

SMOLT PASSAGE BEHAVIOR AND FLOW-NET  
RELATIONSHIP IN THE FOREBAY OF JOHN DAY DAM

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## ABSTRACT

From 1982 to 1984, the National Marine Fisheries Service (NMFS) conducted research to define the migration routes of downstream migrant salmonids in the forebay of John Day Dam and to assess them in relation to current velocities and water turbidity and temperature. Forebay current patterns were obtained from current meters at fixed sampling stations, the distribution of outmigrants was determined from purse seine sampling, and migration routes of yearling chinook salmon and steelhead were identified by radio telemetry techniques.

All species of emigrating salmonids alter their distribution across the forebay as they approach the dam. Upon intercepting the surface oriented turbid water mass discharged from the John Day River, they either avoid or are entrained in it and transported toward the Washington shore. Fish abundance was positively correlated with water clarity. There was no evidence to suggest that the migration routes were in response to current patterns in the forebay.

Radio telemetry studies in 1984 when there was only spill at night demonstrated that a certain segment of yearling chinook salmon approaching the dam are predisposed to spill passage (Washington side of the river) by virtue of their lateral position across the forebay. That segment of fish which arrive at the dam following nightfall are exposed to spill upon arrival. Fish arriving during daylight hours delay passage until nightfall and thus have the opportunity to distribute themselves in front of the powerhouse.

A new application of radio tag methodology was assessed and found to be useful in evaluating the effectiveness of spill for bypassing outmigrant salmon. The technique, referred to as the group release method, entails releasing groups of radio-tagged smolts, each with a unique tag frequency,

upstream from the dam and subsequently recording the passage location of the fish. An antenna array fixed on the face of the dam is used to receive the signals from the tagged fish.

A program system and cartographic model was developed which displays for any specified hour forebay current patterns at prevailing river flows and dam operations. The system can be used at other dam sites where investigations may wish to detail forebay current patterns.

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## INTRODUCTION

Even though collection and transportation facilities are operating at key dams in the Snake-Columbia River system, significant numbers of juvenile salmonids continue to migrate downstream past dams on their own volition (Sims et al. 1982). Mortality through spillways is estimated to be approximately 3% (Bell et al. 1982; Schoeneman et al. 1961) contrasted to mortalities of 15% and higher through turbines (Long et al. 1968). Improved fingerling bypass systems are being developed to ensure the safe passage of these migrants as they encounter the numerous dams on their seaward journey (Krcma et al. 1982, 1983; Swan et al. 1983). However, many dams especially in the mid-Columbia reach do not have bypasses, and spill is being used for interim protection. Special flows, spill levels, and operating techniques at dams such as John Day that have inadequate bypasses (Sims and Johnson 1977) are also being used to enhance smolt survival. These strategies are executed on the premise that the current system in the forebay responds to dam operations and that smolts in turn respond to the flow-net, as suggested by previous juvenile radio tracking studies conducted by the National Marine Fisheries Service (NMFS) in the John Day Dam forebay (Sims et al. 1981; Faurot et al. 1982).

The ultimate objective of the research program reported herein is to define the distribution and migration routes of downstream migrant salmonids in the forebay of John Day Dam over a range of flow conditions and assess those patterns in relation to various physical factors in the forebay. Such information is fundamental in assessing the effectiveness of providing spill, special flows, and dam operations to pass fish through specific areas of the dam and may also be useful in the design of fingerling bypass systems. To advance toward the ultimate objective, it was necessary to begin systematically gathering current data and developing the computer software

required to process and analyze the data. During 1982 and 1983 efforts were concentrated on these important facets of the program.

In 1983, two additional phases were implemented--a purse seining program to define the distribution of fish in the forebay and a radio tracking study designed to identify the routes which juvenile salmonids take as they move downstream.

In 1984, the purse seine sampling area was expanded upstream from the John Day River which enters the Columbia River 4 km above John Day Dam (Fig. 1). In addition, a new application of radio tag technology which may provide statistically sound fish passage data was assessed. This final research report integrates and summarizes the 3 years of field activities.

## LIMNOLOGY AND FISH DISTRIBUTION

### Methods and Materials

During the spring and summer, 1982 through 1984, 11 to 12 magnetic recording current meters (Interocean Systems, Inc., Model 135M<sup>1/</sup>) were deployed in the forebay of John Day Dam. The meters were secured to a self-adjusting buoy system which maintained them at a constant depth 3 m below the surface of the reservoir. In 1982, meters were deployed near the face of the dam, whereas in 1983 and 1984, the sampling grid was more expansive and extended upriver approximately 2 km from the dam. In all, there were 20 mooring stations in the forebay (Fig. 1).

<sup>1/</sup> Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

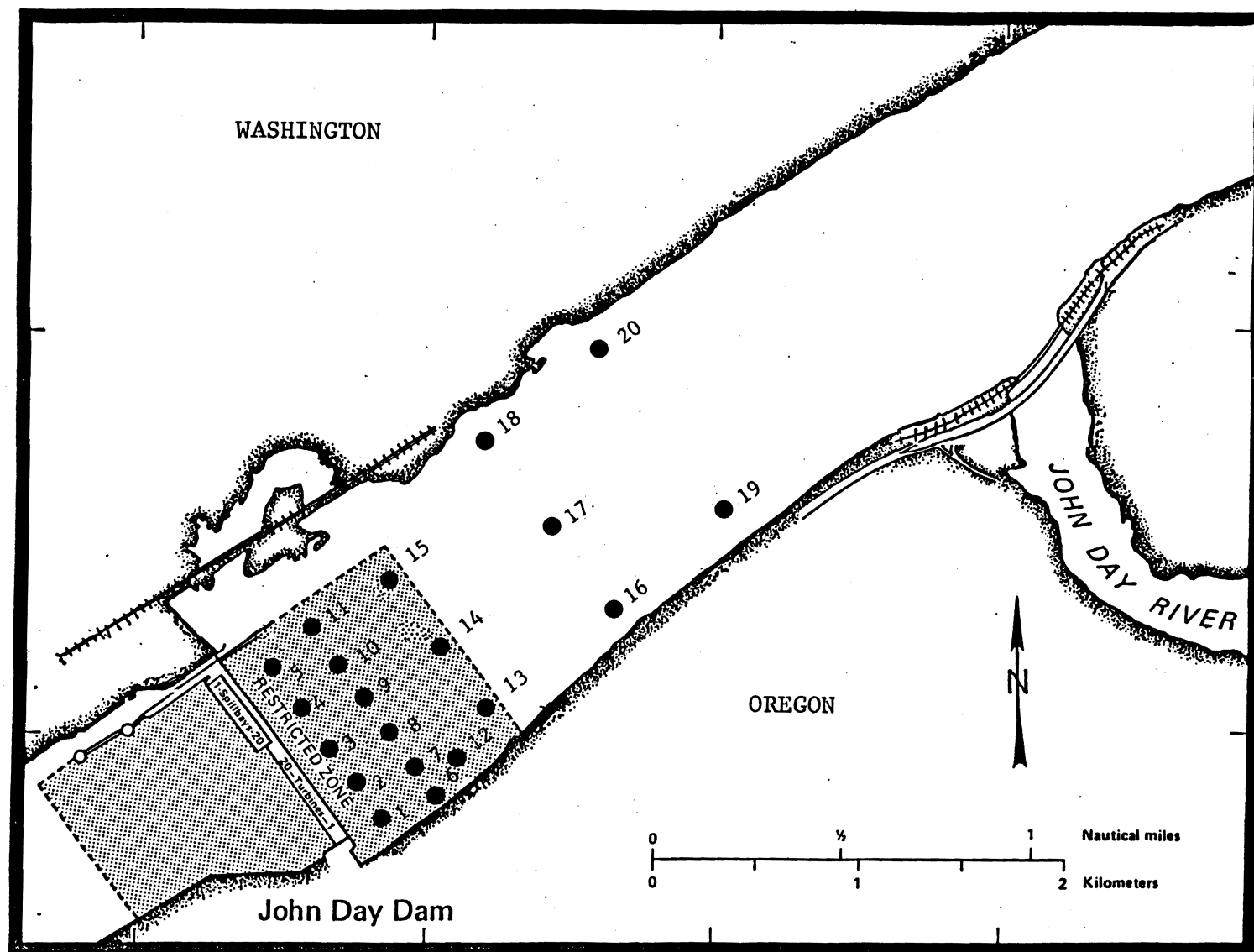


Figure 1.--Current meter mooring stations in the forebay of John Day Dam.

Current velocity and direction were measured for at least one 8-min interval each hour. Cassette tapes and battery packs were replaced every 4 to 6 weeks to ensure that the meters continued to operate throughout the field season. Cassettes with encoded data were read into the Burroughs 7800 computer at the Northwest and Alaska Fisheries Center after which the data were error checked, edited, and processed using program systems developed by our programming staff; procedures are documented in Appendix A. Detailed river flow and dam operations data were acquired from two sources: the Columbia River Operational Hydronet and Management System (CROHMS) and the dam operations office at John Day Dam. These data were processed in conjunction with the current data to produce a cartographic model depicting for any hour the prevailing forebay current patterns and the concomitant discharge volumes associated with the various apertures across the dam.

During the spring and summer of 1983 and the spring of 1984, the species composition and distribution of downstream migrant juvenile salmonids in the forebay of John Day Dam was assessed with purse seine gear. Sampling was conducted with an 11-m power block seine equipped with a 215-m long, 1.3-cm knotless web purse seine net which fished to an approximate depth of 6 m. Sampling schedules are detailed in Table 1.

Six stations were regularly sampled in 1983, three each at the middle and downstream transects (Fig. 2). In 1984, the number of sampling stations was increased to nine with the inclusion of an additional transect upstream at River Kilometer (RKm) 353 (Fig. 2). At nearshore stations, designated as "1" and "3", nets were set approximately 50-100 m from the shore. Transect stations designated by as "2" were midway across the reservoir. Nets were set and closed facing upstream. Sampling occurred between 0500 and 1900 h; salmonid catches were enumerated by species. With each set a secchi disk

Table 1.--Numbers of juvenile salmonids captured by purse seine in the forebay of John Day Dam.

Dates	No. nets sets	Yearling chinook salmon	Steelhead	Sockeye salmon	Coho salmon	Subyearling chinook salmon	Total
20 Apr 83 - 26 May 83	70	3,404	2,348	2,042	266	8	8,068
30 Jun 83 - 20 Sep 83 <sup>a/</sup>	42	9	4	24	0	3,740	3,777
09 May 84 - 06 Jun 84	76	4,094	1,455	1,218	139	1,658	8,564

<sup>a/</sup> Data collected under the BPA funded "Summer Flow Study."

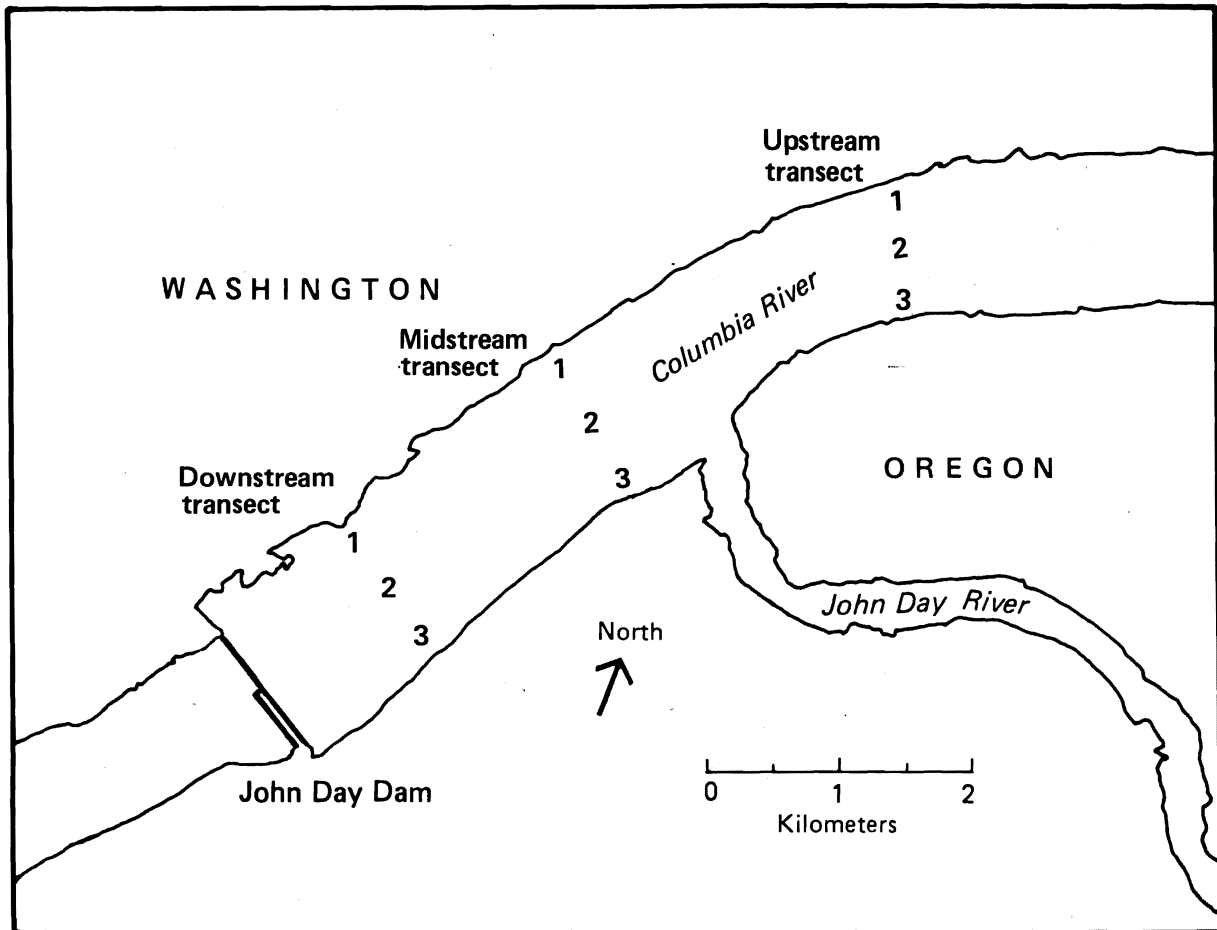


Figure 2.--Purse seine sampling stations in the forebay of John Day Dam.

reading was taken and surface water temperatures were recorded. Additionally, in 1984, vertical profiles of water temperature and turbidity were taken across each transect on most sampling cruises. Temperature ( $^{\circ}\text{C}$ ) was sampled at depth using a vessel mounted Hydrolab. Water samples for turbidity determination were taken at depth using a Nansen-like sampling bottle. Each water sample was placed in an individual container. At the end of the sampling period, turbidity (NTU) was measured with H. F. Instruments turbidimeter, Model DRT-15.

## Results

### Physical Limnology/Spring Outmigration

During the spring freshet when the John Day River flows are at peak volumes, the discharge is extremely turbid by comparison with the Columbia River, so much so that a visible turbid plume emanates from the mouth of the John Day River and often extends to the Washington shore (Fig. 3). As summer approaches, the river's discharge volume decreases. Correspondingly, the silt load and its manifestation in the Columbia River also decreases. Secchi disk readings in the Columbia River near the mouth of the John Day River ranged from 28 cm at 11.9 kcfs to 198 cm when river discharge dropped to 0.39 kcfs (Fig. 4). During our spring sampling periods, John Day River discharge volumes were typically at elevated levels, ranging from 5.8 to 14.0 kcfs in 1983 and 8.4 to 11.9 kcfs in 1984. Water clarity (secchi disk readings) varied throughout the forebay. The poorest water visibilities, as low as 28% of the maximum daily secchi reading, were consistently exhibited near the mouth of the John Day River and downstream along the Oregon shore, whereas the clearest water (81-100% of the daily secchi reading) occurred near the



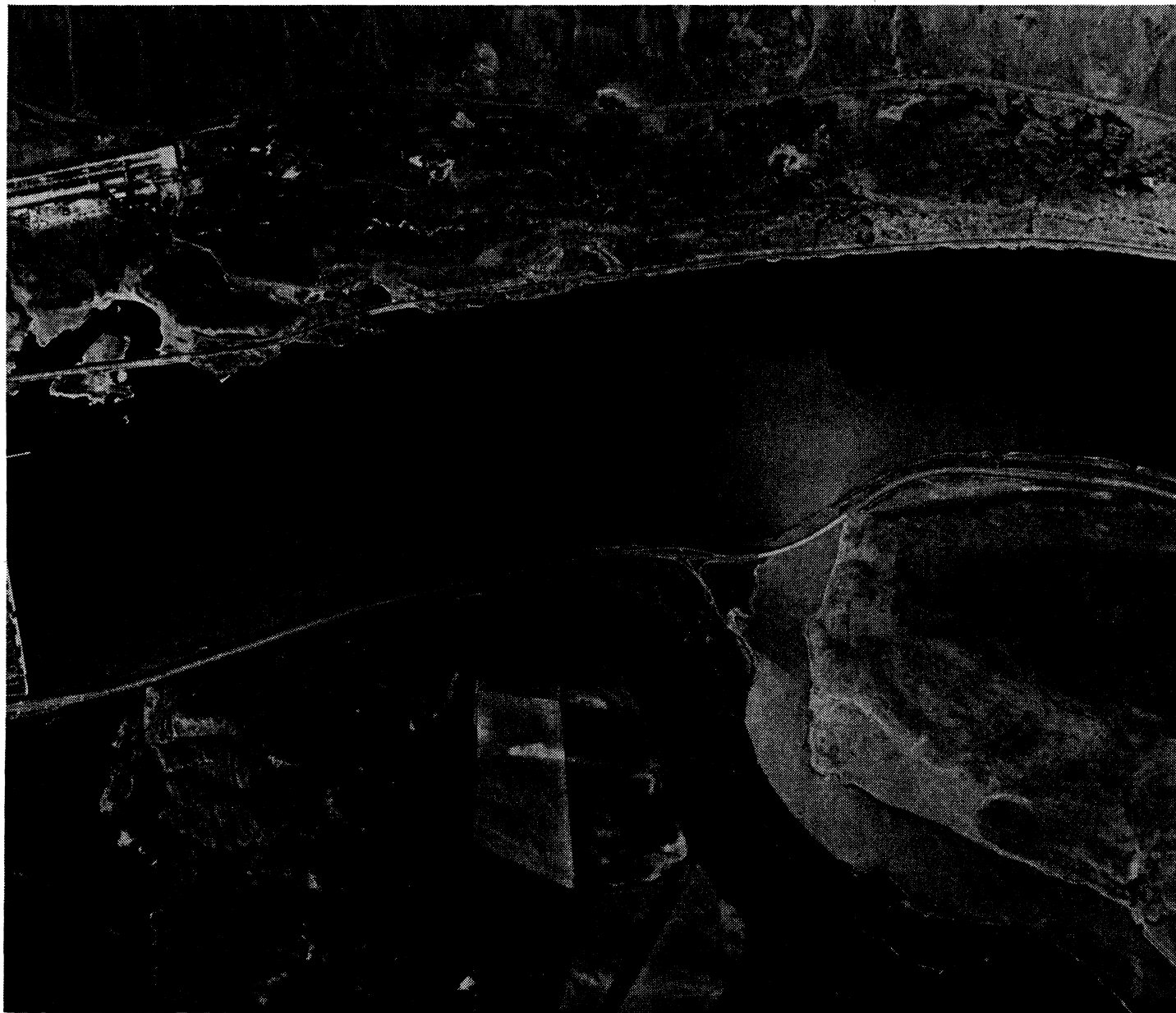


Figure 3.--Aerial photograph of John Day Dam forebay showing the turbid plume emanating from the John Day River. Dam is in the lower left corner.

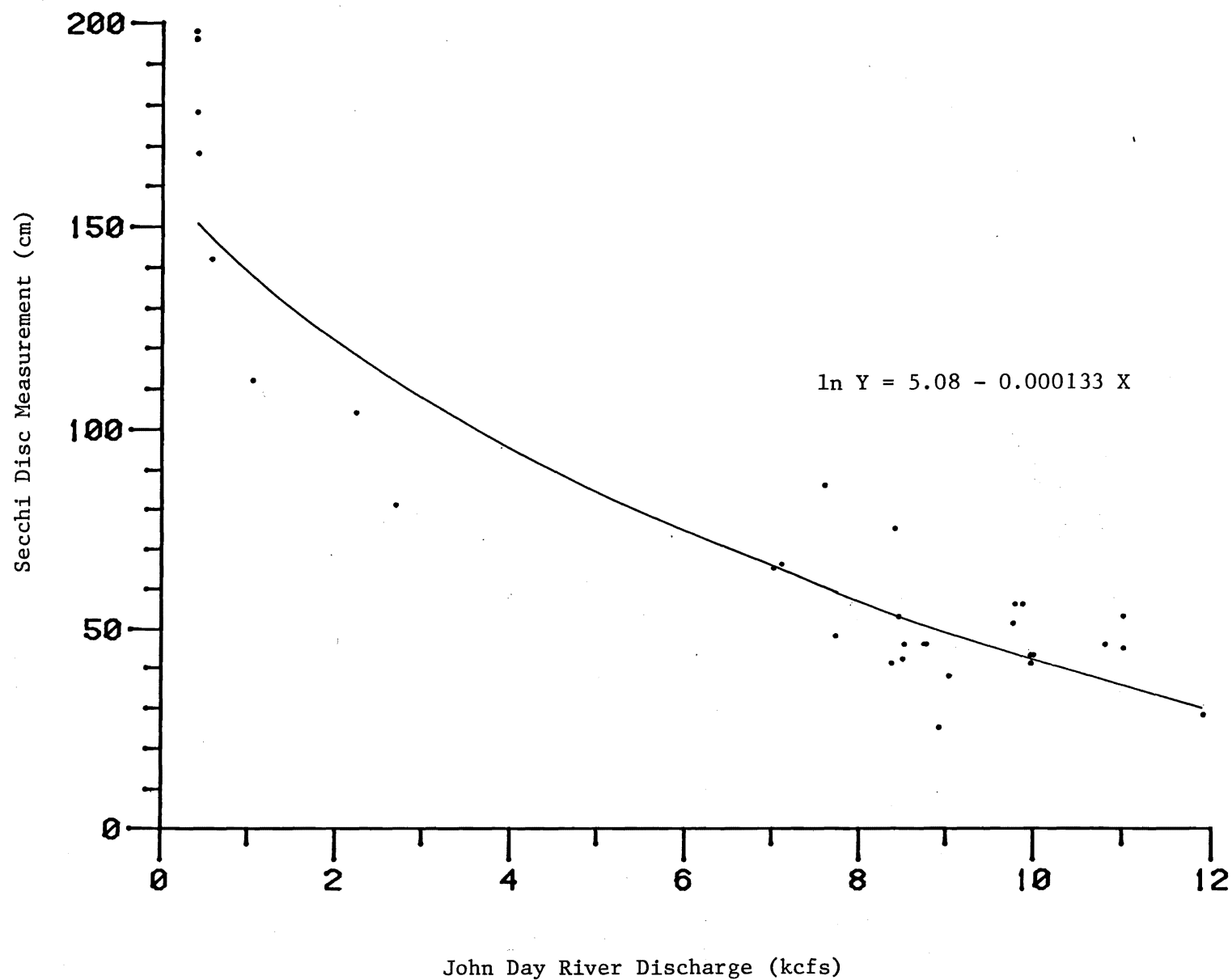


Figure 4.--Relationship between water visibility and John Day River discharge. Water samples were taken at Station 3 on the midstream transect.

Washington shore, farthest from the discharge source, the John Day River (Fig. 5, Table 2).

In addition to being turbid, the John Day River discharge was also warmer than the Columbia River. Surface temperatures near the mouth of the John Day River and downstream along the Oregon shore averaged approximately 1°C higher than the Columbia River (Table 2), but were found to be as high as 3.2°C higher on certain days (see Appendix Table 2).

Vertical profiles of temperature reveal that this warmer, less dense discharge lies on top of the cooler Columbia River water and at times can extend across to the Washington shore (Fig. 6). Turbidity profiles indicate a similar pattern (Fig. 7). However, at the Oregon shore stations downstream from the discharge source, turbidity persists with depth, whereas at the mid-reservoir and Washington shore stations turbidity diminishes and is associated primarily with surface waters. Presumably this situation is a consequence of the heavier particulates falling out near the mouth of the John Day River, while the finer sediments remain in suspension and are carried across the reservoir within the warmer discharge.

During the 1983 and 1984 sampling excursions, current velocities measured at fixed mooring stations varied across the forebay in the vicinity of the midstream and downstream transects. The highest velocities were typically exhibited at the sampling stations in front of the powerhouse on the Oregon side of the river and at mid-reservoir (Table 2). Velocities ranged from < 5 cm/s (the threshold level of the meters) to 33 cm/s during the periods of purse seine sampling. Total river flow was high in 1983 and 1984 averaging 298 and 348 kcfs, respectively, during the spring sampling periods (Figs. 8 and 9). During those periods most of the water was discharged through the

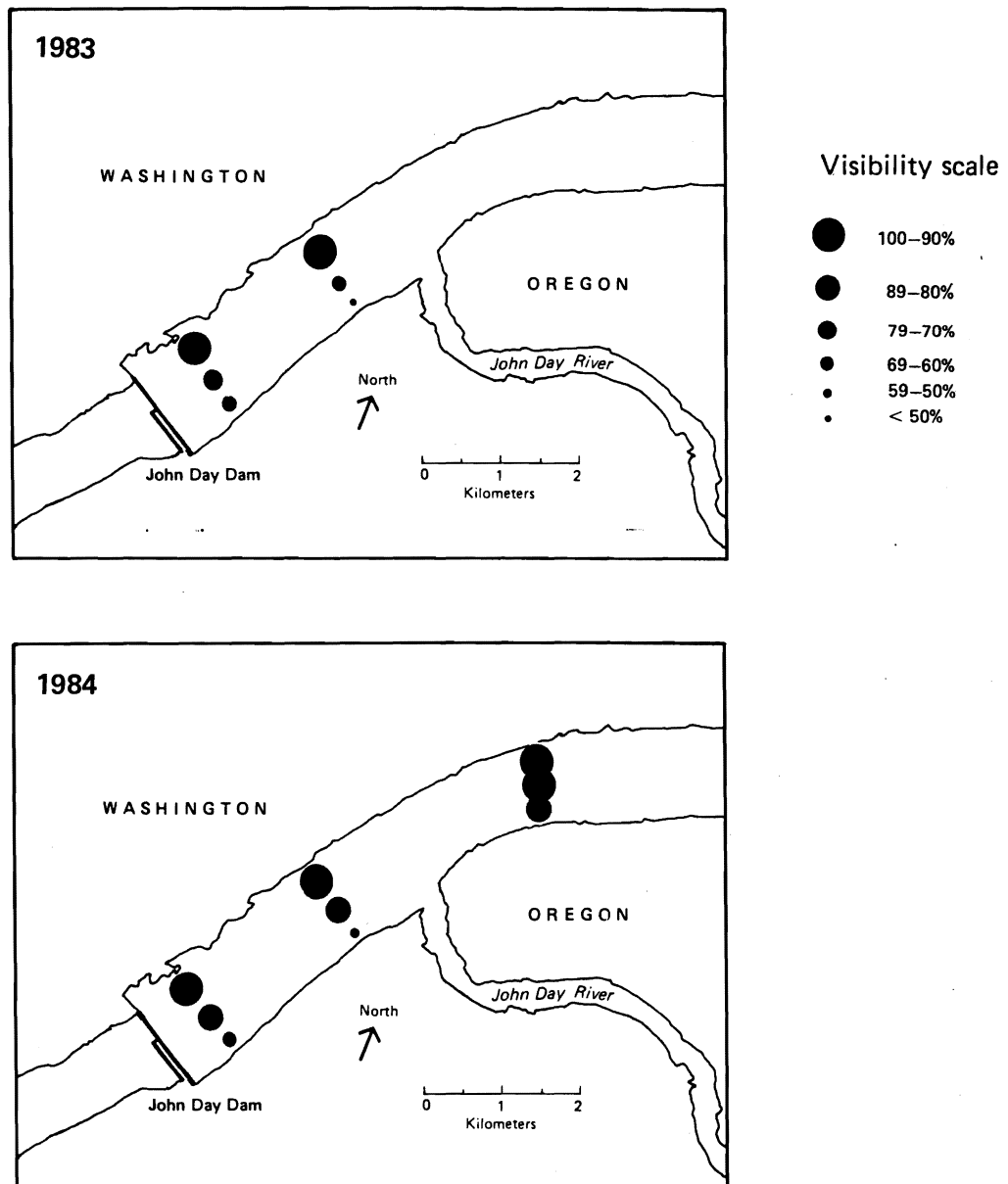


Figure 5.--Average surface water visibility in the forebay of John Day Dam during the spring outmigrations, 1983 and 1984. Visibility is expressed as the percentage of the maximum daily secchi reading. Daily values were averaged over all sampling cruises.

Table 2.--Mean values of secchi disk readings and water velocities and temperatures observed during the spring sampling program 1983-84. Ranges appear in parentheses. The number of observations (n) at each station is indicated.

Transect	Station number	Secchi disk readings				Water velocity				Water temperature	
		cm	n	% of daily max. reading	n	cm/sec	n	% of daily max reading	n	°C	n
1983											
Downstream	1	100 (91-128)	7	92 (79-100)	6	12 (7-17)	6	62 (44-75)	6	14.0 (10.0-16.0)	3
	2	81 (65-122)	9	70 (54-95)	6	19 (13-27)	6	97 (90-100)	6	-	
	3	67 (56-89)	11	60 (48-70)	6	16 (14-20)	6	84 (59-100)	6	14.2 (10.0-16.5)	3
Midstream	1	100 (71-120)	10	92 (74-100)	6	11 (2-25)	9	63 (9-100)	9	13.1 (11.0-16.0)	8
	2	77 (53-108)	10	67 (44-83)	6	9 (5-21)	9	53 (28-100)	9	-	
	3	54 (42-99)	11	48 (38-67)	6	12 (8-15)	4	60 (40-81)	4	14.8 (120-180)	8
1984											
Downstream	1	81 (66-94)	7	96 (83-100)	7	6 (0-12)	7	23 (0-47)	7	12.0 (10.0-13.5)	8
	2	69 (56-81)	7	85 (63-100)	9	15 (8-23)	7	71 (36-100)	7	11.9 (10.0-13.9)	9
	3	49 (41-64)	9	60 (40-90)	9	19 (6-33)	7	86 (50-100)	7	12.2 (10.0-14.0)	9
Midstream	1	82 (53-94)	11	95 (60-100)	10	6 (0-10)	10	52 (0-100)	10	12.5 (10.5-15.5)	11
	2	77 (48-91)	11	89 (54-100)	11	7 (1-14)	10	57 (17-100)	10	13.0 (11.0-14.5)	11
	3	44 (25-56)	11	55 (28-97)	11	8 (0-15)	10	64 (0-100)	10	13.5 (17.0-15.7)	11
Upstream	1	84 (71-94)	8	92 (74-100)	8	-	-	-	-	12.4 (10.0-14.5)	8
	2	86 (81-97)	8	94 (81-100)	8	-	-	-	-	12.7 (10.0-15.0)	8
	3	75 (64-94)	8	82 (69-98)	8	-	-	-	-	12.5 (10.0-14.5)	8

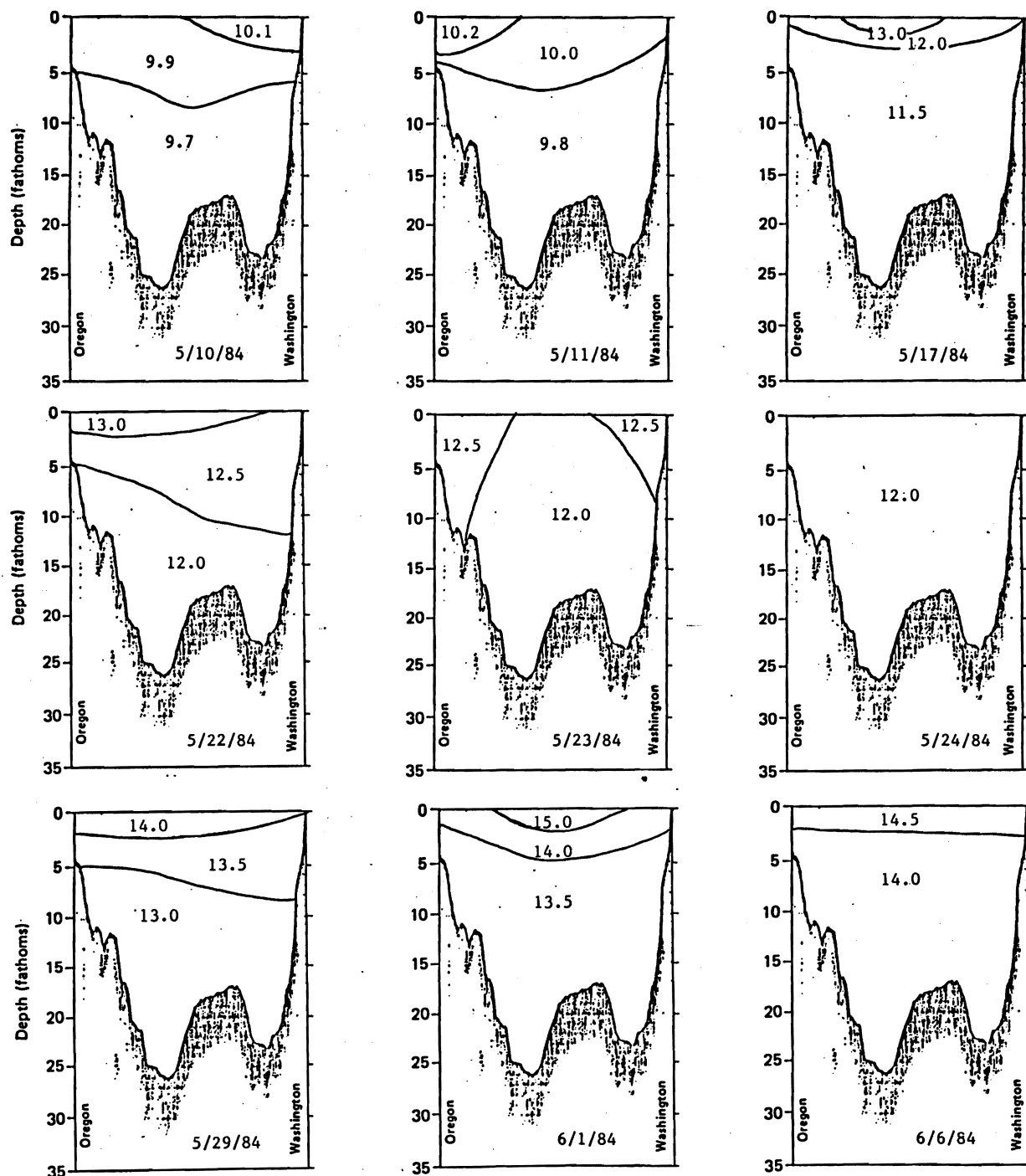


Figure 6A.

Figure 6.--Vertical profiles of water temperature in degrees centigrade across the upstream (A), midstream (B), and downstream (C) transects.

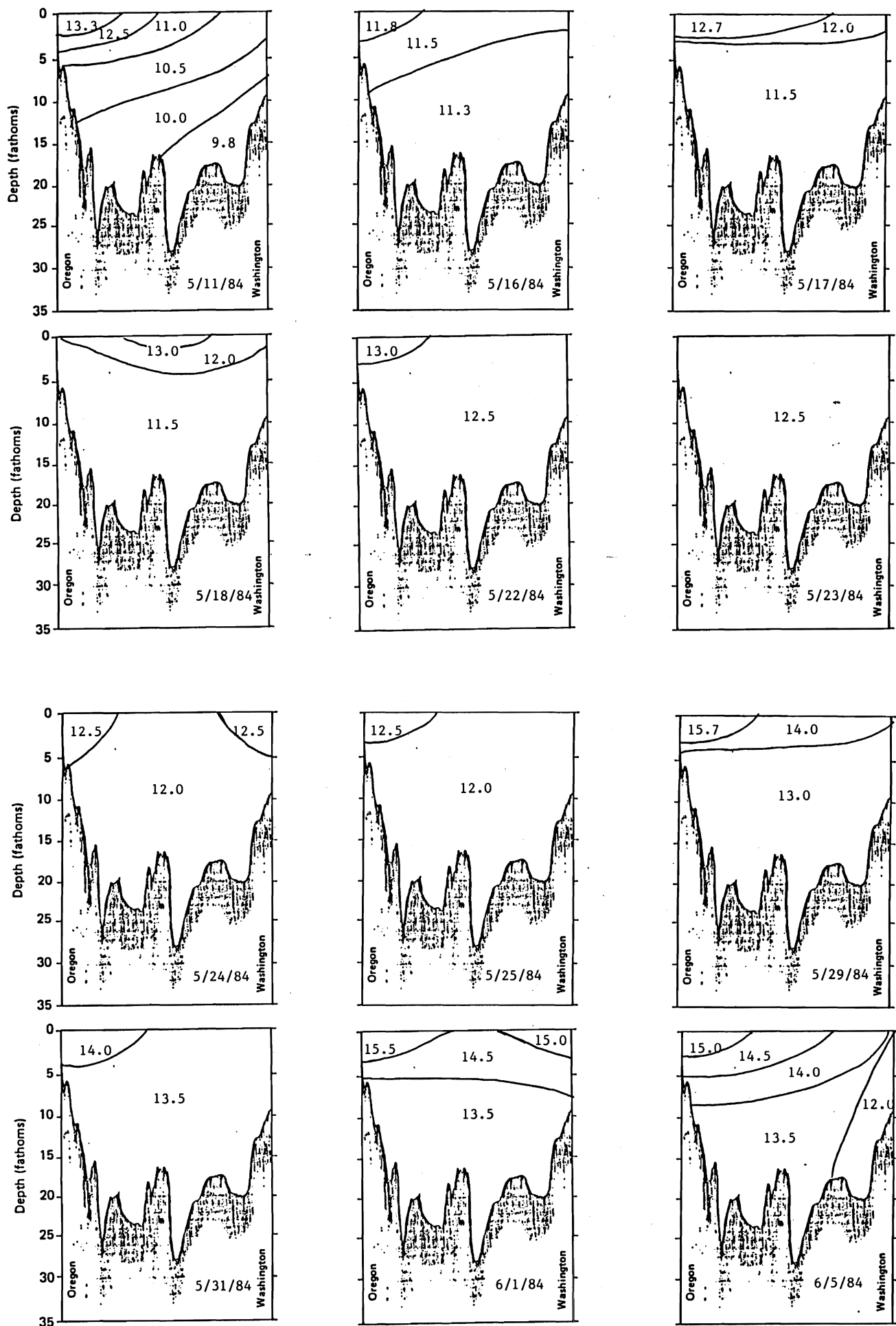


Figure 6B.

