DEFINITIONS

WEEKDAY STRATUM SU	DATE	WEEKEND STRATUM SU	DATE
1	1 Feb	1	6 Feb
2	2 Feb	2	7 Feb
3	3 Feb	3	13 Feb
4	4 Feb	4	14 Feb
|	|	|	|
41	29 Mar	14	21 Mar
42	30 Mar	15	27 Mar
43	31 Mar	16	28 Mar

RANDOM CHOICES

WEEKDAY STRATUM SU	DATE	WEEKEND STRATUM SU	DATE
43	31 Mar	05	20 Feb
25	05 Mar	13	20 Mar
01	01 Feb	03	13 Feb
22	02 Mar	14	21 Mar
40	26 Mar	12	14 Mar

FEBRUARY

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28						

MARCH

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Box 21.3 Stratified Two-stage Sampling

Outline of a stratified two-stage probability sampling procedure where each primary sampling unit (fishing day) was divided into six secondary sampling units (time period/lake section categories), one of which was chosen with nonuniform probability sampling from each primary unit. Chosen secondary units are marked with an "X".

TIME PERIOD PROBABILITIES	
AM	0.40
PM	0.60
	1.00

LAKE SECTION PROBABILITES	
1	0.50
2	0.25
3	0.25
	1.00

SSU	PROBABILITIES	# RANGES
AM-1	0.20	00-19
AM-2	0.10	20-29
AM-3	0.10	30-39
PM-1	0.30	40-69
PM-2	0.15	70-84
PM-3	0.15	85-99

RANDOM CHOICES

WEEKDAY STRATUM			WEEKEND STRATUM		
PSU	# CHOSEN	SSU	PSU	# CHOSEN	SSU
1 Feb	83	PM-2	13 Feb	44	PM-1
2 Mar	39	AM-3	20 Feb	86	PM-3
5 Mar	09	AM-1	14 Mar	07	AM-1
26 Mar	16	AM-1	20 Mar	50	PM-1
31 Mar	62	PM-1	21 Mar	74	PM-2

Weekdays

	1 Feb. AM	1 Feb. PM	2 Mar. AM	2 Mar. PM	5 Mar. AM	5 Mar. PM	26 Mar. AM	26 Mar. PM	31 Mar. AM	31 Mar. PM
Lake Section 1					X		X			X
Lake Section 2		X								
Lake Section 3			X							

Weekends

	13 Feb. AM	13 Feb. PM	20 Feb. AM	20 Feb. PM	14 Mar. AM	14 Mar. PM	20 Mar. AM	20 Mar. PM	21 Mar. AM	21 Mar. PM
Lake Section 1		X			X			X		
Lake Section 2										X
Lake Section 3				X						

to 6 P.M.) in a 12-hour fishing day.

The primary difference in the random, stratified, two-stage probability sampling process relative to the other two designs in the PSUs and SSUs can be chosen with unequal or nonuniform probabilities. In Box 21.3, PSUs were chosen with equal probabilities, but SSUs were chosen with nonuniform probabilities, a desirable approach when SSUs have consistently different fishing pressure (or other characteristic of interest). The A.M. and P.M. time periods were given sampling probabilities of 0.4 and 0.6, respectively, because previous observation indicated that 40% of the fishing effort would occur in the morning and 60% in the afternoon. The unequal probabilities associated with lake sections were based on the same rationale. The sampling probabilities associated with the six SSUs were calculated by multiplying the individual time period probabilities by the lake section probabilities. (Note that the sum of the probabilities equals 1.0.) The random choice for SSUs was based on dividing the number range from 00 to 99 into unequal intervals, according to the probabilities established.

This type of design is similar to that discussed in detail by Malvestuto et al. (1978). The advantage associated with this approach is that, on the average, those sampling units receiving the most fishing effort will occur more often in the sample; more information accrues and precision increases by sampling those units. Fishing effort is typically used to establish probabilities because it is more easily measured (party or boat counts, for example) than other characteristics; however, if information is available on other characteristics which are more closely allied to the objectives of the study (harvest or CPUE), this information should be used to establish sampling probabilities. Additionally, a single set of sampling probabilities (as for SSUs in the current example) may not hold for all strata; a separate set may be desirable for weekdays and weekends, and these, in turn, may change seasonally. The more accurate the probabilities, the better the gain in precision from this type of design. This example was based on a two-stage subsampling design; however, the subsampling process can be extended to three or more stages (multi-stage probability sampling). Pfeiffer (1966) describes a nonuniform probability sampling design for a small lake; Best and Boles (1956) compare the accuracy of four design alternatives to total enumeration data.

21.3 ANGLER CONTACT METHODS

Once the sampling units have been defined and randomly chosen, the creel clerk must contact the anglers and collect the necessary information. Alternatively, anglers can be contacted through household surveys which use telephone or door-to-door canvassing to collect data about earlier trips. In these surveys, the sampling population is usually a list of names (from fishing license receipts or boat registrations, for example), and random sampling is applied directly to the list so that the anglers themselves or their households become the sampling units.

Sampling from lists of names has biases; for example, not all anglers have licenses, and boat registrations allow only boat anglers to be sampled. As Deuel (1980b) points out, the primary advantages of household surveys are that the data can be related to the entire population, response rates are high for telephone and door-to-door interviews, and cost per interview is low for mail and telephone surveys. Household survey information can be unsatisfactory, however, because of the nonsampling errors associated with recall over time—for example, "telescoping," when anglers include events outside the recall period or "omission," when anglers omit events within the recall period (Deuel 1980a). Nonresponse error, as when a particular portion of the target population does not respond to the questionnaire, is an inherent problem associated with mail surveys in particular (although follow-up mailings are possible). Because the mail and telephone surveys are emphasized in chapter 23, the remainder of this section emphasizes on-site anglers contact methods, particularly aerial, roving, access point, and complemented surveys.

