Techniques Used to Obtain Habitat Preference Data on Holding Adult Spring Chinook Salmon in a Clear Stream

Among the anadromous species of salmon (*Oncorhynchus spp.*) and the steelhead trout (*Salmo gairdneri*) there are two races which enter and adult holding stage soon after entering freshwater streams. These races are the spring chinook salmon and the summer steelhead trout. An adult spring chinook typically migrates from the ocean during spring, ascends a cold stream until it finds a suitable place to rest, and then holds there several weeks while it matures before entering the spawning stage (Royal 1972). The amount of suitable holding habitat has declined over the years, due to man's activities. Protection of such holding habitat has become increasingly important to resource agencies. The U.S. Fish and Wildlife Service determined in 1984 that it should perform a study to observe holding spring chinook and to develop holding habitat preference criteria. Field work to develop these criteria was begun by the Fisheries Assistance Office, Olympia, Washington, in 1984, and completed in 1985 (Wampler 1986). This paper describes the field techniques used to gather that data.

Study Area

We gathered observations of holding spring chinook in the Wind River, a tributary to the lower Columbia River, in southwestern Washington Figure 1). Wind River water clarity, abundance of holding spring chinook, and diversity of instream habitat types provided some of the prerequisites for a suitable preference criteria study. The Wind River remains clear

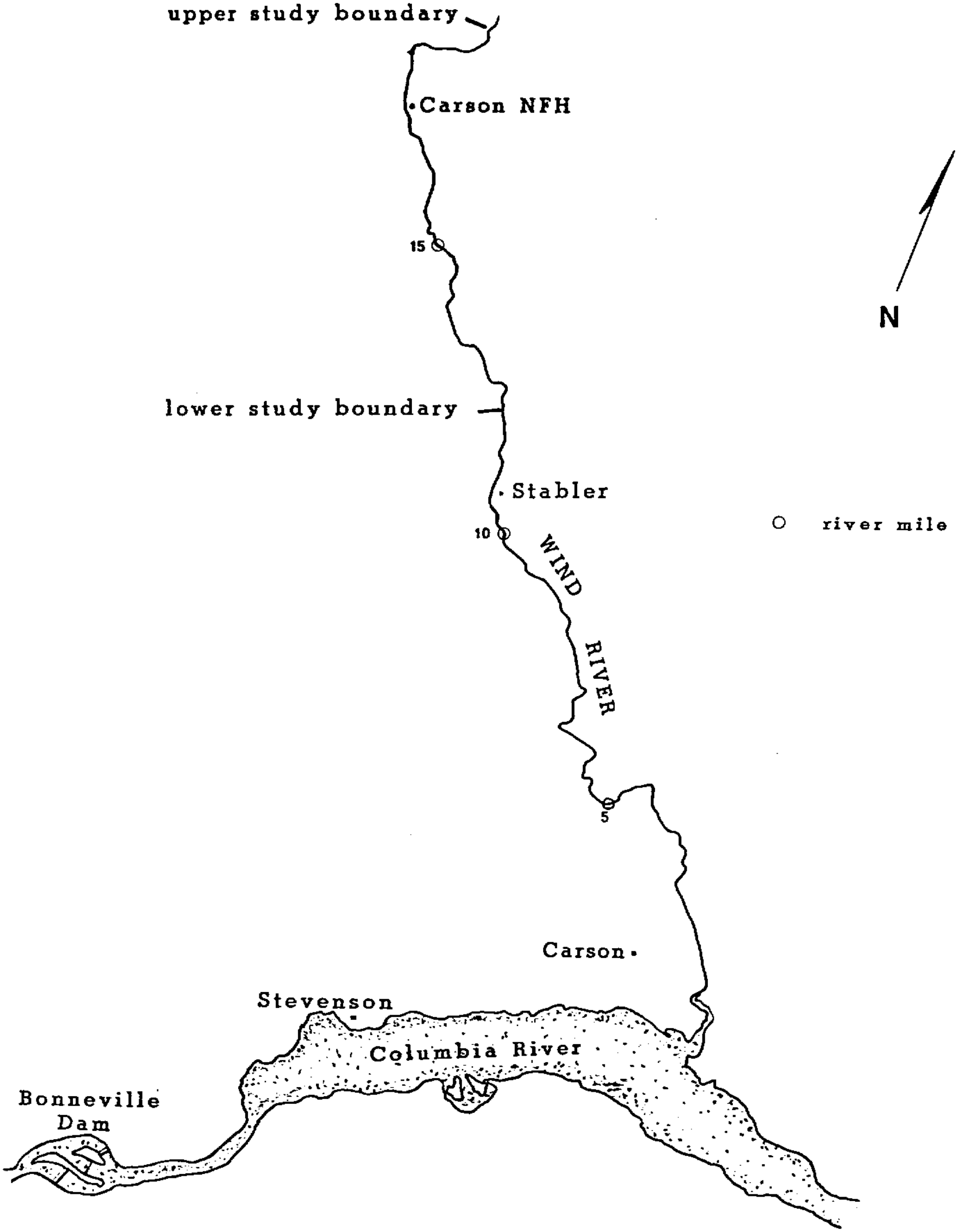

Figure 1. Location of Wind River and the study area.

