PRE-SPAWNING ADULT DISTRIBUTION OF QUEETS RIVER SPRING-SUMMER CHINOOK

and

FEASIBILITY OF RADIO TELEMETRY TO STUDY ADULT IN-RIVER MIGRATION

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ABSTRACT

The spring portion of the Queets River chinook run is depressed. One management goal is to restore the spring component by artificially propagating the progeny of wild broodstock if they can be separated from the summer component. Thus, a primary objective of this work was to identify pre-spawning holding areas from which broodstock could be collected. The pre-spawning distribution of spring-summer chinook in the Queets River just prior to spawning was determined by snorkel survey between River Miles (R.M.) 43 and 9 in the first week of September, 1989. Above average densities relative to other locations occurred in the Olympic National Park wilderness between R.M. 37.2 and R.M. 30.6 as in snorkel surveys conducted in 1987 and 1988. Many pools in this area were suitable for netting broodstock and have adjoining gravel bars where fish could be transported to a hatchery by helicopter. The limiting factors will be turbidity, which limits the ability of snorkelers to verify fish presence before netting, and possible limits on helicopter; access prior to the first week of September by the National Park Service.

A second objective was to evaluate the feasibility of radio telemetry in distinguishing spring and summer returns on the basis of holding area, spawning area, or spawn timing. Ten adult chinook were captured by drift gillnetting in the lower river in May and June of 1989 and tracked from the air weekly until late September. The fate of most tags was also determined by taking close-range radio fixes at ground level.

One fish was lost from the system. Only three of the remaining tagged fish ascended to the spawning grounds. Most of the others were still holding in pools within a mile of their tagging sites long after the snorkel survey had determined that the majority of spring-summer chinook had migrated 15 to 35 miles upriver and were already spawning. Of the nine that remained in the river, three shed their tags before the spawning period. Either the capture and tagging procedure or transmitter presence in the gut may have led to most of the tagged fish losing their migratory tendency.

We recommend 1) discontinuing intensive snorkel surveys, 2) continuing to monitor the monthly run size with catch data, 3) several alternatives for experimental evaluation of the effects of entry timing and broodstock location on return timing of progeny, 4) if evaluation of telemetry is continued, testing several alternative methods to see if any might reduce stress, 5) assessment of feasibility of genetic stock identification techniques to differentiate between run components, and 6) development of a general broodstock collection plan.

ACKNOWLEDGEMENTS

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INTRODUCTION

The Queets River spring-summer chinook run is defined as the native chinook that return to the river between March and late August. Tribal catch data demonstrate a clear trend of depletion compared to historical levels (Figure 1), even though early records may be incomplete and later data reflect increased limits on fishing. Escapements of spring-summer chinook have been below desirable levels. It is not yet clear whether the recent upturn in escapements over the past three years augurs a sustained recovery.

Restoration is most urgent for the spring run, defined here as fish caught between March and late May, because it is more depleted than the summer run. Spring catches collapsed in the late 1950-s and have not shown signs of recovery. This has prevented a directed tribal fishery during these months in most years since 1975 (Wood, WDF, pers. comm.).

The summer run, defined here as fish caught between June and late August, has also declined, although less drastically, since the early 1970-s. A commercial tribal fishery beginning in late June has been allowed in most years, but fishing has usually been restricted to one or two days a week.

River entry and spawning may occur on a continuum in both time and location. No clean break has appeared between spring and summer run entry timing in the Queets fisheries (Figure 2). This may be partly because the tribal fishery opening date and level of effort has varied over the years. Snorkel survey data on brightness of fish and their location in the river in late summer give no clues as to entry timing. Nor has timing and location of spawning indicated separate groups which would allow separate escapement estimates for spring- and summer-returning fish (Larry Lestelle, QDNR, pers. comm.).

Fishery resource managers are examining the possibility of rebuilding the spring-summer run by collecting broodstock, rearing the progeny locally, and releasing them back to the watershed (QDNR, undated). An essential step is to determine the best location from which wild brood could be captured from the river. This requires investigating chinook holding distribution of the fish and evaluating the accessibility of these areas. Our combined 1987 and 1988 snorkel surveys (Hiss 1987, 1989a) yielded a fairly complete picture of live adult distribution, but because some parts of the river were missed in each year, an additional year's data was desired. This would provide at least two years' coverage of every potential holding area within the run's known late summer range.

To selectively capture spring-returning fish for brood, one might either (1) collect brood from the lower river in April and May and attempt to hold them in a hatchery through summer, or (2) try to relate entry timing to holding areas or spawning grounds late in summer. This would only require holding for a short period and thus should increase the chance of survival.

In an attempt to identify the respective holding areas and spawning grounds of spring-and summer-returning fish, a radio telemetry pilot study was proposed for 1989 (Hiss, 1989b) to determine the feasibility of a full-scale effort in the following years.

OBJECTIVES

Our objectives for 1989 were:

I. To more precisely determine the holding distribution of live adult spring-summer chinook and to elucidate the feasibility of broodstock capture.

II. To determine whether radio-tagging is a practical technique for relating spring and summer returns to specific holding and spawning areas and spawning timing.

If radio-telemetry proved acceptable, we hoped that the data would begin to answer the following questions:

1. Do early-returning fish tend to hold and spawn earlier or further upstream than later returns?

2. Do early- and late-returning fish have distinct migration rates and holding areas?

3. If either of the above differences exist, can we use them to selectively capture early- or late-returning broodstock?

STUDY AREA AND FISH USE

The Queets River originates in the Olympic Mountains and enters the Pacific Ocean near Queets Village (Figure 3). The Olympic National Park surrounds the mainstem from the Clearwater Road Bridge upstream to the headwaters. The Park allows a sport fishery on salmon and trout within its boundaries, and manages the valley upriver from Sams River as wilderness. The Quinault Indian Reservation covers the mainstem from the Clearwater Bridge downstream, and the Queets Band fishes here commercially and for subsistence.

Chinook have access to 43 miles of the river. The spring-summer run enters the river from March through August and spawns from mid-August through mid-October. In late summer most spring-summer chinook fish held in large pools or deep runs between Ranger Hole (R.M. 21.9) and Harlow Creek (R.M. 33.1) (Table 1) (Hiss, 1987, 1989a). Most spring-summer chinook spawn between Matheny Creek (R.M. 15.7) and Kilkelly Rapids (R.M. 43.0) (Chitwood, QDNR, pers. comm).

METHODS

Snorkel and SCUBA Survey

The survey was done between September 1 and 6, 1989 from below Kilkelly Creek (R.M. 43.3) to Clearwater Road Bridge (R.M. 6.7). Surveyors were airlifted in and out of roadless areas by helicopter. Equipment failures prevented survey between R.M. 30.5 below Tshletshy Creek, and Sams River (R.M. 23.5). Local turbidity prevented snorkeling for a few miles between Sams River (R.M. 23.5) and Phelan Creek (R.M. 17.5) (see notes to Table 1), but continuous survey was possible from there to Olympus View Hole (R.M. 11.7). From Olympus View to the Clearwater Bridge (R.M. 6.7), SCUBA gear was used to survey the deeper holes.