21.3.1 Aerial Surveys

Aerial surveys can be loosely categorized as a contact method; anglers are counted from an airplane that is flying low enough and slow enough to get an accurate count of individual anglers in boats and on the bank. This will be difficult if the shoreline is irregular or heavily wooded, and biases will occur if portions of the population cannot be counted. It is also important to establish criteria for deciding if people are engaged in fishing or another recreational activity.

Aerial surveys yield only fishing pressure data, measured as the number of anglers or fishing boats operating over a given time period within a given area (*see* section 21.5.1 on measuring fishing effort). The primary advantage is that large areas can be covered in relatively short periods of time so that total enumeration is possible. Where the sampling system has been divided into spatial and/or temporal sampling units, aerial surveys are particularly useful for establishing sampling probabilities (based on fishing effort counts) and adjusting these probabilities as necessary. Major disadvantages are plane rental costs, which can limit the number of overflights possible, and inclement weather, which may deter pilots but not anglers.

21.3.2 Roving Creel Surveys

The roving creel survey is an on-site intercept survey. The basic advantages of intercept surveys are that response rates are high and most anglers are not required to recall catch information (creel clerks identify species and obtain numbers, lengths, and weights). Disadvantages are the high cost per interview, the difficulty of relating survey results to the entire population, and the logistical problems of contacting a representative sample of anglers in large geographical areas (Deuel 1980a).

With the roving survey method, the creel clerk contacts anglers as he moves through the fishing area along a predetermined route. Creel clerks usually travel by boat, and the following discussion will assume boat travel; in certain situations, shore anglers may be contacted more effectively by automobile or on foot. The original statistical formulation of this approach (Robson 1961) dictates that: (1) the route completely covers the survey area, (2) the clerk begins the route at a randomly chosen point of departure, (3) the clerk randomly chooses one of the two alternative directions of travel, and (4) the clerk travels at a constant speed. In practice, item (2) may be logistically difficult, although boat launching sites can be chosen randomly. In certain instances, item (3) may be impossible because of regulations that restrict direction of boat travel. It is critical that the clerk make a complete circuit of the survey area. Where anglers are too numerous to interview, the clerk should systematically skip parties in an objective manner (every second, or third, or tenth group, for example) so that the circuit is completed; if anglers are too few in number to occupy the full time of the clerk, he should slow down enough to complete the full circuit in the allotted time period.

The primary weakness of the roving survey is that catch and effort information is based on incompleted rather than on completed fishing trips, i.e., anglers are contacted while they are fishing. An incompleted fishing trip is measured from the time an angler begins fishing until the time of the interview; a completed fishing trip is measured from the time an angler begins fishing until he thinks he will finish. Obtaining unbiased estimates of fishing success (measured as CPUE) through the roving survey, thus, requires that catch rate not be dependent on the length of a fishing trip. The literature contains conflicting viewpoints on the validity of this assumption; the preponderance of published information where data on incompleted versus completed trips were actually compared (Carlander et al. 1958; Von Geldern 1972; Malvestuto et al. 1978) suggests that the assumption is reasonable, but it should be checked carefully for every fishery.

Another problem with roving surveys occurs because the probability of contacting an angler is proportional to the length of the trip. Therefore, creel clerks will tend to interview anglers who spend more time on the water, and thus overestimate the mean length of a fishing trip. I found that the arithmetic mean of trip length from the roving survey overestimated actual trip length on West Point Reservoir, Alabama-Georgia, but that the harmonic mean compensated for this positive bias. Other disadvantages associated with the roving survey are that night surveys are generally impossible and, because anglers are interrupted while fishing, that public relation problems may occur (*see* section 21.4.1 on behavioral protocol).

The primary advantages of the roving survey as outlined by Von Geldern (1972) are that: (1) contact of anglers is more time efficient where multiple access points are present, i.e., waiting time between interviews is limited to travel time between anglers, (2) all angler types (rental boat, private boat, shore, public and private pier) can be contacted in proportion to their actual abundance, and (3) interviews can be combined with angler counts over a large area. With respect to item (3), the creel clerk either makes separate count and interview circuits, randomly choosing which comes first, or combines counts and interviews into a single circuit; the latter is more cost-effective, but precision may increase by keeping count circuits as short as possible (*see* section 21.5.1 for a discussion of count usage). The suggested count procedure is that the clerk count only those anglers fishing between the shore and the center of the fishing area as he passes them.

21.3.3 Access Point Surveys

The access point survey is another type of on-site intercept survey where the creel clerk is stationed at an access point (boat landing, pier, jetty, beach) so he can contact anglers at the end of their fishing trips. The general advantages and disadvantages of the roving survey previously mentioned hold here as well. Integration of this contact approach with statistical survey techniques dictates that access sites be randomly chosen; it is common to sample access points using nonuniform probabilities proportional to amount of use.

The primary advantage of the access point approach relative to the roving method is that information is based on completed trips rather than on incompleted trips. A basic disadvantage occurs where access points are so numerous that few anglers use any one point, thus contact rates will be low and clerk time is inefficiently used. Also, it is usually impossible to sample all angler types proportional to their level of effort. This is a particular problem with bank anglers who may be widely dispersed along the shoreline and not associated with well-defined access sites. Shoreline facilities may be quite varied, e.g., public and private piers and launch sites, jetties, beaches, parks and other recreational sections of shoreline, so that a very complete sampling design is required. The access point survey is ideal where all anglers must leave from only a small number of points or where anglers must report their catches at a central location (a concession stand, for example).