during most of the spring and summer holding period. The Carson National Fish Hatchery (CNFH), located at river mile 17.4, supports the hatchery portion of the spring chinook run. A wild portion also exists, having developed from spawners that strayed from the hatchery. The Wind River spring chinook run was protected from fishing, which enhanced our opportunity to find a sufficient number of unharassed holding fish. In addition, access to the river was generally good upstream of river mile 10.

METHODS

Through discussions with the CNFH staff and a preliminary snorkel survey I determined that most holding fish were located in the upper river valley, between river miles 12 and 19. This reach was characterized by generally moderate gradient, some meandering, gravel to boulder substrate, a good pool to riffle ratio, and scattered sections offering good protective cover for fish. I concluded that our data collections should be confined within this reach. I excluded from data collection the river section immediately downstream of the CNFH because of the possibility of introducing data bias from unusually high concentrations of spring chinook there.

The field procedure used was largely guided by recommendations of staff at the Instream Flow and Aquatic Systems Group (IFG) and related material in IFG publications (Bovee and Cochnauer 1977, Bovee 1982). Baldrige and Amos (1981) described the general method I employed to analyze field data and to develop preference curves. Collection of field data fell into two principal categories, habitat utilization data and habitat availability data.

Utilization Data Collection

Data collection to develop a utilization function generally followed guidelines for gathering probability-of-use (Bovee and Cochnauer 1977) or habitat utilization curve data (P. Nelson, unpublished). A utilization function is derived from a frequency analysis of microhabitat physical and hydraulic characteristics measured at point locations of target fish (Bovee 1986).

Based upon previous experience and discussions with biologists who had observed holding adult spring chinook, I concluded that observations must be gathered by snorkeling in an upstream direction. Bovee (1986) confirmed that snorkeling in an upstream direction provides equipment simplicity and a preferred sampling strategy. During preliminary snorkeling I concluded that this technique would work satisfactorily.

A number of factors shaped the utilization sampling design. It became obvious that successful fish observation would require that the snorkeler approach any potential holding location with great care to minimize his presence and visibility to fish. An observation would be unuseable if a fish could not be observed over a period long enough to assure that it was exhibiting holding behavior. My criteria to confirm that a fish was holding were as follows: the fish must not leave its original location;

the fish must be an adult spring chinook showing no signs of obvious ill health; and the fish must not have been observed previously during the sampling day, either as a recorded observation or as a frightened fish in flight.

Sampling design was also a factor of holding fish availability and required sample size. Assuming that the minimum required sample size was 200 utilization observations, I expected difficulty in arriving at that goal. Time and project funding were limited. Holding fish locations presumably would be scattered, thus requiring considerable time per collection of successful observation. Given these sample design considerations, I concluded that the only practical design was to sample throughout the utilization reach (mile 12 to 19) and to record an observation for any fish that met my criteria for holding behavior.

We gathered utilization data within a different segment of the utilization reach on each sampling day. This approach eliminated the risk of repeating measurement of a particular fish at the same location. I assumed that if a fish was remeasured at a new location in another river segment, then it was useable data.

Observation procedure

Fitted with full wet suit, mask and snorkel, and felt-soled canvas shoes, one person cautiously moved upstream until an adult spring chinook was located. At that point, the following tasks were performed: (1) the fish (one or more) was observed from a distance to determine if it was a holding spring chinook, i.e., stationary, and at exactly what position in relation to the stream bed and the water column; (2) once a fish was determined to be holding, and its location data were relayed to an assistant on the stream bank, the snorkeler moved to the point of location to gather additional information; (3) total depth and depth of the fish (nose depth) were read from a top-setting wading rod placed at the stream bed point over which the fish's nose had been; (4) flow velocities of the mean water column and at nose depth were measured over the point of fish location (using either a rod-mounted Swoffer-adapted Price AA or Pygmy current meter, or a rod-mounted flow digitizer with a current meter); (5) the dominant substrate category and its percent, and the subdominant substrate category at the point of fish location were recorded (particle size categories were developed by an interagency substrate committee (Washington Department of Fisheries 1983); and (6) presence or absence and category of overhead protective cover, within about four feet of the point of location, were recorded. Any appropriate comments regarding a completed observation were also recorded. At the end of each day, collected data were reviewed for accuracy and completeness. A tally of actual hours spent working in the river were also maintained.