We repeated the procedure of the last two years' surveys. One person in snorkeling gear (from Kilkelly to Olympus View) or two in SCUBA gear (from Olympus View to the Clearwater Road Bridge) swam downstream through any sites where chinook could be holding. Another person walked along shore or floated in a rubber raft and counted live fish that the snorkler might have disturbed but not seen.

All fish were counted and identified to species, and adults were distinguished from jack. The sum of fish observed through snorkel and onshore or raft counts was taken to represent the holding distribution of the fish. Data were summarized by dividing the river into reaches of one to three miles (Table 1). In some reaches the location of each fish was estimated to the nearest tenth of a river mile based on Olympic National Park's aerial photographs marked with WDF river miles.

Radio Telemetry

Feasibility Criteria

Our literature search (Hiss, 1989b) led to the following criteria for a successful tagging study:

1. Our methods must not change fish migration or survival.

2. Fish must not shed tags before spawning.

3. We must be able to capture and safely handle enough fish. Previous studies have tagged 40 to 60 fish per year.

    a. River conditions must permit fishing and tagging from early April through late August.

    b. Enough fish must enter in April, May, and June to permit tagging and comparison of their behavior to fish entering later in the summer.

4. We must be able to monitor the tags.

    a. We must be able to follow individual fish up to six months after tagging in a full-scale study.

    b. Tag detection must be possible from at least 800 feet when tracking by air and up to one-half mile when tracking by land or water.

5. Tagging must not be so close to heavily fished areas that an excessive number of tagged fish are caught before reaching the spawning grounds.

<u>Tagging</u>

Spring chinook were captured for tagging on May 23, 24, and June 14, 1989 (Table 2). Five fish were netted in Kitteridge Hole (R.M. 9.5), three in Anderson Hole (R.M. 10.6), and two in Olympus View Hole (R.M. 11.4). A drift gillnet was fished from a 16-foot aluminum boat with 40-horsepower jet-drive outboard motor. The net most often used was 114 foot long, 20 foot deep when hung, had a stretched mesh of 7-1/4 inches, and was made of clear, heavy, single-strand nylon monofilament. We chose it because it seemed to catch the most fish and rarely snagged on the stream bottom or tangled in the boat. A six inch mesh and multifilament net webbing was occasionally used (Tables 2 and 3) but seemed less efficient and harder to handle.

We used ten Smith-Root type P-4500-L radio tags with an average life of 180 days and a range of one mile in the air. (No endorsement of any Smith-Root product is implied in this report.) The tag consisted of a transmitter in an antenna, both sealed in latex. The transmitter was a 96 mm cylinder, 20 mm in diameter, weighing 20 g underwater and 37 g in air. The antenna extended from one end of the tag, and was about 100 mm long and 5 mm in diameter. The tags were activated by removing a magnet taped to the side of transmitter (thus closing a magnetic reed switch inside the capsule). All ten transmission channels were in the 40-megahertz band and gave one or two pulses per second (Table 2).

We captured fish by drifting the net downstream through a pool while pulling one end or the other with the boat, keeping the net from collapsing or snagging on debris. As soon as one fish was netted, we retrieved the net to where the fish was tangled and gently lifted the fish onboard. Meanwhile, another crew member retrieved the rest of the net and usually released any other fish, although on one occasion we worked two fish at once. We set each fish in the boat bottom, cut away the mesh, then transferred the fish to a container of river water in the boat. In May we used a plastic garbage can for this purpose and in June, a covered metal tub with foam padding.

Upon reaching the shore, we inserted a transmitting radio tag, lubricated with glycerin, into the stomach. The tag was pushed just past the sphincter; the antenna rested against the mouth roof.

We then released the fish if we did not intend to capture more from that pool that day. Otherwise, to prevent recapture during continued fishing, we held the fish in tubs, following a successful technique with fall chinook in the same location (Larry Parker, QDNR, pers. comm.). We inserted the fish into a tube made of plastic pipe 12 inches in diameter and 40 inches long, and anchored the tube in a gentle current to allow good respiration. When the day's tagging was done we opened the tubes and let the fish leave. However, if we needed the tube for more fish, we placed the fish, still in the tube, in the tub and transported it in the boat a half mile upriver, opened the tube, held it in the river, and allowed the fish to leave. To document the stress of tagging, we noted the presence or absence of net scars and scale loss due to capture, and relative speed with which the fish left upon release.

Tracking

Aerial surveys. Each week we flew in a Cessna 182 to the Queets River mouth and proceeded upstream following each bend until all transmitter, channels had been located. We then flew downriver, repeating the observations. We maintained an altitude of 500 to 800 feet above ground and an air speed of 75 to 80 mph. Two nondirectional whip antennas, with length corresponding to 40 megahertz, were taped to the wing struts and wired through the door opening to two receivers inside.

One antenna led to a Smith-Root SR-40 search receiver, powered by a rechargeable battery pack (BP-40). This receiver displayed the reception of each channel by a blinking light and a beeper. We used this visual receiver to establish a range occupied by each tag along the river. One observer in the plane set the scanner at maximum radio frequency gain and called out when each channel was first received and when it disappeared. The other observer would identify the river mile at each of these points to the nearest tenth and mark it on a set of aerial photographs. These photographs, taken by the Olympic National Park in 1984, had a scale of approximately three inches per mile and covered the Queets River within park boundaries. The midpoint of each range of reception was used as the estimated location for each fish.

The other antenna led to a data logger assembly, which served as a backup to the visual receiver. This assembly consisted of a search receiver identical to the one mentioned above, also set for high gain, a Smith-Root FDL-10-ER chart recorder, and a 12-volt aircraft-style gel-cell battery. The logger indicated each channel it received by marking a paper chart one a minute. We started the logger upon reaching the mouth of the river, marked the river mile on the chart when we turned around, and continued running the logger until we returned to the river mouth. This procedure allowed us to convert minutes of flight time into river miles at which each channel was received.

Ground-level surveys. We also monitored by boat, raft, and vehicle. We gained access to the river between Olympus View (R.M. 11.7) to Clearwater Bridge (R.M. 6.7) in a 16-foot aluminum jet boat several times over the season and in an 8-foot rubber raft once in early September. We also periodically surveyed by vehicle along the Queets Valley Road from Olympus View (R.M. 11.7) to Sams River (R.M. 23.5).

To approximate the location of each tag we used a search receiver and chip antenna described above but adjusted the gain to locate tags in a narrow range. Then we obtained an accurate fix with a hand-held loop antenna, about one foot square, built for the 40-megahertz band, attached to a Smith-Root RF-40 delta tuner. Bearings were obtained on tags by rotating the antenna in the horizontal plane and locating the null, that is, the bearing at which the signal faded out. We achieved the narrowest possible null by adjusting the radio frequency gain and fine-tuning the frequency. Fixes on each tag were developed from three or four bearings taken from several points along the bank. This allowed ranges as narrow as 2 m in some cases.