21.3.4 Complemented Surveys

Complemented surveys are those in which more than one survey method is used. Some of the biases of each individual survey approach can be overcome by using a complemented survey, e.g., a night fishery cannot be monitored reasonably using a roving technique, but it could be surveyed via access points; an access point survey may not adequately sample bank anglers, but a roving survey would, so that both together would cover all anglers.

In a strict sense, a complemented survey is one which has two sampling populations. An excellent example of this is the national marine recreational fishery survey currently being conducted by the National Marine Fisheries Service and described in papers by Deuel (1980a, b). Based on extensive pre-survey evaluation of contact methods, the designers determined that a telephone survey, based on a sampling population of all coastal households with telephones, and an access point survey, based on a sampling population of all fishing sites, together would most effectively provide the information needed to estimate total harvest of marine sport fish. The telephone survey provides estimates of the percentage of anglers in the entire population and of the number of fishing trips by type and location of fishing; the intercept survey provides estimates of harvest per trip by species.

The survey methods discussed here are only a few of many possible types. In many cases, catch is recorded in one form or another, and catch records can be sampled; e.g., charter boat captains keep log books, anglers may be required to record catch on fishing permits, and fishing clubs typically keep records. These surveys usually cover only a specific segment of the fishery and must be interpreted accordingly.

21.4 THE INTERVIEW PROCESS

The verbal interview is a behavioral interaction between an interviewer (creel clerk) and respondent (angler). The data collection instrument used by the interviewer is a questionnaire, often called an interview schedule if questions are verbally read to the respondent. The interview schedule consists of predetermined, exactly worded questions that, ideally, are easily and clearly understood and that elicit responses pertinent to the objectives of the survey. Because anglers are clients as well as respondents, the interview should provide a positive social interaction between the management agency and its clientele.

This section provides a brief overview of the interview process by categorizing the subject into two subtopics, behavioral protocol and questionnaire design and presentation. Detailed consideration is given to social research methodology in books by Babbie (1973), Miller (1977), and Bailey (1978).

21.4.1 Behavioral Protocol

On-site intercept surveys require that anglers be contacted during or after their fishing trips. In either case, the interviewer must realize he is interrupting the respondent's privacy and leisure time to request information. At the same time, the respondent, a resource user, is likely to judge the interviewer as a representative of his management agency. The delicacy of this interaction is readily apparent, and there is a behavioral protocol that will help ensure a successful interview.

Establish contact in as courteous a manner as possible. The situation is especially challenging during on-water roving surveys when you must use a boat to reach and contact anglers. There usually will be entries on the interview form that can be answered prior to verbal contact (*see* top of Fig. 21.1), and there is no need to interrupt the respondent before recording this information. Approach anglers slowly and from far enough away to minimize (if not eliminate) boat wake and to avoid tangling the anglers' gear. (A trolling motor is a handy tool for boat-to-boat interviews.) Call to the anglers from a distance that does not interrupt their fishing. Unless the respondent has harvested fish which you must measure, you can conduct the entire interview with minimum inconvenience to the angler.

Try to gain the anglers' trust from the beginning of the interview. Dress in a manner acceptable to the people being interviewed and be officially identifiable (emblem on shirt or cap, boat label, etc.). After greeting the respondent, provide a brief explanation of the purpose of the survey as soon as possible without shouting. Anglers are not required by law to answer questions and their rights should be respected; ask if they are willing to respond to the questionnaire with the understanding that their answers will remain anonymous. If they do not want to participate, do not pressure them to respond. Emphasize to the angler that his or her responses are very important because only a small portion of all anglers using the resource will be interviewed and that the information collected will be used to improve the fishery.

If accurate harvest data are desired, try to check the creel yourself rather than relying on the anglers' recollections. Measuring fish usually will interrupt fishing activity, especially for boat-to-boat interviews. Do not pressure anglers to allow their fish to be measured but emphasize that the information will be important to fishery managers.

Because of the positive social relationship that the creel clerk seeks to establish with the angler, the objectives of the creel clerk and the law enforcement officer are not complementary. If one objective is to remind anglers when they are in violation of fishing regulations, a standard method should be established so that the creel survey is not jeopardized. The value of the interview as an information exchange mechanism can be enhanced by providing anglers with written information about the survey, including current survey results, if available. Respondents, thus, have a better appreciation of the end-result of donating their time and information.

21.4.2 Questionnaire Design and Presentation

The design and presentation of a questionnaire are critical to the collecting of high-quality data. Questionnaire design refers to the intent, sequence, and wording of questions; questionnaire presentation refers to the interviewer's demeanor, knowledge of question intent, phrasing of questions, and use of verbal probes and visual prompts.

Only include questions in the interview schedule that are relevant to the objectives of the survey. Bailey (1978) suggests that if you cannot decide in advance how the answers will be statistically analyzed and published (or otherwise presented), then you should not ask the question. Take care to avoid two-part questions and ambiguous questions, and whenever possible avoid negatively phrased questions and biased terms or phrases. See Babbie (1973) for examples.

The interview schedule should be well organized, not only to enhance the ease

ROVING CREEL INTERVIEW SCHEDULE

Date__________Time_________Lake Section______Sample #_____ No. in party_____

Fishing From: Bank___ Boat___ With:__# rods   Sex: M___F____

Location: Open Water ___ Tree Shelter ___ Rip-Rap ___ Pier ___ Bridge ___

"Good morning (good afternoon). My name is ________________ and I am conducting an angler survey for the (affiliation). We are collecting information that will be used to help manage this resource. Do you mind if I ask you a few questions about your fishing trip today?"