A sample size of 150 to 200 observations is usually sufficient to develop satisfactory suitability curves, but a statistical test should provide the final guidance as to sample size (Bovee 1986). Following the completion of data collection in 1984, I tested the data for sample size (Snedecor and Cochran 1972). We had collected 129 observations. At the 95% probability level the test indicated that larger samples were required for the continuous variables, i.e., total depth, fish nose depth, mean column velocity, and velocity at nose depth. As a result, one additional year to collect fish observations was required, in 1985. We were unable to collect additional data beyond 1985. Following advice regarding data pooling, offered by the IFG staff, I limited our sampling effort exerted during 1985 to that exerted during 1984. This was done to avoid biasing the pooled utilization data.

Some additional measurements were recorded. Water temperature was recorded occasionally during the work period, but not during all sampling days. Presence or absence of shade at a fish location was recorded for each fish observation, during the second year only.

Mean size of observed fish would be of interest to anyone that might later use the study results. We could distinguish underwater between adults and jacks, i.e., precocious males, but we did not attempt to measure fish lengths in order to minimize fish harassment. It was reasonable to assume that mean size of observed fish would not vary significantly from that of fish taken later at CNFH during the annual egg collection and fertilization. Therefore, data on fish size were obtained from CNFH.

Availability Data Collection

After considering habitat availability sampling options suggested by the IFG staff, I chose to use the habitat mapping, or proportional sampling approach (Bovee 1986). Given our available time, this appeared to be the most practical option.

Based on preliminary walking and snorkeling surveys in the utilization reach and use of maps and aerial photographs, I selected an availability sub-reach (AR). Habitat conditions in the AR appeared to represent the relative proportions of those conditions in the total utilization reach. The AR was located at about mile 16.3, and had a length of about 600 feet.

Development of the availability function required that I determine percent of AR surface area for any interval of a variable present during the period of utilization sampling. At the outset I hoped to collect all required utilization observations during a period brief enough that no significant change would occur in the river stage. I established a staff gauge within the AR to monitor river stage. I used the gauge to guide decisions of when to collect availability data. During the 1984 utilization sampling period I concluded that only one availability data set, collected midway through that period, was required. By this same procedure I found it necessary to collect two additional availability data sets during the summer of 1985.

Each availability data set collection required about two days effort from a crew of two or three people. Data collection procedures employed within the AR generally followed standard procedures of the instream flow incremental methodology (IFIM) developed by the IFG. Ten transects, perpendicular to the direction of river flow, were established within the AR. Total depth, mean column velocity, substrate, and protective cover were measured at transect verticals to determine the total AR wetted surface area having specific values or codes of instream variables. Actual measurement procedures were identical to those used in utilization data collection.

One unexpected development arose from comparing the ranges of respective instream variables among utilization data with those among availability data. Development of the total depth preference ratio required that the relative proportion of all increments of total depth available to holding fish be accounted for in the calculations. Maximum water depth in the AR was not as great as at some locations where fish were observed in the utilization reach. It became obvious that those greater depths must be represented in the AR. To correct this, I devised a means of estimating the lineal proportion of the utilization reach that consisted of increments of total depth exceeding the maximum depth found in the AR. This task was accomplished by making map planimeter measurements on a composite set of aerial photographs of the utilization reach. I relied on my familiarity with the deepest sections of the utilization reach to mark these sections on the photographs. The correct proportion of surface area representing water depths greater than in the AR was then added to the calculated AR surface area for total depth. This added area was divided equally among the increments of depth ranging between the maximum depth in the AR and the maximum depth observed anywhere in the utilization reach.

Data Analysis

Following is a brief explanation of my data analysis to help clarify objectives of the field techniques. I performed frequency analyses upon the utilization data, for individual sampling periods and for the three combined sampling periods. I standardized all frequencies (Baldrige and Amos 1981). I then constructed utilization curves. The final utilization calculation was to determine the utilization functions, i.e., the percentages of all holding fish observed at respective variable value intervals and categories.

To derive comparable availability functions I pooled data from the three availability data sets. For each data set, I mapped the AR surface area for variable value intervals and categories using standard IFIM procedures. I then tabulated the mapped data and calculated respective percentages of total available habitat per value interval or category. These percentages represented the availability functions.