RESULTS AND DISCUSSION

Snorkel Survey

In 1989 we observed 157 live adult chinook in 27.1 miles of river (24.9 miles by snorkel) from Kilkelly Rapids down to the Clearwater Bridge (Table 1). Most were concentrated between Paradise Creek (R.M. 37.2) and just below Tshletshy Creek (R.M. 30.6) (Figure 4). The density between Tshletshy Creek and Smith Place (R.M. 29.9) is a minimum estimate based on a spot check in the tenth of a mile below Tshletshy Creek. However, the actual density is probably not much higher, since the 1987 snorkel survey (Hiss, 1987) showed nine fish holding in the area we saw in 1989 and only one between there and Smith Place.

There was also a smaller group between Kilkelly Rapids (R.M. 43.3) and Hee Hee Creek (R.M. 41.7). It is tempting to associate this group with the spring returns, especially since the pattern has repeated for all three years. However, the partial gap between the groups may reflect the shallow, unstable channels, the wide gravel bars, and relative scarcity of holding habitat between Paradise (R.M. 37.2) and Alta Creeks (R.M. 40.3).

There were a few stragglers downstream of Sams River (R.M. 23.5), but nowhere near as many as in 1987 (Figure 4). In particular, no fish were observed in Ranger Hole (R.M. 31.9) in 1989 whereas 12 were seen there in 1987. Also, a smaller proportion of the run occupied the area above Alta Creek than in the two previous years.

Broodstocking Feasibility

The area between Paradise Creek (R.M. 37.2) and Smith Place (R.M. 29.9) has the highest concentration of adults. There are plenty of relatively large pools below Alta Creek (R.M. 40.3) free enough of woody debris to be netted, and most had bars nearby that were wide enough to land a helicopter.

The area between Paradise Creek (R.M. 37.2) and the upper limits of spawning has a lower concentration of adults and broodstocking here will be difficult, but may help decide whether those fish represent the spring run. There are no large holding areas, but some small pools and shallow runs are free enough of trees and boulders to be seined. Snagging or gaffing might yield additional fish for immediate spawning, but at the risk of stressing unripe fish. Also, because of the increasingly narrow canyon and closed tree canopy above Alta

Creek, airlift of early spawners or their eggs will require more care and, in some cases, transporting the fish or eggs to a clearing large enough for a helicopter to land.

Turbidity may influence broodstocking feasibility if snorkelers are employed as scouts for netters. Turbidity is not easy to predict from one day to another because it depends so much on temperature and glacier melt, but in general the river cannot be expected to clear until the last week of August. Turbidity also varies from one reach to another depending on occurrence of clay banks.

Radio Telemetry

Our procedures clearly stopped most tagged fish from migrating upstream to spawn (Figures 5 and 6). Also, several fish shed their tags before the spawning period. However, in other respects the pilot study did not seriously violate our feasibility criteria.

We originally intended to continue applying tags through July to tentatively begin differentiating holding area, spawning area, and spawn the differences between spring- and summer-run fish. However, when fish tagged in May and June remained at the tagging site, we decided to discontinue tagging because we did not want to tag fish that had come in much earlier.

Effect on Fish Behavior

Capture, handling, and/or tag presence affected fish behavior. Telemetry surveys during the first week of September revealed most tagged fish had stayed far downstream (Table 3, Figures 5 and 6) while our snorkel survey (Figure 4) and concurrent tribal spawner survey (Chitwood, pers. comm.) showed that the majority of the run had ascended to the spawning grounds.

Of the ten fish tagged, seven failed to reach the spawning grounds. Six remained within a few miles of the tagging site and one migrated upstream from the tagging site, fell back, and then disappeared from the river. Of the six non-migrators, four survived with their tags into the spawning period, but the other two shed their tags before this time. Only three fish migrated to the principal spawning grounds. One of the three prematurely shed its tag but the other two probably survived with their tags into the spawning period.

One tagged fish disappeared from the river. Fish with tag number 4 was captured in Anderson Hole (R.M. 10.6). He steadily moved 5 miles upstream, just past Matheny Creek (R.M. 15.8), over 23 days. Four days later he had dropped back near Anderson Hole. His tag was last heard during an aerial survey the following day, around R.M. 3.6 near Queets Village. This fish could have left the Queets River voluntarily, could have been caught in the fishery, or else the transmitter suddenly stopped functioning.

Four fish survived with tags but remained in lower river. Fish number 1 fell back about one mile the first week, but by day 13 had ascended to R.M. 14.5, 4 miles above the tagging site. By day 23 she had dropped back to near mile 8 where she remained throughout the monitoring period. Slight movement suggested she was still alive on September 2 during the last boat survey. Her apparent holding site was beneath a small log jam.

Fish number 3 was caught in Anderson Hole and released at R.M. 10.6. The day after being tagged she had moved roughly one mile upstream of her release site. Three days later she had dropped back to Olympus View Hole, where she apparently remained throughout the monitoring period.

Two chinook tagged in June stayed at their tagging site, Kitteridge Hole (R.M. 9.0), throughout the entire monitoring period. These were one male and one female given tags 11 and 12. Throughout the period, both moved whenever we created a disturbance in the pool.

Two fish shed tags before leaving lower river. Tag number 6 was apparently shed early in the monitoring period. During the first week after tagging, the fish moved steadily upstream to Kings Bottom at R.M. 14.6. In the second week, he steadily moved downstream to R.M. 11.0. Definite movement was last detected on June 1 and the tag was found on shore on September 1.

The fish bearing channel 10, tagged in June, stayed at his tagging site, Kitteridge Hole, throughout the monitoring period. He moved when harassed for much of the monitoring period, but the tag ceased moving after July 31. On September 1 we located the signal within a 2 mile square area in shallow water. However, we could not locate the tag or cause it to move despite considerable effort.

One fish reached spawning grounds but shed tag before spawning. The fish with Channel 5 was tagged in May in Olympus View Hole (R.M. 11.7) and moved upstream quickly and steadily. By the 48th day after tagging it had reached R.M. 36.5. One month later the signal had fallen back to R.M. 30. A hiker picked up the tag at R.M. 31.4, above Tshletshy Creek the following day. He reported finding a chinook carcass, which a bear apparently had been eating. several hundred yards upstream of the tag.

Two fish presumed to survive to spawning. Two fish tagged on June 14, given tags 8 and 14, were netted in Kitteridge Hole. Fish number 8 stayed in the area until the end of June, then quickly moved upstream almost 15 miles, reaching R.M. 25.5 eight days later. She remained in this area until August 16 and then again moved upstream another 6 miles in 6 days. Her last location was estimated at R.M. 34.7 on September 29.