"What county and state did your fishing trip today originate from? "
County________ State__________

"What do you estimate that you will spend on the following items for today's fishing trip?" Gas $________ Food $_____ Bait $______ Lodging $__________

If boat fisherman: "Which landing did you use to launch your boat ?"_______

"What time did you begin fishing today?" AM____ PM_____

"What time do you think that you will finish fishing today?" AM____ PM_____

" Now I would like to ask you some questions about your catch "

"What kind of fish are you fishing for ?"______________________________

"How many have you caught and released ?"______________________________

"How would you rate your fishing success today on a scale of poor, fair, good, or excellent ?" Poor___Fair___Good___Excellent___

"Would you mind if I record the number and sizes of fish that you have harvested ?"

SPECIES CAUGHT		LENGTH CLASS (SPECIFY)	TOTAL
	No		
	Wt		
	No		
	Wt		
	No		
	Wt		
	No		
	Wt		
	No		
	Wt		

"That completes the interview. Thank you very much for your time. Do you have any comments that you would like to make about the management of this resource ?"

____

Figure 21.1. An example of a roving creel survey interview form. The example is meant to show logical questionnaire construction, not to provide an exhaustive list of questions.

with which anglers can respond, but also to help the interviewer. Place questions in a logical order; for example, the items on the interview form shown in Fig. 21.1 are ordered so that data which can be collected prior to the interview are entered at the top of the form. The actual angler interview begins in the next section of the form with exactly worded questions that progress from asking the place of trip origin to requesting an estimate of the time that the respondent will finish fishing that day (a time sequence). The final section on the form concerns catch information with a space for recording data on harvested fish. The questionnaire ends with an invitation to respondents to ask questions or express opinions. Concentrate on accurately recording the views of the respondents (keeping in mind that responses will have to be categorized for analysis) and refrain from discussion that might destroy an otherwise positive encounter. Some general rules for question order are (1) ask easy-to-answer questions and questions needed for subsequent interviewing first, (2) put sensitive and open-ended questions late in the questionnaire, (3) vary questions in type and length to

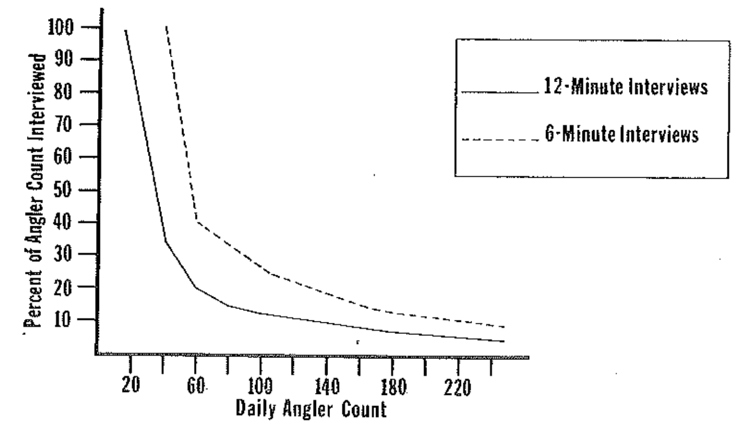

Figure 21.2. Relationship between percent of total anglers interviewed and the total number of anglers counted for two mean interview schedule lengths. The 12-minute interview curve is based on data collected from roving creel surveys conducted on two Alabama-Georgia reservoirs during 1980-81, using four-hour sampling periods; the six-minute interview curve was simulated by doubling the number of people interviewed with the 12-minute schedule.

keep the interest of the respondent, and (4) avoid establishing stereotyped responses. *See* Bailey (1978) for details.

It is tempting to increase questionnaire length because the cost of adding questions is small relative to that of survey equipment and operating costs. However, there is a point of diminishing returns because inconvenience to anglers and data processing time increase to accommodate information of marginal value. Additionally, longer interview schedules reduce the number of anglers that can be interviewed during the sampling period. Figure 21.2 shows the percentage of total anglers interviewed relative to the total number of anglers present during four-hour sampling periods for two interview schedule lengths. In this example, a sample representing 10% of the anglers present during any given sampling period could be collected using either the 6- or 12-minute interview schedule. To sample 20% of the anglers present, however, would require the use of a 6-minute (or shorter) schedule so that the 20% sample could be maintained at pressure counts beyond about 60 anglers per sampling period (Hudgins and Malvestuto 1982). Information trade-offs such as this (more anglers versus more information per angler) must be weighed carefully while designing the survey.

To aid in the consistency of data collection, all questions should be fully expressed on the interview form. Include the introductory remarks, as well as other connecting statements (Fig. 21.1). Interviewers should be trained in questionnaire delivery and should understand the intent of all questions. When a respondent misinterprets a question, the interviewer can provide verbal probes (in a specified manner, as per training) to bring the respondent back on track. Visual prompts, such as holding up a ranking scale (1 = not important, 2 = slightly important, 3 = important, and 4 = very important), can orient the respondent and decrease response error. Data comparability depends on consistent use of the instrument; the interviewer should play a neutral role but facilitate the interview process. Questionnaires should be pretested (Babbie 1973), preferably by conducting a pilot survey.