Figure 6.--Continued

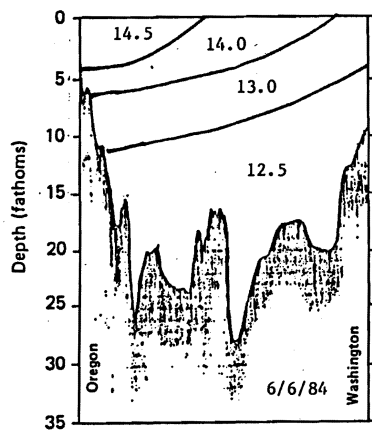


Figure 6B.--Continued

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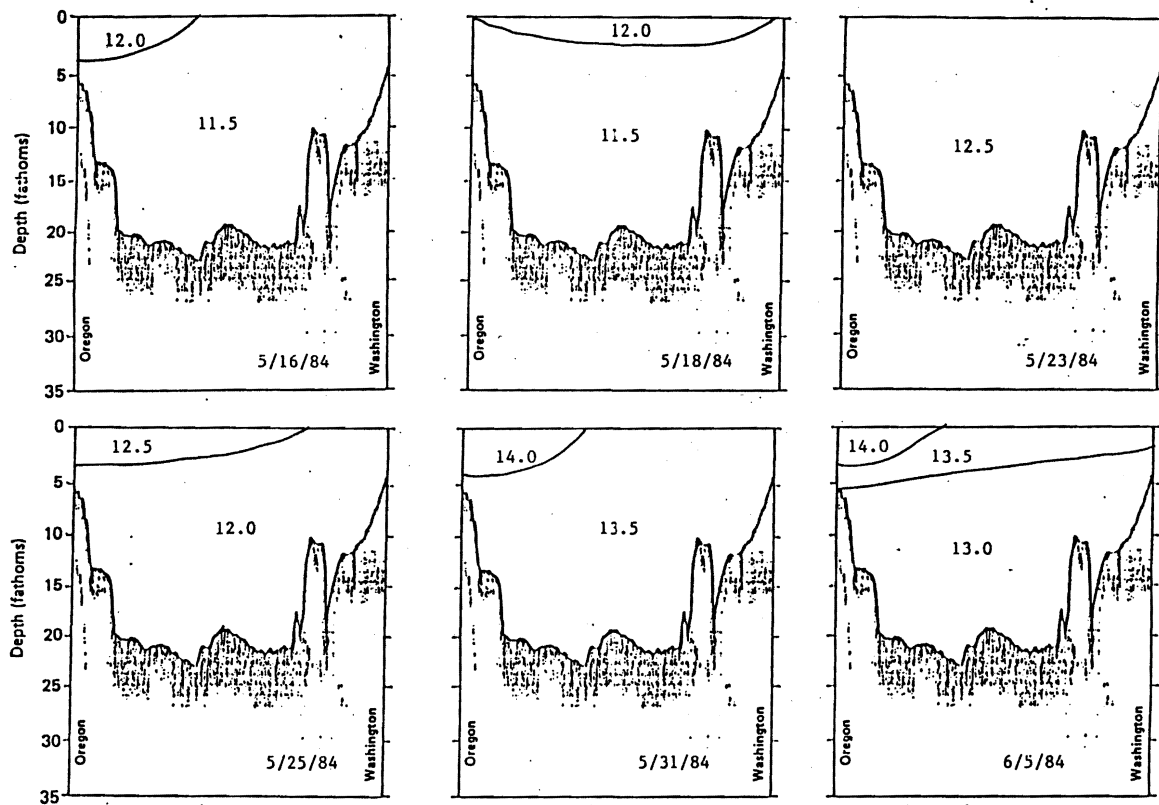


Figure 6C.

Figure 6.--Continued

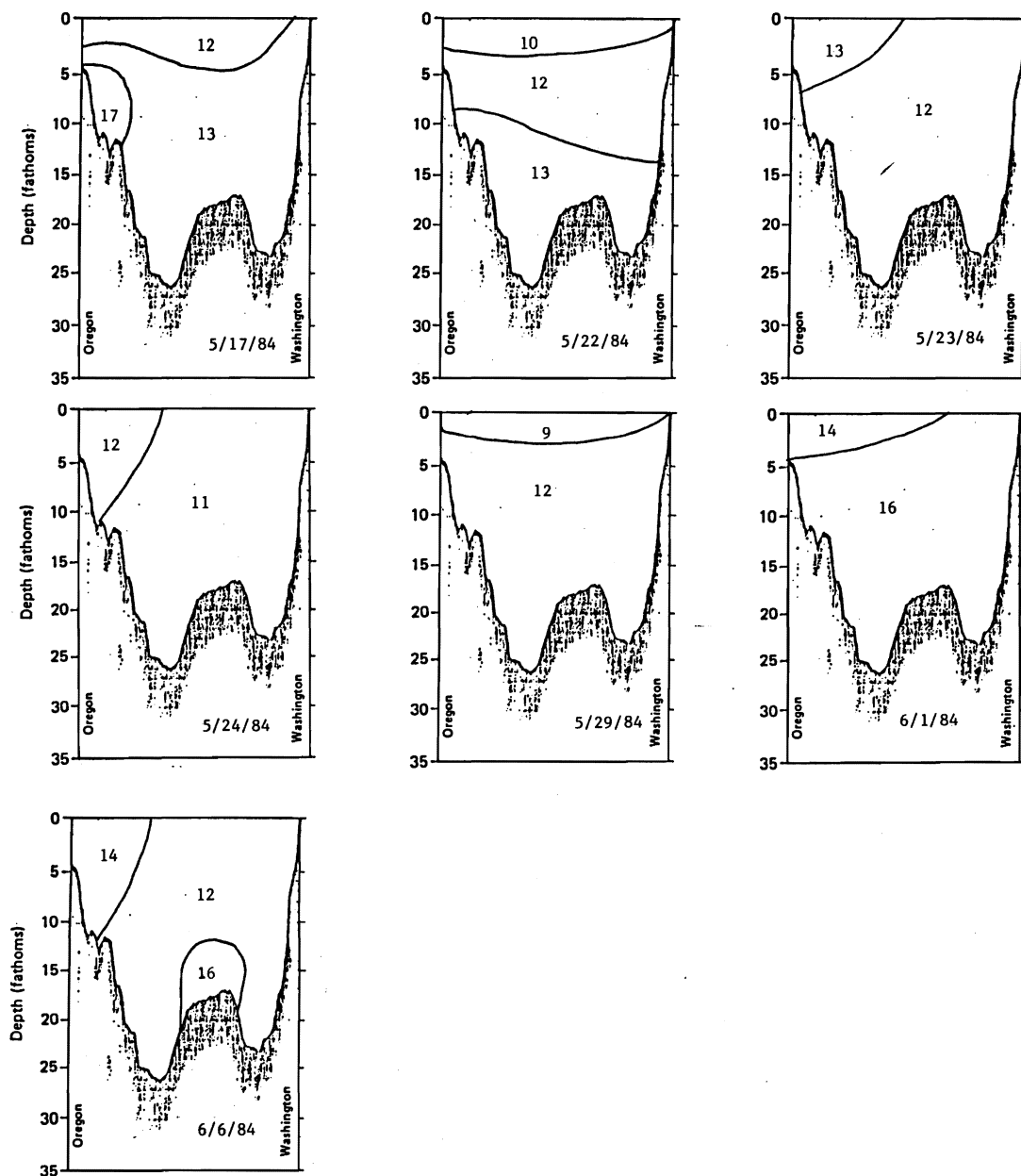


Figure 7A.

Figure 7.--Vertical profiles of water turbidity across the upstream (A), midstream (B), and downstream (C) transects. Water visibility is expressed in nephelometric turbidity units (NTU), the higher the value the more turbid the water (Wilber 1983).

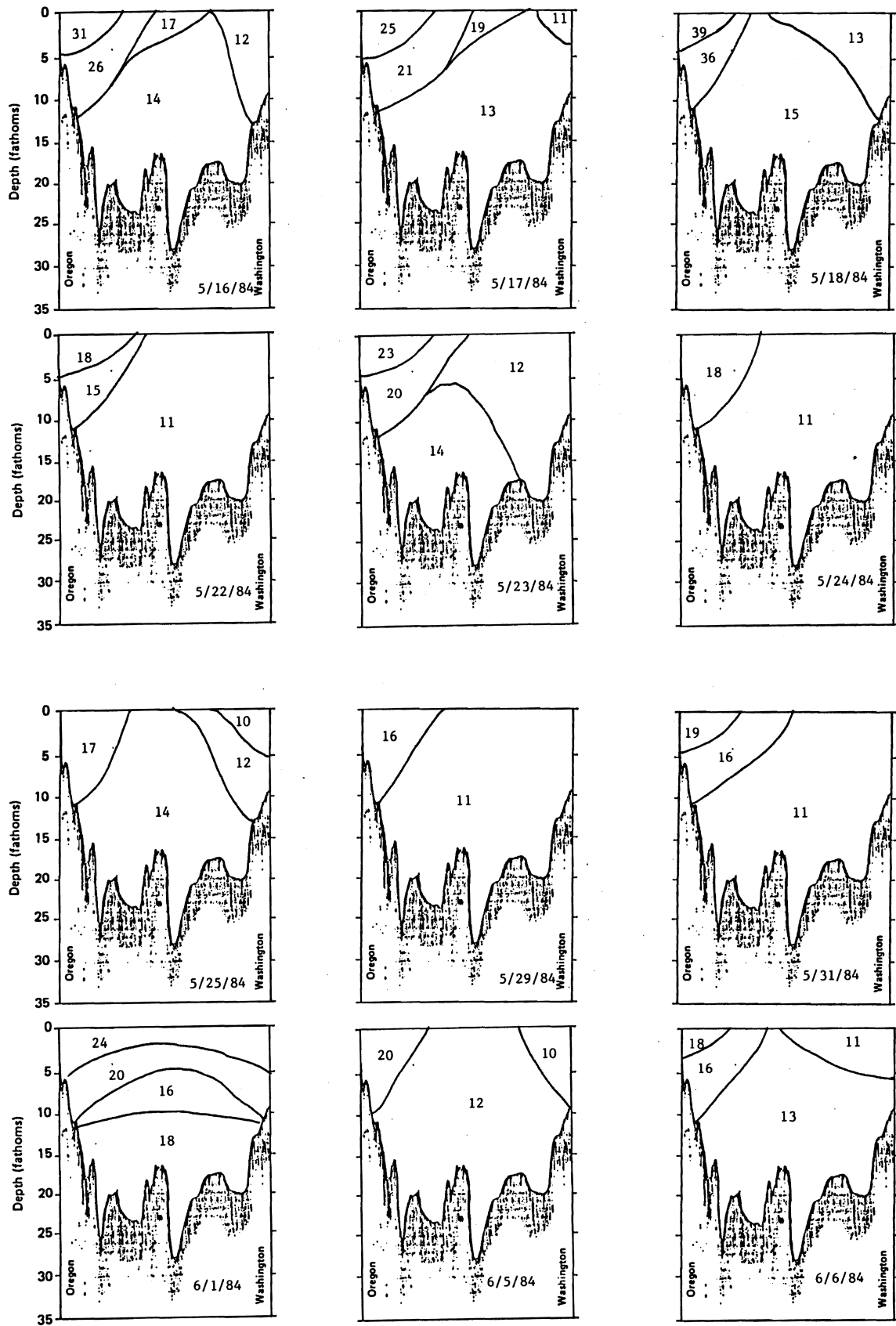


Figure 7B.

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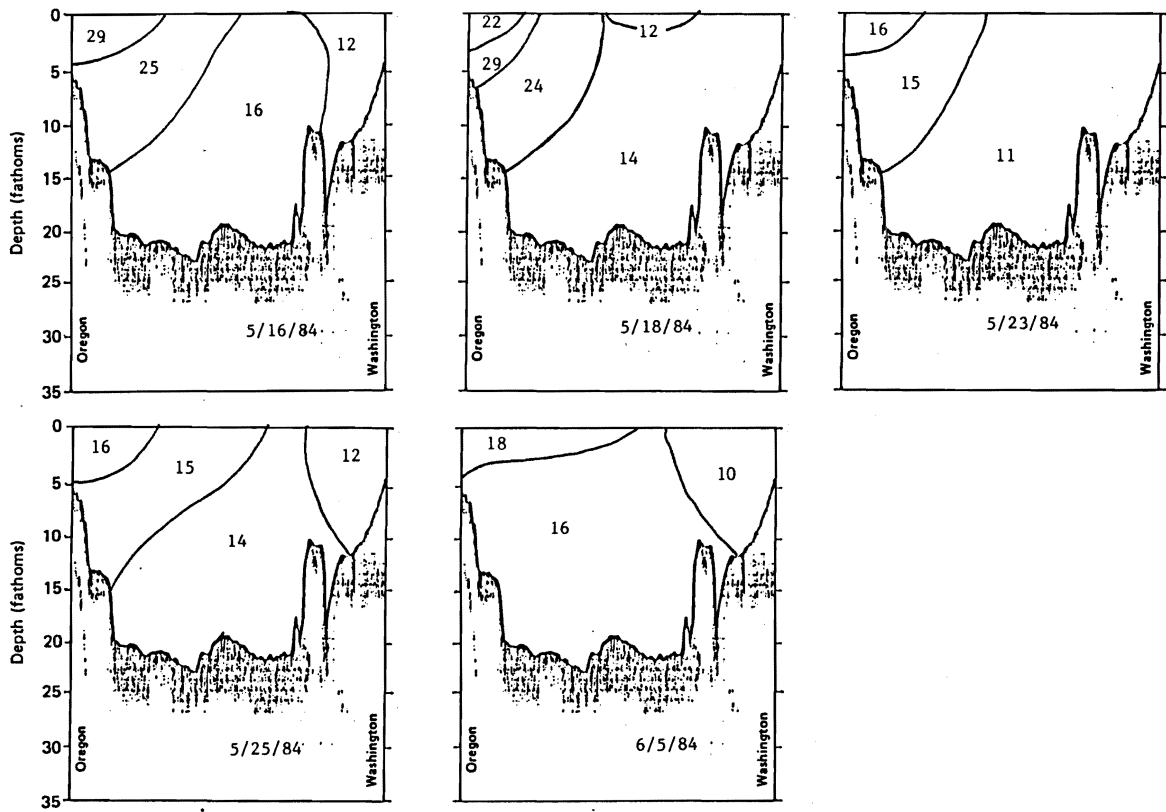


Figure 7C.

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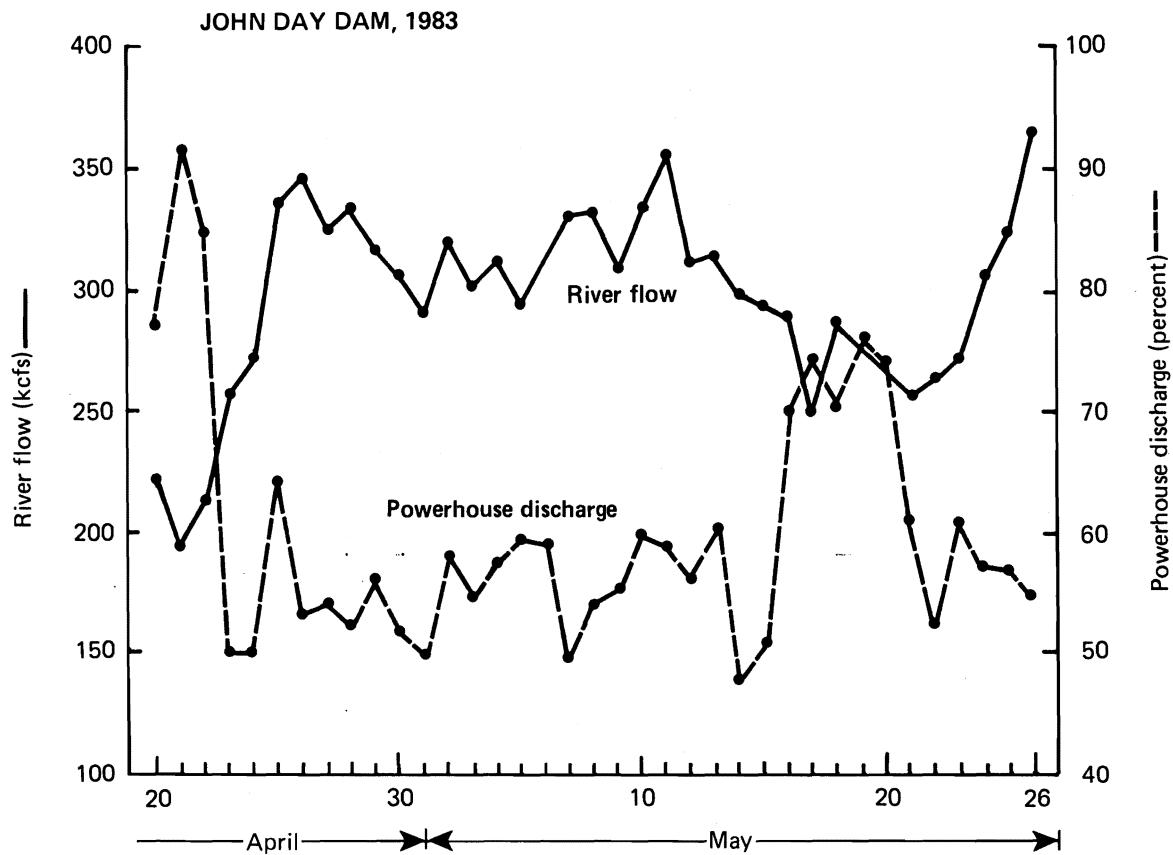


Figure 8.--Daily average Columbia River flow volume and the percentage of the flow discharged through the powerhouse at John Day Dam during the spring sampling season, 1983.

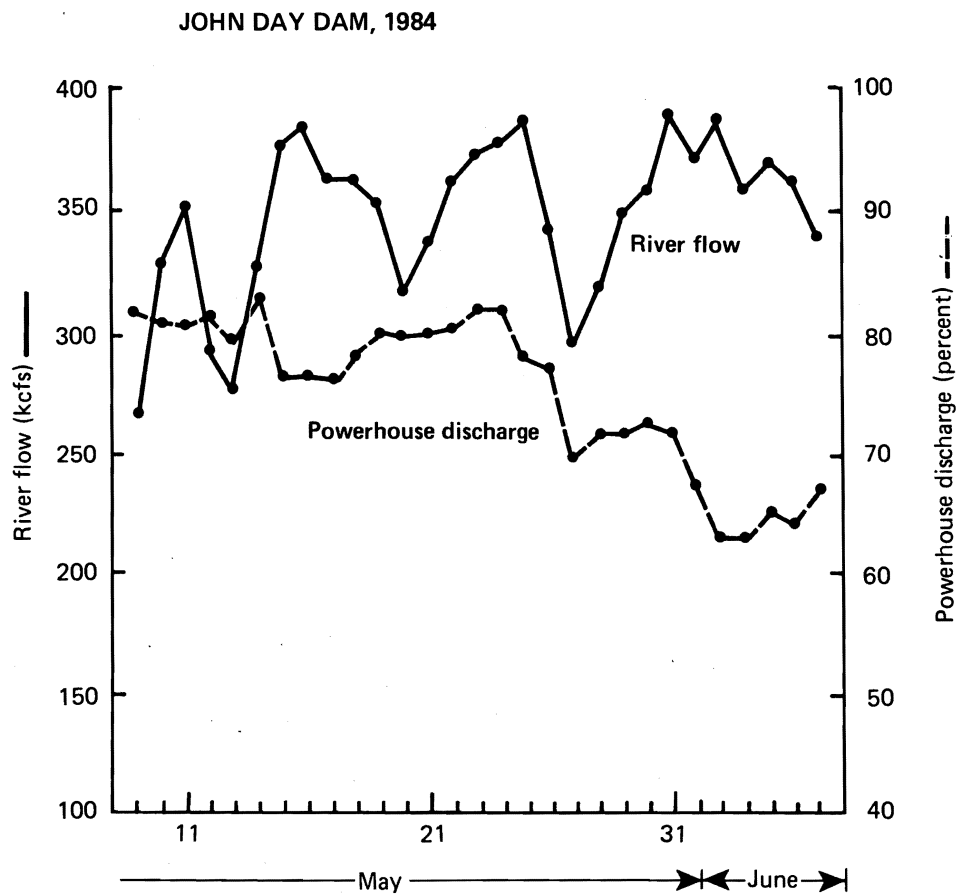


Figure 9.--Daily average Columbia River flow volume and the percentage of the flow discharged through the powerhouse at John Day Dam during the spring sampling season, 1984.

powerhouse, averaging on a daily basis 60 and 75% of the total river flow in 1983 and 1984, respectively.

#### Species Composition

From 20 April through 26 May 1983, 70 purse seine sets were executed. A total of 8,028 juvenile salmonids were captured, identified to species, enumerated, and then released in the reservoir. Yearling chinook salmon, steelhead, and sockeye salmon predominated in the catches, constituting 42, 29, and 25% of the total catches, respectively. Both coho and subyearling chinook salmon were sparse, comprising only 3 and 0.1% of all fish captured, respectively.

During the 1984 spring outmigration, 8,564 juvenile salmonids were captured in 76 net sets. Yearling chinook salmon were most abundant with sockeye and subyearling chinook salmon and steelhead present in appreciable numbers; percentages of the total catch were 48, 14, 18, and 17%, respectively. Coho salmon were rarely encountered: Only 139 were captured over the entire season (Table 1).

During the summer of 1983, the Summer Flow Study, funded by the Bonneville Power Administration, was conducting purse seine sampling for subyearling chinook salmon. A number of those sets were conducted at our downstream and midstream transects. Those data are detailed in Appendix 2 and examined in this study. From 30 June through 20 September 1983, 42 purse seine sets were completed. Of the total 3,777 juvenile salmonids captured, greater than 99% (3,740) were subyearling chinook salmon. Yearling chinook and sockeye salmon and steelhead trout were present in incidental numbers (Table 1).

### Fish Distribution, Spring 1983

During the 1983 spring outmigration, fish distribution patterns across the reservoir were similar for yearling chinook and sockeye salmon; fish were concentrated at mid-reservoir and Washington shore stations and were infrequently encountered at sampling stations near the Oregon shore (Fig. 10). Few were captured immediately downstream from the mouth of the John Day River at the midstream transect, Station 3 (Table 3). Only 1% of the chinook and sockeye salmon collected along the entire midstream transect were captured at that station (Table 4). Steelhead displayed a more uniform distribution across the reservoir. Although, as was the case for the salmon, relatively few, 7% of the midstream transect catch were captured at Station 3. So few coho and subyearling chinook salmon were caught during the spring outmigration, that seasonal distribution patterns could not be established.

### Fish Distribution, Spring 1984

In 1984, the general distribution patterns of yearling chinook and sockeye salmon across the downstream and midstream transects were similar to those observed in 1983. Fish were most abundant at mid-reservoir and Washington shore stations and were notably less abundant on the Oregon side of the river (Fig. 11). As in 1983, few fish were caught on the Oregon side of the Columbia River, immediately downstream from the mouth of the John Day River (Table 3). Only 4 and 7% of the yearling chinook and sockeye salmon, respectively, collected along the entire midstream transect were captured at Station 3 (Table 4). During 1984, steelhead distribution more closely resembled that of yearling chinook and sockeye salmon than was the case in 1983. Similarly, subyearling chinook salmon during the 1984 spring outmigration displayed distribution patterns similar to other salmonids, i.e.,



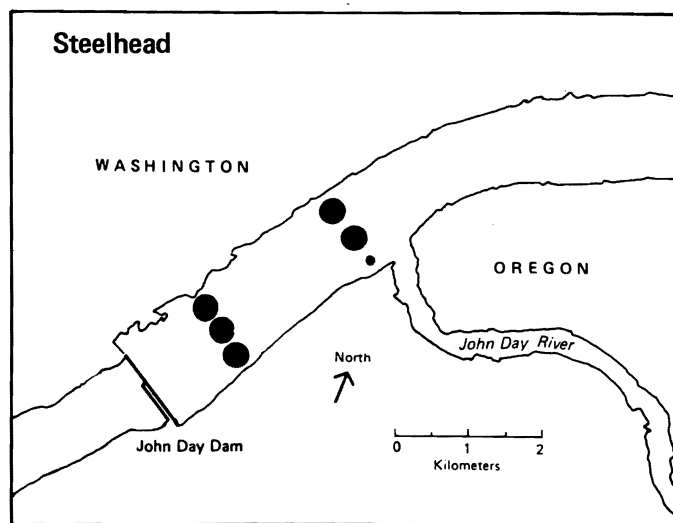
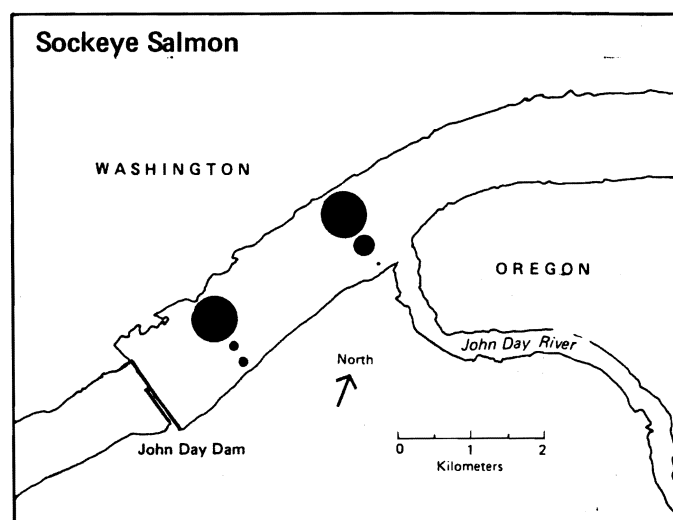
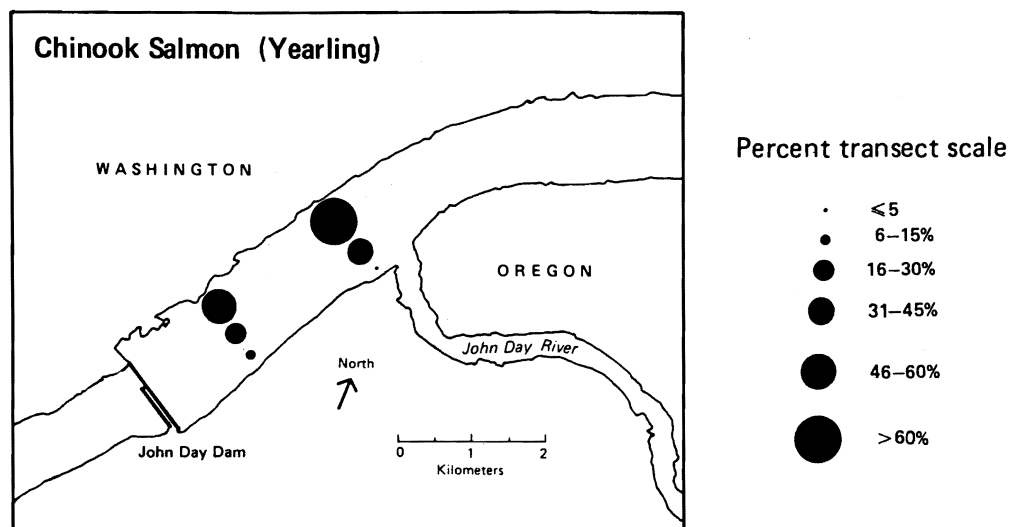


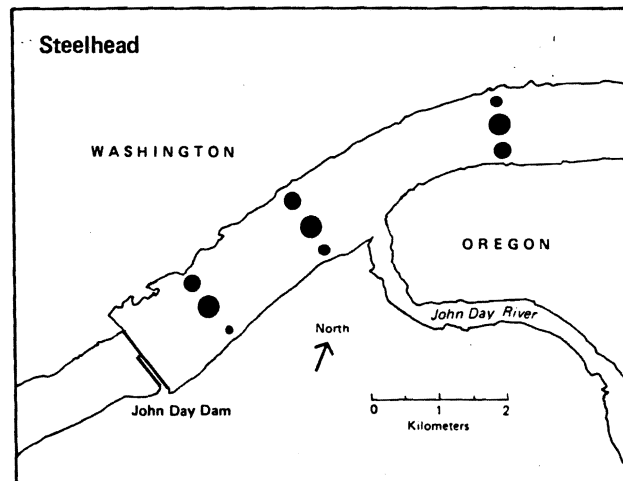
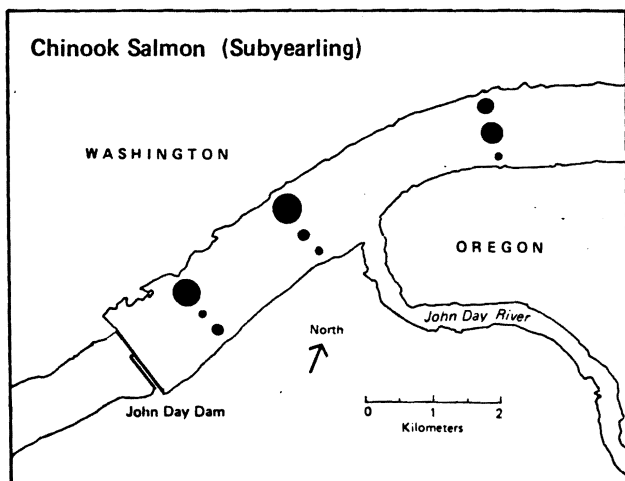
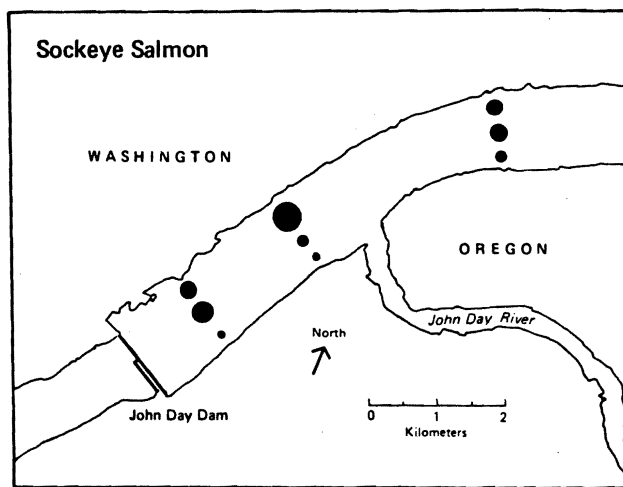
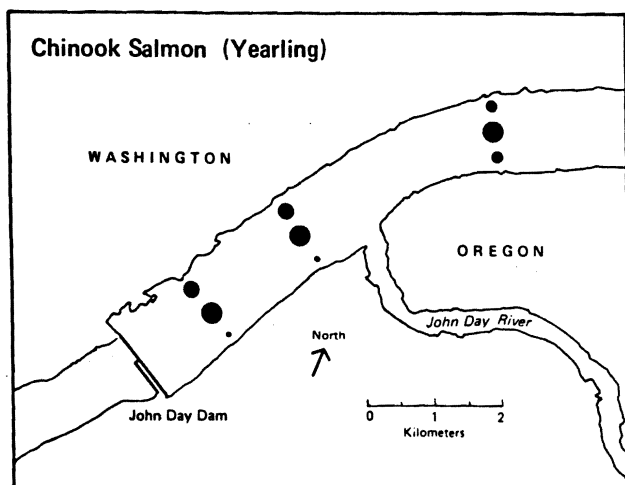
Figure 10.--Distribution of juvenile outmigrants in the forebay, 1983. Values depicted are the percent of each transect's total catch which occurred at that station, averaged over the entire spring sampling period.

Table 3.--Numbers of juvenile salmonids captured in John Day Reservoir during the spring outmigrations, 1983-1984. Number of purse seine sets conducted at each station over the course of the season appear in parentheses. The upstream transect was not sampled in 1983. Data presented here are only from those occasions when entire transects were sampled.

Year and species	Transect and sampling stations								
	Downstream			Midstream			Upstream		
	1	2	3	1	2	3	1	2	3
1983									
Chinook salmon (yearling)	461(7)	247(7)	122(7)	1,118(9)	678(9)	18(9)	-	-	-
Sockeye salmon	391(7)	44(7)	40(7)	887(9)	288(9)	4(9)	-	-	-
Steelhead	185(7)	209(7)	176(7)	554(9)	518(9)	79(9)	-	-	-
1984									
Chinook salmon (yearling)	422(7)	687(7)	55(7)	708(10)	916(10)	66(10)	271(7)	526(7)	173(7)
Chinook salmon (subyearling)	195(7)	25(7)	66(7)	414(10)	197(10)	47(10)	272(7)	375(7)	66(7)
Sockeye salmon	128(7)	145(7)	44(7)	409(10)	127(10)	40(10)	105(7)	88(7)	67(7)
Steelhead	185(7)	221(7)	51(7)	180(10)	301(10)	101(10)	69(7)	152(7)	94(7)

Table 4.--Total catch of juvenile salmonids captured at the designated sampling station in John Day Reservoir during the spring outmigrations 1983-84, expressed as the percentage of the total number of each species sampled along each transect. The upstream transect was not sampled in 1983. Data presented here are only from days when at least one entire transect was sampled.

Year and species	Transect and sampling station								
	Downstream			Midstream			Upstream		
	1	2	3	1	2	3	1	2	3
1983									
Chinook salmon (yearling)	55	30	15	62	37	1	-	-	-
Sockeye salmon	82	9	8	75	24	1	-	-	-
Steelhead	32	37	31	48	45	7	-	-	-
1984									
Chinook salmon (yearling)	36	59	5	42	54	4	28	54	18
Chinook salmon (subyearling)	68	9	23	63	30	7	38	53	9
Sockeye salmon	40	46	14	71	22	7	40	34	26
Steelhead	41	48	11	31	52	17	22	48	30



Percent transect scale



Figure 11.--Distribution of juvenile outmigrants in the forebay, 1984. Values depicted are the percent of each transects total catch which occurred at the station, averaged over the entire spring sampling period.

the preponderance of the fish were caught on the Washington side of the river, 68 and 63% of the downstream and midstream transect total catch, respectively (Fig. 11).

During 1984, the upstream transect established for the first time that year was sampled regularly. It was intended that the inclusion of this transect would indicate whether the distribution pattern first observed in 1983 and confirmed in 1984, i.e., a propensity for fish to be abundant primarily at the mid-reservoir and Washington shore stations, was established prior to their arrival at the midstream transect. For yearling chinook and sockeye salmon and steelhead, the patterns observed at the upstream transect were generally different from those observed at the midstream transect. Of particular interest is the relative abundance of fish along the Oregon shore in comparison to the midstream and a lesser extent the downstream transects. All three species displayed a significant alteration in their distribution across the reservoir as they migrated from the upstream to midstream transect; contingency tests yield chi-square values of 165.6, 86.6, and 21.1 (2 df) for yearling chinook and sockeye salmon and steelhead, respectively. The shift is a result of fish leaving the Oregon side of the river and accumulating toward mid-reservoir and the Washington shore. Subyearling chinook salmon occurred in the catch during only the final three sampling excursions of the 1984 spring outmigration (Appendix Table 2A). Such a limited sample may not establish truly representative distribution patterns for this species, thus a contingency test between the upstream and downstream transects was not performed.