Fish 14 moved similarly. She ascended to Olympus View Hole immediately after tagging and was still holding there June 29. When next located, on July 7, she had moved up to R.M. 19.8 and was at R.M. 25.2 by July 10. She apparently held in this area for over a month before moving further upstream. She moved to approximately R.M. 31.6 on August 26 but dropped back to about R.M. 31.1 by September 7.

That the majority of tagged fish survived but stopped migrating has not been reported in literature we reviewed (Hiss, 1989b). We would have expected most fish to either continue migrating upstream, drop back from the tagging site and then turn and migrate to the spawning grounds, or fall well downstream and eventually disappear from the river (Barclay 1982, Boomer 1983, Burger et al. 1984, Granstrand and Gibson 1982, U.S. Fish and Wildlife Service, 1988).

Failure to migrate could be due to prolonged stress from netting, handling, or tag presence. Netting and handling can lead to scale loss, and, although our sample is very small, this could have been associated with failure to migrate (Table 3). Holding fish in tubes could also have contributed to stress. On the other hand, recovery speed upon release, net material, or presence of net scars did not seem to predict future success in migration (Tables 3 and 4).

Stream temperature at tagging probably did not induce stress or influence migration of our tagged fish. Our proposal (Hiss, 1989b) suggested that temperatures ordinarily do not reach the stressful level of 16° C until July. We tagged all our fish in May and June in cool weather, well below stressful levels.

The effect of handling, viewed in the context of other studies, seems to depend on the predisposition of the fish characteristic of the particular run. For example, on the Yakima River, after extensive handling, 21 spring chinook still migrated to spawning grounds up to 70 miles upstream of the capture site (Cara Berman, Fisheries Research Institute, University of Washington, pers. comm). These fish were dipnetted from a fish ladder, anesthetized with MS-222, and lifted from the water for length and weight measurements. An internal radio tag was inserted into the stomach and a wire antenna was anchored to the mouth roof. The entire tag group was then held in a netpen for 24 hours before release.

Although Queets fish may be more predisposed than Yakima fish to handling stress, handling the fish much less may allow fish to migrate normally. For example, one might attempt to insert the tag while the fish is still in the net in the water, and then cut the fish out to let it swim away. The disadvantage is that tagging would have to stop after one fish had been tagged in each of the three workable holes, and tagging at a given site could not resume until the tagged fish was clear of the netting area. This could take several weeks, based on behavior of the few fish that migrated successfully. This delay might limit the number of tags released.

Stress from continual internal presence of the tag was not assessed but could have been significant. External tags may offer some promise now that newer models combine long life with small size (about 8 x 30 mm as opposed to 20 x 96 mm in this study).

<u>Tag loss</u>

Many factors could have been responsible for separating tags from fish. Fish could have shed their tags by regurgitation, elimination, or mortality. This, in turn, could be due to prolonged stress from the experiment, predation, fishing, or spawning.

Availability of Fish for Tagging

We easily captured enough fish for tagging in May and June. Fishing would have been more difficult if the water were clearer or lower. However, clear water is usually not a problem on the Queets because of strong glacial influence. Lower water would have prevented access by boat to Anderson and Kitteridge Holes, and this might be a problem in most years later in the summer. Capture would also have been more difficult if the run were smaller. The 1989 escapement was possibly the largest in the last 20 years (Chitwood, pers. comm.). If run sizes continue to increase, hatchery involvement in rebuilding the natural production may not be needed.

Not all the run may be available to nets of any single mesh size. The two fish captured with 6 inch mesh measured 67 and 89 mm, but those captured with 7-1/4 inch mesh ranged from 80 to 115 mm (Table 2).

Ability to Monitor Tags

Our equipment, procedures, and air access over Park lands allowed us to monitor tags accurately enough to document migration to spawning grounds and determine movement within about a quarter mile. However, the lack of roads along the upper river made it difficult to prove if the fish had died or shed its tag. This could give a slight bias to the spawning distribution.

Interference from Fisheries

Only one fish fell back into the tribal fishing area, despite the short distance from our tagging sites. The river sport fishery could have captured several of our tags because it is conducted in the deeper pools all along the accessible lower river during most of the spring-summer chinook run.

CONCLUSIONS

1. We now have enough information to concentrate spring-summer chinook broodstocking efforts at a few potentially very productive river miles. The best sites for collecting pre-spawning broodstock consistently occur between Harlow Creek (R.M. 33.1) and just below Tshletshy Creek (R.M. 30.6), in those pools and deep runs free of log jams. However, if a decision is made to collect broodstock at the time of spawning, then collection efforts might be shifted somewhat upstream.

2. Radio tagging in the manner performed was not feasible for investigating the migration of Queets spring-summer chinook. We suspect that the combination of capture, handling, and the presence of the internal tag produced chronic stress from which most fish never fully recovered. Capture involving less handling could be attempted but there would still be some risk to migratory behavior. Therefore, we conclude that attempts to focus rebuilding efforts on the spring returns probably should not depend on radio tagging to identify holding areas, spawning areas, or spawn timing.

RECOMMENDATIONS

We present a variety of possible courses of action below. Some are mutually exclusive and some will depend on selected courses of action.

1. Further extensive snorkel surveys in the future will not be needed to accomplish the project's goals.

2. Continue using lower river catch data throughout the April-August season and spawner surveys to evaluate relative strength of the spring and summer runs and necessity for hatchery involvement in rebuilding either or both.

3. Experimentally evaluate the timing of broodstock capture in the lower river to select for early-returning stock. Take one group of broodstock in April and May at 1989 tagging sites and the other in July and August. Attempt to hold them in a hatchery until spawning in September. If holding proves feasible, and if numbers in both groups are sufficient, tag the progeny of each group to evaluate when they enter the tribal fishery as adults. This would both help determine feasibility of long-term holding and define extent or run separation.

4. Experimentally evaluate the hypothesis of spring returns spawning further upriver and earlier than summer returns. A general idea might to be collect brood from spawning grounds beginning in mid- to late August between Paradise (R.M. 37.2) and Kilkelly Rapids (R.M. 40.3) and in late September between Sams River (R.M. 23.5) and Tshletshy Creek (R.M. 30.6). If numbers of fish in both groups are sufficient, tag the progeny of each to evaluate their return timing to the tribal fishery.

5. After considering run status, risk to fish, and cost relative to other aspects; of run rebuilding, reassess the feasibility of radio telemetry using one or more alternative techniques.

   a. Minimize handling, using procedure described in the preceding discussion.

   b. Attempt to reduce stress by anesthetizing fish with CO_2 as described in the pilot study proposal (Hiss, 1989b).

   c. Evaluate external tags using recently-developed miniature transmitters.

6. Assess feasibility of performing genetic stock identification by electrophoresis of tissues from carcasses recovered on the spawning grounds, to evaluate potential differences between early upriver spawners and fish spawning later and farther downriver.

7. Develop a general broodstock plan, including proposed methods under various scenarios, to serve as a focus for discussion.

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Table 1. Results of snorkel surveys between September 1 and 6, 1989.