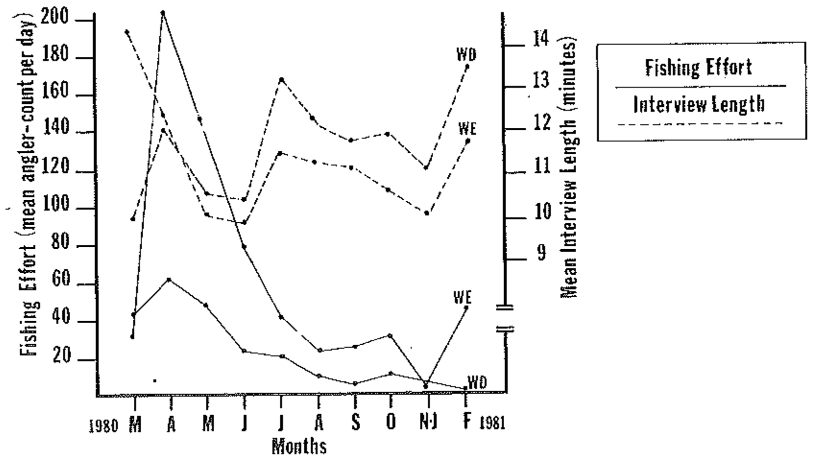

Figure 21.3. Trends in mean length of interview versus mean angler-count for weekdays (WD) and weekend days (WE) from March 1980 - February 1981 on West Point Reservoir. Trends are based on 502 interviews taken on 60 sampling days.

Interviewer inconsistencies can be caused by many factors operating in the system. Hudgins and Malvestuto (1982) show that length of an interview (not including time for collection of harvest data or open-ended comments) was affected by the number of anglers present. Creel clerks tended to shorten interview length as the number of anglers increased in an effort to obtain more interviews and to gain time for pressure counts. The negative relationship was evident both seasonally and between weekdays and weekends (Fig. 21.3). *See* Cannell et al. (1977) for an excellent summary of interviewing methodology.

21.5 OVERVIEW OF QUANTITATIVE PROCEDURES

The primary focus of this section is on collecting information necessary to estimate fishing effort, catch (harvest), and catch per unit of effort (CPUE). Regardless of the sampling design or contact method, catch can be estimated as the product of effort and CPUE so that the primary concern centers on estimating these two components. Effort is estimated using pressure counts, but CPUE is obtained through the interview process. The basic information that must be recorded for each interview is the amount of time spent fishing (unless the chosen unit of fishing effort is something other than the angler-hour) and the number and weight of each species harvested. Taking length measurements will provide additional information on the length structure of the harvestable-sized stocks.

21.5.1 Estimating Fishing Effort

Fishing effort estimates from creel surveys are based on angler count data; the clerk should strive to count all anglers operating within the specified sampling unit. Counts are converted to angler-hours by multiplying the number of anglers by the number of hours in the sampling period (Neuhold and Lu 1957; Lambou 1961). The validity of this calculation rests on the assumption that the number of anglers counted

is an unbiased estimate of the number of angler-hours in progress at any given instant, i.e., an "instantaneous count." Twenty anglers fishing during one instant means that after one hour, 20 angler-hours have been expended; after four hours, 80 angler-hours have been expended. This assumption remains the same regardless of how the count is taken, e.g., from a high vantage point, or from a plane or a boat progressively circling the sample section. Field studies show that short counting periods provide better data, and the ideal situation is to take short counts within any given sampling period and average them to obtain an estimate of the true instantaneous count. However, Neuhold and Lu (1957) showed that progressive counts taken over a one-hour sampling period were similar to counts taken from a vantage point, and I found that progressive counts taken over a four-hour sampling period were similar to counts taken over a one-hour sampling period at West Point Reservoir, Alabama-Georgia. Lambou (1961) gives a detailed quantitative discussion of angler count data.

The sampling unit frequently represents only a portion of the angling population present on any given day, as when the day has been divided into sampling periods, a body of water has been divided into sections, or only one of several access points is being sampled. In these cases, angler-hours within the sampling unit are expanded to an estimate of total angler-hours for the entire day by dividing the sampling unit value by the sampling probability associated with the particular unit. Total angler-hours are converted to angler-trips by dividing by the mean time spent fishing per trip. It is usually feasible to count anglers separately by fishing type (bank versus boat), and independent effort estimates can then be calculated. Boat-trips and angler-trips can be converted by knowing the mean number of anglers per boat.

In most instances, it is desirable to partition effort according to the species or group of species sought. This requires that anglers be asked to identify the type of fish they intend to catch. Given a statistically valid sampling design, the sample percentages of effort expended for each class of fish can be multiplied by total effort to estimate "fished for" or "intended" effort. Sample percentages should be obtained using completed trip information.

21.5.2 Estimating CPUE

Creel survey estimates of CPUE are obtained by dividing measured (recorded) harvest by measured effort (usually angler-hours). For the roving survey, measured (incomplete trip) effort is taken as the number of hours from the time the fishing trip began to the time of interview. When fishing days are being subsampled, the calculated CPUE for the subsampling unit is taken to represent the CPUE for the entire day.

There are three major reasons to measure CPUE: (1) to estimate total harvest or harvest by species over a specified time period, (2) to obtain an index of stock abundance for particular species or classes of fish, and (3) to measure fishing quality or fishing success for particular species or classes of fish. To estimate total harvest for a survey period, calculate CPUE by dividing total measured harvest by total measured effort. Then multiply CPUE by the total estimated effort for the survey period. To partition CPUE according to species, divide the recorded harvest of each species by total measured effort; the separate species estimates of CPUE will add to the estimate based on all species combined. Total harvest by species is obtained by multiplying each CPUE by the total estimated effort for the survey period.