As noted previously in this document, the physical properties of the reservoir changed radically between the upstream and midstream transect. The

warm, turbid John Day River discharge projected to varying degrees across the reservoir in this area. Graphical representation of the data suggests that as fish migrate from the upstream to midstream transect and encounter the John Day River plume, they avoid and/or are shunted away from the turbid water which is most pronounced along the Oregon shore. To test this hypothesis, Page's "L" nonparametric test (Hollander and Wolfe, 1973) was employed to assess the correlation between fish abundance along the midstream transect and two indices of the John Day River plume, turbidity and temperature. An alternative hypothesis was also tested, that is, downstream migrants are attracted to, or accumulate within the swiftest water to expedite migration.

In no case, for any species was fish abundance across the midstream transect correlated with increasing water velocity. However, for all species fish abundance was significantly correlated with water clarity, i.e., juvenile salmonids were rarely encountered in the turbid waters associated with the John Day River (Table 5). The only exception was observed for steelhead in 1984. However, even though no significant correlation could be demonstrated, steelhead still showed a strong tendency to be more abundant in the clearer water. No correlations could be demonstrated between fish abundance and water temperature.

At the downstream transect, the association between fish abundance and water clarity persists at least for yearling chinook and sockeye salmon; significant correlations were demonstrated for both species (Table 6). The question arose as to whether fish closer to the dam might be responsive to elevated water velocities which could be associated with large volumes of water being discharged through either the powerhouse or spillway. However, no correlation could be so demonstrated for any species, even though spillway

Table 5.--Summary of correlations between fish abundance and physical conditions across the midstream transect, spring 1983 and 1984. Test based on Page's L statistic, Hollander and Wolfe (1973).

Factor	Species	1983	1984
Water clarity	Yearling chinook	***	**
	Sockeye	***	**
	Steelhead	***	N.S. <sup>a/</sup>
	Subyearling chinook	N.D.	**
Water velocity	Yearling chinook	N.S.	N.S.
	Sockeye	N.S.	N.S.
	Steelhead	N.S.	N.S.
	Subyearling chinook	N.D.	N.S.
Water temperature	Yearling chinook	N.D.	N.S.
	Sockeye	N.D.	N.S.
	Steelhead	N.D.	N.S.
	Subyearling chinook	N.D.	N.S.

<sup>a/</sup> p = 0.053.

\* = Significant at  $0.01 < p < 0.05$   
 \*\* = Significant at  $0.001 < p < 0.01$   
 \*\*\* = Significant at  $p < 0.001$   
 N.D. = No data  
 N.S. = Not significant

Table 6.--Summary of correlations between fish abundance and physical conditions across the downstream transect, spring 1983 and 1984. Test based on Page's L statistic, Hollander and Wolfe (1973).

Factor	Species	1983	1984
Water clarity	Yearling chinook	**	*
	Sockeye	**	N.S.
	Steelhead	N.S.	N.S.
	Subyearling chinook	N.D.	N.S.
Water velocity	Yearling chinook	N.S.	N.S.
	Sockeye	N.S.	N.S.
	Steelhead	N.S.	N.S.
	Subyearling chinook	N.S.	N.S.
Water temperature	Yearling chinook	N.D.	U.D.
	Sockeye	N.D.	U.D.
	Steelhead	N.D.	U.D.
	Subyearling chinook	N.D.	U.D.

\* = Significant at  $0.01 < p < 0.05$

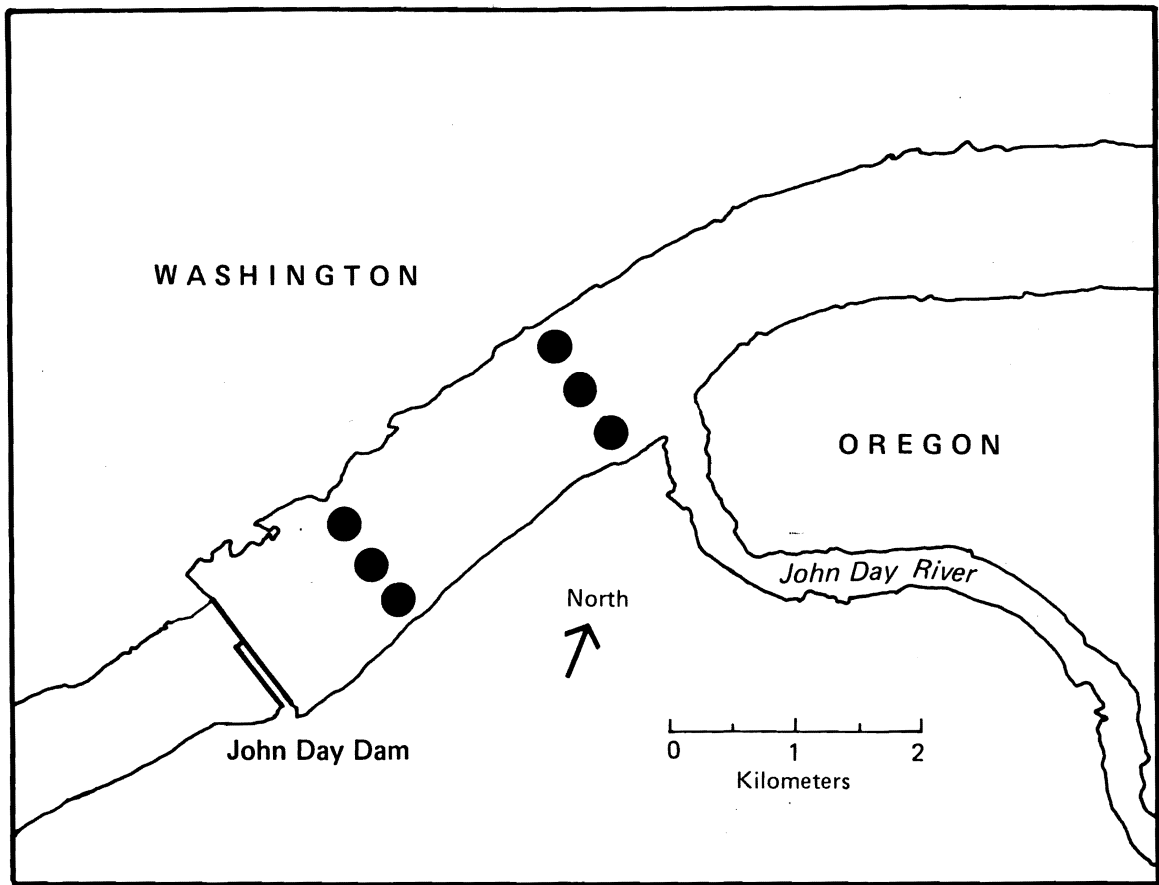
\*\* = Significant at  $0.001 < p < 0.01$

N.D. = No data

N.S. = Not significant

U.D. = Unrankable data; conditions uniform across forebay





Visibility scale

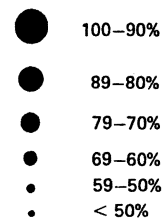


Figure 12.--Surface water clarity during the summer 1983. Clarity is expressed as the percentage of the maximum daily secchi reading. Daily values were averaged over all sampling cruises.

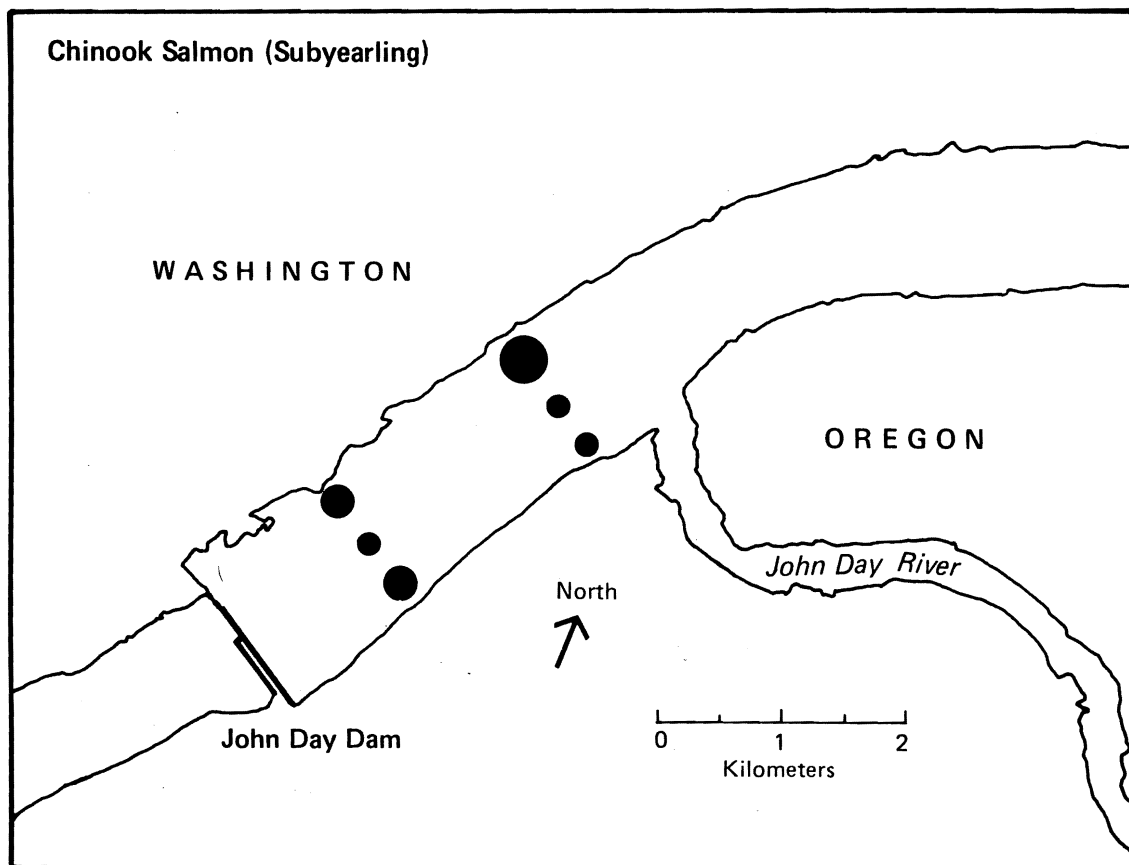
discharge levels ranged from 0 to 62% of the total river flow over the 2 years during purse seine sampling.

#### Summer Outmigration, 1983

During the summer of 1983, water clarity conditions were dissimilar from those observed during the spring outmigrations of 1983 and 1984. Water clarity was relatively uniform throughout the forebay (Fig. 12; data are detailed in Appendix B). Correspondingly, the discharge volume from the John Day River was low, ranging from 0.37 to 3.57 kcfs and carried little appreciable silt load into the mainstem Columbia River.

Subyearling chinook salmon were the only species caught in abundance during the summer of 1983 (Table 1). Their distribution across the reservoir was similar to the general patterns for subyearling chinook salmon observed during the spring outmigrations, 1984. At the midstream transect, fish were most abundant at the Washington shore station (53% of the total transect catch); whereas, only 16% of the transect catch occurred at the Oregon shore station (Fig. 13). Similarly, at the downstream transect, fish occurred in greatest numbers at the Washington and Oregon shore stations, 43 and 36% of the transect catch, respectively.

Using the same nonparametric test for correlation applied to the spring outmigration data, we examined the possible association between fish abundance and either water clarity or velocity at both the midstream and downstream transects. The only significant correlation was demonstrated at the midstream transect between fish abundance and water clarity (Table 7). Even though the plume emanating from the John Day River was weak and usually ill-defined, the secchi disc measurements displayed enough of a turbidity gradient across the reservoir to suggest that the accumulation of fish (56%) on the Washington



Percent transect scale



Figure 13.--Distribution of subyearling chinook salmon during the summer 1983.

Table 7.--Summary of correlations between subyearling chinook salmon abundance and physical characteristics of the reservoir during the summer of 1983. Test based on Page's L statistic (Hollander and Wolfe 1973). Water temperatures were uniform throughout the reservoir on any given sampling day thus precluding their ability to be ranked and tested.

Transect	Factor	Summer 1983
Midstream	Water clarity	*
	Water velocity	N.S.
Downstream	Water clarity	N.S.
	Water velocity	N.S.

\* = Significant at  $0.01 < p < 0.05$

N.S. = Not significant

side of the river was in response to the tributary's discharge. At the downstream transect, the distribution pattern was different. Fish were most abundant at both the Washington and Oregon shore stations, 43 and 36% of the total transect catch, respectively. No correlations could be demonstrated with respect to either water clarity or velocity at the downstream transect.

#### RADIO TELEMETRY

Between 1980 and 1982, the NMFS, with funding by the U.S. Army Corps of Engineers, evaluated the recently developed juvenile radio tag as a tool to monitor migration routes of smolts passing through the reservoir and their passage locations at the dam (Stuehrenberg and Liscom 1982).

In the spring of 1983, under this BPA contract, we detailed the migration routes of radio-tagged smolts by tracking them through the reservoir. Most of our effort focused on spring chinook salmon, although some coho salmon and steelhead were also tagged. Additionally, a monitor system was deployed across John Day Dam to identify the passage locations (powerhouse vs. spillway) of tagged smolts which could not be tracked through to passage. Based on the results of the 1983 work, the 1984 study was designed to change the emphasis from detailing migration routes to identifying passage locations at the dam. The primary objective was to test the concept of using group releases of radio-tagged smolts to evaluate fish passage locations. The radio telemetry part of the program again focused on spring chinook salmon, although some steelhead were also tagged when chinook salmon were not available.

#### Methods and Materials

##### Study Area

Radio-tagged juvenile salmonids were tracked in the immediate vicinity of John Day Dam in the area extending from the upstream purse seine transect to

the dam (Fig. 2). Smolts have two primary routes to pass John Day Dam: the spillway or the powerhouse. Other seldom used passage routes include the navigation lock and the two fish ladders. Flows through the John Day Dam project typically range from 130 to 450 kcfs during the spring outmigration, and involuntary spill begins when flows reach about 300 kcfs. In 1983, spill occurred during 24 h per day for most of the spring migration. In 1984, spill was restricted to the hours from dusk to dawn.

#### Equipment

The juvenile radio tag was developed by NMFS electronics personnel to provide a means of monitoring movements of individual salmonid smolts. The radio tags are battery powered transmitters that operate on a carrier frequency of approximately 30 megahertz (MHz). The transmitter and batteries are coated with Humiseal and then a mixture of paraffin and beeswax to form a flattened cylinder 26 x 9 x 6 mm, which weighs approximately 2.9 g in air. A 127-mm long flexible whip antenna is attached to one end of the tag. For identification purposes, each tag transmitted on one of nine frequencies spaced 10 kilohertz apart (30.17 through 30.25 MHz). Individual tags on each frequency were pulse coded to provide individual identification of each tag. Tracking range of the tag varied from 100 to 1,000 m depending on the output of the tag and the depth of the fish. The pulse rate was two per second, and the tag life was a minimum of 3 days.

Two types of tracking receivers were used, one for mobile operations and the other as a stationary monitor. Smith-Root RF-40 receivers in conjunction with hand held directional loop antennas were used during mobile operations, and a combination of our search unit, a pulse decoder, and a digital printer was used with antennas at the fixed monitor locations. Fixed monitors were

located in each of the two fishladders, at the upstream end of the navigation lock, and at the centers of the spillway and active turbine bays. In the fishladders, two underwater antennas provided signal input for the monitors. At the navigation lock, a single loop antenna, shielded from the watermass in front of the spillway by concrete, provided signal input. The powerhouse and spillway were monitored with two systems of 10 loop antennas linked together with 10 signal amplifiers.

### Tagging

Juvenile chinook salmon were collected at John Day Dam from an airlift pump in the gatewell of Turbine Unit 3 (Sims et al. 1981). All were longer than 148 mm fork length and showed a minimum amount of descaling. Before tagging, the fish were mildly anesthetized with MS-222. After the fish was measured, the tag was dipped in glycerin and inserted into the fish's stomach. The tag's flexible antenna extended out of the fish's mouth and trailed back along the side of the fish.

In 1983, fish were allowed to recover for at least 5 h prior to release. In 1984, the recovery period was extended to at least 8 h.

### Radio Tracking - 1983

In 1983, the NMFS used radio telemetry to define salmonid migration routes in the forebay of John Day Dam and identify their ultimate passage location. The objective was to identify potential effectors which influence the observed migration patterns.

Single radio-tagged fish were released at one of five locations in the forebay of John Day Dam. The three primary sites were along the upstream purse seine transect 6.3 km upstream from the dam (Washington side, mid-river,

and Oregon side). When poor weather conditions prevented tracking from the primary sites, the releases were moved downstream to the area across from the mouth of the John Day River that was used in 1981 and 1982. One release was made on the Oregon side of the Columbia River just upstream from the John Day River. Releases were generally between 1300 and 1800 h to allow sufficient time for the fish to arrive at the dam by dusk.

The limited tracking range and large size of the study area (6.3 km long by 1 km wide) required tracking from two boats, each with a two-man crew. One person operated the boat while the second person operated the antenna and receiver. To maintain contact with the fish, one boat was deployed upstream from the fish, and the other boat was deployed to one side of the fish's expected location. As the relative position of the boats and fish changed, the boats would change positions, one at a time, in anticipation of the relative movement.

Because of the wind's influence on the boats and the short tracking ranges, constant cross bearings were needed to stay with the fish. If the signal was lost, the area was searched until the signal was relocated or for at least 1 h before the track was ended.

Four fixed monitor units were placed on the upstream face of the dam to obtain passage location for the fish either lost during tracking or left upstream because the fish were not moving. Two units divided the space occupied by the 16 active turbines and two monitors covered the 20 spill gates. The monitors were operational throughout the study, and the output was checked daily.

Fixes for plotting the fish's location on tracking maps were made by placing a boat directly over the fish's location and then fixing the location



of the boat on the map. The boat was judged to be directly over a fish when a strong signal was received throughout the entire 360° rotation of the antenna. The location of the boat was established by measuring with a sextant the horizontal angle between fixed navigational aids and/or brightly colored and lighted markers placed at known positions on the river bank. The angles, when plotted with a three-arm protractor, provide a very accurate and fast method of locating fish position on a navigational chart (Dunlap and Schufeldt 1969).

#### Group Releases - 1984

In 1984, emphasis shifted from detailing migration routes to identifying passage locations at the dam. The primary objective was to assess the technical feasibility of releasing groups of radio-tagged yearling chinook salmon to evaluate spill effectiveness.

Groups of 28 fish each were released 6.3 km upstream from John Day Dam on three dates (1, 10, and 14 May 1984). An additional 11 fish were released on 25 May 1984. Half of each group was released in the morning, the other half in the afternoon, except on 25 May when all fish were released in the afternoon. The purpose of temporally partitioning each release was to assess whether arrival time at the dam influenced actual passage time, i.e., was there was a distinct temporal passage pattern? After the fish were released in the morning, water samples were taken, meteorological data recorded, and the location of the John Day River plume was plotted. Subsequently, a random search pattern was executed with a radio tracking vessel to locate as many of the early release fish as possible. As the fish released early in the day approached the dam, the fish to be released during the afternoon were moved to the boat, and the monitors were turned on. These afternoon fish were held in

the live well on the boat upstream from the monitors until the afternoon release time. After the afternoon fish release and again near sunset, random searches were made for tags in the forebay.

Monitor operation was checked before tests, at least twice during the night after the releases, and twice a day between tests. Range tests for the monitor antenna systems were conducted on the day before the fish were released.

The evaluation of group radio tag release techniques was based on the number of fish from each release that were detected at the dam and the ability of the antenna systems to separate powerhouse, spillway, navigation lock, and fishladder passage locations.

## Results

### Radio Tracking - 1983

From 22 April to 22 June 1983, 34 juvenile salmonid smolts (21 chinook salmon, 11 steelhead, and 2 coho salmon) were radio tracked (Table 8). The mean length of the chinook salmon was 159 mm, steelhead 174 mm, and coho salmon 165 mm. Of the 34 fish, passage locations are known for 19.

River flows during the tracking periods ranged from 158.3 to 434.4 kcfs, with spill rates of up to 62% of total river flow. During the 218 h of radio tracking, the spill rates were greater than 34% of the river flow during 157 h and less than 2% during 48 h. The remaining hours (13) were scattered between spill rates of 2 to 34%. Illustrations of individual radio tracks are included in Appendix C.

In 1983, radio tracking was able to detect delaying or holding actions in three areas. Delay activity was defined as upstream movement, or no movement between fish location readings. The first holding area was along the release

Table 8.--Summary of data for 1983 radio-tracked fish.

Fish code	Species	Length (mm)	Release				Track time	Reason end track	Passage			Forebay Time-h	Discharge (kcfs)					
			Site	Month	Day	Time			Location	Date	Time		Average			At passage time		
													Total	Spill	%Spill	Total	Spill	%Spill
766	Chinook	170	B	4	22	1341	2.4	Tag failure	-	-	-	2.4	189.5	0	0	-	-	-
633	Chinook	150	A	4	23	1251	8.1	Weather	Spill	26 Apr	1609	76.0	308.1	150.3	49	350.2	218.5	57
176	Chinook	148	A	4	24	1250	6.1	No movement	-	-	-	6.1	270.7	134.6	50	-	-	-
677	Chinook	158	C	4	26	1347	6.8	Passage	Spill	26 Apr	2034	6.8	349.5	193.0	55	347.2	174.6	50
278	Chinook	160	B	4	27	1347	5.5	Passage	Apill	27 Apr	1917	5.5	349.2	191.9	55	355.5	176.0	50
977	Chinook	149	C	5	4	1343	7.5	Passage	Spill	04 May	2111	7.5	305.7	132.3	43	298.0	150.4	50
876	Chinook	155	A	5	6	1352	6.6	Lost	Spill	08 May	0346	39.0	328.4	159.7	49	316.0	156.7	50
372	Chinook	150	A	5	7	1341	4.5	Passage	Spill	07 May	1811	4.5	337.4	135.5	55	341.9	162.0	47
735	Chinook	154	A	5	8	1344	1.1	Weather	Spill	09 May	2000	31.0	317.1	141.2	45	329.6	166.0	50
364	Chinook	155	E	5	10	1630	5.5	Passage	Powerhse	10 May	2218	5.5	360.5	136.2	38	358.0	148.8	42
270	Chinook	165	B	5	11	1339	3.8	Lost	-	-	-	3.8	345.9	150.4	43	-	-	-
515	Chinook	177	A	5	17	1516	4.0	Lost	-	-	-	4.0	207.9	27.0	13	-	-	-
746	Chinook	162	D	5	18	1350	9.8	Lost	-	-	-	9.8	269.3	69.5	26	-	-	-
474	Chinook	162	A	5	19	1412	5.5	Seagull	-	-	-	5.5	282.0	27.2	10	-	-	-
127	Chinook	164	C	5	20	1348	7.7	Upstream	-	-	-	7.7	270.3	58.4	22	-	-	-
627	Chinook	174	B	5	21	1421	8.7	Passage	Spill	21 May	2303	8.7	258.8	123.1	48	242.1	127.4	52
267	Coho	152	A	5	22	1357	9.5	Passage	Powerhse	22 May	2330	9.5	297.0	145.8	49	242.3	139.9	58
928	Coho	179	C	5	23	1419	6.5	No movement	Spill	24 May	0420	15.0	208.2	120.9	43	270.5	140.8	52
766	Steelhead	165	B	5	24	1438	4.9	No movement	Spill	25 May	1734	28.0	315.0	130.0	41	366.5	150.1	41
144	Chinook	159	C	5	25	1342	7.3	Lost	Spill	25 May	2329	7.3	337.4	146.8	44	353.8	180.5	51
547	Steelhead	175	B	6	2	1345	0	High wind	-	-	-	-	-	-	-	-	-	-
133	Steelhead	165	B	6	3	1338	0	Lost	-	-	-	-	-	-	-	-	-	-
667	Steelhead	189	A	6	5	1338	8.3	No movement	Powerhse	7 Jun	0515	43.0	365.8	183.0	50	377.6	188.4	50
246	Chinook	180	A	6	6	1415	5.1	Passage	Powerhse	6 Jun	1920	5.1	374.1	183.1	49	372.1	177.3	48
575	Steelhead	175	C	6	7	1339	5.5	Passage	Powerhse	7 Jun	1910	5.5	350.2	153.6	44	347.3	150.2	43
728	Steelhead	172	B	6	8	1334	5.7	No movement	-	-	-	5.7	349.8	153.8	43	-	-	-
146	Steelhead	177	A	6	9	1418	4.8	No movement	-	-	-	4.8	339.5	133.8	39	-	-	-
363	Chinook	150	B	6	15	1714	0	High wind	-	-	-	-	-	-	-	-	-	-
527	Steelhead	173	C	6	16	1425	6.1	No movement	Powerhse	18 Jun	0503	40.0	281.1	66.7	24	244.3	55.7	23
126	Chinook	149	D	6	17	1426	1.1	Weather	-	-	-	1.1	275.6	0	0	-	-	-
228	Steelhead	183	D	6	18	1344	2.3	Weather	Spill	22 Jun	0022	84.0	242.8	46.0	19	241.1	118.7	49
867	Chinook	150	D	6	19	1339	7.6	Upstream	Spill	20 Jun	0032	12.0	237.2	51.0	22	222.9	110.9	50
327	Steelhead	187	D	6	20	1726	4.3	No movement	-	-	-	4.3	260.8	56.1	22	-	-	-
170	Steelhead	173	B	6	22	1411	7.5	No movement	-	-	-	7.5	254.2	19.8	8	-	-	-

## Release Sites

6.3 km Transect

A - Washington side

B - Mid river

C - Oregon side

## Rough water release site

D - Washington side 4 km upstream

Plume test

E - Oregon side into John Day River water



Figure 14.--Locations where radio-tracked juvenile chinook salmon either delayed their downstream migration or moved upstream.



Figure 15.--Locations where radio-tracked juvenile steelhead either delayed their downstream migration or moved upstream.

Passage locations were notably different for the two species. Greater than 90% of the chinook salmon (10 of 11) passed through the spillway during periods when spill volumes averaged about 50% of the river flow. In contrast, only 40% of the steelhead (2 of 5) passed through the spillway at times when spill levels averaged about 41% of the total river discharge volume.

#### Group Releases - 1984

A total of 75 or nearly 80% of the 95 fish released were subsequently detected passing either through the spillway or powerhouse. Passage locations through the spillway and powerhouse were: 5 and 14 from the 1 May release; 12 and 13 from the 10 May release; 15 and 8 from the 14 May release; and 5 and 3 from the 25 May release, respectively. During periods of spill, 68 fish passed the dam--41 (60%) through the spillway and 27 (40%) through the powerhouse.

Detection rates for individual release groups ranged from 100% for the morning release of 10 May to 57% for the afternoon release on 1 May (Table 9), with the best rates demonstrated by the morning release groups (average 90%). See Appendix Table C1 for additional detail on each of the 75 detected fish. We have no explanation for the lower passage rates of afternoon releases.

Separation of passage locations was very clear. The overlap of the antenna ranges of the powerhouse and the spillway monitors fell within the four empty turbine bays that separate the active turbines and the spillway. Fish detected on both monitors while some distance upstream from the dam were only detected on one of the monitors at the time they were last heard near the face of the dam. No fish passed downstream via the fishladders or navigation lock. The navigation lock monitor did record tag data while the fish were near the upstream gate. Those fish were later recorded as they passed

Table 9.--Detection rates of groups of radio-tagged fish at John Day Dam - 1984.

Release groups			No. detected at Dam			% detected at dam
Date	Time	No. released	Spillway	Powerhouse	Nav. lock- fishways	
1 May	0850	14	4	7	0	79
	1339	14	1	7	0	57
10 May	0851	14	6	8	0	100
	1413	14	6	5	0	79
14 May	0836	14	7	6	0	93
	1403	14	8	2	0	71
25 May	1405	<u>11</u>	<u>5</u>	<u>3</u>	<u>—</u>	73
Total		95	37	38	0	79

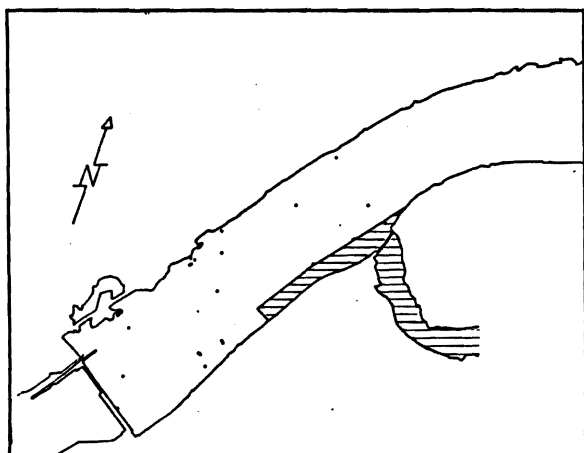
downstream via the spillway. Separation of the spillway and navigation lock approaches was successful by using a concrete corner to shield the navigation lock antenna from fish in the spill channel.

Analysis of spill effectiveness at John Day Dam is complicated by two factors. First, in 1984 spill was only provided at night for fish passage. Consequently, fish that passed the facility prior to initiation of spill, typically around 1900-2000 h, could only pass via the powerhouse. Also fish that arrived at the dam prior to spill often distributed themselves in front of the powerhouse and were not attracted to the spill when it was initiated. This then would reasonably limit the usable sample in assessing spill efficiency to fish which arrived at or passed the dam while spill was being provided. The second complicating factor involves the presence or absence of the John Day Dam river plume across the Columbia River. Data have been presented that demonstrates its affect on the migration routes of juveniles and correspondingly to their predisposition to spill passage by virtue of their position laterally across the forebay. The following analyses are formulated in accordance with the above mentioned complicating factors. Fish used in this analysis satisfied two criteria: (1) they were first detected near the dam while spill was occurring and (2) they passed the dam during the dusk to dawn period of or following their arrival. Furthermore, spill effectiveness was evaluated for only three (10, 14, and 25 May) of the four release dates (Table 10). The 1 May release is not incorporated into this test, as the plume was not present across the forebay as it was on the other three occasions (Fig. 16) and because the lateral position of the fish in the forebay, as influenced by the plume, would be different as they approached the dam.

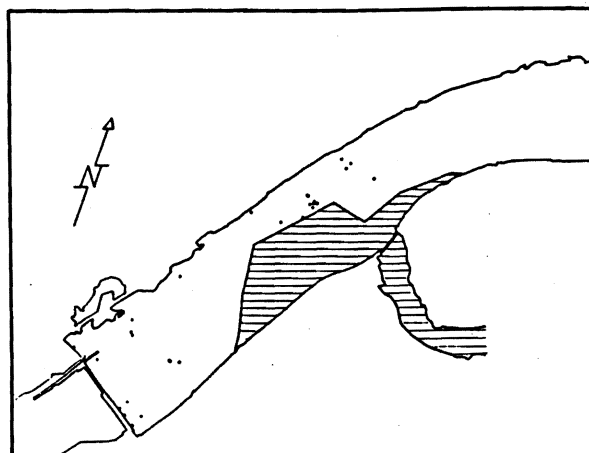


Table 10.--Fish which arrived at and passed the dam within the time frame indicated.

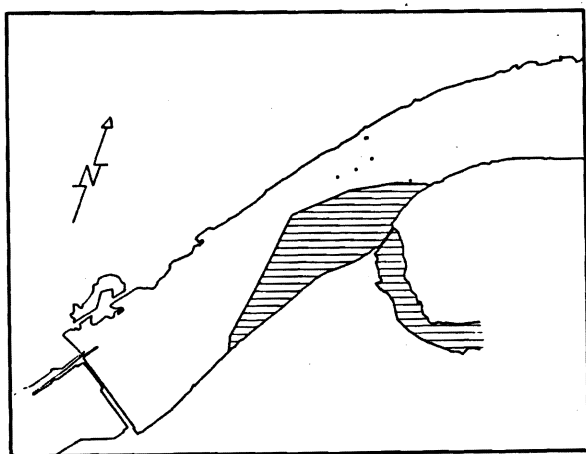
Date	Time of day of spill period (h)	% spill	No. fish passing		Fish code
			Spillway	Powerhouse	
10 May 84	2000-0515	42	5	3	246, 262, 373, 636, 770, 730, 830, 760
14 May 84	2000-0510	42	10	1	128, 332, 451, 550, 340, 440, 758, 834, 864, 935, 971
25 May 84	1800-0500	43	5	3	131, 145, 257, 661, 735, 856, 928, 963



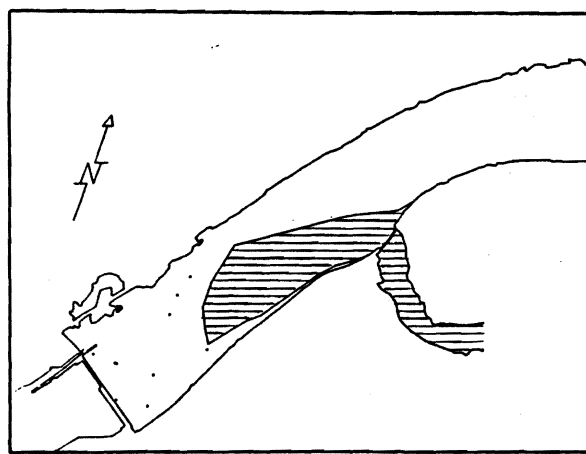
RELEASE DAY 1  
MAY 1



RELEASE DAY 2  
MAY 10



RELEASE DAY 3  
MAY 14



RELEASE DAY 4  
MAY 25

Figure 16.--Location of the John Day River plume and radio-tagged chinook salmon on each release day, 1984.

During the night/early morning detection period (approximately 2000-0600 h) on 10, 14, and 25 May, the average spill levels were 42, 42, and 43% of the total river flow, respectively. The mean spill level for the three dates was 42%. On those three dates, 74% of the fish (20 of 27) passed over the spillway (Table 10). Using Fisher's method of combining probabilities for independent tests of significance (Sokal and Rohlf 1981) we tested the hypothesis that radio-tagged fish passed over the spillway in equal proportion to the percentage of river flow discharged over the spillway. The null hypothesis ( $H_0: p = 0.42$ ) was rejected,  $0.001 < P < 0.005$  (Table 11). We concluded that fish were detected at the spillway at a rate (74%) significantly in excess of the percentage of the river flow being spilled (42%).

As observed in 1983, fish were noticeably absent within the John Day River plume as determined by the random search patterns conducted in the forebay. Only 1 of the 67 fish detected in the forebay was found in the water that we could visually classify as John Day River water.

The groups of radio-tagged yearling chinook salmon in 1984 displayed the same diel passage pattern at John Day Dam as individual tracks in 1983. Passage occurred primarily during the dusk to dawn period (Fig. 17). Fish arriving at the dam during daylight hours (1300-2000 h) held up in the forebay until dusk before passing the dam. The delay was significantly greater than those which arrived during the dusk to dawn period; as determined using a Mann Whitney-U Test of median forebay residence times ( $P < 0.01$ ).

Table 11.--Summary of statistical analysis used to evaluate spill passage effectiveness. Procedures follow those detailed by Sokal and Rohlf (1981) for Fisher's method of combining probabilities from independent tests of significance.

Date	No. of fish passing		p under $H_0$ <sup>a/</sup>	ln p
	Spillway	Powerhouse		
10 May	5	3	0.2062	-1.5789
14 May	10	1	0.0012	-6.7254
25 May	<u>5</u>	<u>3</u>	0.2062	<u>-1.5789</u>
Total	20	7		-9.8832

<sup>a/</sup>  $H_0: p = 0.42$

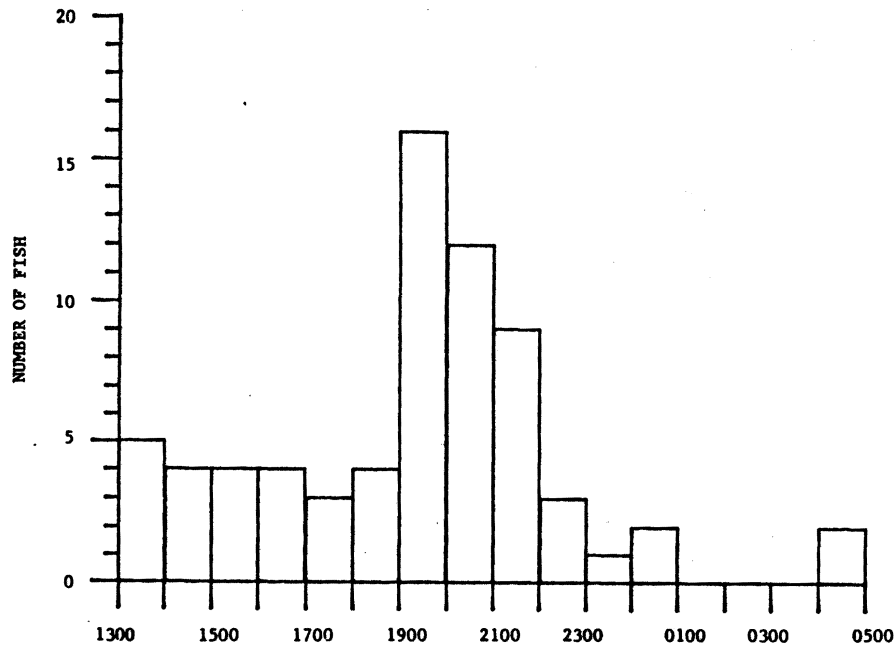
Calculations according to Sokal and Rohlf (1981):

$$-2 \sum_{i=1}^3 \ln p_i = 19.7665$$

level of  
significance:  $0.001 < p < 0.005$

Therefore, reject the null hypothesis.