Reach	Upper mile	Lower mile	Fish location	Count	Miles surveyed	Fish/ mile
Kilkelly Cr. to Hee Hee Cr.	43.3	41.7	42.8	2		
			42.7	4		
				6	1.1	5.5
Hee Hee Cr. to Alta Cr.	41.7	40.3		0	1.4	0.0
Alta Cr. to Paradise Cr.	40.3	37.2	39.0	2	3.1	0.6
Paradise Cr. to Bob Cr.	37.2	34.7	37.2	2		
			37.1	2		
			37.0	8		
			36.0	3		
			35.8	1		
			35.7-35.0	33		
				51	2.5	20.4
Bob Cr. to Harlow Cr.	34.7	33.1	34.7-33.1	15	1.6	9.4
Harlow Cr. to Tshletshy Cr.	33.1	30.6	33.1-30.6	56	2.5	22.4
Tshletshy to Smith Place	30.6	29.9	30.6-30.5	20	0.7	28.6
Sams River to Ranger Hole	23.5	21.9	23.5	1	1.1(a)	0.9
Ranger Hole to Trib. 0201	21.9	20.2		0	0.7(b)	0.0
Trib. 0201 to Phelan Cr.	20.2	17.5		0	1.9(c)	0.0
Phelan to Streeter's Crossing	17.5	16.5	17.4	1	1.0	1.0
Streeter's to River View	16.5	14.4		0	2.1	0.0
River View to Tacoma Cr.	14.4	13.0	14.4-13.0	2	1.4	1.4
Tacoma Cr. to Olympus View	13.0	11.7		0	1.3	0.0
Olympus View Hole to Salmon R	11.7	10.5	11.3	1	1.2	0.8
Salmon R. to Kitteridge Hole	10.5	9.0	9.2	0	1.5	0.0
Kitteridge to Clearwater Br.	9.0	6.7	9.0	2	2.3	0.9
Total:				157	27.1	5.8

(a) Walked entire reach but snorkeled only Miles 23.5 to 22.4.
(b) Walked entire reach but snorkeled only Miles 21.6 to 20.9.
(c) Walked entire reach but snorkeled only Miles 19.6 to 18.7 and 18.6 to 17.5.

Table 2. Characteristics of fish and tags released.

Date tagged	Mesh size (in)	Fish brightness	Fish length (cm)	Channel	Frequency (mHz)	Pulses/ sec
5/23	7-1/4	not noted	89	4	40.6300	1
5/23	6	moderate	89	5	40.6399	2
5/24	7-1/4	bright	101	1	40.5999	2
5/24	7-1/4	moderate	100	3	40.6202	2
5/24	6	not noted	67	6	40.6502	1
6/14	7-1/4	bright	90	8	40.6710	2
6/14	7-1/4	bright	100	10	40.6900	1
6/14	7-1/4	bright	115	11	40.6997	2
6/14	7-1/4	bright	80	12	40.7105	1
6/14	7-1/4	bright	100	14	40.7317	1

Table 3. Effect of Capture and handling on fish migration.

Migration	Channel	Web material	Tube	Net scars	Scales lost	Recovery speed
Reached spawning grounds	5	multi	yes	no	(a)	good
	8	mono	no	yes	low	(a)
	14	mono	no	no	low	good
Did not reach spawning grounds	1	mono	yes	no	(a)	good
	3	mono	yes	no	(a)	fair
	4	multi	yes	yes	moderate	good
	6	multi	yes	no	moderate	good
	10	mono	yes	yes	low	good
	11	mono	yes	no	low	good
	12	mono	no	no	low	poor

(a) No record.

Table 4. Fate of radio-tagged fish.

Outcome	Channels	Total
Tagged fish moved to spawning grounds		3
presumed to survive to spawning	8, 14	2
Shed tag before spawning	5	1
Tags did not move to spawning grounds		7
Tag present in river at spawning time		6
Fish survived with tag	1, 3, 11, 12	4
Fish shed tag	6, 10	2
Tagged fish presumed to have left river	4	1

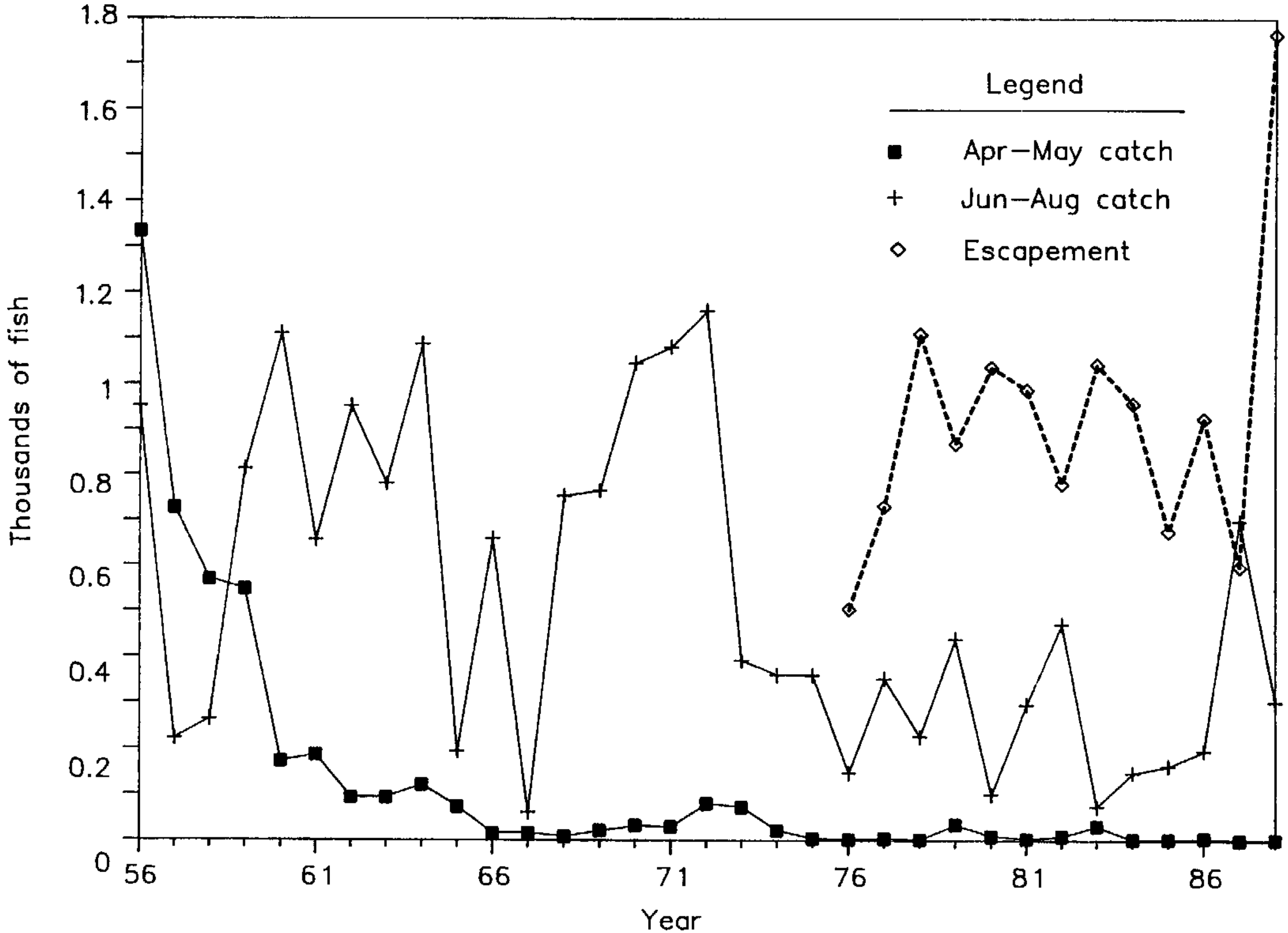

Figure 1. Estimated tribal catch and spawning escapement, 1956–1988.
Source: WDF.