It is generally accepted that estimates of CPUE based on total measured effort are not appropriate when interest centers on a particular species or class of fish unless all species are equally vulnerable to all angling techniques or unless the proportional contribution to total effort by anglers fishing for different species is constant over time. The most appropriate measure of CPUE for objectives (2) and (3), therefore, is obtained by dividing the harvest of a given species of fish by the angler-hours directed toward that species (Lambou and Stern 1958; Lambou 1966; Von Geldern 1972; and Von Geldern and Tomlinson 1973). As an index of fishing success, this form of CPUE assumes either that: (1) anglers catch primarily what they seek; or (2) fish caught, but not sought, have little bearing on an angler's perception of his fishing success. *See* Ricker (1975) for a discussion of the use of CPUE as an index of stock abundance.

Catch per unit of effort is a ratio estimate. There are two basic ratio estimators that can be used to calculate it, the mean of ratios estimator and the total ratio estimator. The objectives of the survey will determine which estimator should be used. Given that fishing days are being chosen at random, one way of estimating CPUE for the survey period is to calculate daily CPUE values and take an average of these values over the number of days sampled. This is called the "mean of ratios estimator" and gives equal weighting to each day, regardless of the amount of fishing effort expended. It is the proper estimator if mean daily values of fishing success are desired; the variance for this ratio is calculated as for any set of independent observations.

The other approach to estimating CPUE is to calculate a single ratio by dividing the sum of measured catch over all sampling days by the sum of measured effort over all sampling days. This is called the "total ratio estimator" and is self-weighting, i.e., it is influenced by differences in daily fishing effort and is representative of fishing success for the population as a whole. (*See* Snedecor and Cochran 1980, section 21.12, for the appropriate variance estimator.) The total ratio estimator seems to be the most appropriate for calculating total harvest over the survey period as long as measured effort is proportional to actual effort during the days sampled. Given that there will be a physical limit to the number of people that can be interviewed during a sampling period, measured effort may not be proportional to actual effort over the entire range of possible values. Figure 21.4 is an example of this. With a roving design used on several Alabama reservoirs (four-hour sampling periods), proportionality was

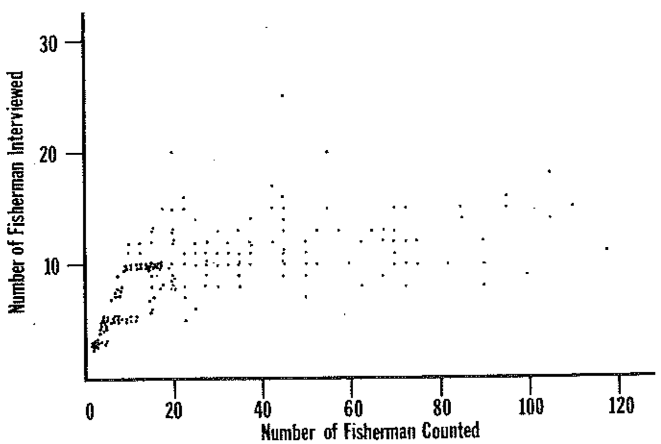

Figure 21.4. Scatter diagram showing relationship between number of anglers counted and number interviewed for roving creel surveys (four-hour sampling periods) on several reservoirs in Alabama.

maintained only when there were fewer than 25 anglers in the sampling section; beyond this density, the number of anglers interviewed was relatively constant regardless of the number counted. In this case, it would be better to use the mean of ratios estimator or to weight daily (CPUEs) by counts of total anglers.

Von Geldern and Tomlinson (1973), who were primarily interested in obtaining an estimate of fishing success applicable to the average angler, suggested a modification of the mean of ratios estimator. They calculated CPUE for each angler (or fishing party) interviewed and a mean of these values for each sample day. They averaged the daily values over the number of days sampled to estimate fishing success on a per angler basis.

The best procedure for estimating effort, CPUE, harvest, and the standard errors of these values depends on the survey sampling design used. Survey design books, such as Cochran (1977), provide the specific statistical formulas. Bazigos (1974) gives formulas and numerical examples. Pinkas et al. (1964) outline the quantitative aspects associated with a stratified random sample of marine sport fishermen using launching and mooring sites and piers and jetties. Malvestuto et al. (1978) provide a step-by-step outline of calculations for a roving survey using stratified nonuniform probability sampling. (*See* section 21.2.3.)

Keep in mind that even if the catch and effort information collected is accurate, it will be of little value for documenting change in the fishery unless it is also precise. Strive to keep relative standard errors as small as possible; values in excess of 20% are not desirable. It may be difficult to increase the number of sampling units because of money and labor restrictions, but appropriate modification of the sampling design can reduce sampling variance.

21.6 MEASURING ECONOMIC BENEFIT

So far, this chapter has focused on estimation of the traditional sport fishery descriptors of effort, catch, and CPUE. These values are the basis of the maximum sustained yield (MSY) approach to fisheries management where the primary objective is usually to improve fishing success (CPUE) for a given species or group of species. Given that yield from a recreational fishery encompasses more than CPUE, the concept of optimum sustained yield (OSY), which incorporates economic and social benefits associated with fishing, is certainly more applicable to the recreational setting. The OSY concept suggests the need for the measurement of economic and social components and the subsequent integration of these values into fishery assessment procedures and management strategies. This section provides an overview of current economic valuation techniques with an emphasis on conceptual problems and data collection. The discussion is based largely on papers by Crutchfield (1962), Knetsch (1963), Gordon et al. (1973), and Dwyer et al. (1977).