### ARRIVAL TIMES



### PASSAGE TIMES

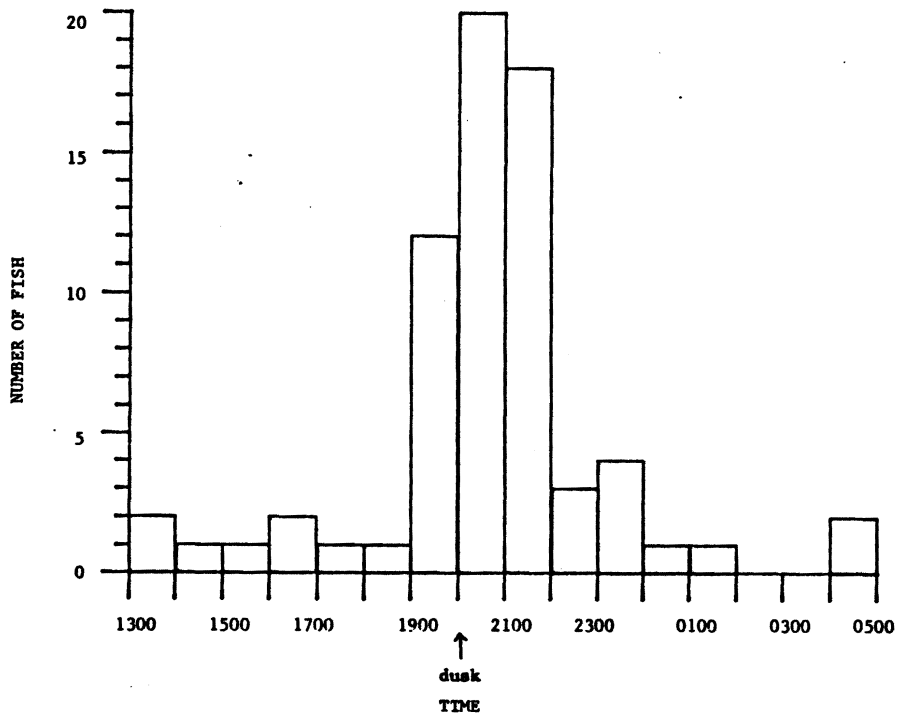


Figure 17.--Arrival and passage times of radio-tagged chinook salmon at John Day Dam, 1984.

## FOREBAY CURRENTS

The flow-net database detailed in Appendix A was used to address three questions: (1) does altering spillbay flow substantially change water velocity or direction in the forebay? (2) is there a relationship between total flow volume through the dam and water velocity at a given position in the forebay? (3) at given flow volumes, what is the pattern of water velocities throughout the forebay?

Addressing these questions required a method of summarizing the raw data available on flow volume, water velocity, and water direction. It was felt that any characterization of these quantities should be made using periods of stable flow conditions at the dam. In addition, the number of such periods must be large enough to allow the detection of meaningful patterns in the data. The following method of extracting data from the database was chosen with the above needs in mind.

A stable flow period was defined as four or more hours in which: (1) the range of flow volume through each of the spill and power orifices was less than or equal to 2.0 kcfs, (2) the range of total spill volume during this time period was less than or equal to 10% of the average spill volume, and (3) the range of total powerhouse volume during this time period was less than or equal to 10% of the average powerhouse volume. To guard against the possibility that the presumed stable period included transitions to other flow regimes, data from the first and last hours were excluded from the analysis.

For each steady state period, the arithmetic means of the hourly water velocities and total flow volumes were calculated. The mean water direction was calculated for each active meter position as in Zar (1984):

$$\bar{A} = \cos^{-1} \frac{X}{\sqrt{X^2 + Y^2}}$$

where  $\bar{a}$  = the mean of the  $n$  hourly angles  $A_i$ ,  $X = \frac{\sum_{i=1}^N \cos(A_i)}{N}$

$Y = \frac{\sum_{i=1}^N \sin(A_i)}{N}$ . However, mean flow volume, water velocity, and water direction were calculated for a given meter only if there were two or more hourly velocities or directions present during the stable period.

#### Current Responses to Changes in Spill Discharge

The response of forebay currents to changes in spill discharges was studied by visually inspecting flow diagrams depicting water velocity and direction at various meter positions in the forebay. Situations were examined in which: (1) two consecutive steady state periods were separated in time by a single change in spill discharge and (2) the spill flow change was either a substantial increase in flow volume or a change from a "coronal" to a "split" configuration of flow through the spillbays. Flow diagrams representing each hour of both steady state periods were then examined to: (1) identify meter positions where a change in velocity or direction occurred following a spill flow change and (2) verify that the change was stable through time. In addition, we determined the elapsed time between the spillbay change and the first meter recording at which the flow change was observed and then remained stable.

Examples presented here are taken on dates when spill fluctuation was abrupt and pronounced, typically changing from 0 to greater than 40% spill within a single hour. Responses in the forebay current system should be at a maximum under these conditions. Changes in current velocity and direction were discernable within an hour of spillway adjustment and were essentially

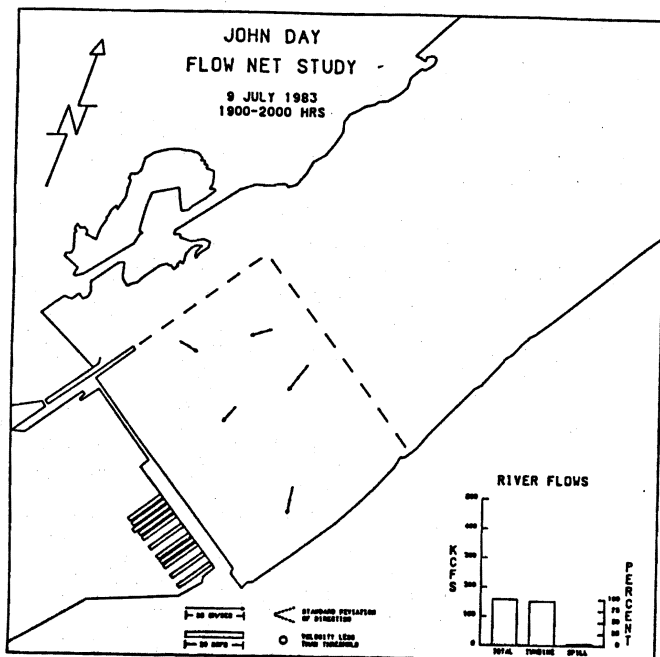
stable within 2 h (Figs. 18 to 21; Table 12). Typically, at low river flows (approximately 100-200 kcfs) spill increases only affected current direction within the restricted zone; appreciable changes in velocity were not observed, e.g., 9 July 1983 and 25 August 1984 (Figs. 18 and 21). In all figures, currents directly in front of the spillway displayed the most noticeable change in direction.

At higher river flows, 300 to 420 kcfs, velocities within the restricted zone do show appreciable response to increasing spill. Within the restricted zone, velocities displayed increases up to 28 cm/sec depending on the proximity to the dam, e.g., 24 May 1984 (Table 13). Areas closer to and immediately upstream from the spillway displayed the most pronounced responses (Figs. 18 to 21). Current velocity upstream from the restricted zone to a distance approximately 1.7 km upstream from the dam changes, increasing by approximately two fold, with elevated spill (~ 40 to 50%) and concomitant increases in flow volume.

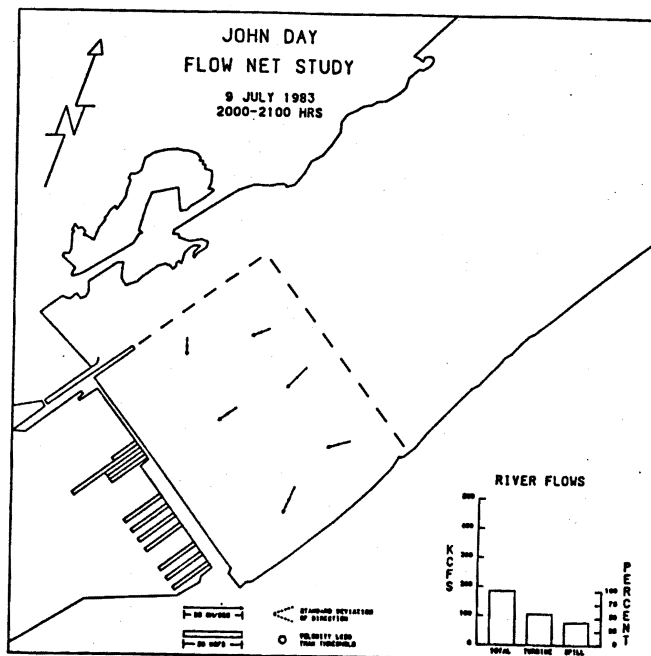
Generally, changing the configuration of flow through the spill gates from a "coronal" to a "split" pattern had no apparent effect on water velocity and direction in the forebay. Three examples presented herein illustrate pronounced alterations in spill configurations with negligible fluctuations observed in the forebay currents (Figs. 22 through 24; Table 12). However, a slight increase in velocity was observed at Station 9 on 1 July 1984 following a configuration change (Table 12) indicating that such changes may influence forebay flow dynamics to some minor degree. It appears that increasing spill flow volume is more effective in modifying forebay flow patterns than changing the spill flow configuration.



A



B



C

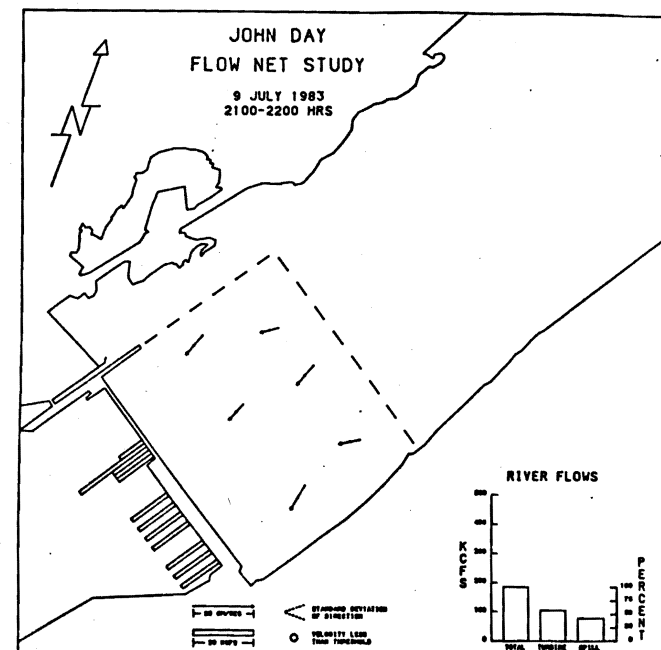
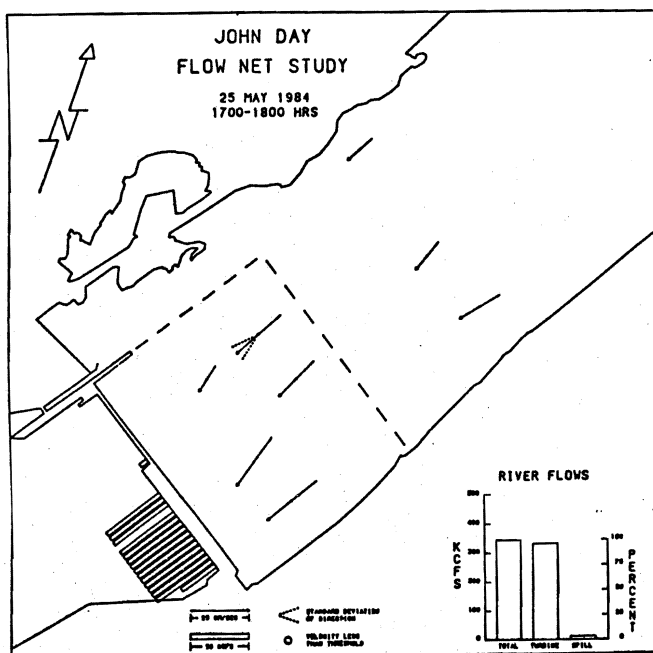


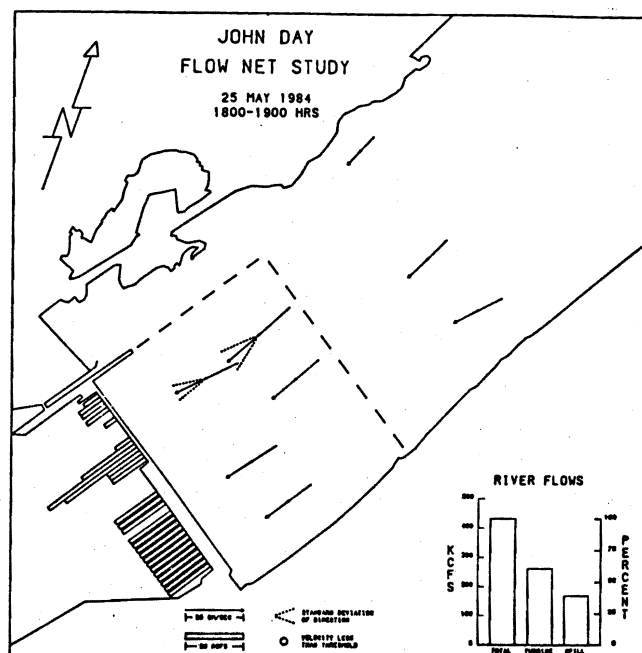
Figure 18.--Responses in forebay currents following changes in spillway discharge volumes, 9 July 1983. Data for plots were taken 50 minutes after the hour. Spillway manipulations occurred on the hour between Plots A and B. Plot C is presented to illustrate the stability of the current patterns approximately 2 h following spillway manipulations. Photo reduction of figures resulted in small legend print, refer to Appendix Figure A1 for a legible legend display. Prior to initiation of spill, river flow was 158 kcfs (A). Following spillgate adjustments, 44% of the river flow (185 kcfs) was passed through the spillway.



A



B



C

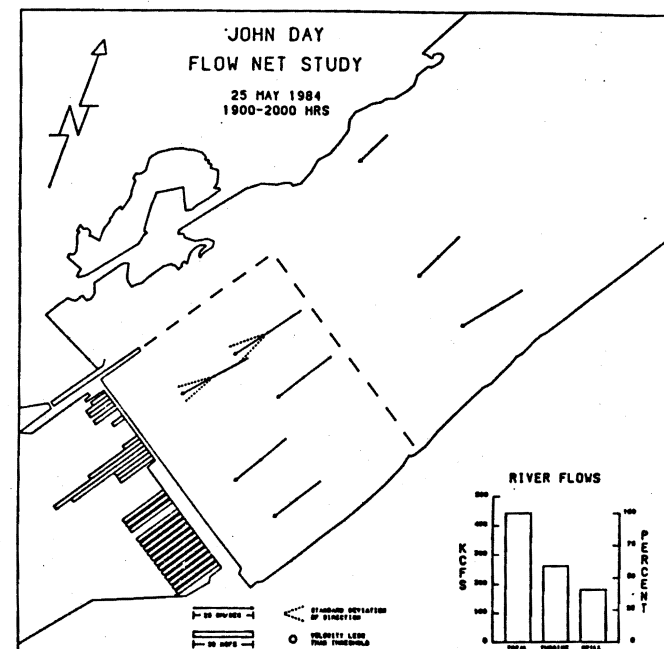


Figure 20.--Response in forebay currents following changes in spillway discharge volumes, 28 May 1984. Data for plots were taken on the half hour. Spillway manipulations occurred on the hour between Plots A and B. Plot C is presented to illustrate the stability of the current patterns 1.5 h following spillway manipulations. Photo reduction of figures resulted in small legend print, refer to Appendix Figure 1A for a legible display. Prior to the initiation of spill, river flow was 345 kcfs (A). Following spillgate adjustments, 40% of the river flow (433 kcfs) was passed through the spillway.

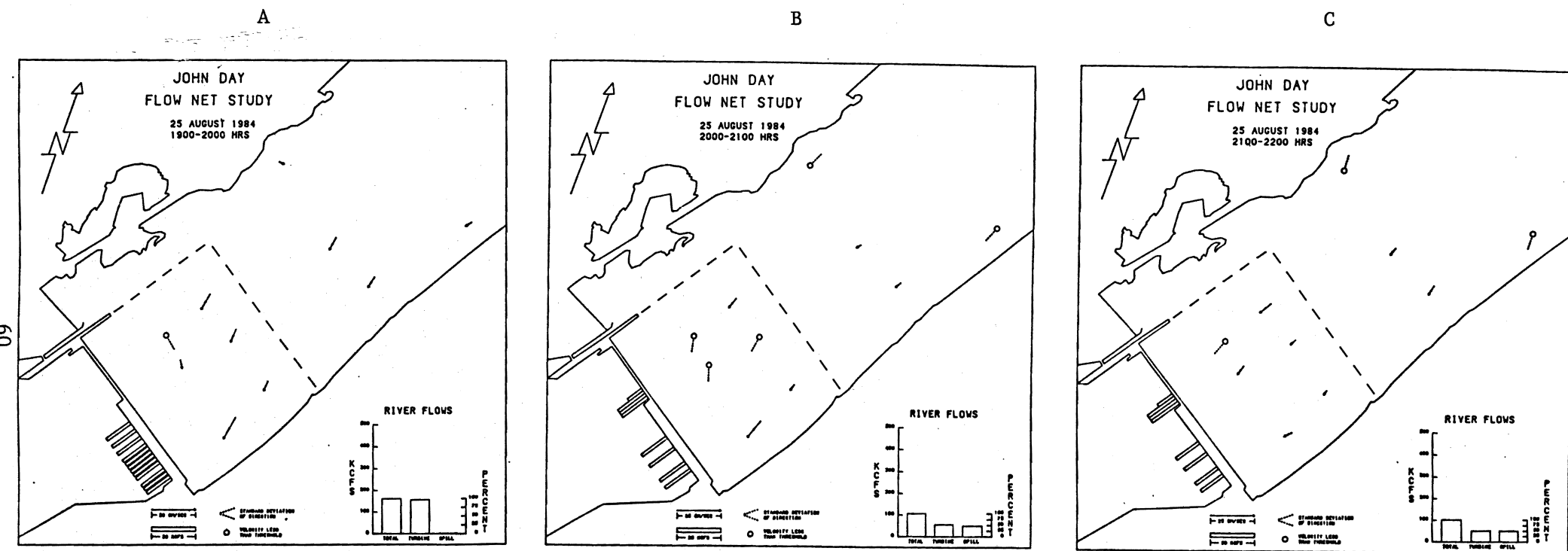


Figure 21.--Response in forebay currents following changes in spillway discharge volumes, 25 August 1984. Data for plots were taken on the half hour. Spillway manipulations occurred on the hour between Plots A and B. Plot C is presented to illustrate the stability of the current patterns 1.5 h following spillway manipulations. Photo reduction of figures resulted in small legend print, refer to Appendix Figure 1A for a legible display. Prior to the initiation of spill, river flow was 163 kcfs (A). Following spillgate adjustments, 49% of the river flow (107 kcfs) was passed through the spillway.

Table 12.--Dates, times, and types of spill flow changes; percent spill; total dam flow before and after spill changes; and time between the spill change and the first meter recording at which a change in water direction or velocity was apparent. Figures for percent spill and total kcfs are from the hour preceding and the hour following the spill change.

Date	Type of <sup>a/</sup> spill change	Time of day of spill change (h)	% spill before change	% spill after change	Total kcfs before change	Total kcfs after change	Minutes to first recorded forebay response
9 Jul 83	I	2000	0	44.1	157.8	185.0	54 <sup>b/</sup>
25 May 84	I	1800	0.9	40.5	344.9	432.5	34 <sup>c/</sup>
28 May 84	I	1800	1.1	41.0	292.7	424.9	34 <sup>c/</sup>
25 Aug 84	I	2000	0	49.2	162.9	106.9	34 <sup>c/</sup>
3 Jun 82	II	2000	36.1	40.8	348.9	356.8	NC
29 Jun 82	II	0900	36.2	36.2	419.8	420.5	NC
1 Jul 84	II	1800	47.2	47.3	377.8	377.2	34 <sup>d/</sup>

<sup>a/</sup> I = increase in spill flow volume; II = spill change from "coronal" to "split" pattern.

<sup>b/</sup> Meter Position 11.

<sup>c/</sup> Meter Position 10.

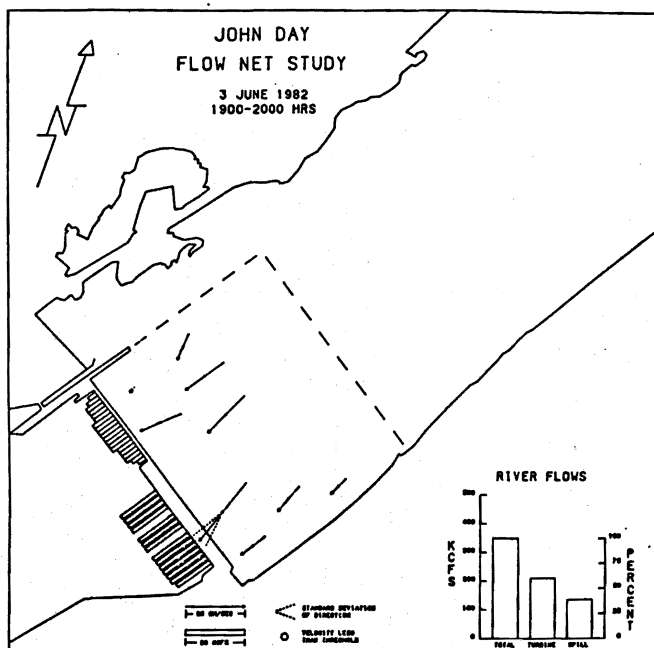
<sup>d/</sup> Meter Position 9.

NC = No apparent change in forebay flow.

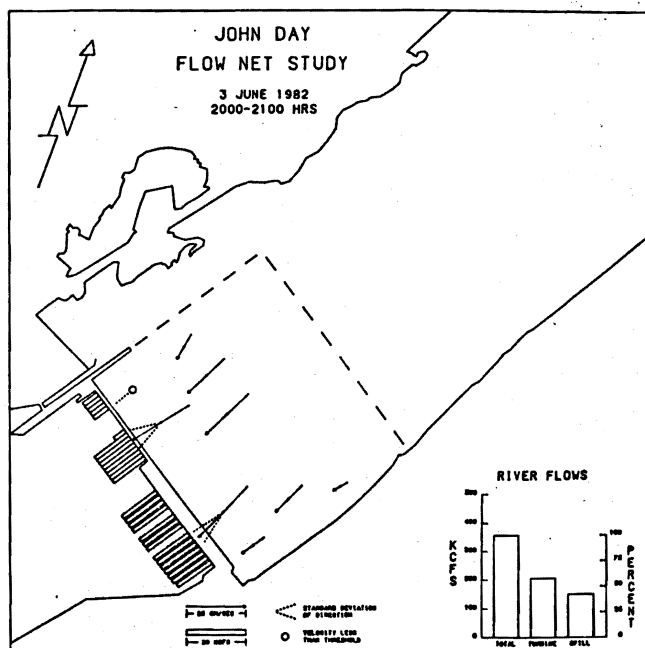
Table 13.--Water directions and velocities ( $\pm$  S.E.) before and after major increases in spill flow at selected meter positions in the forebay. The meter positions chosen are those at which the most pronounced change occurred in direction or velocity. Standard errors are the angular deviation for directions and the standard error of the mean (Zar 1974). The sample size (n) is the number of hours over which data were averaged to yield the direction and velocity estimates.

Date	Meter position	Current conditions					
		Preceding spill flow change			Following spill flow change		
		n(hour)	Direction( $^{\circ}$ )	Velocity( $\frac{\text{cm}}{\text{sec}}$ )	n(hours)	Direction( $^{\circ}$ )	Velocity( $\frac{\text{cm}}{\text{sec}}$ )
9 Jul 83	11	5	77.8 $\pm$ 5.7	9.0 $\pm$ 1.2	4	170.0 $\pm$ 7.4	7.5 $\pm$ 0.7
24 May 84	10	6	120.5 $\pm$ 11.1	3.8 $\pm$ 1.0	4	213.1 $\pm$ 1.4	30.8 $\pm$ 1.1
25 May 84	10	11	193.1 $\pm$ 7.6	12.5 $\pm$ 1.8	6	218.0 $\pm$ 2.5	32.3 $\pm$ 0.5
28 May 84	10	6	176.6 $\pm$ 11.2	8.5 $\pm$ 1.3	5	215.9 $\pm$ 3.6	35.2 $\pm$ 1.7
25 Aug 84	10	3	150.9 $\pm$ 30.7	1.7 $\pm$ 1.7	8	194.0 $\pm$ 15.0	0.6 $\pm$ 0.3

A



B



C

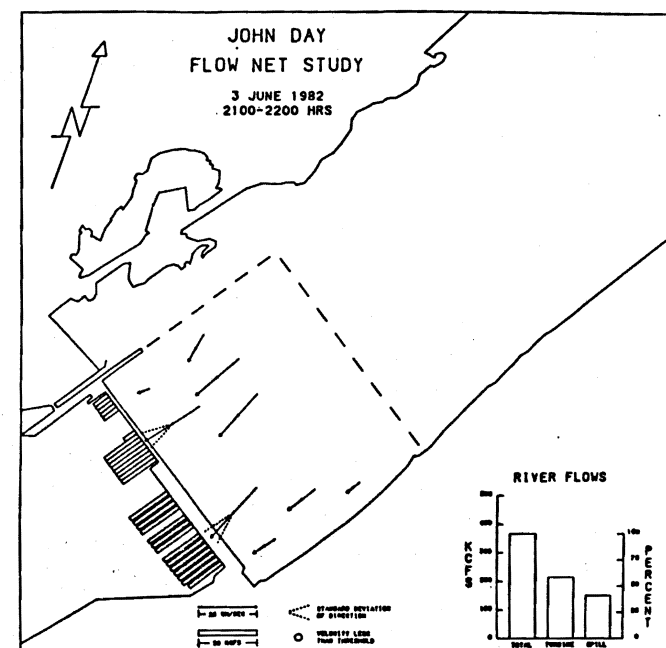


Figure 22.--Response in forebay currents following changes in spillway configuration, 3 June 1982. Data for plots were taken on the half hour. Spillway manipulations occurred on the hour between Plots A and B. Plot C is presented to illustrate the stability of the current patterns 1.5 h following spillway manipulations. Photo reduction of figures resulted in small legend print, refer to Appendix Figure 1A for a legible display. River flow ranged from 349 to 357 kcfs, with approximately 38% of the water being spilled.





A

B

C

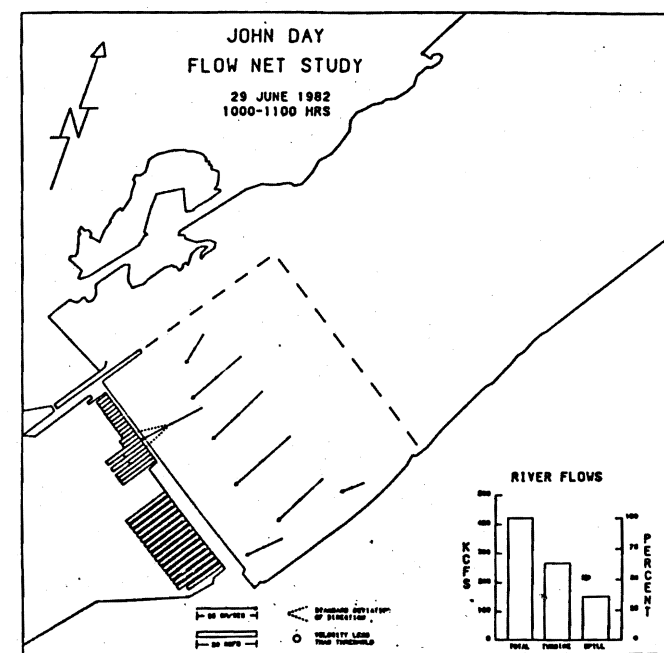
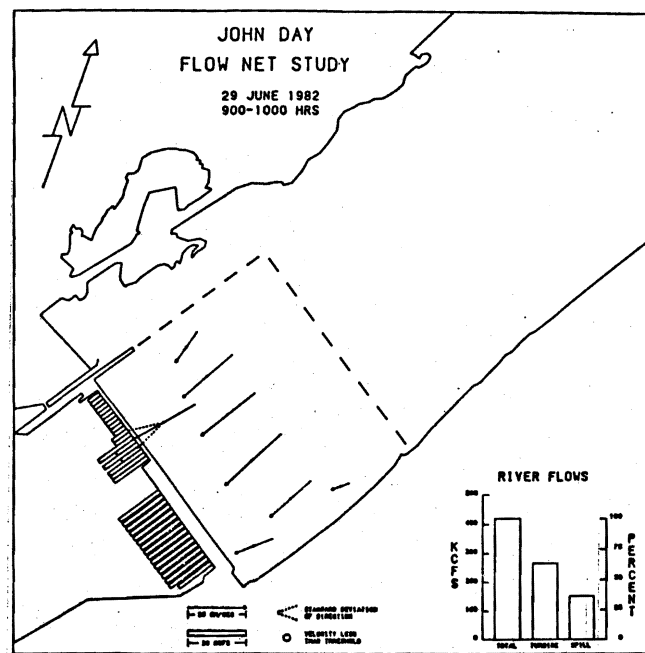
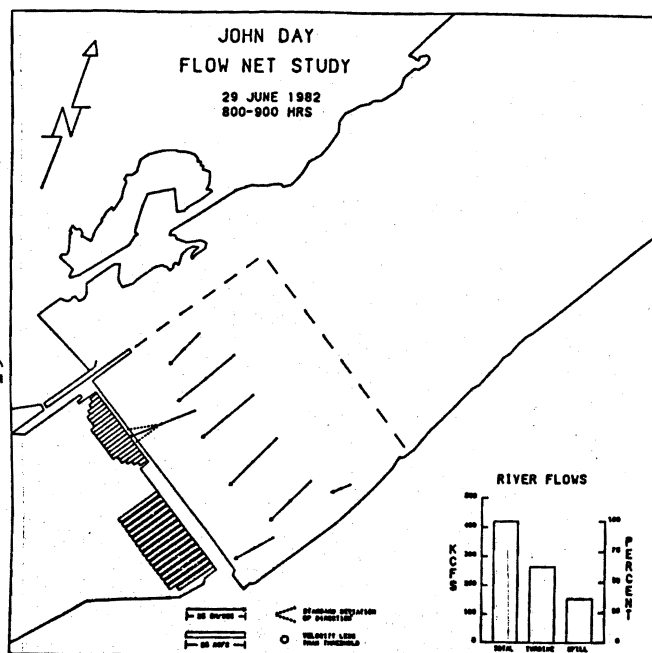


Figure 24.--Responses in forebay currents following changes in spillway configuration, 29 June 1982. Data for plots were taken on the half hour. Spillway manipulation occurred on the hour between Plots A and B. Plot C is presented to illustrate the stability of the current patterns 1.5 h following spillway manipulation. Photo reduction of figures resulted in small legend print, refer to Appendix Figure 1A for a legible display. River flow was 420 kcfs with 36% of the water being spilled.

### Relationship Between River Flow Volume and Forebay Water Velocity

Data from two meter stations for the years 1983 and 1984 were analyzed to examine the relationship between water velocity and total water flow volume through the dam. Positions 17 and 18 are approximately 1.7 km above the dam; the former near midstream and the latter near the Washington shore.

A plot of water velocity vs river flow volume at Position 17 is presented in Figure 25. Velocity increases with increasing flow volume, with the rate of increase most pronounced at higher flow levels. The plotted curve and given numerical relationship are based on a least-squares fit as in Zar (1981). A quadratic equation was fit to the data because the linear fit underestimated velocity at low and high flow levels. Predicted velocities ranged from 3.2 cm/sec at 100 kcfs to 29.3 cm/sec at 460 kcfs.

Figure 26 shows a similar plot for Position 18. The plotted relationship also displays a quadratic increase in velocity with increasing flow. At 100 kcfs, predicted velocities were 4.3 cm/sec, faster than observed at mid-reservoir. However, at high flows of 460 kcfs, water velocity was only 14.8 cm/sec, about one half the speed observed at mid-reservoir. This disparity between mid-reservoir and near shore velocities was also observed at other meter positions. These observations are consistent with principles of open-channel hydraulics. Water velocities typically attenuate with decreasing distance from both the shoreline and bottom of the reservoir (French, 1985; p. 29-37).

### Water Velocities Throughout the Forebay

Figures 27 to 30 show water velocities at all meter positions throughout the forebay for different river flow levels. The data used to produce these figures were obtained as follows: At each meter position velocities were

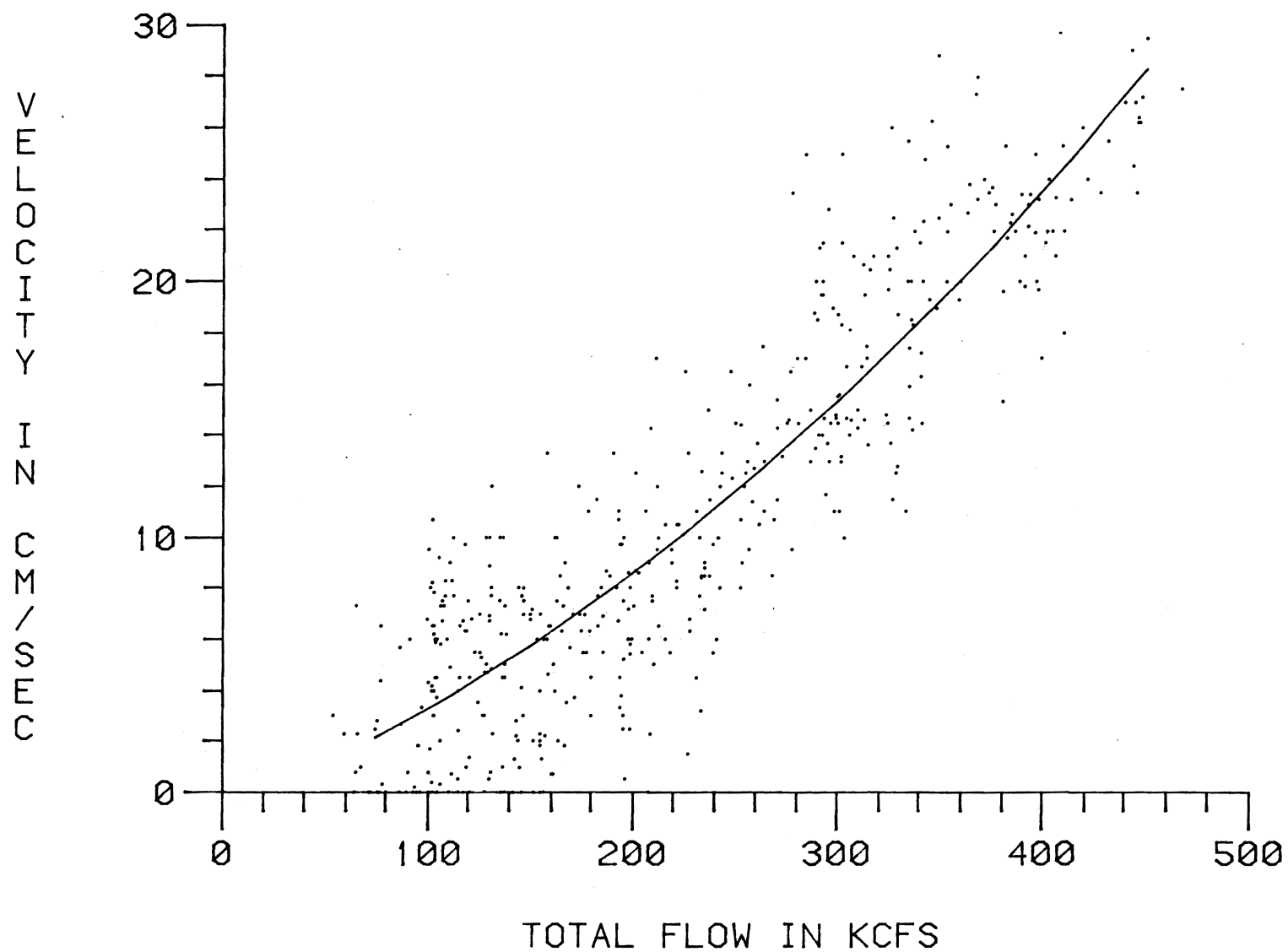


Figure 25.--Plot of water velocity vs river flow at Meter Position 17. The plotted curve is  $Y = 0.61 + 0.031 X + 0.00007 X^2$ .