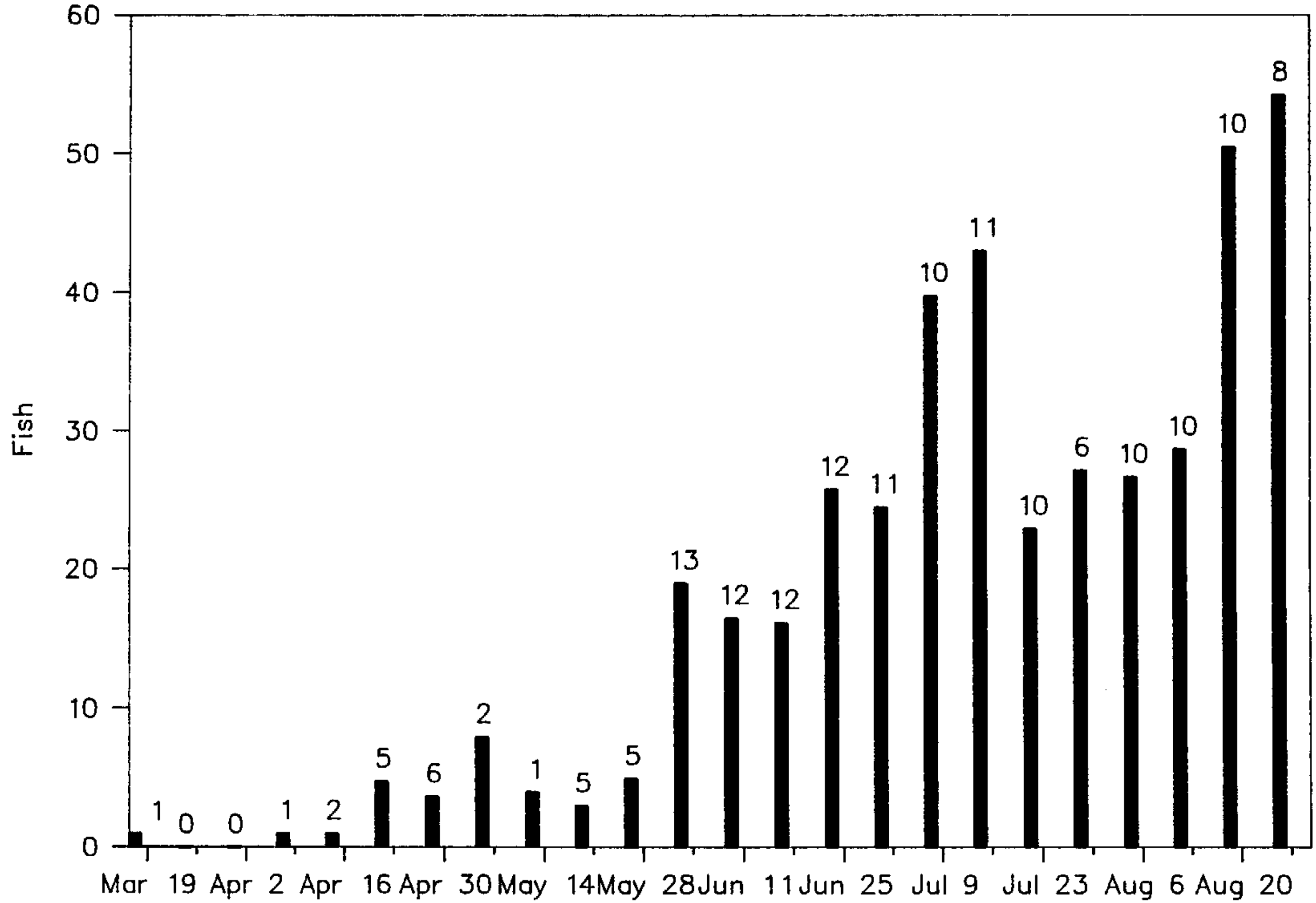

Figure 2. Mean catch by week, 1975–1988. Numbers indicate years when catch was reported. Source: QDNR.