21.6.1 The Concept of Economic Benefit

The economic component of yield is referred to as benefit, worth, or value. The gross economic value of a recreational fishery is composed of (1) explicit costs of local, state, and federal services which contribute directly to the fishery; (2) total angler expenditures directed toward the fishery (license and on-site fees, equipment and travel costs, etc.); (3) the value over and above actual expenditures that anglers would be willing to spend, or could be induced to spend, to fish; and (4) the additional value based on nonusers' willingness to pay just for preservation of the fishery. Items (1) and

(4), although contributing to gross economic worth and national or regional welfare, do not contribute directly to the "user-oriented" benefits from the fishery (the value people receive from fishing) and thus are not a part of our focus here. It is the benefits accruing to users of the fishery that are of primary concern. In economic terms, the proper measure of these benefits is simply the total amount of money that people are willing to pay to engage in fishing, i.e., components (2) and (3) above. It should be pointed out that these two components provide a measure of the value of the entire fishing experience to the user; the value of the fish is only a portion of the entire trip value and may be approximated by placing a monetary figure on the harvest as per appropriate market, hatchery, or reimbursement costs (Monetary Values of Fish Committee 1978).

Although actual expenditures and the amount anglers would be willing to spend in excess of actual expenditures both contribute to total willingness to pay, it is the latter component that is theoretically equivalent to the value that we place on items in a market economy. Willingness to pay in excess of actual expenditures is called "net willingness to pay" or "consumers' surplus" and measures the profit, rent, or net value attributable to the fishery, a value theoretically collectable if anglers could be induced to pay this excess amount. Actual expenditures simply measure the costs associated with getting to, using, and returning from the resource and could not be collected as a use fee if, for example, the fishery were privately owned. In other words, if the fishery were to disappear, actual expenditures would be redirected, and the economic loss could not be measured in terms of these expenditures, but rather in terms of the theoretical profit loss associated with abolishment of the fishery. Brown et al. (1964) contrast the two components by pointing out that using total expenditures as a measure of economic worth is similar to stating that the worth of a logging operation is the total monetary outlay by the logger, which is obviously wrong. The primary problem is that although consumers' surplus is the value which must be measured, most recreational fisheries are offered free of charge; therefore, this value cannot be directly estimated. Indirect measurement is possible, however, and two common valuation procedures will be outlined below; Stabler (1980a, b) provides reviews of these techniques and discusses recent developments and future needs. First, however, because actual expenditures do represent a part of angler benefits, a brief overview of expenditure estimation is presented.

21.6.2 Determination of Angler Expenditures

Actual expenditures fall into two general categories: (1) variable or fishing trip costs, which include expenditures for items such as gas, food, bait, and lodging incurred while traveling to, using, and returning home from a fishing trip, and (2) fixed or durable costs for fishing equipment (boats, gear, special clothing), which can be used over a number of years (Gordon et al. 1973). On-site angler surveys can provide estimates of average expenditures per angler-trip and total trip expenditures over a survey period. The quantitative procedures are analogous to those previously discussed for estimating CPUE and total harvest; that is, cost per angler-trip (or angler-hour) is multiplied by the total number of trips (hours) expended over the survey period to give total trip expenditures. Expenditure information is obtained via the interview process and should be itemized (Fig. 21.1). Expenses can be partitioned by type of fishing or type of angler so that the relative contribution of different segments of the fishery to variable cost can be compared.

Fixed expenditures are more difficult to estimate accurately because anglers must

recall what they paid for the items (which may have been purchased years previously) and the cost of each item must be depreciated over the period of ownership to determine current value. Another approach is to ask anglers what they have expended recently, over a period of one to two months at most, and then to calculate current fixed expenditures over the survey period. As Gordon et al. (1973) indicate, this method will likely lead to high variance estimates because, for example, one angler may have just spent thousands of dollars on a new boat and others may have purchased nothing. Actual cost values, however, will be less subject to recall bias and depreciation errors. When estimating both fixed and variable costs, care should be taken to determine what portion of these costs are actually spent for fishing. If the primary purpose for visiting an area is to fish, then variable costs can reasonably be attributed to the fishing trip; when other activities are involved, costs should be partitioned, as well as possible, between activities and expressed on a daily basis. Many durable items such as recreational vehicles or clothes can be used for a variety of purposes, and the respondent should be asked to estimate the percentage of time the particular items are used for fishing at the site in question.

Actual expenditures are typically taken to represent the economic worth of a fishery because they can be measured directly and because many people misunderstand what constitutes the true benefit of the fishery. As discussed, expenditures do contribute to the total economic benefit, and consumers value a fishery at least as much as other things that could have been purchased for the same amount (Crutchfield 1962). In addition, expenditure analysis provides insight into how much and for what anglers are spending money, and it can prove useful for allocating personnel and resources toward specific management objectives (Gordon et al. 1973). The true net worth of the fishery, however, is defined as the consumers' surplus, and emphasis should be placed on estimating this value.