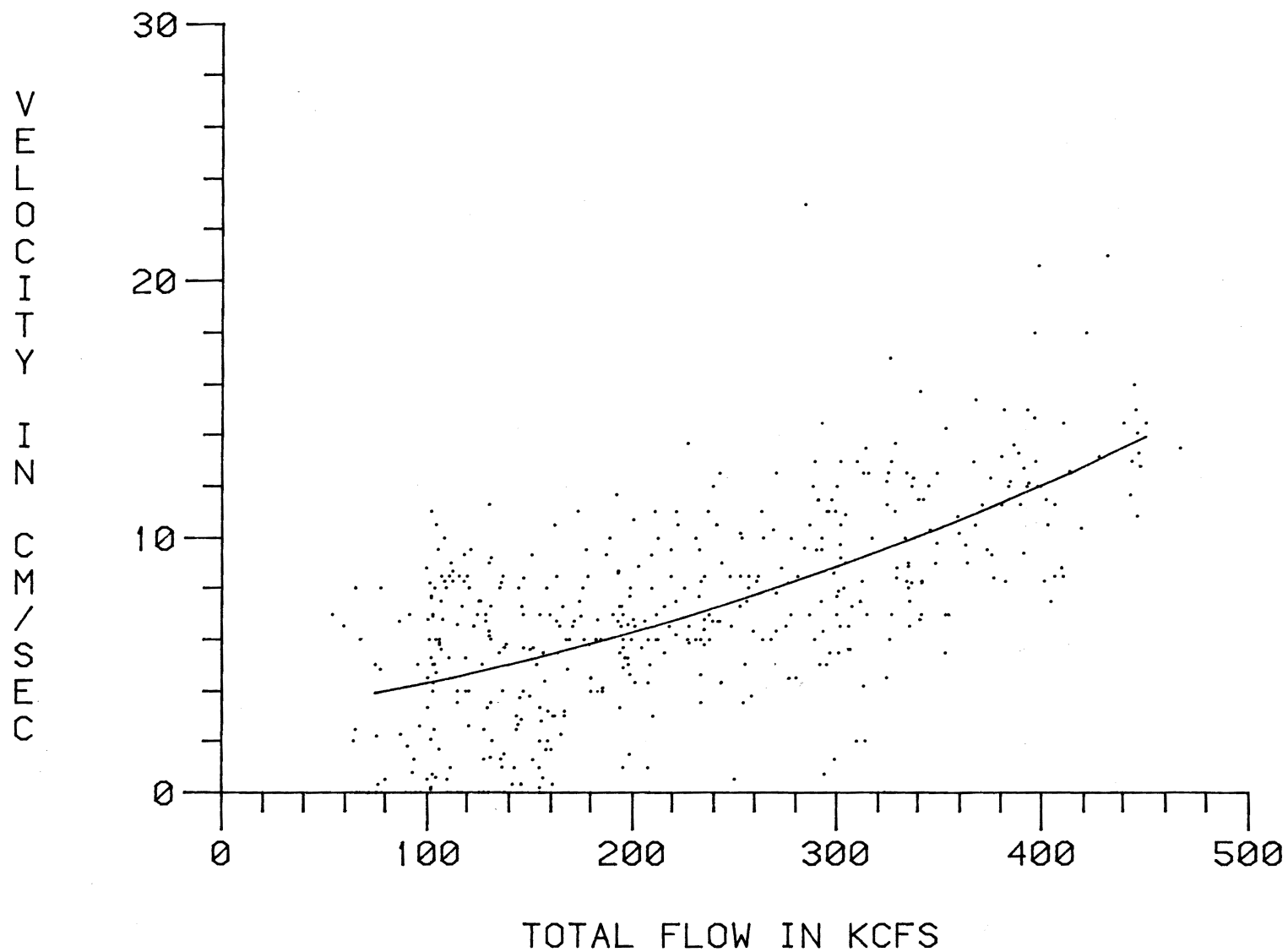


Figure 26.--Plot of water velocity vs river flow at Meter Position 18. The plotted curve is  $Y = 0.30 + 0.010 X + 0.00003 X^2$ .

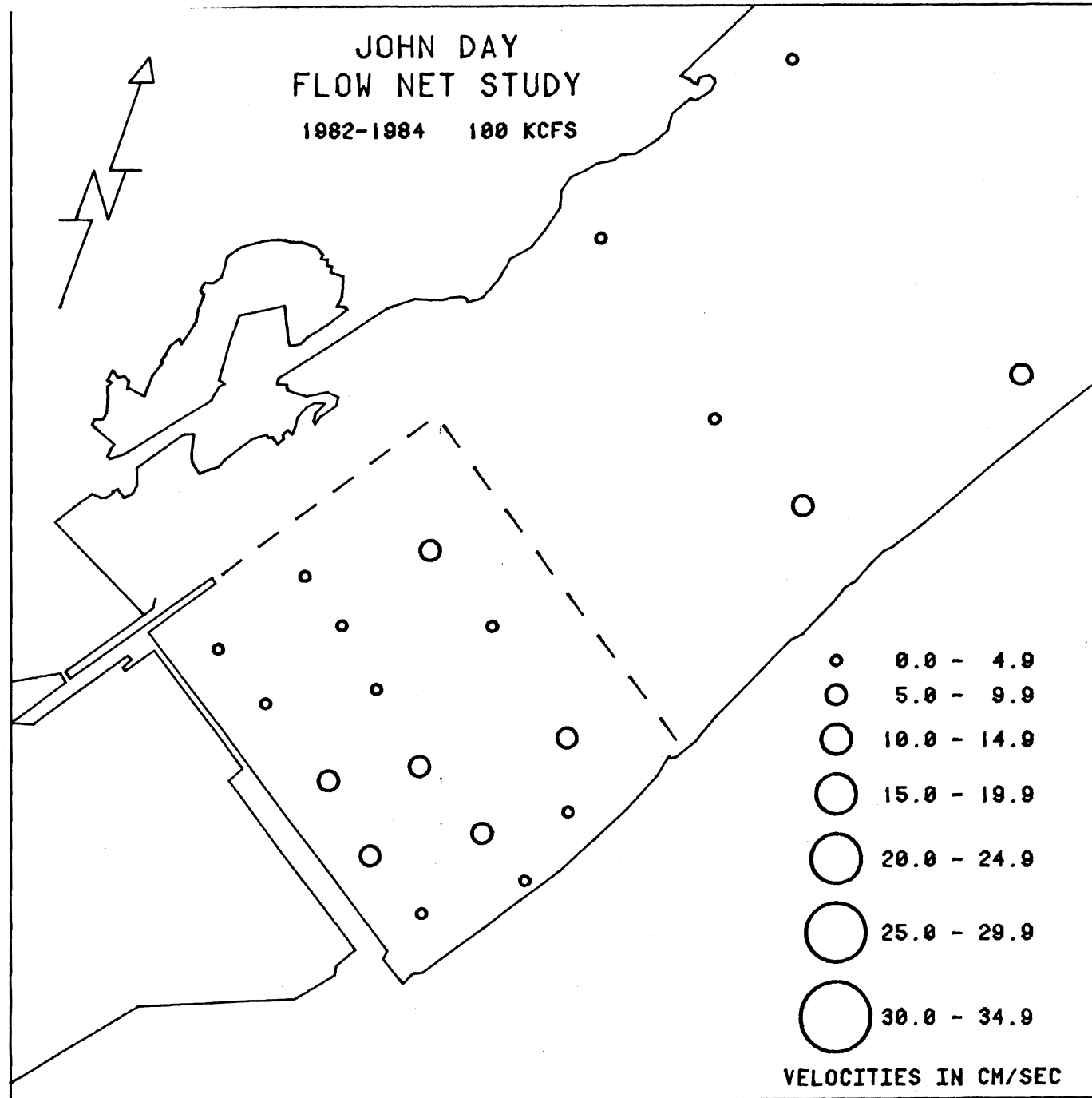


Figure 27.--Prevailing current velocities in the forebay when the river flow ranges from 50 to 149 kcfs; nominal flow = 100 kcfs.

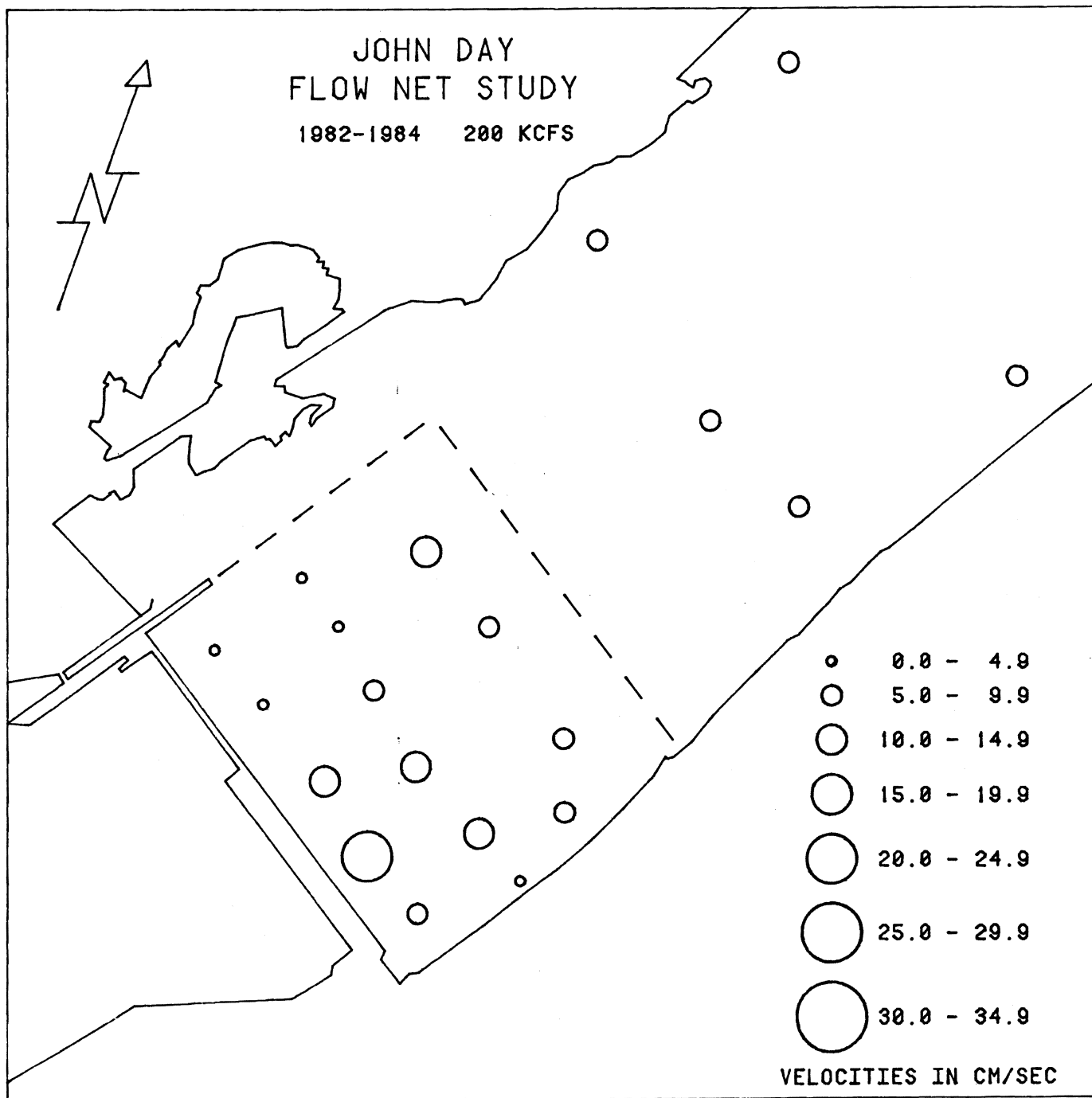


Figure 28.--Prevailing current velocities in the forebay when the river flow ranges from 150 to 249 kcfs; nominal flow = 200 kcfs.

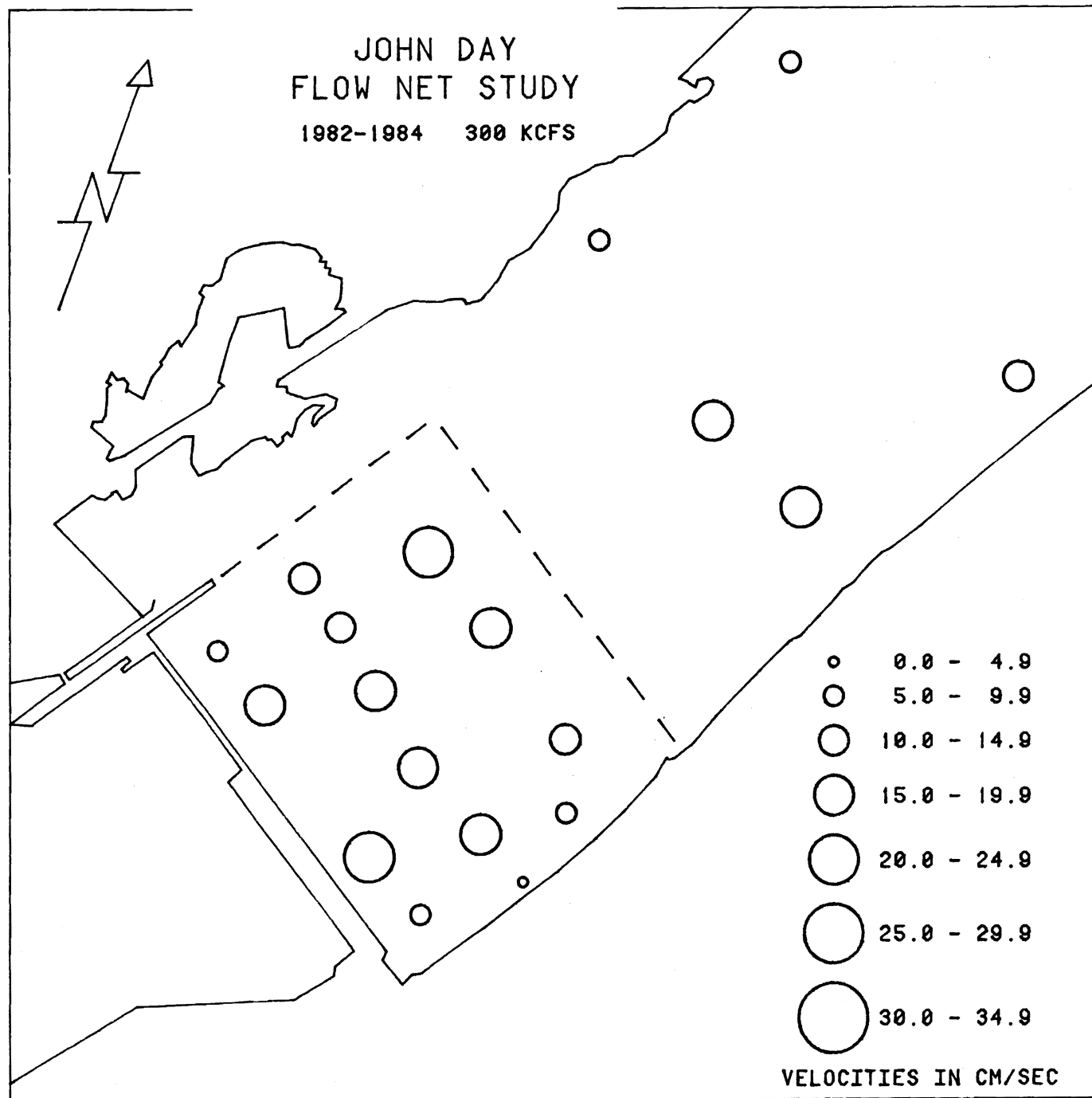


Figure 29.--Prevailing current velocities in the forebay when the river flow ranges from 250 to 349 kcfs; nominal flow = 300 kcfs.

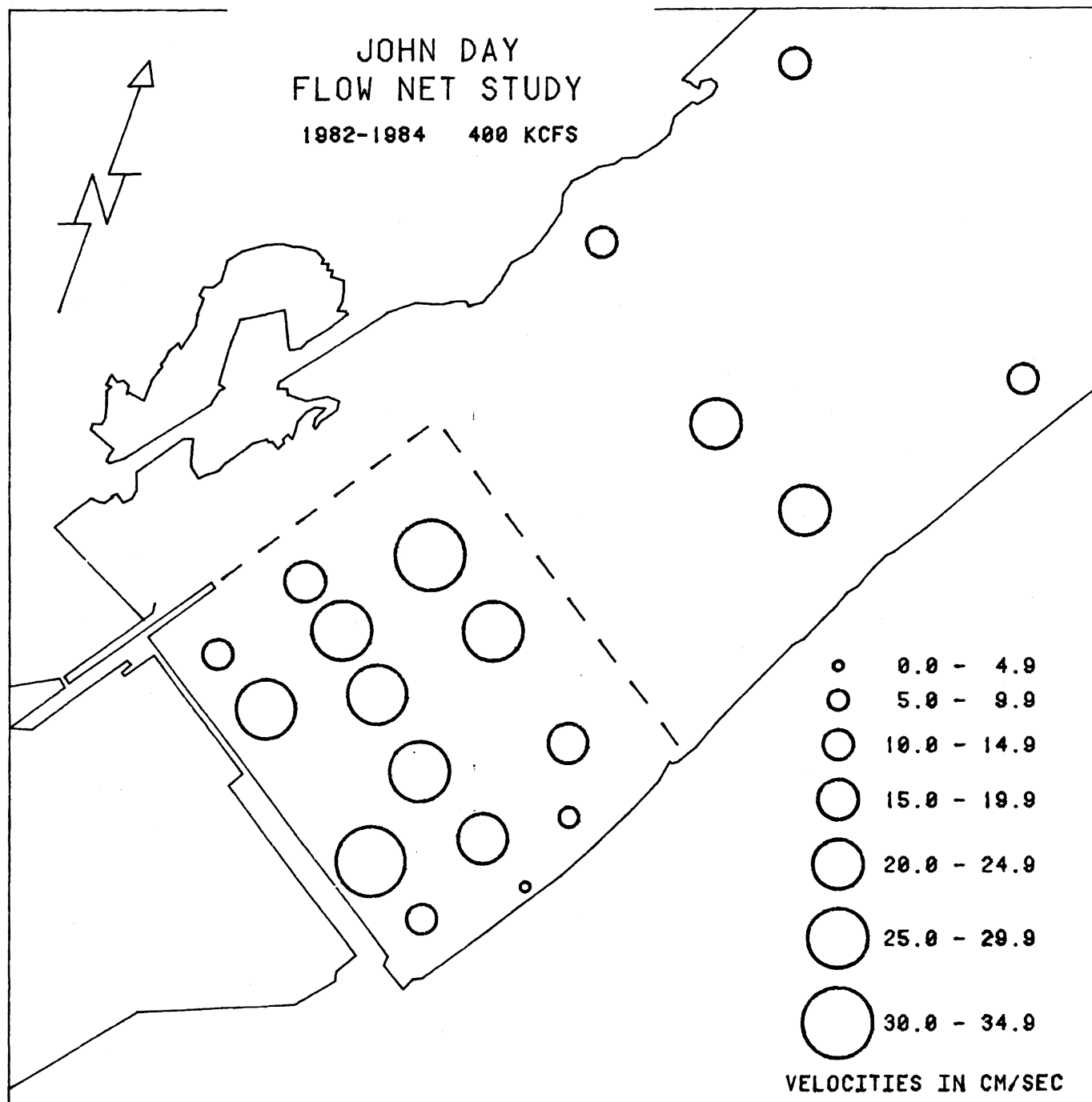


Figure 30.--Prevailing current velocities in the forebay when the river flow ranges from 350 to 449 kcfs; nominal flow = 400 kcfs.



identified corresponding to flows of 50-150, 150-250, 250-350, and 350-450 kcfs (labeled "100," "200," "300," and "400" kcfs, respectively). For each meter position/flow category velocities were pooled over all 3 years and the mean velocity calculated. Each mean velocity was represented for plotting purposes as a circle whose diameter indicated one of seven velocity ranges (0.0-4.9, 5.0-9.9, ..., 30.0-34.9 cm/sec).

Pooling data across years was based on the assumption that the overall flow pattern in the forebay at a given flow level did not vary substantially between years; the assumption is reasonable. At meter positions for which more than 1 year of data was available, there was at most a 6.6-cm/sec difference in mean velocities between years. The plotted circle size would have been the same or differed by one diameter gradation from year to year, and the resulting plotted flow pattern for any single year would not have varied substantially from those in Figures 27 to 30. At meter positions represented by 1 year of data only, the above assumption could not be examined. Because of the year to year similarity observed at other meter positions, though, we believe that velocities at the 1-year positions were representative of the overall flow patterns in the forebay. Appendix Table A1 lists mean velocities at each meter position by flow category for the 3 years separately and pooled.

At low river flow volumes near 100 and 200 kcfs, the highest current velocities occurred primarily in front of the powerhouse. This pattern reflects the fact that spill discharge is low or absent during period of low flow. As river flows increase, current velocities increase until they are nearly uniform throughout most of the forebay (Figs. 29 and 30), since water is discharged through both the spillway and powerhouse when flows are high. Examination of Figures 27 thru 30 also reveal that current velocities are

typically faster closer to the dam. However, there are some exceptions to these general trends. Nearshore stations consistently exhibited lower velocities than those situated away from the shoreline, particularly Stations 1, 6, 12, 18, and 20 (Figs. 1, 29, and 30). It is possible that the bathymetry of the river bottom plays a role in these forebay current patterns. For example, the shallow shelf under Meter 11 (Fig. 31) appears to deflect the bulk of the flow away from Meter 5 immediately downstream, partially accounting for the latter's lower observed velocities relative to velocities at nearby Meter Stations 4, 10, and 11 (Figs. 29 and 30). A further illustration of potential bathymetric effects is apparent at low flows (Figs. 27 and 28). Under these conditions the highest velocities within the restricted zone occurred at stations situated in the deeper channels of the reservoir (Fig. 31). It may be that these channels concentrated flows in specific areas, particularly at low flows.

#### DISCUSSION

As downstream migrants in the mainstem Columbia River approach John Day Dam they alter their migration routes upon intercepting the turbid plume discharged from the John Day River. Purse seine data demonstrated that in the vicinity of and on the Oregon side of the river downstream from the John Day River, salmonid emigrants were concentrated toward the Washington side of the river in the clearer waters of the mainstem Columbia River. However, at the upstream transect, above the mouth of the John Day River, emigrants were more evenly distributed across the Columbia River. This pattern was observed for all species but to a somewhat lesser degree for steelhead.

The observed distribution patterns were in response to the intrusion of the turbid warm water emanating from the John Day River. For all species,

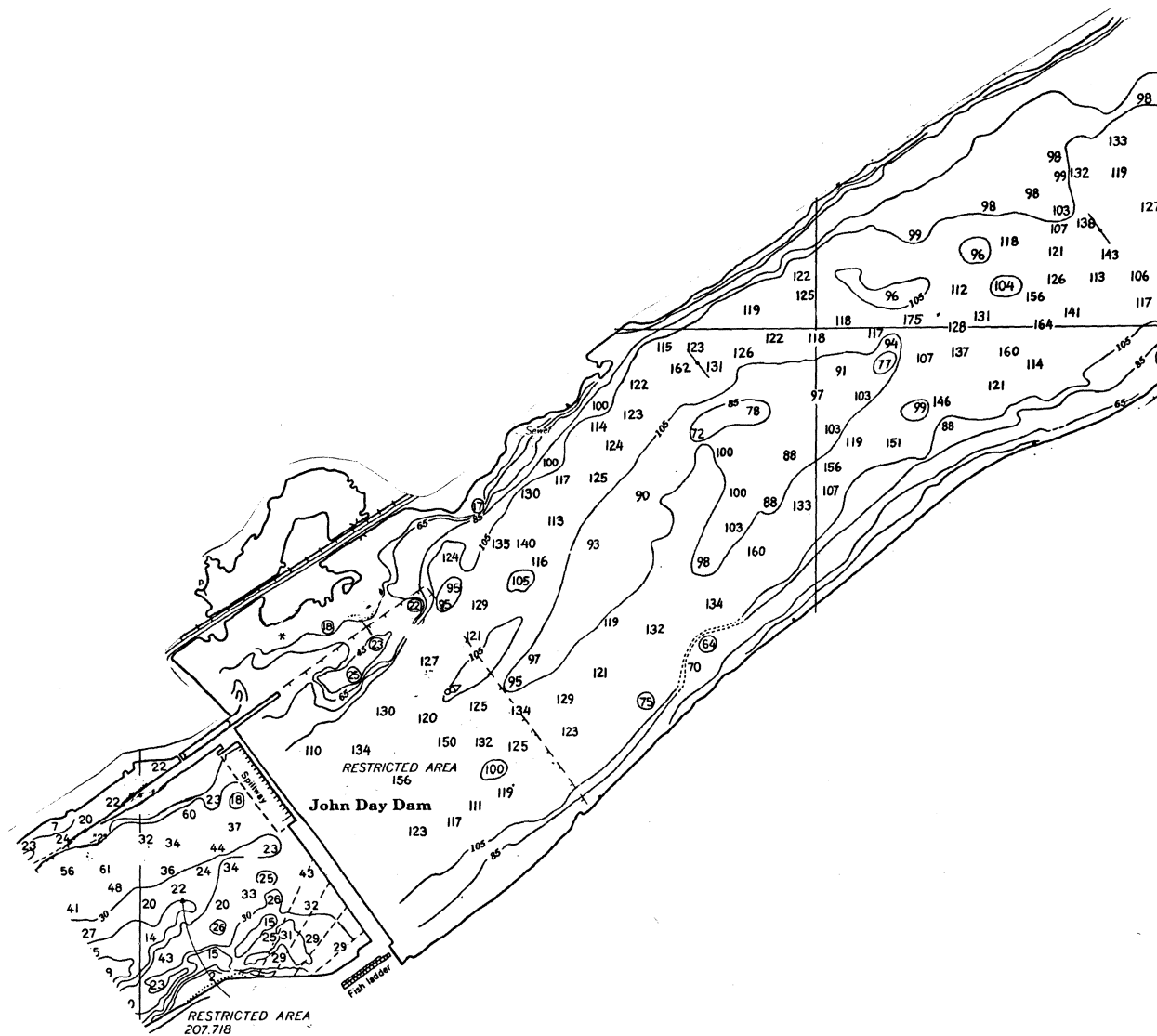


Figure 31.--Bottom contours of the John Day Dam forebay.

fish abundance was significantly correlated with water clarity, i.e., fish were concentrated in the clearest waters associated with the mainstem Columbia River and were rarely caught within the turbid plume. Radio telemetry studies of yearling chinook salmon corroborate purse seine observations. In 1983, nine of eleven fish, which intercepted the plume during their emigration, were tracked along the upstream demarcation of the plume toward the Washington shore. In 1984, when group release methodology was employed, random searches were conducted in the forebay following releases of radio-tagged yearling chinook salmon. Again, fish were observed primarily in the clear water associated with the mainstem Columbia River; only 1 of 67 detections occurred in water which could be visually classified as the turbid plume of John Day River.

The overall result of the shift in distribution across the forebay was that juvenile salmon (and steelhead to a lesser degree) are shunted to the Washington side of the reservoir where the spillway is situated, predisposing the smolts to passage over the spillway by virtue of their lateral location upon approach. The radio telemetry study using group releases demonstrated that fish were detected passing over the spillway at a rate significantly greater ( $p < 0.005$ ) than the proportion of the river being spilled. At spill levels averaging 42%, 72% of the radio-tagged fish were detected passing over the spillway. However, the passage estimate stated above applies only to those fish which arrived at and passed the dam at night while spill was provided. Most fish which arrived during the day delay their passage until nightfall (Fig. 17). These fish have an opportunity to distribute themselves in front of the powerhouse and would not be attracted to the spillway. Since the proportion of the population represented by each of the groups is not known, overall spill effectiveness at John Day Dam cannot be ascertained.

Similar findings on unmarked fish were reported by Sims et al. (1976). Such diel passage patterns are not peculiar to John Day Dam. Long (1968) observed similar diel passage patterns at McNary Dam.

An average of 79% of all tagged fish released as groups were detected at the dam; part of the nondetection is attributable to fish loss, failure to migrate, tag regurgitation, and mechanical failures or limitations of the electronic equipment. Variations in transmitter signal strength and the depth of the transmitter in the water column affect detectability. With the monitor gain settings employed at John Day Dam, fish deeper than 10 m could not be detected. In the context of this paper, the passage location as identified with radio telemetry is defined as the location at which the last signal reading was recorded. Thus it is possible that some fish could, at the site of last detection sound below 10 m, traverse the face of the dam and exit at some other location.

We are aware of these limitations, and our electronics group is confident that the development of new antenna/monitor systems will improve tag detectability and more accurately identify exact passage locations. However, gear development is an empirical process. The design, construction, field test, and evaluation procedure may have to be repeated several years before satisfactory results are attained and the true capabilities of the devices are identified. This process was initiated in FY85 at Lower Granite Dam under a BPA funded project. In addition to evaluating spill effectiveness, this application of radio telemetry may also be useful in providing other estimates such as collection efficiency, fish guidance efficiency, and system residence time, if certain assumptions can be met or accommodated.

In the Snake and Columbia River system, salmonid outmigrants are surface oriented residing primarily in the top 5 to 8 m of the water column. Vertical profiles of turbidity and temperatures illustrate that the warm turbid discharge of the John Day River floats across the top of the dense Columbia River waters and predominates the surface waters at the midstream and downstream transects (Figs. 6 and 7). Consequently, the majority of emigrants directly intercept this turbid plume. It is uncertain as to whether outmigrants are intentionally avoiding this foreign water mass or if they are being physically swept across the reservoir by the John Day River discharge. It is apparent that at times the John Day River discharge is forceful enough to project across the entire reservoir to the Washington shore (Fig. 3). It is possible that the surface oriented migrants get entrained in the plume and are passively transported across the reservoir. Those deeper in the water column or the larger, stronger swimmer may not be so affected. There is evidence to support this position; steelhead, the largest of the emigrant species, display the weakest correlation between abundance and water density.

Alternatively, the response may be actual avoidance. Gammon (1970) found that certain warm water species tended to avoid turbid water associated with lime stone quarry operations. Smith (1940) observed that adult chinook salmon in the Yuba River avoided turbid silt laden streams and concentrated in clear tributaries. Whether juveniles react similarly was not addressed. Although it is impossible to identify the actual effect, it is quite clear that water turbidity is the best index of the John Day River's impact. Whether or not fish would respond to current patterns if the turbidity was not present is uncertain. At another dam where extraneous effectors are not present,

currents may play an important role in governing the distribution and migration routes of outmigrants. At the onset of this study we had no inclination that the tributary could have such a pronounced effect on migratory behavior. There may be other as yet undetected effectors which radically alter migratory behavior at other dam sites.

The original objective of this project was to define the relationship between both smolt migration patterns and passage location and the forebay currents as they might be affected by dam operations. Reasonably, it was postulated that changes in the spillway discharge level could affect the intensity of the currents in the forebay. Elevated spill could presumably produce faster currents in front of the spillway for some distance upstream to attract migrants and direct them over the spillway (generally thought to be the safest passage conduit). At least at John Day Dam the evidence does not support this premise because for no species observed was fish abundance across either the midstream and downstream transects correlated with increased water velocity (Tables 5, 6, and 7).

In the course of this investigation, we have developed a program system which cartographically displays the prevailing current patterns in the forebay and dam operations data for any hourly interval for which there are data. The system is portable, i.e., similar plots can be generated for any dam site where there is an interest in assessing current patterns under specified modes of dam operation and river flow.

#### SUMMARY

During 1982 through 1984, research was conducted to define the migration of downstream migrant juvenile salmonids in the forebay of John Day Dam and to

assess them in relation to current velocities, water turbidity, and temperature. To accomplish this, we monitored current velocities at fixed positions in the forebay during the outmigrations and collected physical limnological data describing turbidity and temperature patterns in the forebay. Fish distribution patterns and migration routes were identified using both purse seine sampling and radio telemetry techniques. Major findings included:

1. There is no evidence to suggest that juvenile salmonids approaching John Day Dam alter their migration routes in response to current patterns in the forebay.

2. All juvenile salmonids species observed alter their distribution across the forebay as they approach the dam. Upon intercepting the foreign novel water mass discharged from the John Day River, they either avoid the plume or are entrained in it and swept toward the Washington shore.

3. Radio telemetry studies of yearling chinook salmon corroborate the purse seine results; 82% of radio tracked fish followed the demarcation of the plume toward the Washington shore. Less than 2% of radio-tagged chinook salmon were detected in water that could be visually identified as the turbid plume.

4. Juvenile outmigrants are predisposed to spill passage by virtue of their lateral distribution across the forebay. Fish are concentrated on the Washington side of the river where the spillway is situated.

5. Radio-telemetry studies demonstrated that yearling chinook salmon which arrive at the dam at night when spill was provided were detected at the spillway at a rate significantly in excess of the percentage of the river flow being discharged over the spillway (42% spill; 74% passage over the spillway).



6. Radio-tagged chinook salmon displayed a similar night passage pattern as unmarked fish at John Day Dam. Typically, fish arriving during daylight hours delayed passage until nightfall. Fish arriving at night pass the dam with little delay.

7. The John Day River discharges a warm, turbid plume which floats on top of the cooler, denser Columbia River. At times, the plume can project across to the Washington shore.

8. The program system developed for this study which cartographically displays forebay current patterns at prevailing river conditions and dam operations can be utilized in investigations at other dam sites.

9. Extreme variations in dam operations cause only slight perturbations in forebay current patterns. Current perturbations were apparent within an hour and stabilized within 2 h.

10. Changing the configuration of water flowing through the spill gates from a "coronal" to a "split" pattern may influence forebay flow dynamics, but apparently less predictably than substantially increasing spill flow.

11. At two upstream meter positions there was a quadratic increase in water velocity with total dam flow. The rate of quadratic increase and the average velocity at a given total flow were greater at the midstream position than at the position near shore.

## CONCLUSIONS

1. There is no evidence that fish migration routes and their ultimate passage locations can be manipulated by changing dam operations at John Day Dam. Fish do, however, tend to migrate down the Washington side of the river, the side on which the spillway is situated, in response to the John Day River plume and are more prone to spillway passage.

2. The radio telemetry group release methodology employed in this study is a feasible means to evaluate spill effectiveness at other damsites.

3. With respect to their migration patterns, radio-tagged yearling chinook salmon are representative of the general population. In the forebay, tagged fish were detected in the same areas where purse seine sampling indicated fish were concentrated. Furthermore, the diel passage patterns witnessed for radio-tagged fish are consistent with similar observations made in other investigations.

4. When the turbid John Day River plume extends into the forebay, juvenile salmonids are predisposed to spill passage by virtue of their lateral distribution across the forebay. Fish are generally concentrated on the Washington side of the river where the spillway is situated. This was only demonstrated for fish which arrive at the dam at night. Fish arriving during daylight hours are reluctant to pass the dam until nightfall and have the opportunity to redistribute themselves before passing the facility.

## ACKNOWLEDGMENTS

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We thank the personnel at the National Marine Fisheries Service field station at Rufus, Oregon, who provided support and assistance crucial to the execution of this project, especially Dean Brege, Richard Johnsen, and Dennis Umphres. Jane Ramonda-Powell, David Brastow, and Jay Wilson performed data processing, programming, and statistical analyses. Chuck Bartlett, John Govig, and Mark Kaminski provided the design, construction, and maintenance of all electronic equipment employed during the study. Susan Ferriby and Laurie Barber meticulously typed and edited the report.

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## APPENDIX A

### Program Documentation for Current Meter Management and Display

## DATA COLLECTION AND EDITING

### Columbia River Operations and Hydronet Management System

Dam operation and river flow data are collected by the U.S. Army Corps of Engineers (CofE), transferred to their computer facility in Portland, Oregon, and then edited and archived.

We requested that each week a file of their data be created and transmitted electronically to the Seattle CofE office where a data tape was written. We would then pick up the tape and load the data onto our Burroughs computer using a WFL job. Using either another job or CANDE (editor) program, the weekly data would be appended to the yearly file.

Even though the data we obtained were edited, we found that it contained too many errors. An editing program was therefore written that would check for both blatant errors and data that were unreasonable. The output from this program was a report which we followed to make necessary changes to the data with CANDE.

### Individual Turbine Data

Data on the complete status of all the turbines were kept by the operations staff at the dam on a paper listing. This was then picked up by one of our personnel and entered onto a cassette tape using a Datacorder data entry device. The tape was then mailed to the Montlake facility where it was loaded onto the Burroughs system.

Once again a program was needed to both edit and convert the data into average hourly flows. This program produced an editing report so that errors in the data could be isolated and corrected. The corrections were accomplished using CANDE.

### Individual Spill Data

The spill data were collected and processed in exactly the same manner as the individual turbine data. The programs to convert and display the data are different in detail only.

### River Current Data

River flow data from each of the battery of current meters were internally recorded on a cassette tape. These tapes were changed every 4 to 6 weeks, and they were brought to the Montlake facility and entered on the Burroughs computer using a special tape reader and an entry program.

The program CURRENT/METER/EDITOR was written to verify, correct, or to flag portions of the data that could not be rendered intelligible. The program produces a report showing the corrections made and the reasons for rejection of bad data.

In FY83, the current meters were electronically modified to produce a timestamp on the tape. The editing program was rewritten to use this timestamp as part of the verification process.

Any corrections that the data needed could be made using CANDE; or a special editing program called MANUAL/EDITOR could be used. This program was designed to expedite the manipulation of the five record data groups.