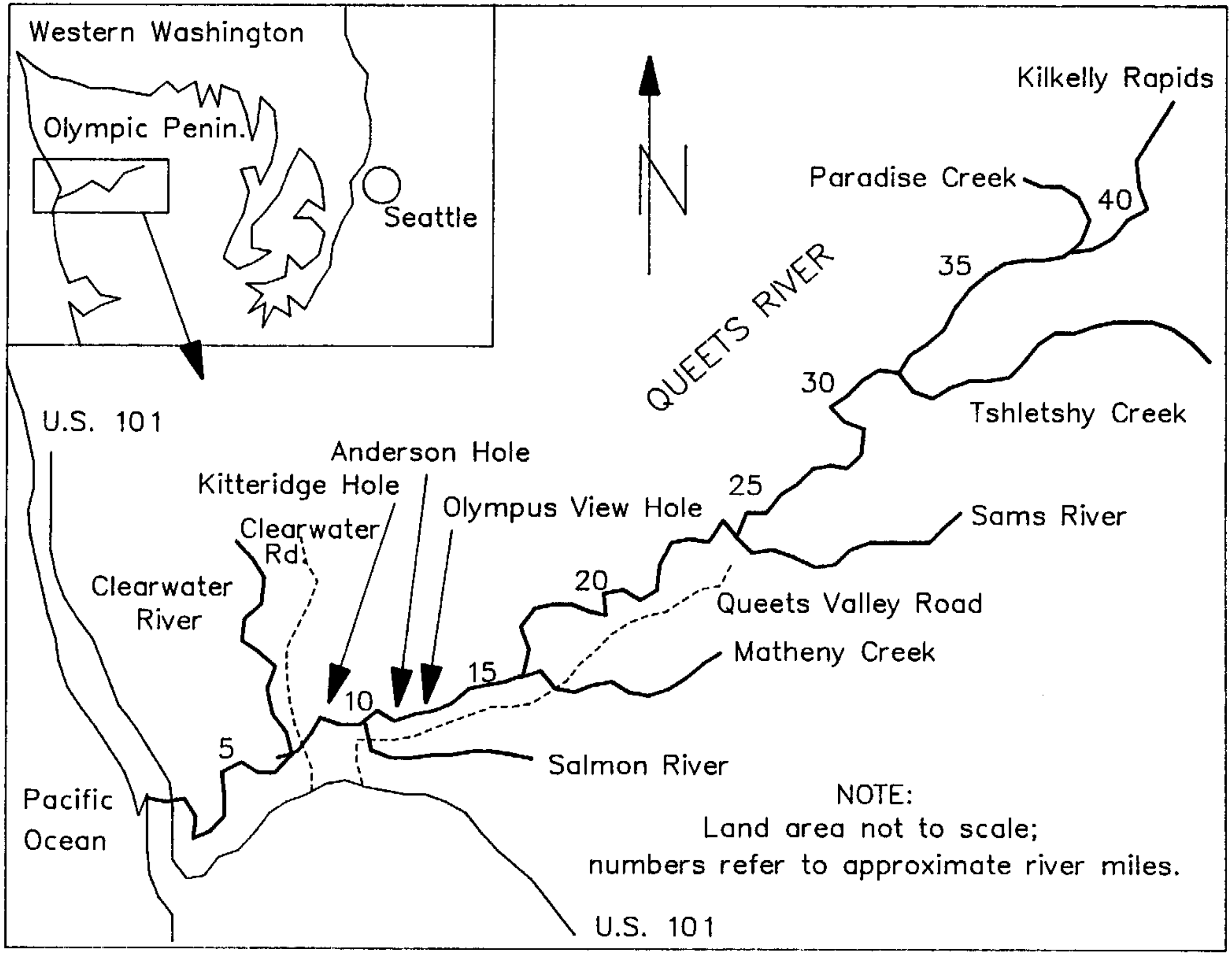

Figure 3. Queets River showing tagging sites and major tributaries.

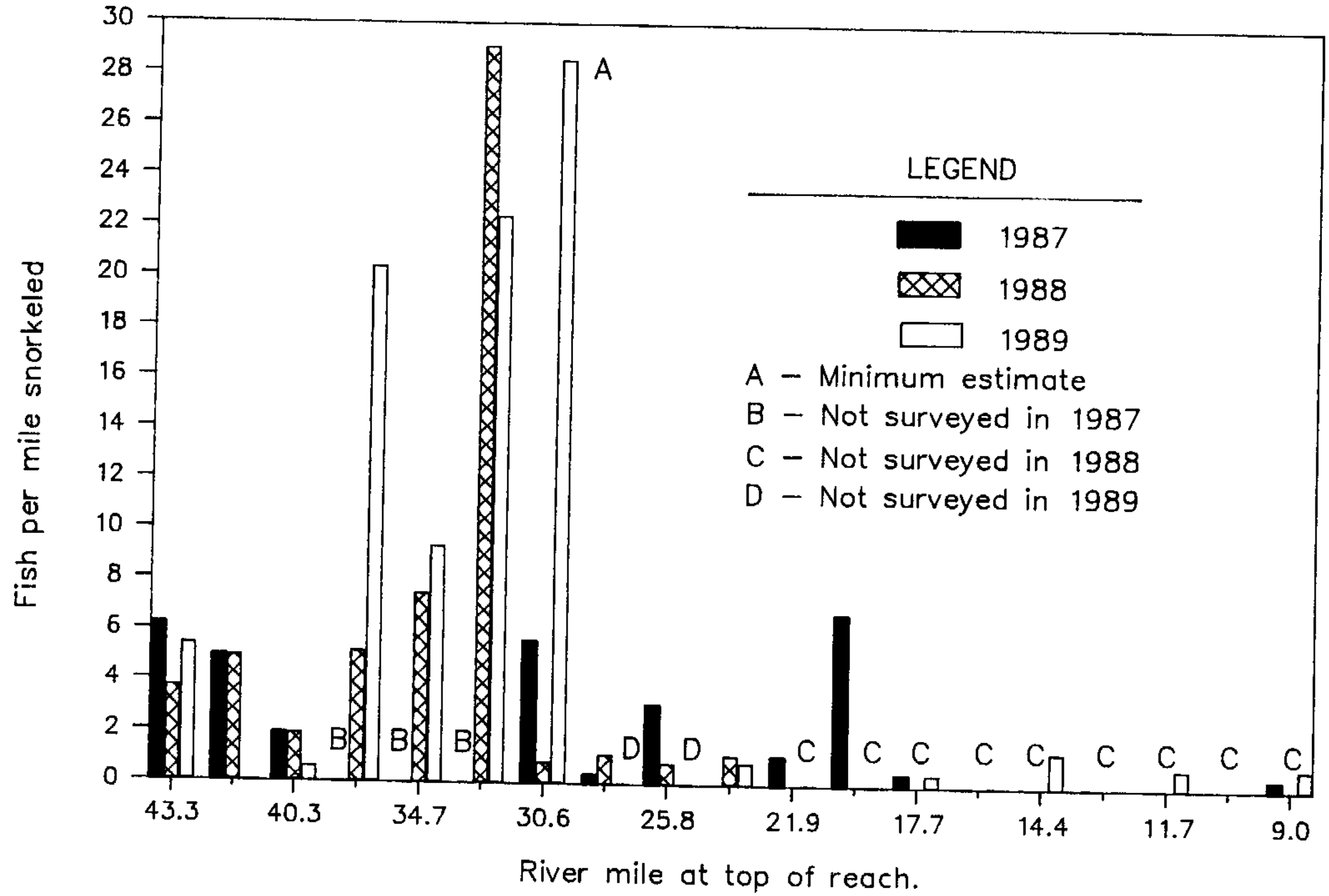

Figure 4. Distribution of live adults in annual snorkel survey, 1987–89. Reaches are defined in Table 1.