RESULTS and DUSCUSSION

Snorkeling

Snorkeling in an upstream direction to gather observations of exact holding locations worked well. The snorkeler was able to move upstream by pulling on rocks or wood objects on the stream bed or on submerged logs and limbs extending from the bank. This technique was normally silent. We thereby avoided the surface disturbance that typically occurs when using swim fins. Occasionally, the snorkeler encountered stronger currents that required walking against the current. Felt-soled shoes greatly reduced the difficulty of this task. There was almost never any need for the snorkeler to submerge for more than a few seconds. The maximum depth encountered in any pool was about 15 feet. When in deep water we found it necessary to wear weights to aid in submerging to depths where fish might be hidden from view. In consideration of our relative snorkeling success, given the maximum pool depths and excellent water clarity, it appeared that the use of SCUBA was unnecessary for this study.

Excellent water clarity and mid-morning to late afternoon daylight generally provided very adequate fish viewing conditions. Typically, water clarity permitted the snorkeler to see stream bed detail in the deepest pools. Fish were usually sighted before they appeared to detect the snorkeler's presence, and they normally tolerated the snorkeler within the distance required to secure data, even after detection. Some fish refused to leave their holding location despite the immediate presence of the snorkeler and sampling equipment; but some fish swam away rapidly.

Holding Behavior

The following description of observed holding behavior is included to further define the type of snorkeling effort required. We found holding fish behavior to be generally consistent within the utilization reach. Certain stream habitat types appeared to attract holding fish, regardless of river mile. Deep pools or glides with some form of overhead cover often contained concentrations of holding fish. However, one form or another of overhead cover frequently sheltered one or more holding fish when located in more shallow water.

Early in the process of collecting utilization data I observed that holding fish frequently used cavities formed under large boulders or stream banks. If possible, they would position themselves entirely under an object so that they were not visible except to the snorkeler viewing them from the same depth. Fish holding under such objects were found facing in all possible directions. On several occasions such fish were observed respiring at a depressed rate. When touched by the snorkeler these fish did not react normally, but instead appeared to be quite lethargic. Similar behavior has been observed among holding summer steelhead trout (J. Cederholm, Washington Department of Natural Resources, personal communication).

Fish that appear to be holding that also show signs of ill health should not be included among recorded observations. More than once we encountered badly fungused spring chinook whose behavior was entirely altered from that of normal fish. For example, one such fish had no fear of the snorkeler and appeared to be curious rather than alarmed.

The activity level of holding spring chinook appeared to increase with increased presence of other holding fish. This was most apparent in the larger, deeper pools. One or two fish holding alone usually remained stationary until the snorkeler moved close to take measurements. However, in this situation larger groups of fish usually began moving about the pool, and individuals appeared to react to the movements of other fish.

It appeared that holding fish sought out the deepest pools available to them. Deep stream segments, when they existed, appeared to attract and provide suitable holding for the greatest number of fish. More holding fish per stream surface area in the Wind River could always be found in such stream segments.

Data Collection

We developed a utilization sampling strategy that made maximum use of a two-person crew. The snorkeler carried nothing as he searched for holding fish. He worked more safely with his hands free, and was able to maintain greater efficiency and alertness. Meanwhile, the assistant provided total support, i.e., recording all data, carrying all required equipment, always available to render emergency help, and standing ready to substitute when the snorkeler became too cold to continue. This work structure freed the snorkeler from the complexities and difficulty of recording data (Bovee 1986). Another advantage of the small crew was better continuity in our fish observations and variable measurement techniques.

While the use of markers for later relocation of fish positions has been recommended (Bovee 1986), we experienced no difficulty without their use. The snorkeler moved onto each holding location almost immediately after observing a fish and had no difficulty relocating the correct point over the stream bed.

Proportional sampling to determine availability provided certain advantages. Correct procedures for habitat mapping have been well documented (Trihey and Wegner 1981). Familiarity with those procedures improved our efficiency in data collection. By being able to concentrate all our attention on the mapping during three brief periods, we benefitted from greater effectiveness during both mapping and gathering fish observations. The concept of pooling together the additive mapping data (Bovee 1986) was relatively easy to grasp, and calculations, even by hand, were not too demanding.

The need for caution in selecting a suitable proportional mapping site (Bovee 1986) was demonstrated in this study. Overlooking the comparability of the full range of values for any one variable can potentially invalidate, or at least weaken, the respective preference function. I found a way to correct for my oversight, i.e., adjusting for missing maximum depths in the AR. However, this might not be possible for similar instances in some future study.

Applications

Application of the techniques described above obviously must be limited to certain streams and objectives. At some level of increased turbidity, snorkeling becomes impractical. In streams that are clear enough, this technique should be considered first for studies to observe adult holding salmonids. It should work particularly well for holding spring chinook or steelhead trout. If preference criteria development is the objective of a study proposed for a single stream, the researcher should be reasonably confident that the population of the target species is large enough to allow success. Ideally, observations should be secured in a brief enough period to avoid the need to collect numerous sets of availability data.

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