The editing program also performed the tasks of units conversion (directions to degrees magnetic, velocities to centimeters per second), inserting dummy records for corrupt or missing data groups and, if there were no fatal errors, the creation of an edited data file where each record included a timestamp detailing the day and hour associated with the data.



## ACCESS AND BACKUP OF DATA FILES

Data files are kept on hard disk for program access. Several times during the year backup tapes were made of the data to ensure the retention of the data in case of accident or error. Until that time, the cassette tapes served as backup for the data that came to us on that medium. The automatic tape backup provided on a daily basis by the operations staff for the Burroughs user community sufficed to protect against loss of the CROHMS data.

## DEPICTION OF DISCRETE DATA FILES

Two programs have been written to display the CROHMS data and several ratios of the data items. The first program is titled PRINT/HOURLY/FLOWDATA/PROGRAM and is used to print out all the hourly data for a given date or range of dates. The second program is the PRINT/DAILY/FLOWDATA/PROGRAM and is used to print the averaged data for a range of hours on successive days.

Programs were written that used the edited turbine data and spill data files. One of these lists data for selected date ranges to a report and/or to another disk file. The other examines the data for periods of a steady state condition, that is, where there are no changes in any of the flows or dam operations for three or more hours.

To get a preliminary assessment of the utility of the data being gathered by the current meters, a program was written that actually used two components of the data system. The CURRENT/METER/PROGRAM averages the meter data specified on an hourly basis, combines this with the CROHMS data, and prints a report that shows all the data for each hour and for the first time presents the meter data graphically.

## MERGING THE DATA

All of the data had to be converted to a common time base. Since the CROHMS data could not have a better resolution than an hourly interval, it was decided to convert all the data to this time base.

The turbine and spill data files were already converted by their editing programs.

The current meter data files were all run through a program called the CURRENT/METER/AVERAGER that accomplished the time base conversion. Due to experimentation, there are a varying number of data groups recorded per hour.

Using a set of loading programs, each of these data files could be merged into a single file that contained all the data in hourly records. There are 123 different pieces of data for each hour. These files were called Yearly Current Profile Files and in conjunction with the program referred to in the following text constitute the operational database.

## USING THE RIVER PROFILE FILES

### River/Profile/Look

The RIVER/PROFILE/LOOK program interrogates the user as to what date and time should be displayed, and after given a chance to view the data for the requested hour (if any), can direct the data to either a remote printer in the same report format as on the screen or to a disk file in the same format as the River Profile File. This disk file is used by the Calcomp plotting program as the data source for the plots.

### Map/Plot/Preview

The MAP/PLOT/PREVIEW program must be run on a graphics terminal that is capable of emulating either a Tektronix 4010 or 4027 terminal.

Again, the program asks for a date and time of interest. A picture of John Day Dam and the area including the forebay are drawn on the screen, and the data for the hour asked for are overlaid as histograms and bar graphs. The primary purpose of this program is to see if the data demonstrates some characteristic that is being sought.

#### Map/Plot/Calcomp

The Calcomp high speed plotter is used to produce the maps of John Day Dam that are suitable for publication. These plots are made by the MAP/PLOT/CALCOMP program using the input data file created by the RIVER/PROFILE/LOOK program. Changes to this program must be made to reflect the amount of paper and the color of ink desired. The program also prints a listing of the River Profile data used to make each plot.

#### Steady/State/Program and Jays/Delight

The STEADY/STATE and JAYS DELIGHT programs were used by the statisticians in their analysis of the interrelationships of the river currents and dam operations.

The first program is used to select periods where there are no changes greater than specified interactively by the user of the program. Both a listing of the results of the steady state search and a file containing the record numbers of the periods found are created by this program.

The second program uses the file output by the previous program to control access to the River Profile data and makes a number of statistical calculations for each of the steady state periods. The output from this program consists of a listing of the data and results and a disk file that can be loaded into one or more of the online statistical packages on the Burroughs computer.

Appendix Table A1.--Mean water velocities (cm/sec) by meter positions, year, and total water flow volume (kcfs). See text for further details.

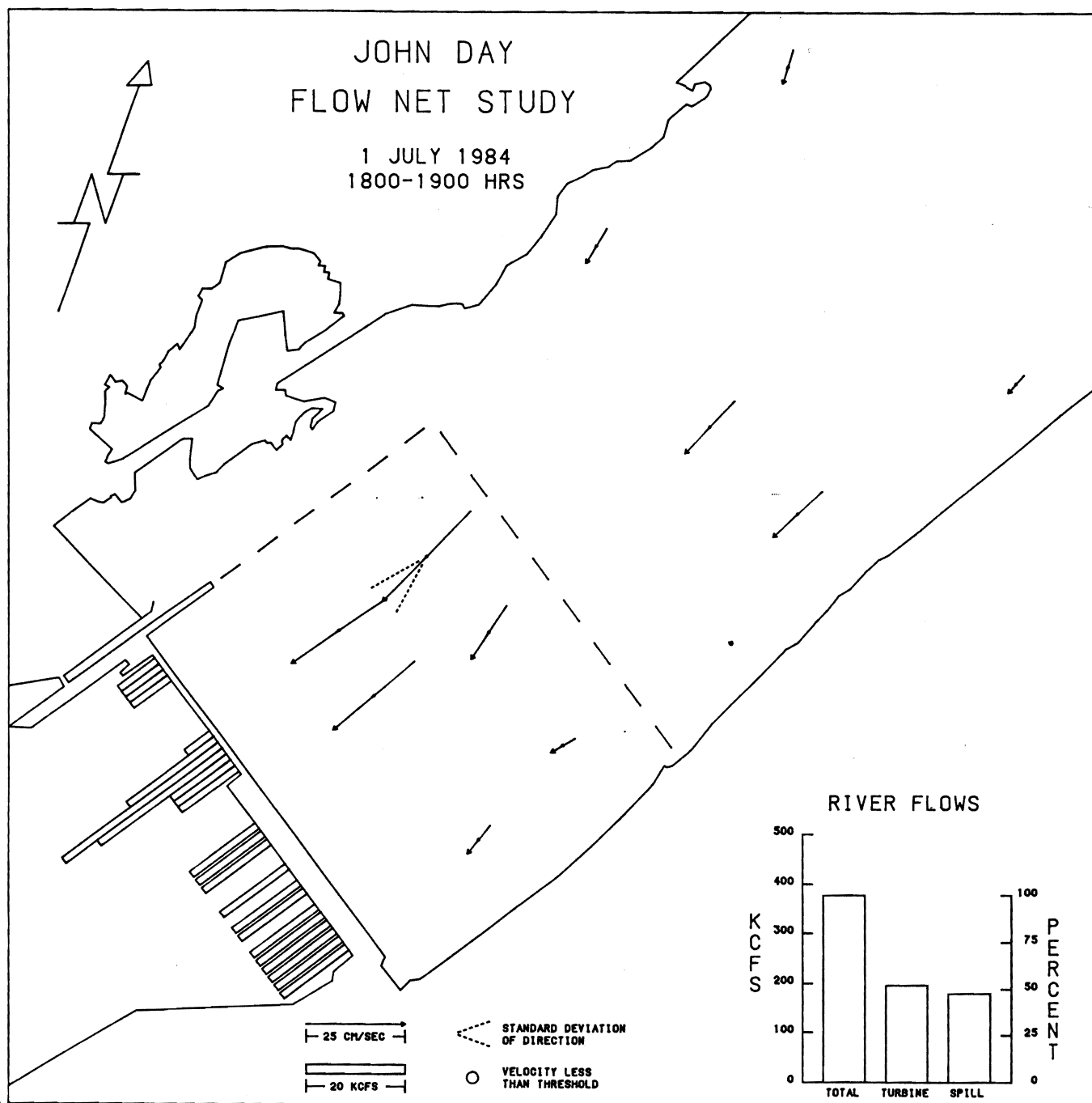
Meter position	Year	Total river flow (kcfs)			
		100	200	300	400
1	1982	4.7	9.3	9.3	14.0
	1983	-	- -	-	
	1984	-	- -	1-	
	pooled	4.7	9.3	9.3	14.0
2	1982	8.9	20.5	24.7	32.0
	1983	-	- -	-	
	1984	-	- -	-	
	pooled	8.9	20.5	24.7	32.0
3	1982	6.6	13.2	- -	
	1983	-	- -	-	
	1984	-	- -	-	
	pooled	6.6	13.2	- -	
4	1982	1.3	3.4	19.6	29.3
	1983	-	- -	-	
	1984	-	- -	-	
	pooled	1.3	3.4	19.6	29.3
5	1982	0.7	0.6	6.4	11.4
	1983	-	- -	-	
	1984	-	- -	-	
	pooled	0.7	0.6	6.4	11.4
6	1982	1.0	3.2	2.0	2.6
	1983	-	- -	-	
	1984	-	- -	-	
	pooled	1.0	3.2	2.0	2.6
7	1982	5.2	11.7	13.3	20.1
	1983	5.6	10.4	14.8	16.9
	1984	5.4	9.6	17.4	21.1
	pooled	5.3	10.6	15.5	20.5

Appendix Table A1.--cont.

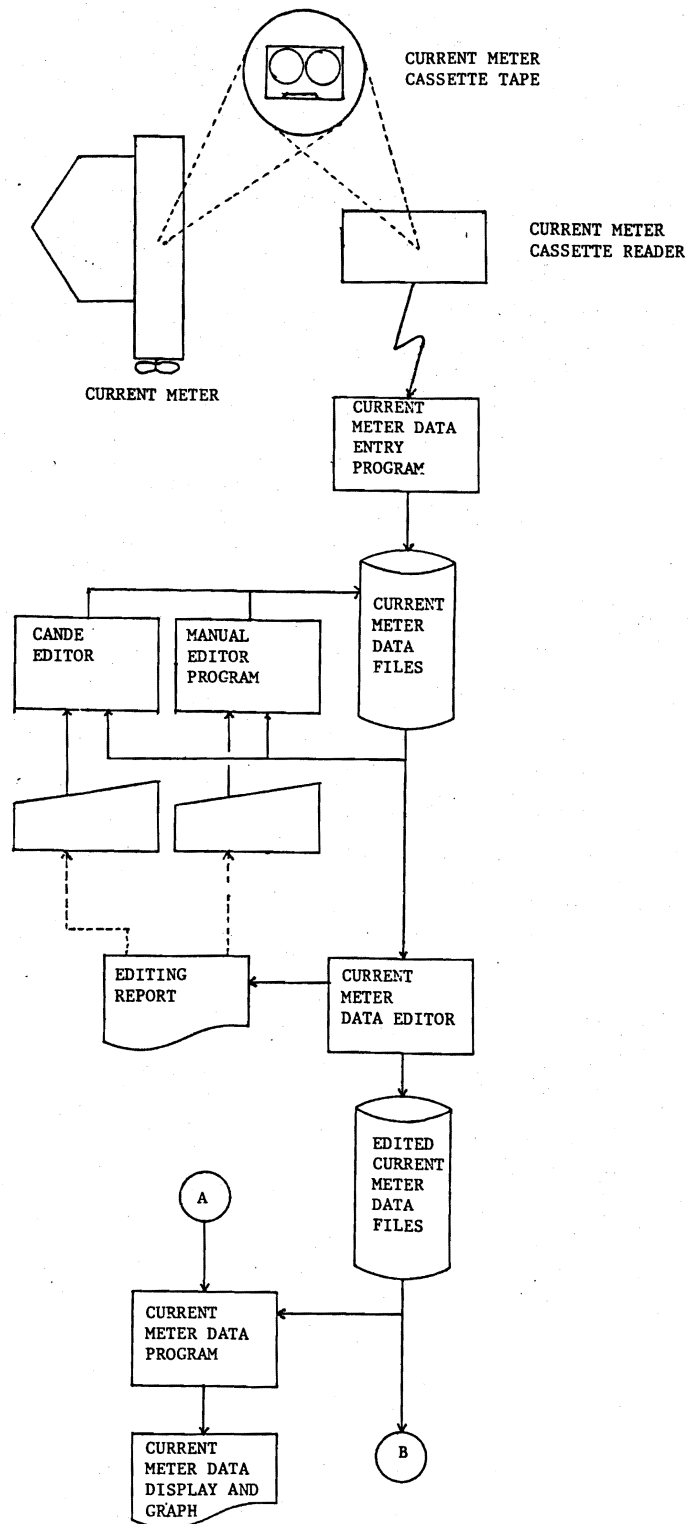
Meter position	Year	Total river flow (kcfs)			
		100	200	300	400
8	1982	5.9	13.1	17.1	26.1
	1983	-	- -	-	-
	1984	-	12.0	20.5	23.4
	pooled	5.9	13.0	19.6	25.1
9	1982	3.8	8.9	18.3	27.0
	1983	5.8	9.5	18.2	29.4
	1984	2.6	7.0	17.6	24.1
	pooled	3.6	8.4	18.2	26.5
10	1982	1.1	3.4	18.5	30.2
	1983	-	- -	-	-
	1984	1.8	3.8	11.9	27.0
	pooled	1.4	3.6	14.6	28.9
11	1982	-	4.9	11.7	17.6
	1983	3.3	4.7	12.5	13.8
	1984	-	- -	-	-
	pooled	3.3	4.7	12.1	17.5
12	1982	2.3	6.3	6.1	8.1
	1983	-	- -	-	-
	1984	-	- -	-	-
	pooled	2.3	6.3	6.1	8.1
13	1982	-	- -	-	-
	1983	5.5	9.3	12.9	15.4
	1984	-	- -	-	-
	pooled	5.5	9.3	12.9	15.4
14	1982	-	- -	-	-
	1983	4.6	9.0	17.1	23.0
	1984	3.8	8.9	17.8	25.1
	pooled	4.2	8.9	17.4	25.0

Appendix Table A1.--cont.

Meter position	Year	Total river flow (kcfs)			
		100	200	300	400
15	1982	-	- -	-	
	1983	5.8	10.3	17.9	27.1
	1984	8.4	12.4	22.0	31.5
	pooled	7.2	11.1	20.0	31.2
16	1982	-	- -	-	
	1983	6.2	9.8	15.3	21.0
	1984	7.3	9.7	16.6	23.0
	pooled	6.8	9.8	16.1	22.9
17	1982	-	- -	-	
	1983	3.7	7.0	19.1	26.9
	1984	4.8	7.6	14.9	22.8
	pooled	4.3	7.3	16.5	23.0
18	1982	-	- -	-	
	1983	4.3	6.0	10.5	12.6
	1984	4.9	6.4	7.8	12.0
	pooled	4.6	6.2	8.8	12.0
19	1982	-	- -	-	
	1983	7.7	8.9	13.7	19.0
	1984	6.1	6.9	10.2	13.0
	pooled	6.9	8.0	12.3	13.4
20	1982	-	- -	-	
	1983	4.0	4.9	8.6	14.9
	1984	6.2	7.4	12.0	13.3
	pooled	4.1	5.4	9.3	13.4



Appendix Figure A1.--Example of current pattern plot.

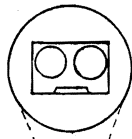


Appendix Figure A2.--Flow chart of programs and data files used in the analysis and display of current data.





TURBINE FLOW DATA  
CASSETTE TAPE



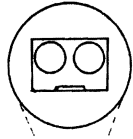
DATAORDER

TURBINE  
FLOW DATA  
ENTRY  
PROGRAM

WEEKLY  
TURBINE  
FLOW  
DATA  
FILE

E

SPILL FLOW DATA  
CASSETTE TAPE



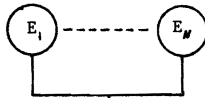
DATAORDER

SPILL  
FLOW DATA  
ENTRY  
PROGRAM

WEEKLY  
SPILL  
FLOW  
DATA  
FILE

C

WEEKLY TURBINE  
FLOW DATA FILES



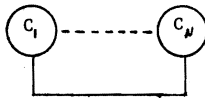
TURBINE FLOW  
AVERAGER  
PROGRAM

AVERAGED  
HOURLY  
TURBINE  
FLOW  
DATA

F

PROCESSING  
SUMMARY  
REPORT

WEEKLY SPILL  
FLOW DATA FILES



SPILL FLOW  
AVERAGER  
PROGRAM

AVERAGED  
HOURLY  
SPILL  
FLOW  
DATA

D

PROCESSING  
SUMMARY  
REPORT

YEARLY CROHMS  
FLOW DATA FILE



EDITED CURRENT  
METER DATA FILES

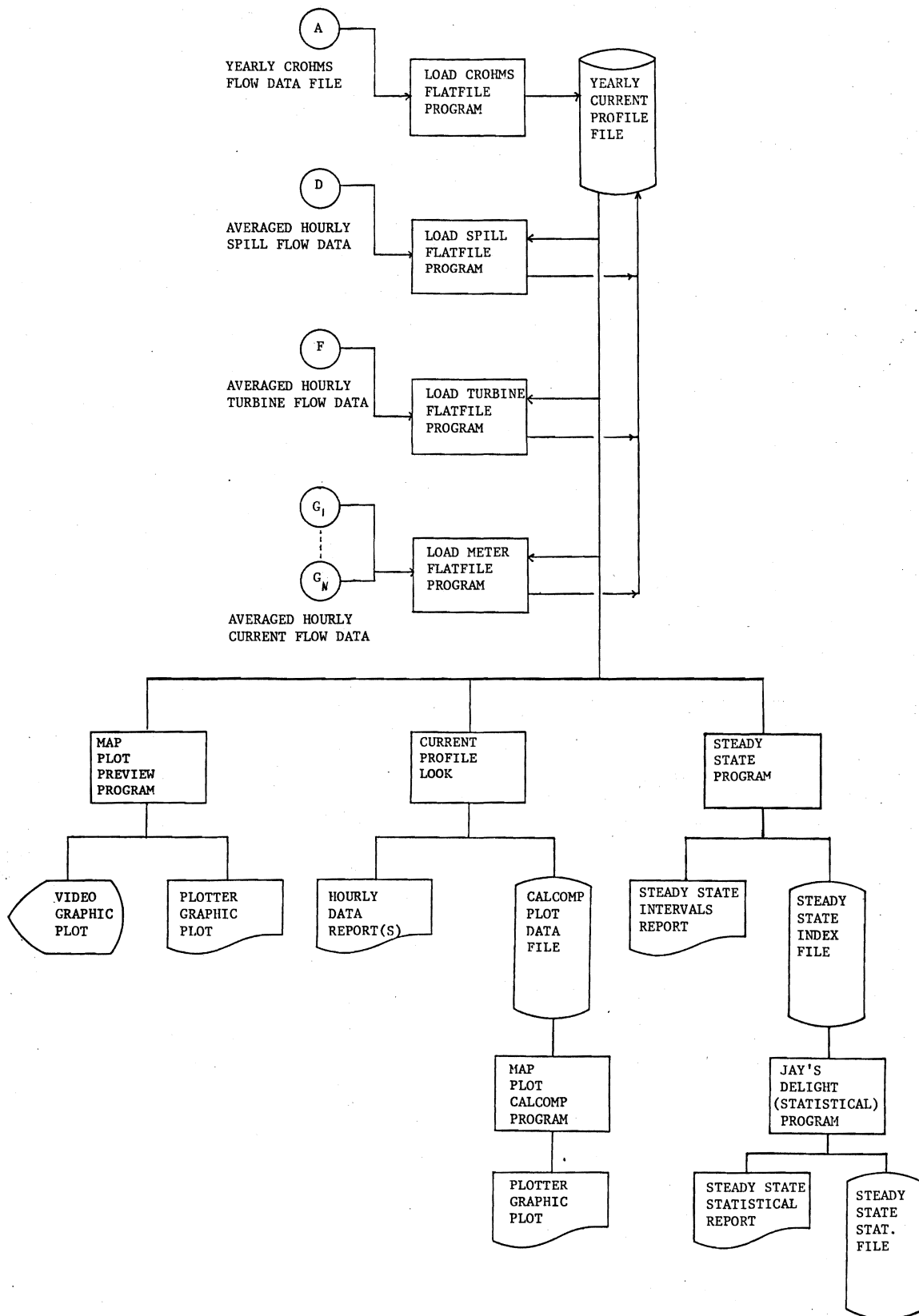


CURRENT FLOW  
AVERAGER  
PROGRAM

AVERAGED  
HOURLY  
CURRENT  
FLOW  
DATA

G

Appendix Figure A2.--Continued



Appendix Figure A2.--Continued

## APPENDIX B

### Purse Seine and Physical Limnology Data

Appendix Table B1.--Spring 1983 purse seine catches and accompanying limnological data.

Transect	Station	Date	Number of fish caught				Secchi reading		H <sub>2</sub> O velocity (C.S. <sup>-1</sup> )	Temp. (°C)
			Yearling chinook	Sockeye	Steelhead	Subyearling chinook	% of daily max	cm		
Downstream	1	20 Apr 83	9	-	4	-	-	-	-	10.0
	2	20 Apr 83	1	-	3	-	-	-	-	10.0
	3	20 Apr 83	12	-	6	-	-	-	-	10.0
Midstream	1	26 Apr 83	68	10	44	-	100	117	15	11.0
	2	26 Apr 83	77	9	35	-	74	86	9	-
	3	26 Apr 83	1	0	6	-	39	46	-	12.0
Downstream	1	26 Apr 83	52	5	3	-	83	97	17	-
	2	26 Apr 83	16	0	5	-	65	76	27	-
	3	26 Apr 83	2	0	6	-	48	56	16	-
Midstream	1	27 Apr 83	40	3	34	-	100	119	19	12.0
	2	27 Apr 83	137	19	83	-	72	86	21	-
	3	27 Apr 83	2	0	1	-	40	48	-	13.0
Midstream	1	28 Apr 83	35	3	11	-	93	91	2	12.0
	2	28 Apr 83	14	5	8	-	83	81	7	-
	3	28 Apr 83	2	0	5	-	67	66	-	14.0
Downstream	1	28 Apr 83	106	5	15	-	100	98	14	-
	2	28 Apr 83	24	1	13	-	65	64	22	-
	3	28 Apr 83	24	2	19	-	70	69	19	-
Midstream	1	02 May 83	73	19	139	-	100	107	8	13.0
	2	02 May 83	93	27	179	-	88	94	8	-
	3	02 May 83	4	0	16	-	43	46	-	14.0
Midstream	1	03 May 83	283	244	65	-	100	102	9	13.0
	2	03 May 83	244	147	53	-	68	69	7	-
	3	03 May 83	3	0	10	-	45	46	-	14.0
Downstream	1	03 May 83	129	184	13	-	89	91	9	-
	2	03 May 83	78	19	69	-	63	64	13	-
	3	03 May 83	37	25	67	-	55	56	14	-
Midstream	1	04 May 83	182	55	12	-	100	97	25	13.0
	2	04 May 83	32	5	37	-	48	47	7	-
	3	04 May 83	3	2	4	-	43	42	10	-
Midstream	1	19 May 83	39	31	48	-	82	105	6	15.0
	2	19 May 83	55	50	67	-	71	91	5	-
	3	19 May 83	3	0	19	-	51	65	8	16.0

Appendix Table B1.--(cont.)

Transect	Station	Date	Number of fish caught				Secchi reading		H <sub>2</sub> O velocity (C.S <sup>-1</sup> )	Temp. (°C)
			Yearling chinook	Sockeye	Steelhead	Subyearling chinook	% of daily max	cm		
Downstream	1	19 May 83	53	76	48	-	100	128	11	-
	2	19 May 83	56	10	67	-	95	122	18	-
	3	19 May 83	26	7	19	-	70	89	14	-
Midstream	1	24 May 83	289	339	138	-	74	69	12	-
	2	24 May 83	12	15	9	-	60	56	11	-
	3	24 May 83	0	1	3	-	46	43	13	17.0
Downstream	1	24 May 83	86	59	54	-	100	93	7	16.0
	2	24 May 83	64	9	33	-	78	73	16	-
	3	24 May 83	16	4	26	-	68	63	15	16.0
Midstream	1	26 May 83	109	183	79	-	100	120	7	16.0
	2	26 May 83	14	11	31	-	44	53	8	17.0
	3	26 May 83	0	1	23	-	38	46	15	18.0
Downstream	1	26 May 83	26	62	48	-	79	95	15	16.0
	2	26 May 83	8	5	19	-	54	65	18	-
	3	26 May 83	4	2	33	-	51	61	20	16.5

Appendix Table B2.--Summer 1983 purse seine and accompanying limnological data.

Transect	Station	Date	Time	Chinook salmon, subyearling		Secchi reading:		H <sub>2</sub> O velocity cm.sec <sup>-1</sup>
				No.	% of transect catch	% of daily max.	cm	
Downstream	1	30 Jun 83	0900	93	63	100	107	-
	2	" " "	0800	30	20	100	107	-
	3	" " "	0700	25	17	91	97	-
Midstream	1	30 Jun 83	1000	16	53	97	104	-
	2	" " "	1100	3	10	93	99	-
	3	" " "	1200	11	37	76	81	-
Downstream	1	07 Jul 83	0450	186	73	97	104	-
	2	" " "	0815	49	19	100	107	-
	3	" " "	0940	20	8	97	104	-
Downstream	1	21 Jul 83	0900	627	40	100	117	6
	2	" " "	0715	389	25	97	114	12
	3	" " "	0540	547	35	96	112	13
Downstream	1	04 Aug 83	0535	91	19	98	145	3
	2	" " "	0640	43	9	100	147	5
	3	" " "	0740	336	72	100	147	8
Midstream	1	04 Aug 83	1100	219	48	100	147	0
	2	" " "	1000	165	36	99	145	0
	3	" " "	0900	77	17	97	142	7
Downstream	1	18 Aug 83	0715	56	55	99	183	6
	2	" " "	0635	30	29	100	185	12
	3	" " "	0545	16	16	96	178	13

Appendix Table B2.--(cont.)

Transect	Station	Date	Time	Chinook salmon, subyearling		Secchi reading:		H <sub>2</sub> O velocity cm.sec <sup>-1</sup>
				No.	% of transect catch	% of daily max.	cm	
Midstream	1	18 Aug 83	1030	179	63	99	183	1
	2	" " "	0830	28	10	97	180	5
	3	" " "	0930	79	28	91	168	8
Downstream	1	01 Sep 83	0530	81	62	97	193	5
	2	" " "	0630	38	29	97	193	7
	3	" " "	0720	11	9	95	188	7
Midstream	1	01 Sep 83	1015	117	75	100	198	9
	2	" " "	0910	24	15	97	191	6
	3	" " "	0820	16	10	90	178	11
Downstream	1	15 Sep 83	0800	12	60	100	208	2
	2	" " "	0715	5	25	99	206	0
	3	" " "	0615	3	15	98	203	1
Midstream	1	15 Sep 83	0840	8	53	99	208	2
	2	" " "	0910	4	27	100	211	0
	3	" " "	1005	3	20	94	198	0
Downstream	1	20 Sep 83	0840	28	57	98	203	4
	2	" " "	0750	1	2	99	206	0
	3	" " "	0700	20	41	97	201	5
Midstream	1	20 Sep 83	0940	26	48	99	206	3
	2	" " "	1035	2	4	100	208	0
	3	" " "	1120	26	48	95	198	8



Appendix Table B3.--Purse seine and associated limnological data, 1984. Stations 1, 2, and 3 were located near the Washington shore, center of the reservoir, and Oregon shore, respectively.

Date	Transect	Station	Time	No. of fish (catch/set)					Secchi disc reading		Temp (°C)
				Chin 1's	Coho	Sockeye	Steelhead	Chin 0's	cm	% of daily max	
09 May 84	downstream	1	1310	53	0	8	52	0	-	-	10.0
		2	1030	60	0	17	18	0	69	97	10.0
		3	1150	28	0	11	12	0	64	90	10.0
		1	0820	95	0	33	41	0	71	100	10.0
		2	0530	62	0	11	24	0	61	86	10.0
		3	0650	13	0	26	10	0	61	86	10.0
10 May 84	upstream	1	1145	44	0	5	19	0	79	94	10.0
		2	1300	67	0	3	46	0	84	100	10.0
		3	1420	29	0	7	11	0	66	79	10.0
11 May 84	upstream	1	0530	47	0	6	6	0	74	91	10.0
		2	0635	115	0	13	19	0	81	100	10.0
		3	0750	14	0	1	7	0	69	85	10.0
	midstream	1	1230	43	0	11	19	0	79	98	10.5
		2	1115	171	0	21	26	0	76	94	11.0
		3	1000	8	0	22	18	0	38	47	13.5
15 May 84	downstream	2	0605	-	-	-	-	-	58	-	11.0
		3	0530	-	-	-	-	-	53	-	11.0
16 May 84	midstream	1	1010	-	-	-	-	-	71	100	11.5
		2	0930	-	-	-	-	-	58	82	11.5
		3	0910	-	-	-	-	-	28	39	12.0
	downstream	1	0800	-	-	-	-	-	66	93	11.5
		2	0630	68	0	8	40	0	56	79	11.5
		3	0510	40	0	21	24	1	41	58	12.0
17 May 84	upstream	1	1220	29	0	26	8	0	71	78	12.0
		2	1105	79	0	14	16	0	81	89	13.0
		3	0945	57	0	25	30	0	69	76	12.5
	midstream	1	0730	43	0	6	13	0	89	98	12.0
		2	0615	89	0	14	39	0	91	100	13.0
		3	0510	5	0	3	6	0	41	45	12.5

Appendix Table B3.--(cont.)

Date	Transect	Station	Time	No. of fish (catch/set)					Secchi disc reading		Temp (°C)
				Chin 1's	Coho	Sockeye	Steelhead	Chin 0's	cm	% of daily max	
18 May 84	midstream	1	0740	151	0	33	39	0	89	100	12.0
		2	0620	223	0	31	39	0	79	89	13.0
		3	0510	3	0	1	8	0	25	28	12.0
	downstream	1	1000	157	0	19	42	0	74	83	12.0
		2	1120	176	0	42	53	0	76	85	12.0
		3	1235	3	0	3	5	0	36	40	12.0
22 May 84	upstream	1	1000	129	0	46	21	0	91	100	12.5
		2	1115	162	0	23	28	0	84	92	13.0
		3	1225	21	0	10	17	0	89	98	13.0
	midstream	1	0730	204	0	103	22	0	89	98	12.5
		2	0615	97	0	3	74	0	89	98	12.5
		3	0500	11	0	2	20	0	56	62	13.0
24 May 84	upstream	1	1120	143	7	14	22	0	86	97	12.0
		2	1320	-----no fishing---too windy-----					86	97	12.0
		3	0955	19	0	22	15	0	81	91	12.0
	midstream	1	0725	126	11	154	33	0	89	100	12.5
		2	0615	108	9	18	36	0	86	97	12.0
		3	0500	16	0	5	11	0	53	60	12.5
25 May 84	midstream	1	0715	103	6	62	13	0	79	98	12.0
		2	0605	151	23	17	17	0	81	100	12.0
		3	0500	14	0	1	2	0	51	63	12.5
	downstream	1	0930	93	28	54	6	0	81	100	12.0
		2	1040	367	32	73	69	0	81	100	12.5
		3	1200	7	0	4	6	0	48	59	12.5
29 May 84	upstream	1	0930	3	0	1	1	16	94	97	14.0
		2	1035	57	7	5	15	1	97	100	14.0
		3	1150	36	7	12	0	5	94	97	14.0
	midstream	1	0500	19	1	13	8	0	94	97	13.5
		2	0605	36	1	0	19	0	91	94	14.5
		3	0710	3	0	1	5	0	56	58	15.7

Appendix Table B3.--(cont.)

Date	Transect	Station	Time	No. of fish (catch/set)					Secchi disc reading		Temp (°C)
				Chin 1's	Coho	Sockeye	Steelhead	Chin 0's	cm	% of	
										daily max	
31 May 84	downstream	1	0600	3	0	1	19	17	94	100	13.5
		2	0705	6	1	2	23	0	81	86	13.5
		3	0500	3	0	0	8	7	51	54	14.0
	downstream	1	1140	4	3	3	17	16	91	97	13.5
		2	1030	9	2	0	21	0	79	84	13.5
		3	0925	1	0	0	4	3	46	49	14.0
01 Jun 84	upstream	1	0915	5	0	8	2	113	86	97	14.0
		2	1030	27	0	21	13	336	89	100	15.0
		3	1140	7	0	4	6	40	67	75	14.0
	midstream	1	0450	6	0	11	17	69	53	60	15.5
		2	0555	22	1	5	16	62	48	54	14.5
		3	0715	3	0	0	2	9	43	48	15.0
05 Jun 84	midstream	1	0720	4	0	13	5	156	86	97	12.5
		2	0610	6	0	9	12	79	71	80	14.5
		3	0455	2	0	3	10	9	41	46	15.0
	downstream	1	1130	17	0	10	8	162	89	100	13.5
		2	1030	7	0	0	13	25	56	63	13.5
		3	0920	0	0	0	6	56	43	48	14.0
06 Jun 84	upstream	1	0935	14	0	13	12	143	89	100	14.5
		2	1040	19	0	9	15	38	84	94	14.5
		3	1145	9	0	8	23	21	64	72	14.5
	midstream	1	0715	9	0	3	11	189	89	100	13.5
		2	0605	13	0	9	23	56	81	91	14.5
		3	0405	1	0	2	19	29	53	60	15.0
TOTALS				4,094	139	1,218	1,455	1,658			

Appendix Table B4.--Vertical profile data, upper Transect John Day  
Reservoir 1984.

Date	Time	Sample depth (m)	Temperature (°C)			Turbidity (NTU)		
			Station #			Station #		
			1	2	3	1	2	3
10 May 84	1145-1420	0	10.2	10.1	10.0	-	-	-
		5	10.1	10.0	09.9	-	-	-
		10	09.9	10.0	09.9	-	-	-
		15	09.9	09.9	09.8	-	-	-
		20	09.9	09.9	09.7	-	-	-
		25	09.8	09.8	09.8	-	-	-
		30	09.8	09.8	-	-	-	-
		35	09.8	09.7	-	-	-	-
		40	-	09.7	-	-	-	-
		45	-	09.6	-	-	-	-
		50	-	09.6	-	-	-	-
11 May 84	0530-0750	0	10.0	10.0	10.2	12	-	-
		5	09.9	10.0	10.2	13	-	-
		10	09.9	10.0	09.9	13	-	-
		15	09.8	09.8	09.9	13	-	-
		20	09.8	09.9	09.8	13	-	-
		25	09.7	09.9	09.8	13	-	-
		30	09.8	09.8	-	13	-	-
		35	09.8	09.8	-	13	-	-
		40	-	09.8	-	-	-	-
17 May 84	0945-1220	0	12.0	13.0	12.5	13	11	12
		5	11.5	11.5	11.5	13	12	13
		10	11.5	11.5	11.5	13	12	16
		15	11.5	11.5	11.5	14	12	18
		20	11.5	11.5	-	13	13	-
		25	11.5	11.5	-	13	13	-
		30	11.5	11.5	-	13	13	-
22 May 84	1000-1225	0	12.5	13.0	13.0	10	11	10
		5	12.5	12.5	12.5	10	11	12
		10	12.5	12.5	12.0	10	11	11
		15	12.5	12.5	12.0	10	12	13
		20	12.5	12.0	-	12	13	-
		25	-	12.0	-	-	14	-
		30	-	12.0	-	-	15	-
23 May 84	0450-0545	0	12.5	12.0	12.5	12	11	13
		5	12.5	-	-	-	-	-
		10	12.5	12.0	12.5	12	12	14
		15	12.5	-	-	-	-	-
		20	12.5	12.0	12.5	13	12	18
		25	-	-	-	-	-	-
		30	-	12.0	-	-	11	-

Appendix Table B4.--cont.

Date	Time	Sample depth (m)	Temperature (°C)			Turbidity (NTU)		
			Station #			Station #		
			1	2	3	1	2	3
24 May 84	0955-1320	0	12.0	12.0	12.0	10	10	12
		5	12.0	-	12.0	10	-	12
		10	12.0	12.0	12.0	11	10	12
		15	12.0	-	12.0	12	-	12
		20	12.0	12.0	12.0	12	11	12
		25	-	-	-	-	-	-
		30	-	12.0	-	-	11	-
29 May 84	0930-1150	0	13.8	14.0	14.0	10	9	9
		5	13.3	13.3	13.5	10	10	11
		10	13.3	13.3	13.0	10	11	13
		15	13.0	13.0	13.0	10	12	14
		20	13.0	13.0	13.0	10	12	14
		25	-	13.0	-	-	12	-
		30	-	13.0	-	-	12	-
01 Jun 84	0915-1140	0	14.0	15.0	14.0	15	12	14
		5	13.5	14.5	13.5	18	16	14
		10	13.5	13.5	13.5	18	18	16
		15	13.5	13.5	13.5	18	16	14
		20	13.5	13.5	13.5	16	16	16
		25	13.5	13.5	-	19	15	-
		30	-	13.5	-	-	15	-
06 Jun 84	0935-1145	0	14.5	14.5	14.5	11	12	13
		5	14.0	14.0	14.0	11	12	13
		10	14.0	14.0	14.0	11	12	14
		15	14.0	14.0	14.0	11	12	14
		20	14.0	14.0	14.0	12	12	14
		25	14.0	14.0	-	12	16	-
		30	-	14.0	-	-	17	-
MIDDLE TRANSECT								
11 May 84	1000-1230	0	10.4	11.0	13.3	-	-	23
		5	10.2	10.8	12.5	-	-	21
		10	09.9	10.5	11.0	-	-	20
		15	09.8	10.2	10.5	-	-	20
		20	09.8	10.0	10.5	-	-	20
		25	09.9	10.0	10.2	-	-	20
		30	09.8	09.9	10.2	-	-	20
		35	09.8	09.8	10.2	-	-	20
		40	-	09.9	-	-	-	-
45	-	09.7	-	-	-	-		

Appendix Table B5.--Vertical profile data, middle transect, John Day Reservoir, 1984.