21.6.3 Determination of Consumers' Surplus

Fundamental considerations. The following discussion is taken largely from Dwyer et al. (1977) who provide an excellent overview of current recreational resource

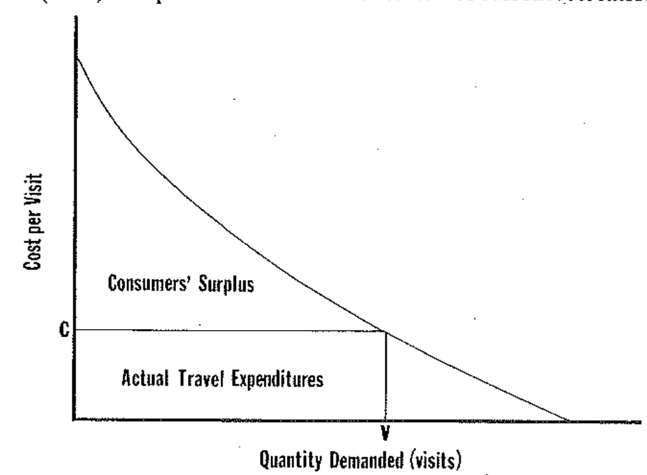

Figure 21.5. Theoretical demand curve showing relation between actual angler expenditures and consumers' surplus.

valuation procedures. The basis of determining consumers' surplus or net willingness to pay is simulation of the demand schedule for the fishery. A demand schedule is simply a curve which indicates the quantity of a good (level of use or visitation) that buyers (anglers) are willing and able to purchase at various prices. Figure 21.5 depicts a hypothetical demand curve. Demand curves generally have a downward slope indicating that decreased amounts of a good are desired at higher prices. Benefits are approximated by the area under the demand curve so that in Figure 21.5, if V number of visits occurred at C cost per visit, then actual angler expenditures are approximated by the area labeled as such under the curve. The area above actual expenditures approximates the amount of money anglers are willing to pay in excess of actual monetary outlay, i.e., consumers' surplus. The entire area under the curve out to point V represents total willingness to pay, or gross consumers' benefits.

The two methods for determination of consumers' surplus, the survey method and the travel cost method, rely on simulation of a demand curve by development of models (equations) that predict (explain) willingness to pay as a function of site and socio-economic characteristics, as well as of location of users relative to the fishery.

Survey method. The term survey method is a misnomer because both this technique and the travel cost method depend on properly designed surveys and interviews (sections 21.2 and 21.4). The basis of the survey method is that anglers are asked what they would be willing to pay over and above actual expenses to fish at a particular site rather than to be deprived of the fishing experience. These dollar values are then quantitatively related to other information obtained via the interview using standard multiple regression techniques. The final outcome is a multiple regression model that allows average willingness to pay (per individual, fishing party, or household) to be predicted using relevant, obtainable information. These predicted values are then used in conjunction with estimates of the number of resource users to simulate the demand function (Fig. 21.5) and calculate consumers' surplus. Dwyer et al. (1977) describe and evaluate several examples of the survey method.

The choice of predictor variables depends on the specific situation at hand but may include standard demographic information (age, sex, income, family size, etc.), number and length of visits to the site, years of experience with the site, distance traveled to the site, a measure of availability of alternate sites, and perhaps a measure of the success of the fishing trip. Basic problems with the method are that respondents may not be able to accurately place a value on willingness to pay over and above actual expenses, they may not understand the questions properly, and the questions may not be phrased correctly. Advantages of the method are that small changes that would not be expected to influence travel costs or number of visits can be evaluated; estimates of the value of a site that is one of many destinations on a single trip may be obtained; and effects of crowding on site benefits can be considered.

The survey method can be used with mail or telephone surveys. Users of specific resource sites are difficult to identify this way. Alternatively, the method can be used on-site. The travel cost method, however, is restricted to on-site surveys. Both methods are ideally suited for integration into the creel survey approaches discussed previously.

Travel cost method. The travel cost method is based on a model predicting use at a particular site by measuring the actual behavior of participants. The method estimates the demand function for a fishery by using the travel costs associated with distances of users from the fishery as a proxy price variable. Because travel cost (as well as travel time) increases as distance from the fishery increases, less participation

per unit population will be forthcoming from the more distant locations. This relationship simulates the demand curve that would result if fishing fees were progressively increased—causing fewer people to participate in the recreational activity (Fig. 21.5).

In general, the travel cost method is the appropriate valuation technique when: (1) there is sufficient variation in travel costs (distances) among anglers to estimate the demand function via multiple regression procedures; (2) management strategies being evaluated are significant enough to alter the number of angler-trips that will be made at existing travel costs; and (3) travel expenses have been made primarily for the purpose of fishing at the specific site in question. The method presumes that anglers react to increases in entry fees just as they do to increases in travel cost and that all users place the same value on fishing at the site in question so that they all would be willing to pay the same maximum travel cost per trip. Dwyer et al. (1977) provide a detailed treatment of quantitative advantages over the survey method because the method: (1) explicitly recognizes the price alternatives of the users based on their location relative to the fishery, (2) is based on market behavior of anglers rather than on responses to questions, and (3) does not rely as heavily on the skills of the interviewer.

A simple travel cost model requires information on (1) the total number of visits made from several (not necessarily all) population origins at different distances from the site, where origins are often taken to be towns, counties, or concentric rings around the site; (2) the total population at each origin; and (3) the average trip cost for anglers traveling from each origin, including expenditures for transportation, food, lodging, bait, tackle, and equipment and guide rental. This information allows derivation of a trip demand curve by regressing visits per capita on travel cost. The next step involves derivation of the site demand curve showing how many total visits would be made at various hypothetical fishing fees where differential travel costs simulate these fees. The area under this curve, obtained by integration of the demand function, estimates consumers' surplus.

Angler attendance is partially dependent on factors other than travel cost, and more complex models are usually necessary to accurately predict visitation. Relevant factors include travel distance, travel time, age, sex, family structure, income, and familiarity with the fishery and substitute recreational areas. Recent examples of these are found in Merewitz (1966), Cauvin (1978, 1980), Copes and Knetsch (1981), Palm and Malvestuto (1983), and Weithman and Haas (1982).

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