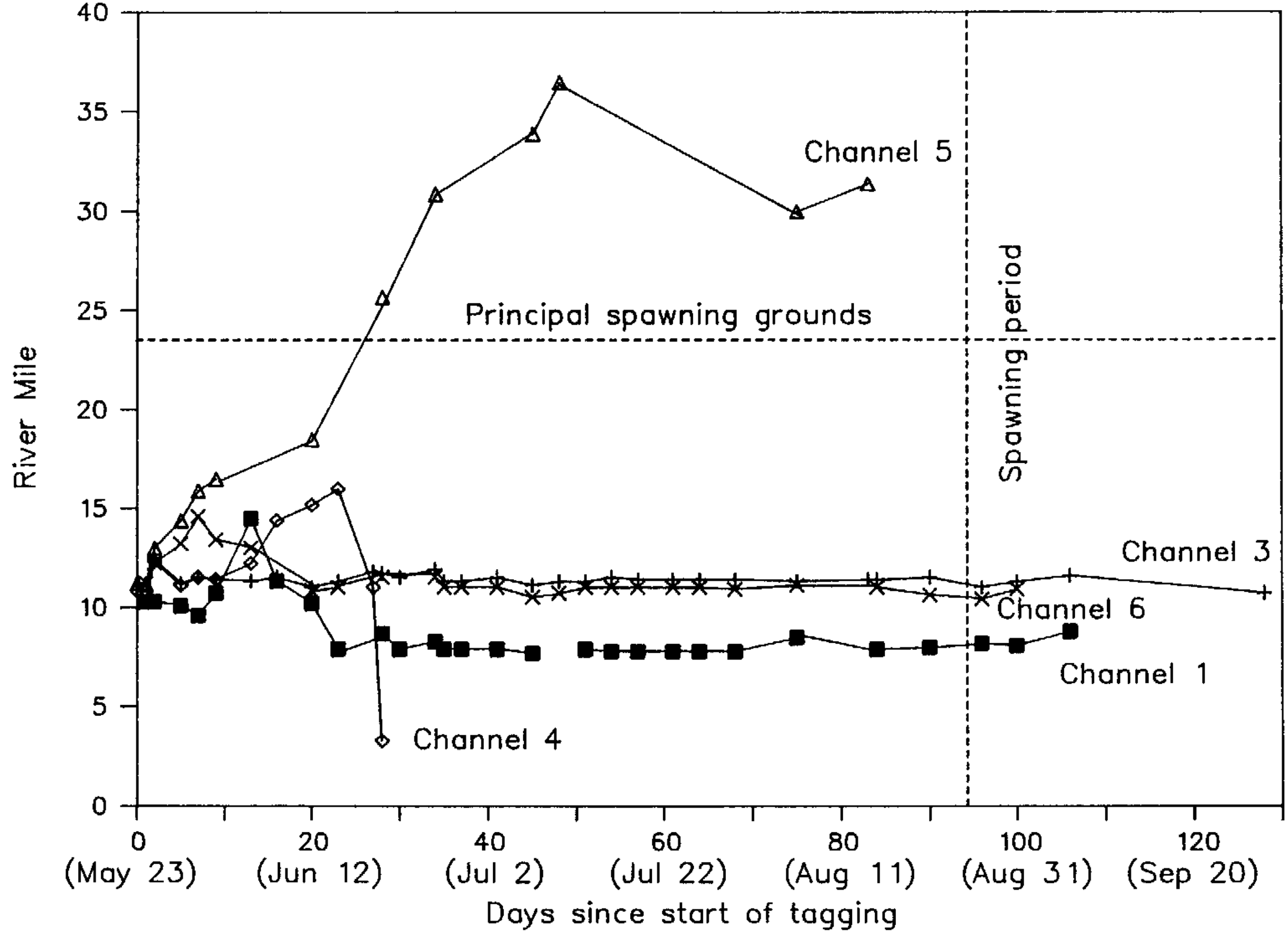

Figure 5. Migration of radio tags placed in fish on May 23 and 24, 1989.

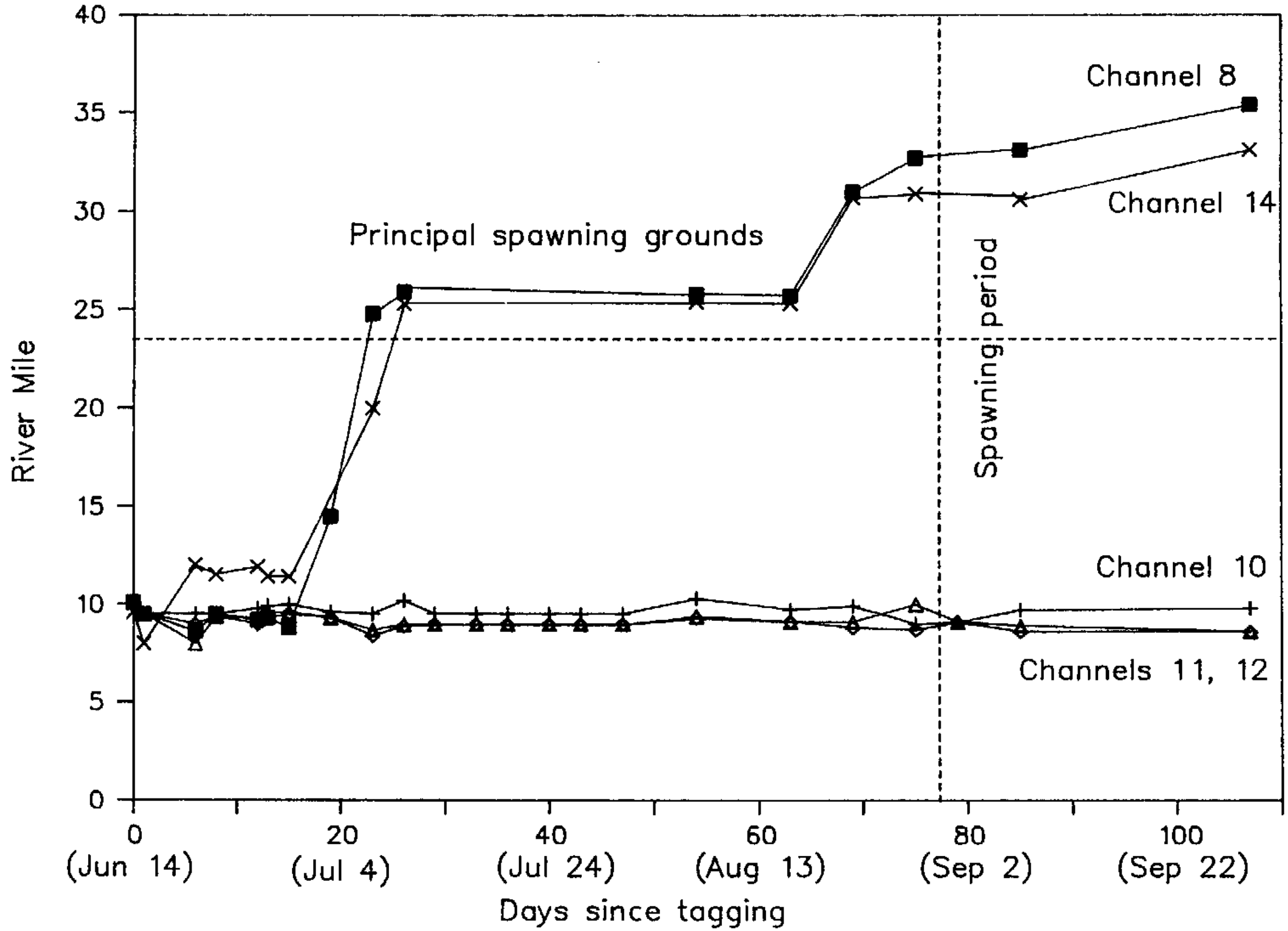

Figure 6. Migration of radio tags placed in fish on June 14, 1989.