Date	Time	Sample depth (m)	Temperature (°C)			Turbidity (NTU)		
			Station #			Station #		
			1	2	3	1	2	3
16 May 84	0910-1010	0	11.5	11.4	11.8	12	17	31
		5	11.5	11.4	11.6	12	13	30
		10	11.5	11.3	11.5	12	13	26
		15	11.5	11.3	11.5	12	13	24
		20	11.4	11.3	-	11	14	-
		25	11.4	11.3	-	11	14	-
17 May 84	0510-0730	0	12.0	13.0	12.5	11	19	24
		5	11.5	11.5	11.5	11	15	26
		10	11.5	11.5	11.5	13	13	21
		15	11.5	11.5	11.5	13	13	22
		20	11.5	11.5	11.5	13	13	-
		25	11.5	-	-	13	-	-
18 May 84	0510-0740	0	12.0	13.0	12.0	13	13	39
		5	11.5	11.5	11.5	13	15	37
		10	11.5	11.5	11.5	14	15	35
		15	11.5	11.5	11.5	14	16	36
		20	-	11.5	-	-	16	-
		25	-	11.5	-	-	15	-
22 May 84	0500-0730	0	12.5	12.5	13.0	10	11	18
		5	12.5	12.5	12.5	10	11	17
		10	12.5	12.5	12.5	10	11	16
		15	12.5	12.5	12.5	10	11	14
		20	12.5	12.5	12.5	11	11	25
		25	-	12.5	-	11	11	-
23 May 84	0625-0700	0	12.5	12.5	12.5	11	12	23
		5	-	-	12.5	-	-	19
		10	12.5	12.5	12.5	12	14	21
		15	-	-	12.5	-	-	18
		20	12.5	12.5	12.5	12	14	20
		25	-	-	-	-	14	-
24 May 84	0500-0725	0	12.5	12.0	12.5	10	11	18
		5	12.5	-	12.5	11	-	18
		10	12.5	12.0	12.5	11	11	18
		15	12.0	-	12.5	11	-	17
		20	12.0	12.0	12.0	12	10	18
		25	-	-	-	-	-	-
		30	-	12.0	-	-	10	-

Appendix Table B5.--cont.

Date	Time	Sample depth (m)	Temperature (°C)			Turbidity (NTU)		
			Station #			Station #		
			1	2	3	1	2	3
25 May 84	0500-0715	0	12.0	12.0	12.5	10	12	16
		5	12.0	12.0	12.0	11	12	17
		10	12.0	12.0	12.0	11	12	19
		15	-	12.0	12.0	-	14	16
		20	12.0	12.0	12.0	12	14	24
		25	12.0	12.0	-	13	15	-
		30	-	12.0	-	-	17	-
29 May 84	0500-0710	0	13.5	14.5	15.7	10	10	17
		5	13.0	14.0	13.0	10	10	15
		10	13.0	13.0	13.0	10	10	15
		15	13.0	13.0	13.0	11	11	17
		20	13.0	13.0	13.0	11	11	17
		25	13.0	-	-	11	11	-
		30	-	13.0	-	-	11	-
31 May 84	1255-1335	0	13.5	13.5	14.0	11	15	19
		5	13.5	-	14.0	10	12	18
		10	13.5	13.5	14.0	10	11	16
		15	13.5	-	13.5	10	-	17
		20	13.5	13.5	13.5	10	11	28
		25	-	-	-	-	-	-
		30	-	13.5	-	-	11	-
01 Jun 84	0915-1140	0	15.0	14.5	15.5	24	24	20
		5	14.5	14.5	14.5	25	19	22
		10	14.0	14.0	13.5	17	14	23
		15	14.0	14.0	13.5	21	16	20
		20	13.5	13.5	13.5	22	18	18
		25	-	13.5	-	-	18	-
		30	-	13.5	-	-	18	-
05 Jun 84	0455-0720	0	12.5	14.5	15.0	10	13	21
		5	12.0	14.5	14.5	10	13	17
		10	12.0	14.0	14.5	10	13	17
		15	12.0	13.5	14.0	11	12	19
		20	12.0	13.5	14.0	11	12	28
		25	12.0	13.5	-	12	12	-
		30	-	13.5	-	-	12	-
06 Jun 84	0450-0715	0	13.5	14.5	15.0	11	11	18
		5	13.0	14.0	14.5	11	12	18
		10	12.5	14.0	14.0	11	13	16
		15	12.5	14.0	14.0	11	13	15
		20	-	14.0	14.0	-	13	21
		25	-	14.0	-	-	14	-
		30	-	14.0	-	-	14	-

Appendix Table B6.--Vertical profile data, lower transect, John Day Reservoir, 1984.

Date	Time	Sample depth (m)	Temperature (°C)			Turbidity (NTU)		
			Station #			Station #		
			1	2	3	1	2	3
09 May 84	0530-0820	0	09.9	09.9	09.9	-	-	-
		5	09.9	09.9	09.9	-	-	-
		10	09.9	09.9	09.9	-	-	-
		15	09.8	09.9	09.9	-	-	-
		20	09.8	09.8	-	-	-	-
		25	09.8	09.8	-	-	-	-
		30	09.8	09.9	-	-	-	-
		35	09.7	09.8	-	-	-	-
		40	-	09.7	-	-	-	-
		45	-	09.7	-	-	-	-
		50	-	09.7	-	-	-	-
09 May 84	1030-1310	0	10.1	09.9	09.9	-	-	-
		5	10.0	09.9	09.9	-	-	-
		10	09.9	09.9	09.9	-	-	-
		15	09.9	09.9	09.9	-	-	-
		20	09.9	09.9	-	-	-	-
		25	09.7	09.8	-	-	-	-
		30	09.7	09.8	-	-	-	-
		35	09.7	09.8	-	-	-	-
		40	-	09.7	-	-	-	-
		45	-	09.7	-	-	-	-
		50	-	09.6	-	-	-	-
		55	-	09.6	-	-	-	-
15 May 84	0530-0605	0	-	11.0	11.0	-	13	16
		5	-	11.0	11.0	-	14	16
		10	-	11.0	11.0	-	14	16
		15	-	11.0	11.0	-	13	16
		20	-	11.0	11.0	-	14	16
		25	-	11.0	11.0	-	14	-
		30	-	11.0	-	-	14	-
15 May 84	0510-0800	0	11.5	11.5	12.0	12	16	29
		5	11.4	11.5	11.5	11	18	25
		10	11.4	11.5	11.5	12	17	24
		15	11.4	11.5	11.5	12	18	25
		20	11.3	11.5	11.5	12	17	-
		25	11.3	11.5	11.5	12	16	-
		30	11.3	11.5	11.5	12	16	-
		35	-	11.5	-	-	16	-
		40	-	11.5	-	-	16	-



Appendix Table B6.--cont.

Date	Time	Sample depth (m)	Temperature (°C)			Turbidity (NTU)		
			Station #			Station #		
			1	2	3	1	2	3
18 May 84	1000-1235	0	12.0	12.0	12.0	14	12	22
		5	11.5	11.5	11.5	13	14	29
		10	11.5	11.5	11.5	13	14	24
		15	11.5	11.5	11.5	13	14	24
		20	11.5	11.5	11.5	14	14	24
		25	11.5	11.5	11.5	14	15	-
		30	11.5	11.5	-	13	14	-
23 May 84	0720-0800	0	12.5	12.5	12.5	10	11	16
		5	-	-	-	-	-	14
		10	12.5	12.5	12.5	-	-	15
		15	-	-	-	-	-	-
		20	12.5	12.5	12.5	10	12	15
		25	-	-	-	10	-	-
		30	12.5	-	-	10	-	-
25 May 84	0930-1200	0	12.0	12.5	12.5	11	15	16
		5	12.0	12.0	12.0	12	14	16
		10	12.0	12.0	12.0	12	14	15
		15	-	12.0	12.0	-	-	15
		20	12.0	12.0	12.0	12	13	15
		25	-	12.0	-	-	14	-
		30	12.0	12.0	-	14	18	-
31 May 84	0500-0705	0	13.5	13.5	14.0	10	-	17
		5	13.5	13.5	14.0	10	-	16
		10	13.5	13.5	14.0	10	-	15
		15	13.5	13.5	13.5	11	-	15
		20	13.5	13.5	13.5	11	-	21
		25	-	13.5	-	-	-	-
		30	-	13.5	-	-	-	-
05 Jun 84	0920-1130	0	13.5	13.5	14.0	10	17	18
		5	13.5	13.0	13.5	10	17	18
		10	13.5	13.0	13.5	11	15	16
		15	13.0	12.5	13.5	11	15	15
		20	13.0	12.5	13.0	10	16	17
		25	-	13.0	13.0	-	16	21
		30	-	12.5	-	-	16	-

## APPENDIX C

### Radio Telemetry Data 1983, 1984

Appendix Table C1.--Radio-tagged yearling chinook salmon from group releases which were detected at John Day Dam - 1984.

Release		Fish code	Arrival at Dam		Passage at dam		Passage location
Date	Time		Date	Time	Date	Time	
01 May 84	0850	136	01 May 84	1930	01 May 84	1930	S
"	0850	256	"	1510	03 May 84	1005	P
"	0850	336	"	1446	01 May 84	2038	P
"	0850	356	"	1620	"	1716	P
"	0850	455	"	2008	"	2036	P
"	0850	555	"	2033	"	2319	P
"	0850	635	"	1917	"	1929	S
"	0850	656	"	1344	"	1403	P
"	0850	767	"	1339	"	1930	S
"	0850	833	"	2105	"	2109	P
"	0850	864	"	1819	"	1931	S
"	1339	246	02 May 84	2107	02 May 84	2113	P
"	1339	344	01 May 84	2130	01 May 84	2150	P
"	1339	365	"	1948	"	1948	P
"	1339	445	"	1758	"	2030	P
"	1339	544	"	1617	"	2128	P
"	1339	665	02 May 84	0028	02 May 84	0100	P
"	1339	945	01 May 84	2133	01 May 84	2142	P
"	1339	436	"	2122	"	2146	S
10 May 84	0851	167	10 May 84	1425	10 May 84	2055	P
"	0851	144	"	1523	"	1547	P
"	0851	278	"	1344	"	1354	P
"	0851	246	"	2010	"	2010	S
"	0851	262	"	2150	"	2207	S
"	0851	373	"	2002	"	2145	P
"	0851	346	"	1412	"	2007	S
"	0851	337	"	1548	"	2127	P
"	0851	446	"	1527	"	2134	S
"	0851	575	"	1821	"	1834	P
"	0851	673	"	1627	"	1957	P
"	0851	741	"	1717	"	2049	S
"	0851	750	"	1924	"	2008	S
"	0851	960	"	1343	"	1353	P
"	1413	137	"	1939	"	2139	P
"	1413	360	"	1944	"	2307	P
"	1413	436	"	2120	"	2333	S
"	1413	636	"	2043	"	2055	P
"	1413	659	"	1957	"	2018	S
"	1413	770	11 May 84	0055	11 May 84	0055	S
"	1413	760	10 May 84	2006	10 May 84	2043	P
"	1413	730	11 May 84	0405	11 May 84	0408	S
"	1413	871	10 May 84	1949	10 May 84	2032	S

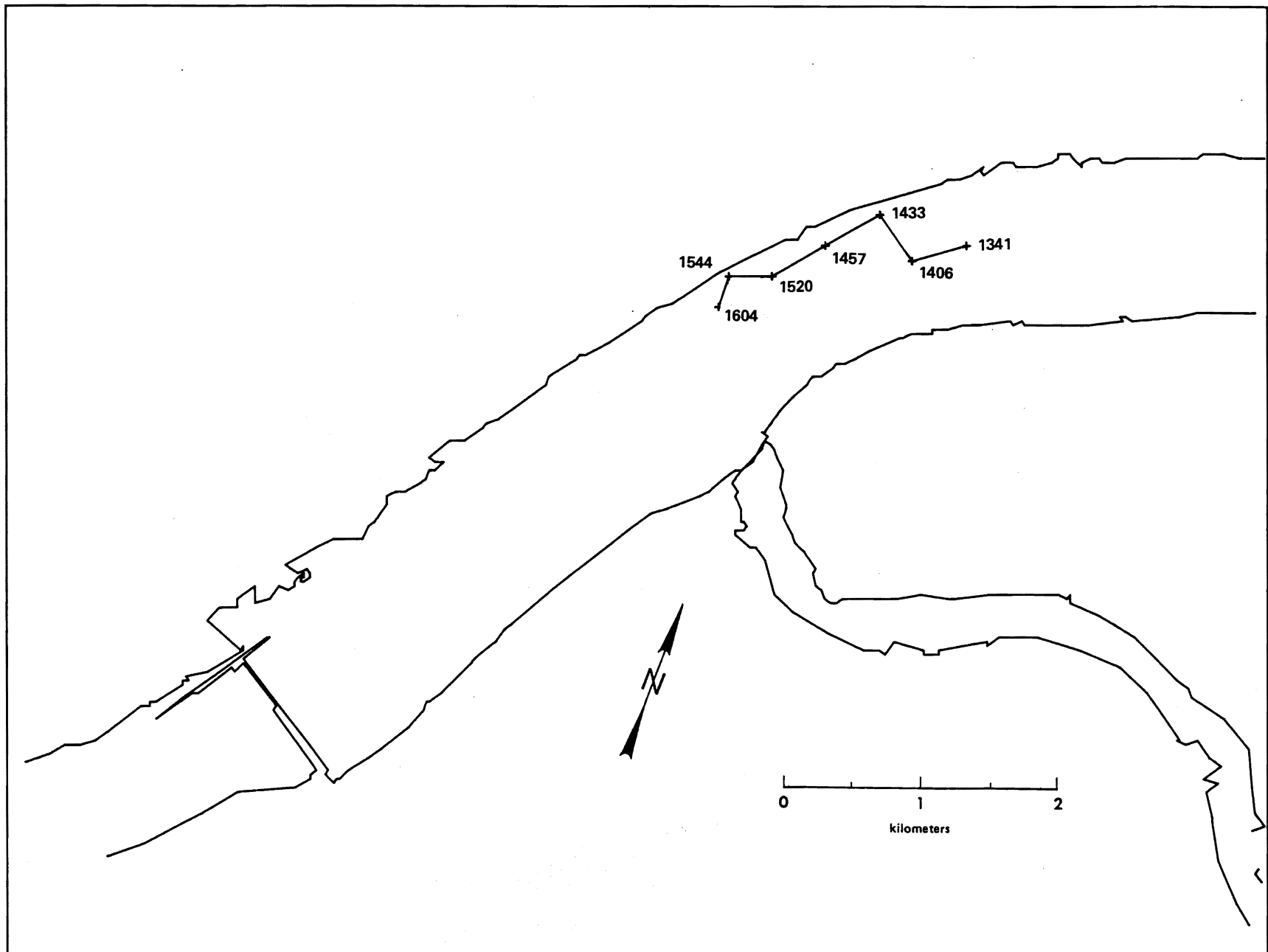
Appendix Table C1.--cont.

Release		Fish code	Arrival at Dam		Passage at dam		Passage location
Date	Time		Date	Time	Date	Time	
10 May 84	1413	830	11 May 84	0400	11 May 84	0410	S
"	1413	970	13 May 84	0428	13 May 84	0440	P
14 May 84	0836	128	14 May 84	2210	14 May 84	2216	S
"	0836	152	"	1526	"	1643	P
"	0836	230	15 May 84	0408	15 May 84	1111	P
"	0836	252	14 May 84	1330	14 May 84	2133	P
"	0836	332	"	2303	"	2320	S
"	0836	351	"	1938	"	2045	P
"	0836	430	"	1756	"	1959	P
"	0836	451	"	2251	"	2343	P
"	0836	531	"	1429	"	1647	S
"	0836	550	"	2140	"	2140	S
"	0836	628	"	1925	"	1948	S
"	0836	651	"	1608	"	2114	S
"	0836	746	"	1424	"	2052	S
"	1405	272	"	1856	"	2033	S
"	1405	340	"	2115	"	2117	S
"	1405	371	"	1922	"	2108	P
"	1405	440	"	2026	"	2026	S
"	1405	736	"	1933	"	2056	S
"	1405	758	"	2002	"	2107	S
"	1405	834	"	2109	"	2113	S
"	1405	864	"	2229	"	2230	S
"	1405	935	"	2045	"	2100	P
"	1405	971	"	2144	"	2144	S
25 May 84	1405	131	25 May 84	1911	25 May 84	1920	P
"	1405	145	"	1944	"	1958	S
"	1405	257	"	1919	"	1919	S
"	1405	661	"	2028	"	2050	S
"	1405	735	"	2005	"	2008	S
"	1405	856	"	1843	"	2051	P
"	1405	928	"	1902	"	1905	S
"	1405	963	"	2054	"	2054	P

P = Powerhouse

S = Spillway

Appendix Figure C1.--Radio tracking data for Fish Code 766.



RELEASE DATE: 23 APRIL 1983

INDIVIDUAL FISH CODE: 633

SPECIES: SPRING CHINOOK

LENGTH: 150 MM

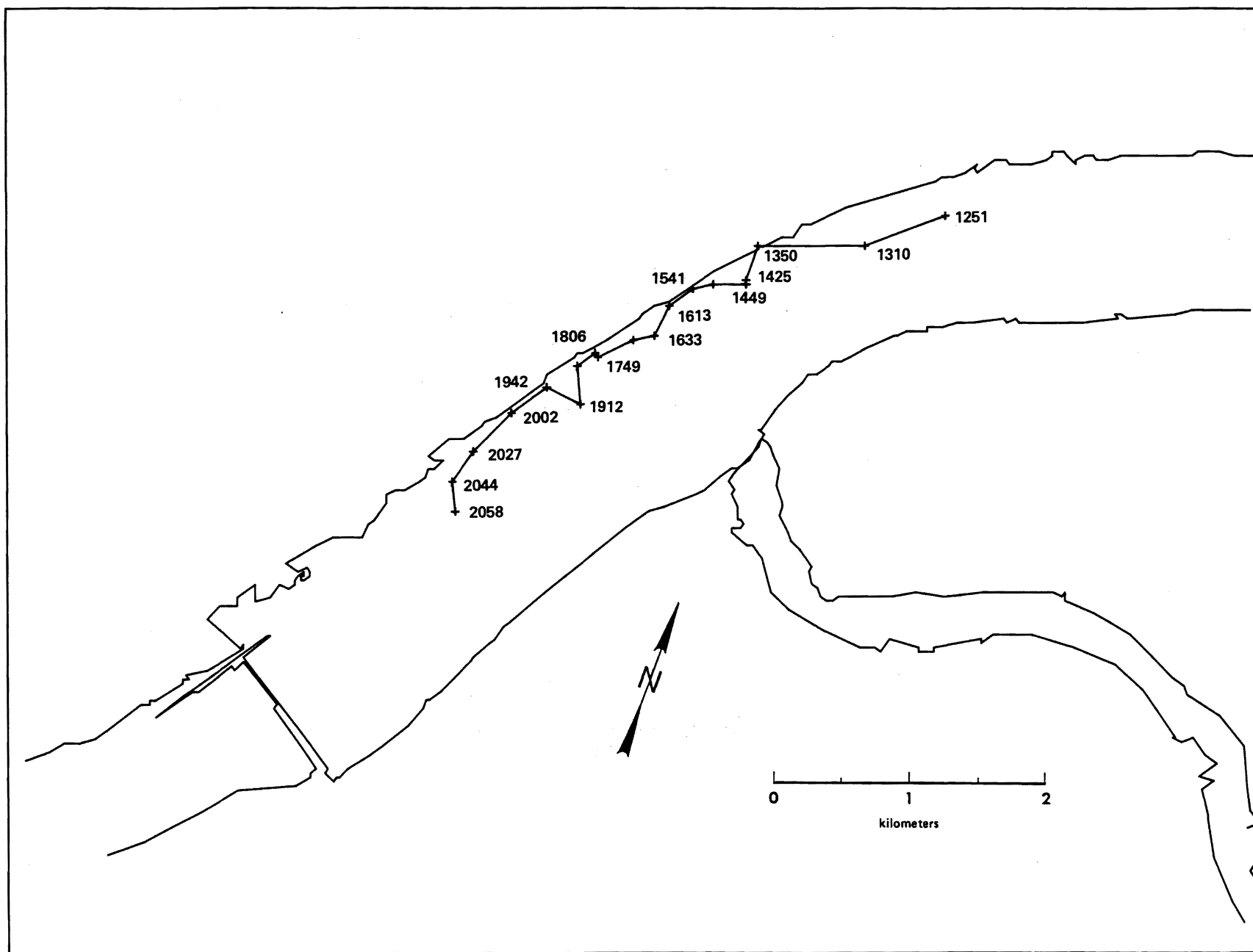
.....

TIME	FLOW (KCFS) TOTAL SPILL	PERCENT SPILL	DISTANCE (METERS)	TIME SPAN	VELOCITY (M/HR)	DIRECTION (DEG MAG)	CUMULATIVE DISTANCE	TIME
12:51	234.5	120.3						
13:10	217.4	120.3	55					
13:50	217.4	120.3	55	623	0:19	1,967	230	623 0:19
14:25	227.5	120.3	53	778	0:40	1,167	250	1,401 0:59
14:49	227.5	120.3	53	262	0:35	449	180	1,663 1:34
15:20	233.2	120.3	52	31	0:24	78	160	1,694 1:58
15:41	233.2	120.3	52	238	0:31	461	250	1,932 2:29
16:13	246.5	120.3	49	154	0:21	440	239	2,086 2:50
16:33	246.5	120.3	49	213	0:32	399	215	2,299 3:22
16:54	246.5	120.3	49	242	0:20	726	187	2,541 3:42
17:49	241.1	120.3	50	154	0:21	440	239	2,695 4:03
18:06	240.5	120.3	50	287	0:55	313	225	2,982 4:58
18:41	240.5	120.3	50	38	0:17	134	305	3,020 5:15
19:12	259.1	130.8	50	159	0:35	273	215	3,179 5:50
19:42	259.1	130.8	50	279	0:31	540	156	3,458 6:21
20:02	274.7	140.9	51	268	0:30	536	278	3,726 6:51
20:27	274.7	140.9	51	319	0:20	957	215	4,045 7:11
20:44	274.7	140.9	51	395	0:25	948	206	4,440 7:36
20:58	274.7	140.9	51	264	0:17	932	195	4,704 7:53
				217	0:14	930	154	4,921 8:07

#

This fish was the first that delayed at the John Day River plume. It did not move past the plume until after sunset. The signal from this fish was high and low throughout the track, indicating that the fish may have been diving while trying to pass the plume. The track was terminated when weather conditions became bad and the contact with the tag could not be maintained. This fish passed through the spillway on April 26 at 1609.

Appendix Figure C2.--Radio tracking data for Fish Code 633.



RELEASE DATE: 24 APRIL 1983

INDIVIDUAL FISH CODE: 176

SPECIES: SPRING CHINOOK

LENGTH: 148 MM

.....

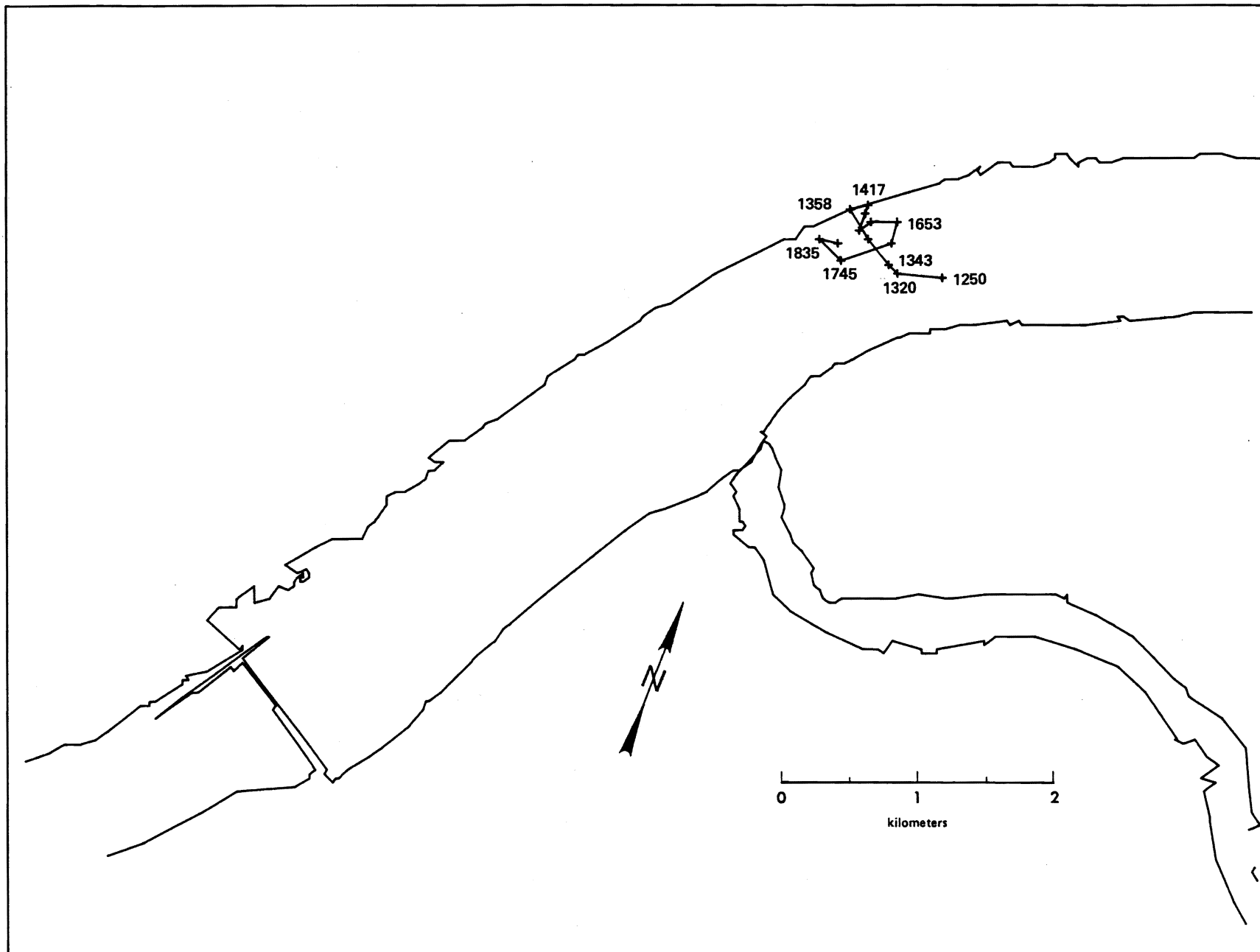
TIME	FLOW (KCFS) TOTAL SPILL	PERCENT SPILL	DISTANCE (METERS)	TIME SPAN	VELOCITY (M/HR)	DIRECTION (DEG MAG)	CUMULATIVE DISTANCE	TIME
12:50	278.6	134.6	48					
13:20	263.1	134.6	51	0:30	652	256	326	0:30
13:43	263.1	134.6	51	0:23	235	294	416	0:53
13:58	263.1	134.6	51	0:15	956	301	655	1:08
14:17	263.9	134.6	51	0:19	796	309	907	1:27
14:36	263.9	134.6	51	0:19	420	57	1,040	1:46
14:59	263.9	134.6	51	0:23	170	180	1,105	2:09
15:23	268.9	134.6	50	0:24	328	180	1,236	2:33
15:50	268.9	134.6	50	0:27	236	35	1,342	2:60
16:53	273.6	134.6	49	1:03	186	70	1,537	4:03
17:22	274.6	134.6	49	0:29	331	176	1,697	4:32
17:45	274.6	134.6	49	0:23	1,012	232	2,085	4:55
18:35	271.9	134.6	50	0:50	259	296	2,301	5:45
18:56	271.9	134.6	50	0:21	380	84	2,434	6:06

#

This fish track was terminated when the fish did not move downstream into the area that would supply information to the forebay data pool. With no lights on the navigation markers above the John Day River, we could not fix the tags location after sunset.



Appendix Figure C3.--Radio tracking data for Fish Code 176.



RELEASE DATE: 26 APRIL 1983

INDIVIDUAL FISH CODE: 677

SPECIES: SPRING CHINOOK

LENGTH: 158 MM

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.....
TIME      FLOW (KCFS)  PERCENT  DISTANCE  TIME  VELOCITY  DIRECTION  CUMULATIVE
TOTAL    SPILL    SPILL    (METERS)  SPAN  (M/HR)    (DEG MAG)  DISTANCE  TIME

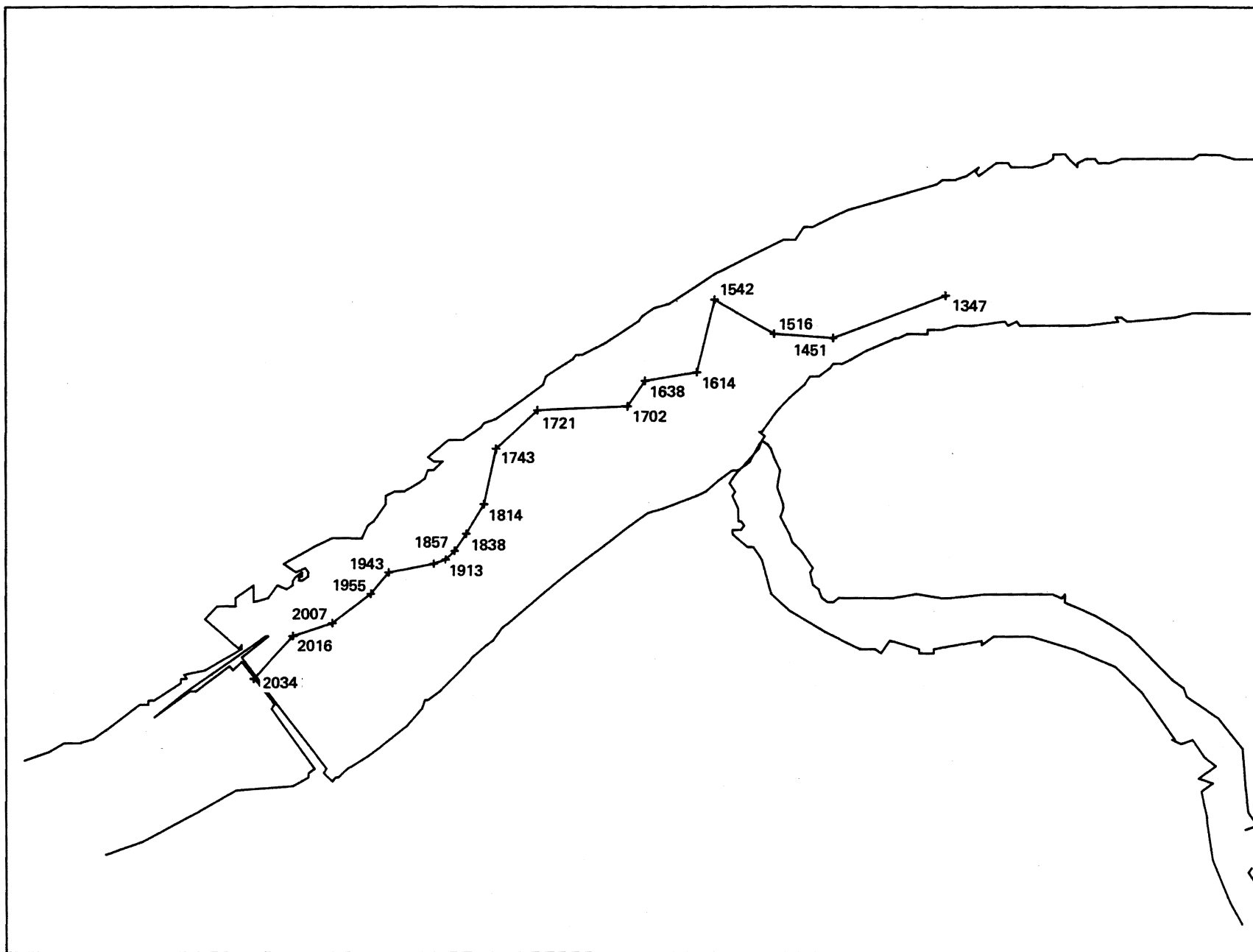
13:47     351.5   178.9    51
14:51     348.8   204.0    58      878    1:04      823      230      878    1:04
15:16     345.0   212.4    62      434    0:25     1,042     254     1,312    1:29
15:42     345.0   212.4    62      498    0:26     1,149     280     1,810    1:55
16:14     350.2   218.5    62      541    0:32     1,014     174     2,351    2:27
16:38     350.2   218.5    62      373    0:24      933      241     2,724    2:51
17:02     353.0   200.5    57      226    0:24      565      195     2,950    3:15
17:21     353.0   200.5    57      649    0:19     2,049     247     3,599    3:34
17:43     353.0   200.5    57      411    0:22     1,121     208     4,010    3:56
18:14     348.7   178.0    51      410    0:31      794      172     4,420    4:27
18:38     348.7   178.0    51      252    0:24      630      191     4,672    4:51
18:57     348.7   178.0    51      151    0:19      477      195     4,823    5:10
19:13     351.5   177.3    50       90    0:16      338      207     4,913    5:26
19:28     351.5   177.3    50       92    0:15      368      231     5,005    5:41
19:43     351.5   177.3    50      330    0:15     1,320     239     5,335    5:56
19:55     351.5   177.3    50      202    0:12     1,010     200     5,537    6:08
20:07     347.2   174.6    50      355    0:12     1,775     213     5,892    6:20
20:16     347.2   174.6    50      296    0:09     1,973     232     6,188    6:29
20:34     347.2   174.6    50      417    0:18     1,390     203     6,605    6:47

```

#

During this track the John Day River plume did not reach accross the Columbia River to the Washington side. The only slow movement was just above the restricted zone before sunset. The fish was tracked to Spillgate number 10 where the signal was lost. The spillway monitors last recorded the tag at 2035.

Appendix Figure C4.--Radio tracking data for Fish Code 677.



RELEASE DATE: 27 APRIL 1983

INDIVIDUAL FISH CODE: 278

SPECIES: SPRING CHINOOK

LENGTH: 160 MM

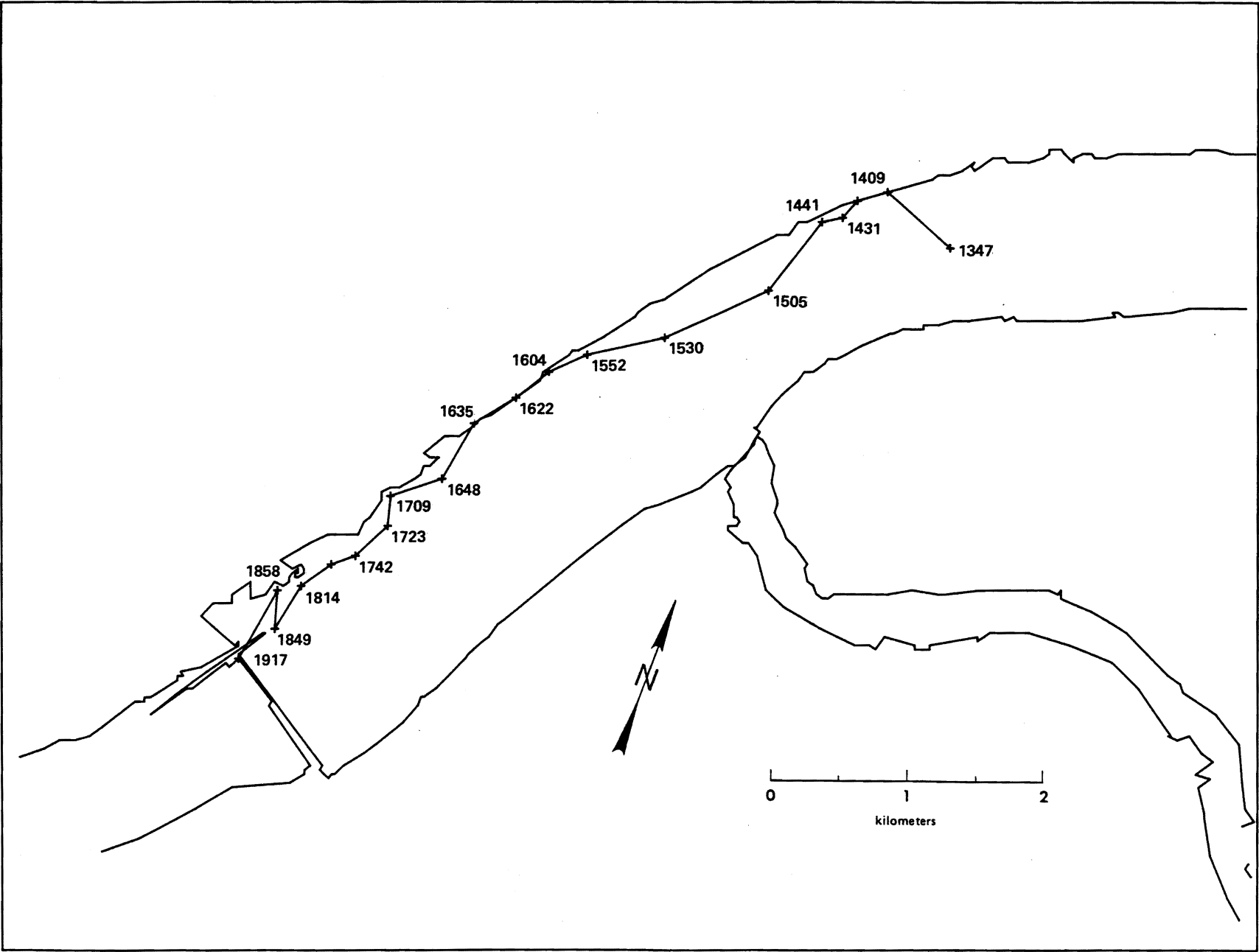
.....

TIME	FLOW (KCFS)	PERCENT	DISTANCE	TIME	VELOCITY	DIRECTION	CUMULATIVE
	TOTAL SPILL	SPILL	(METERS)	SPAN	(M/HR)	(DEG MAG)	DISTANCE TIME
13:47	345.7	209.8	61				
14:09	352.1	207.8	59				
14:17	352.1	207.8	59	606	0:22	1,653	606 0:22
14:31	352.1	207.8	59	225	0:08	1,688	831 0:30
14:41	352.1	207.8	59	164	0:14	703	995 0:44
15:05	345.1	214.0	62	154	0:10	924	1,149 0:54
15:30	345.1	214.0	62	629	0:24	1,573	1,778 1:18
15:52	345.1	214.0	62	829	0:25	1,990	2,607 1:43
16:04	343.7	184.6	54	576	0:22	1,571	3,183 2:05
16:22	343.7	184.6	54	307	0:12	1,535	3,490 2:17
16:35	343.7	184.6	54	301	0:18	1,003	3,791 2:35
16:48	343.7	184.6	54	355	0:13	1,638	4,146 2:48
17:09	351.0	175.7	50	466	0:13	2,151	4,612 3:01
17:23	351.0	175.7	50	388	0:21	1,109	5,000 3:22
17:42	351.0	175.7	50	217	0:14	930	5,217 3:36
17:57	351.0	175.7	50	321	0:19	1,014	5,538 3:55
18:14	351.6	175.7	50	184	0:15	736	5,722 4:10
18:49	351.6	175.7	50	266	0:17	939	5,988 4:27
18:58	351.6	175.7	50	365	0:35	626	6,353 5:02
19:17	355.5	176.0	50	279	0:09	1,860	6,632 5:11
				568	0:19	1,794	7,200 5:30

#

This fish moved downstream with little delay until it got to the outfall from the aluminum plant. After a short time there, it moved to the area just above the restricted zone where it slowed down again. When the fish moved closer to the spillway it changed direction moving toward the Washington shore and upstream. Just before sunset the fish moved to the spillway and was last heard at Spillgate number 1. The last record on the spill monitor was at 1912.

Appendix Figure C5.--Radio tracking data for Fish Code 278.



RELEASE DATE: 4 MAY 1983

INDIVIDUAL FISH CODE: 977

SPECIES: SPRING CHINOOK

LENGTH: 149 MM

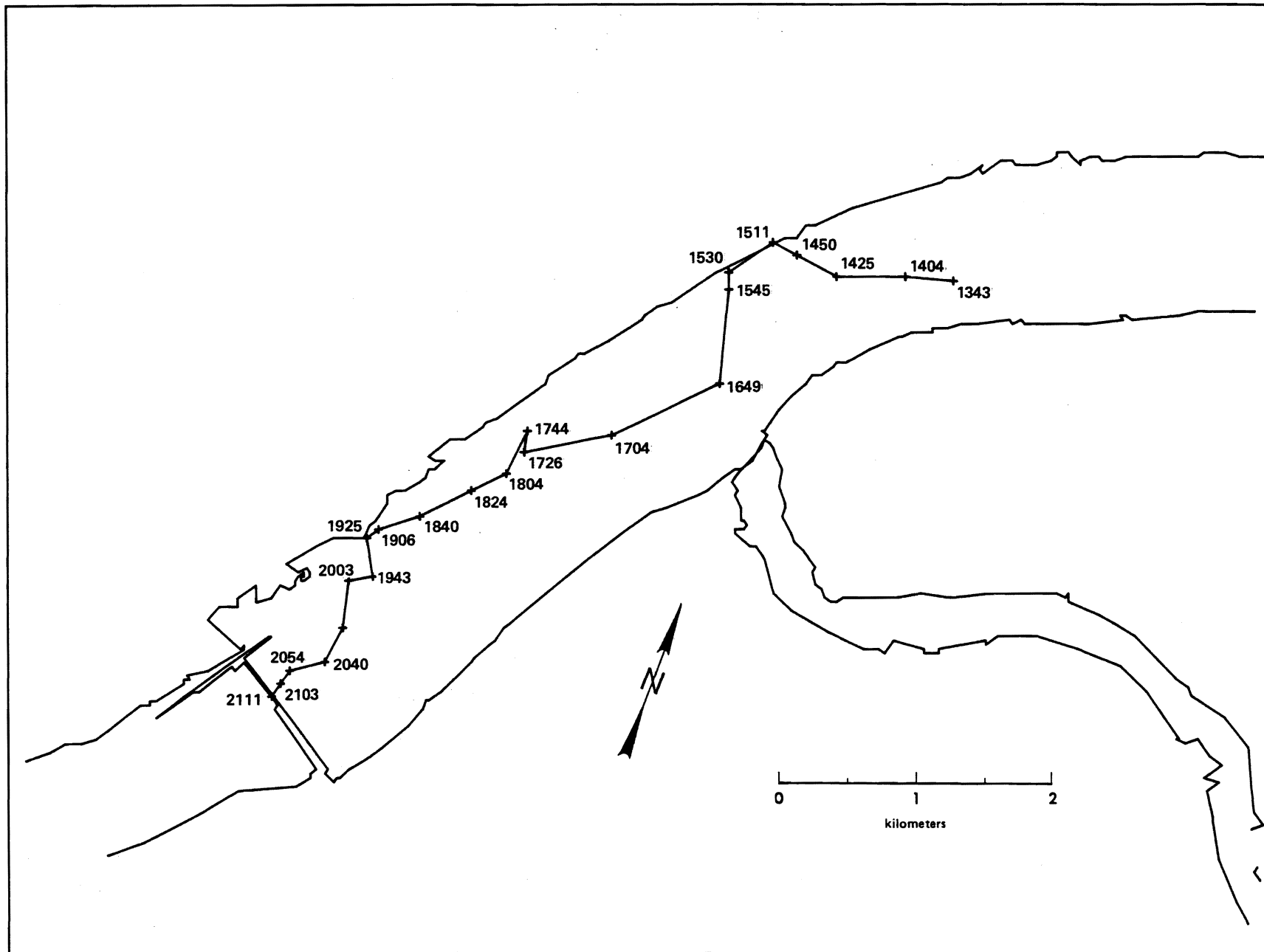
.....

TIME	FLOW (KCFS)	PERCENT	DISTANCE	TIME	VELOCITY	DIRECTION	CUMULATIVE	
	TOTAL SPILL	SPILL	(METERS)	SPAN	(M/HR)	(DEG MAG)	DISTANCE	TIME
13:43	345.8	120.3	35					
14:04	321.5	120.3	37					
14:25	321.5	120.3	37	497	0:21	255	347	0:21
14:50	321.5	120.3	37	421	0:21	250	844	0:42
15:11	308.6	120.3	39	196	0:25	279	1,165	1:07
15:30	308.6	120.3	39	390	0:21	278	1,361	1:28
15:45	308.6	120.3	39	123	0:19	217	1,751	1:47
16:49	286.4	120.3	42	682	1,232	160	1,874	2:02
17:04	282.9	120.3	43	862	0:15	166	2,556	3:06
17:26	282.9	120.3	43	639	0:15	225	3,418	3:21
17:44	282.9	120.3	43	156	0:22	239	4,057	3:43
18:05	266.8	120.3	45	344	0:18	348	4,213	4:01
18:24	266.8	120.3	45	287	0:21	186	4,557	4:22
18:40	266.8	120.3	45	412	0:19	225	4,844	4:41
19:06	298.8	149.1	50	317	0:16	223	5,256	4:57
19:25	298.8	149.1	50	106	0:26	233	5,573	5:23
19:43	298.8	149.1	50	281	0:19	215	5,679	5:42
20:03	342.6	169.4	49	176	0:18	151	5,960	6:00
20:26	342.6	169.4	49	342	0:20	240	6,136	6:20
20:40	342.6	169.4	49	279	0:23	167	6,478	6:43
20:54	342.6	169.4	49	267	0:14	188	6,757	6:57
21:03	298.0	150.4	50	113	1,196	237	7,024	7:11
21:11	298.0	150.4	50	113	0:14	195	7,137	7:20
					0:09	195	7,250	7:28
					0:08			

#

This fish moved to the Washington shore before reaching the John Day River plume. As it continued downstream it approached the plume but did not enter it. The tracking range for the tag was very short. The fish was tracked to Spillgate number 19.

Appendix Figure C6.--Radio tracking data for Fish Code 977.



RELEASE DATE: 6 MAY 1983

INDIVIDUAL FISH CODE: 876

SPECIES: SPRING CHINOOK

LENGTH: 155 MM

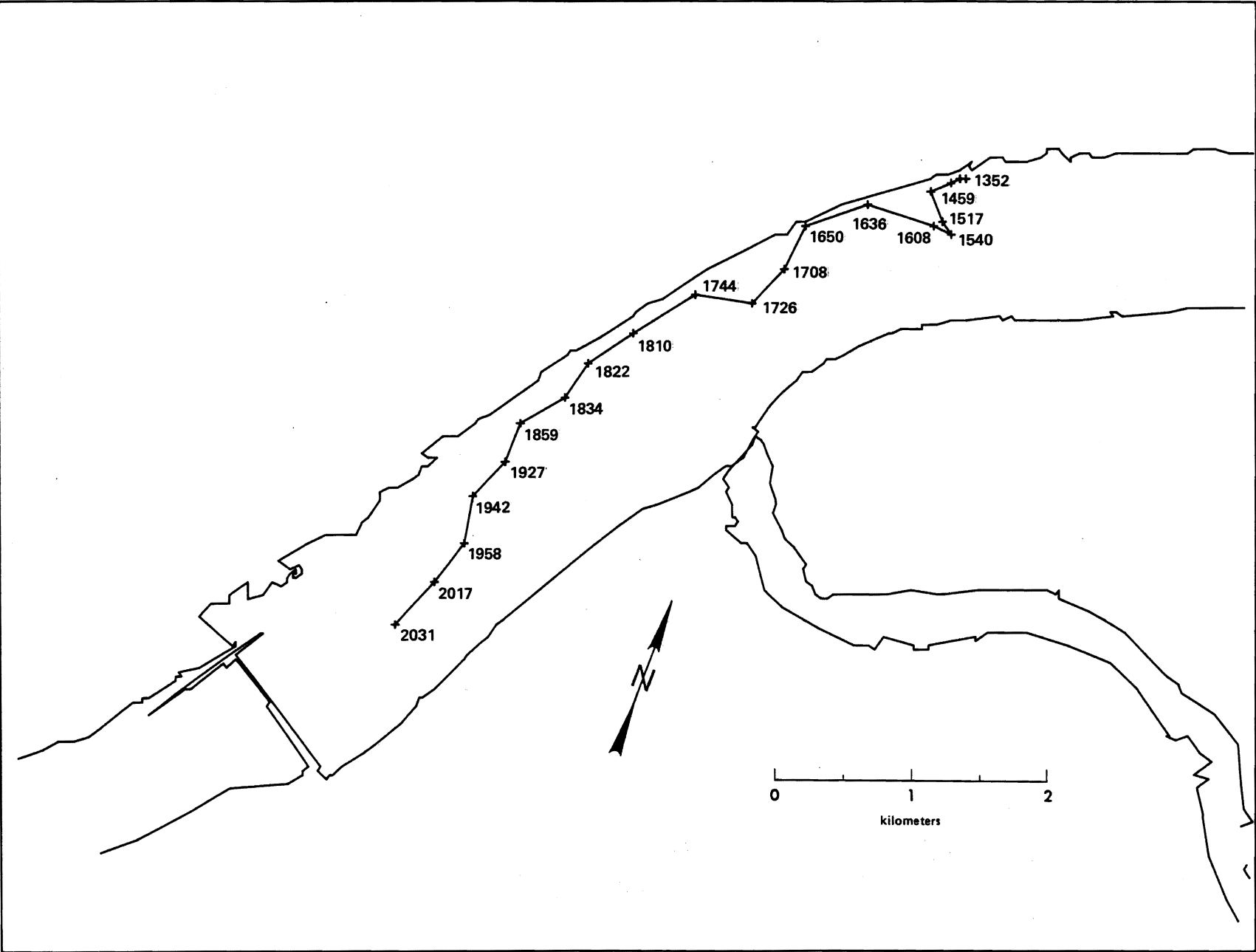
TIME	FLOW (KCFS)	PERCENT	DISTANCE	TIME	VELOCITY	DIRECTION	CUMULATIVE	
	TOTAL SPILL	SPILL	(METERS)	SPAN	(M/HR)	(DEG MAG)	DISTANCE	TIME
13:52	305.7	80.9	26					
14:08	312.8	121.6	43	0:16	161	250	43	0:16
14:40	312.8	121.6	72	0:32	135	225	115	0:48
14:59	312.8	121.6	163	0:19	515	228	278	1:07
15:17	309.6	152.9	233	0:18	777	138	511	1:25
15:40	309.6	152.9	113	0:23	295	125	624	1:48
16:08	313.0	156.7	144	0:28	309	276	768	2:16
16:36	313.0	156.7	500	0:28	1,071	268	1,268	2:44
16:50	313.0	156.7	480	0:14	2,057	231	1,748	2:58
17:08	322.7	156.7	344	0:18	1,147	186	2,092	3:16
17:26	322.7	156.7	343	0:18	1,143	204	2,435	3:34
17:44	322.7	156.7	415	0:18	1,383	259	2,850	3:52
18:10	331.1	156.7	532	0:26	1,228	219	3,382	4:18
18:22	331.1	156.7	390	0:12	1,950	217	3,772	4:30
18:34	331.1	156.7	301	0:12	1,505	195	4,073	4:42
18:59	331.1	156.7	373	0:25	895	220	4,446	5:07
19:27	370.9	183.0	298	0:28	639	181	4,744	5:35
19:42	370.9	183.0	343	0:15	1,372	204	5,087	5:50
19:58	370.9	183.0	346	0:16	1,298	171	5,433	6:06
20:17	377.4	185.2	352	0:19	1,112	198	5,785	6:25
20:31	377.4	185.2	417	0:14	1,787	203	6,202	6:39

#

As this track progressed the weather got worse. At the time the fish approached the restricted zone it was almost dark. The fish appeared to sound and the signal was lost. The track was terminated after an unsuccessful search. Passage through the spill was recorded on the spillway monitor (0346, 8 May).



Appendix Figure C7.--Radio tracking data for Fish Code 876.



RELEASE DATE: 7 MAY 1983

INDIVIDUAL FISH CODE: 372

SPECIES: SPRING CHINOOK

LENGTH: 150 MM

```

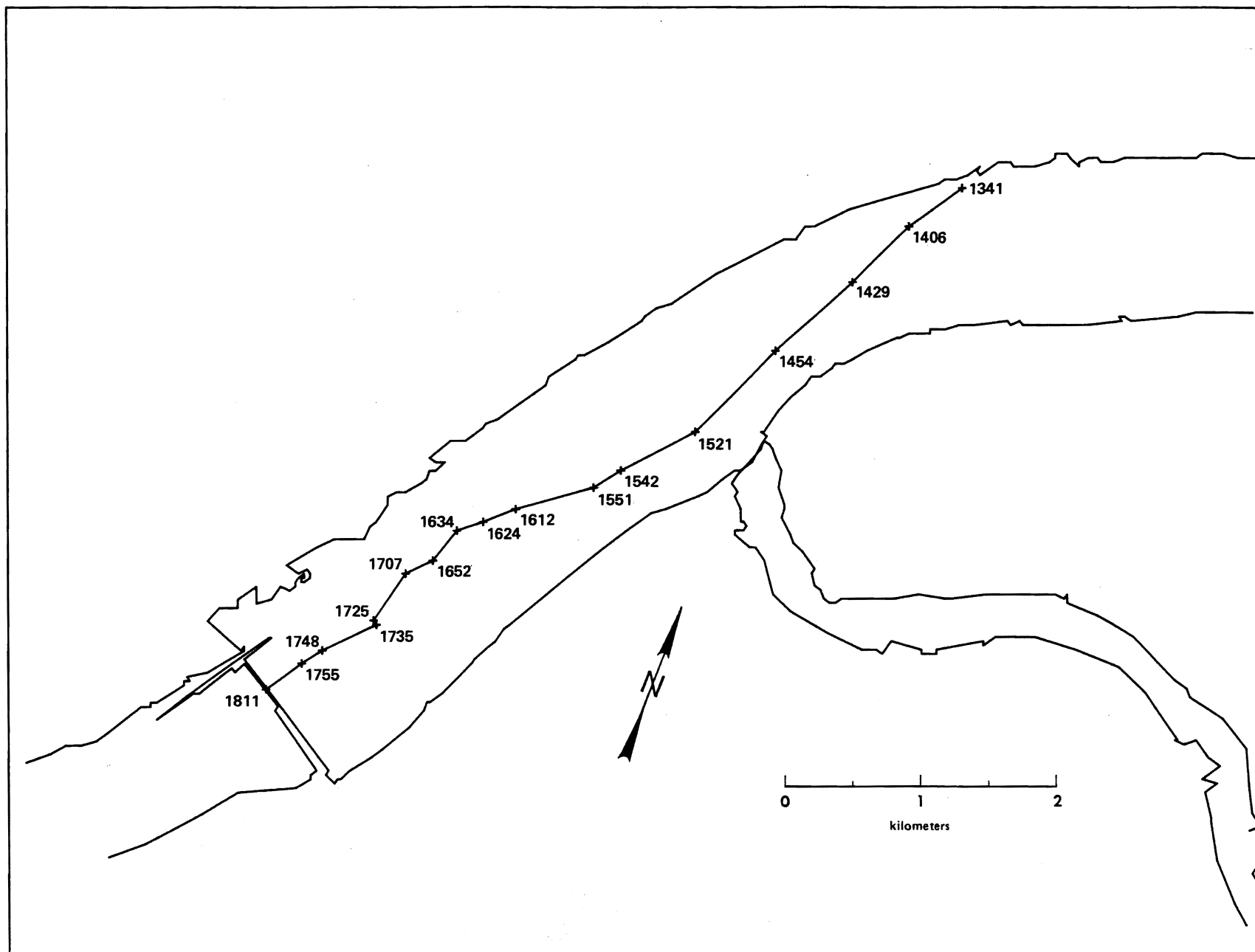
.....
TIME      FLOW (KCFS)  PERCENT  DISTANCE  TIME  VELOCITY  DIRECTION  CUMULATIVE
TOTAL SPILL  SPILL    (METERS)  SPAN    (M/HR)    (DEG MAG)  DISTANCE  TIME

13:41     329.4  199.3    61
14:06     344.7  195.1    57      478    0:25    1,147     215      478    0:25
14:29     344.7  195.1    57      574    0:23    1,497     206     1,052    0:48
14:54     344.7  195.1    57      748    0:25    1,795     209     1,800    1:13
15:21     340.9  198.0    58      828    0:27    1,840     205     2,628    1:40
15:42     340.9  198.0    58      608    0:21    1,737     223     3,236    2:01
15:51     340.9  198.0    58      230    0:09    1,533     218     3,466    2:10
16:12     333.6  175.3    53      583    0:21    1,666     235     4,049    2:31
16:24     333.6  175.3    53      255    0:12    1,275     229     4,304    2:43
16:34     333.6  175.3    53      204    0:10    1,224     233     4,508    2:53
16:52     333.6  175.3    53      277    0:18      923     199     4,785    3:11
17:07     334.0  171.0    51      216    0:15      864     225     5,001    3:26
17:25     334.0  171.0    51      415    0:18    1,383     195     5,416    3:44
17:35     334.0  171.0    51       38    0:10      228     125     5,454    3:54
17:48     334.0  171.0    51      431    0:13    1,989     225     5,885    4:07
17:55     334.0  171.0    51      177    0:07    1,517     219     6,062    4:14
18:11     341.9  162.0    47      319    0:16    1,196     215     6,381    4:30
#

```

During this track the wind was out of the northwest. This pushed the John Day River plume up to the Oregon side of the river. When the fish encountered the plume the signal was lost for a short period, indicative of diving behavior. The only slow movement was taking place just upstream from the restricted zone and from there the fish moved to the spillway for a daylight passage through Gate number 14. The spillway monitors last recorded the signals at 1814.

Appendix Figure C8.--Radio tracking data for Fish Code 372.



RELEASE DATE: 8 MAY 1983

INDIVIDUAL FISH CODE: 735

SPECIES: SPRING CHINOOK

LENGTH: 154 MM

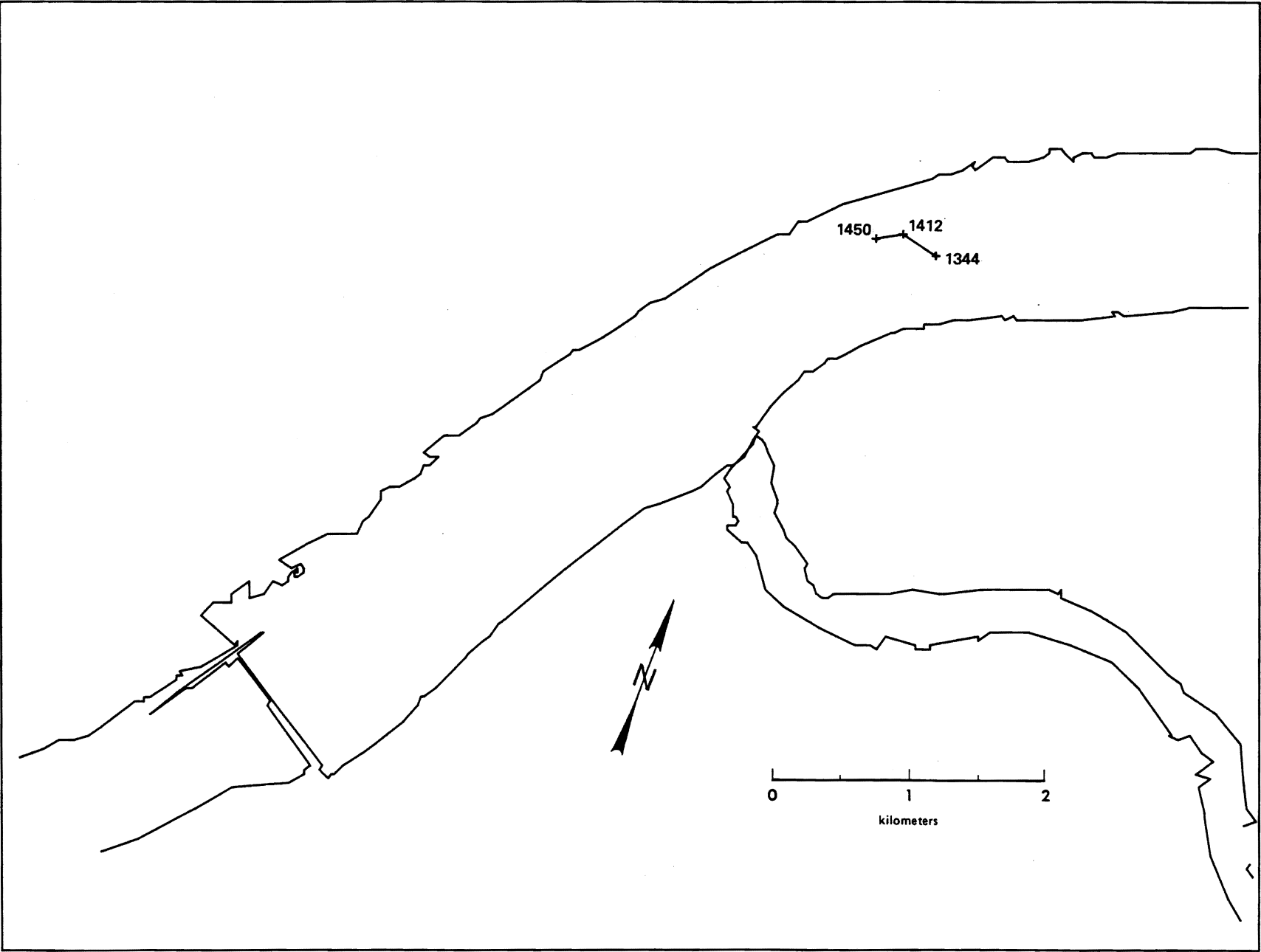
.....

TIME	FLOW (KCFS) TOTAL	SPILL	PERCENT SPILL	DISTANCE (METERS)	TIME SPAN	VELOCITY (M/HR)	DIRECTION (DEG MAG)	CUMULATIVE DISTANCE	TIME
13:44	330.1	120.3	36						
14:12	324.9	154.0	47	284	0:28	609	283	284	0:28
14:50	324.9	154.0	47	197	0:38	311	241	481	1:06

#

During this track the battery on the large boat quit. After repairing the problem a storm moved into the area and the track was terminated because of rough water. Passage at the dam was recorded on 9 May at 2000 by the spillway monitors.

Appendix Figure C9.--Radio tracking data for Fish Code 735.



RELEASE DATE: 10 MAY 1983

INDIVIDUAL FISH CODE: 364

SPECIES: SPRING CHINOOK

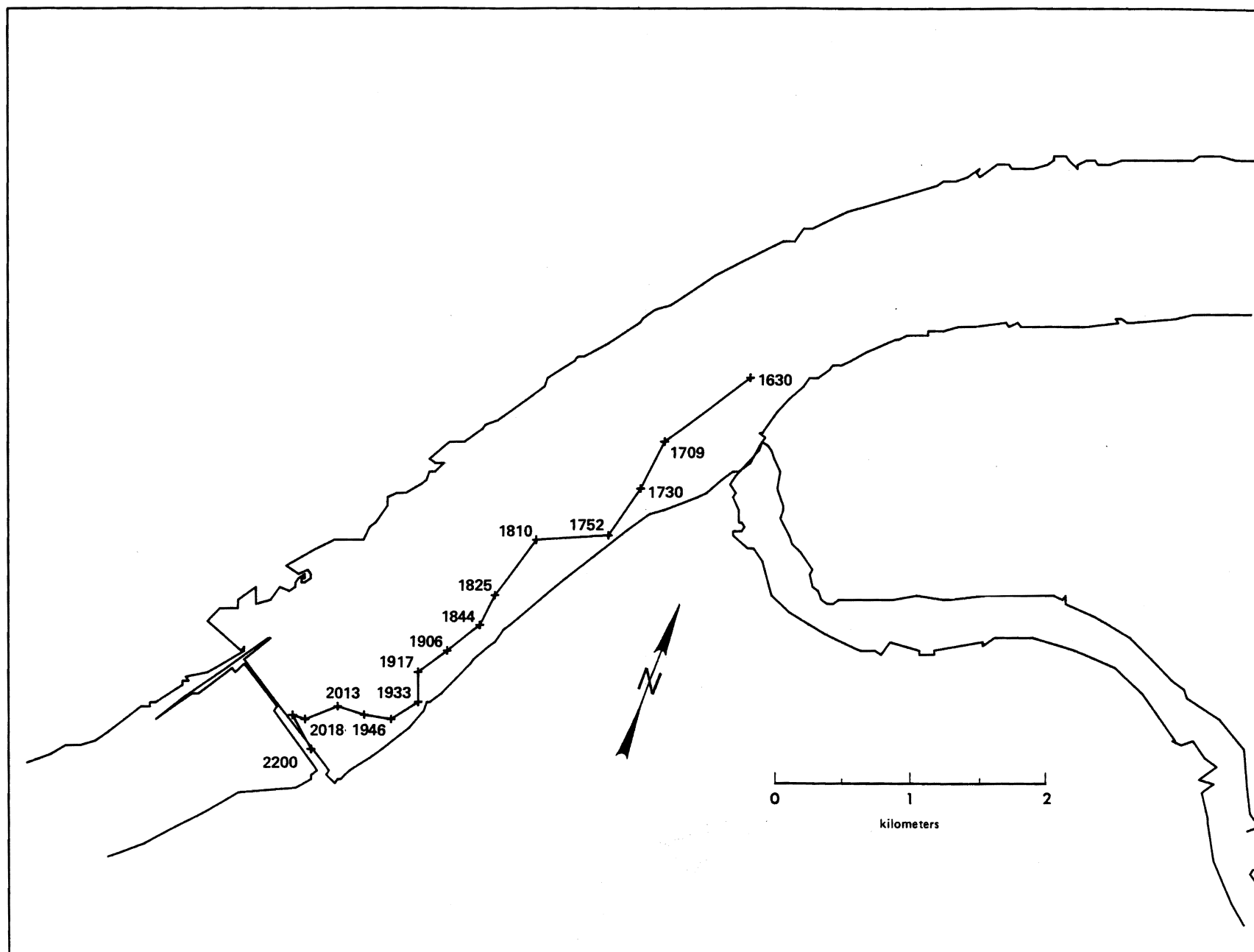
LENGTH: 155 MM

TIME	FLOW (KCS)	PERCENT	DISTANCE	TIME	VELOCITY	DIRECTION	CUMULATIVE	
	TOTAL SPILL	SPILL	(METERS)	SPAN	(M/HR)	(DEG MAG)	DISTANCE	TIME
16:30	334.2	120.3	36					
17:09	336.6	120.3	36	779	0:39	1,198	214	779 0:39
17:30	336.6	120.3	36	381	0:21	1,089	187	1,160 1:00
17:52	336.6	120.3	36	415	0:22	1,132	195	1,575 1:22
18:10	337.8	120.0	36	520	0:18	1,733	247	2,095 1:40
18:25	337.8	120.0	36	503	0:15	2,012	197	2,598 1:55
18:44	337.8	120.0	36	242	0:19	764	187	2,840 2:14
19:06	378.2	146.4	39	301	0:22	821	212	3,141 2:36
19:17	378.2	146.4	39	266	0:11	1,451	215	3,407 2:47
19:33	378.2	146.4	39	216	0:16	810	160	3,623 3:03
19:46	378.2	146.4	39	230	0:13	1,062	218	3,853 3:16
19:55	378.2	146.4	39	197	0:09	1,313	259	4,050 3:25
20:13	418.2	148.8	36	204	0:18	680	268	4,254 3:43
20:18	418.2	148.8	36	255	0:05	3,060	229	4,509 3:48
20:35	418.2	148.8	36	92	0:17	325	270	4,601 4:05
22:00	360.7	148.8	41	279	1:25	197	132	4,880 5:30

#

This fish was released just upstream of the John Day River plume to observe behavior in the plume. Upon entering the plume the signal became weak and was hard to follow. We believe that the fish stayed deep throughout the track. The signal was lost for several short periods in the restricted zone. The last tracking contact with this fish was at Turbine 13 at 2025, but the powerhouse monitors last recorded the signal at 2218 and the fish was recovered from the airlift Turbine Unit 3, during the 2200 sample.

Appendix Figure C10.--Radio tracking data for Fish Code 364.



RELEASE DATE: 11 MAY 1983

INDIVIDUAL FISH CODE: 270

SPECIES: SPRING CHINOOK

LENGTH: 165 MM

.....

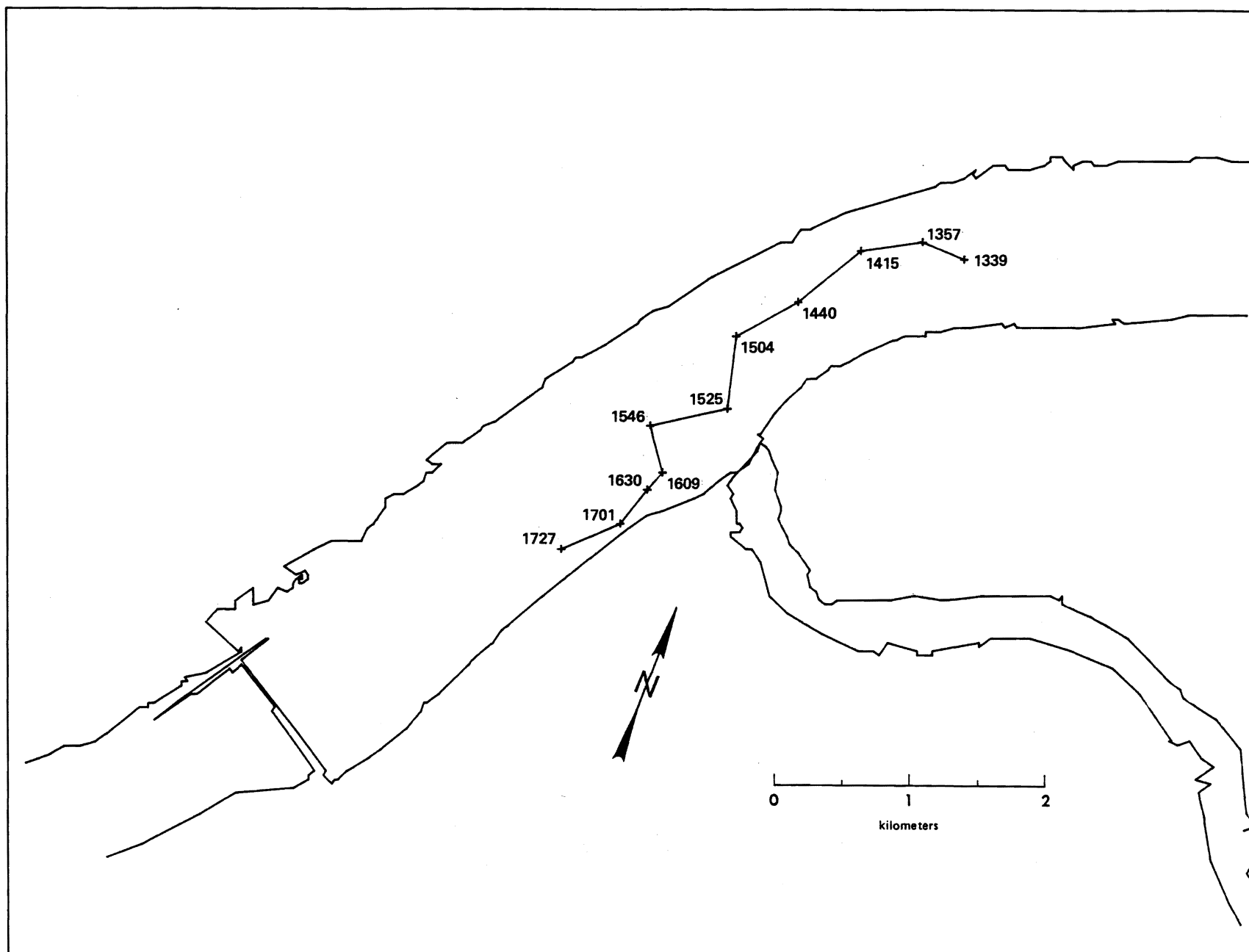
TIME	FLOW (KCFS)	PERCENT	DISTANCE	TIME	VELOCITY	DIRECTION	CUMULATIVE	
	TOTAL SPILL	SPILL	(METERS)	SPAN	(M/HR)	(DEG MAG)	DISTANCE	TIME
13:39	335.5	150.4	45					
13:57	335.5	150.4	45	0:18	1,090	272	327	0:18
14:15	355.2	150.4	42	0:18	1,527	242	785	0:36
14:40	355.2	150.4	42	0:25	1,406	211	1,371	1:01
15:04	343.5	150.4	44	0:24	1,293	222	1,888	1:25
15:25	343.5	150.4	44	0:21	1,511	167	2,417	1:46
15:46	343.5	150.4	44	0:21	1,646	238	2,993	2:07
16:09	347.0	150.4	43	0:23	913	146	3,343	2:30
16:30	347.0	150.4	43	0:21	469	201	3,507	2:51
17:01	348.3	150.4	43	0:31	608	198	3,821	3:22
17:27	348.3	150.4	43	0:26	1,085	227	4,291	3:48

#

Upon release this fish moved toward the John Day River. The plume was visible only near the Oregon shore. As the fish moved downstream from the John Day River, its movements slowed and the signal began to fluctuate. At 1727 the signal was lost and the track was terminated after an unsuccessful search.



Appendix Figure C11.--Radio tracking data for Fish Code 270.



RELEASE DATE: 17 MAY 1983

INDIVIDUAL FISH CODE: 515

SPECIES: SPRING CHINOOK

LENGTH: 177 MM

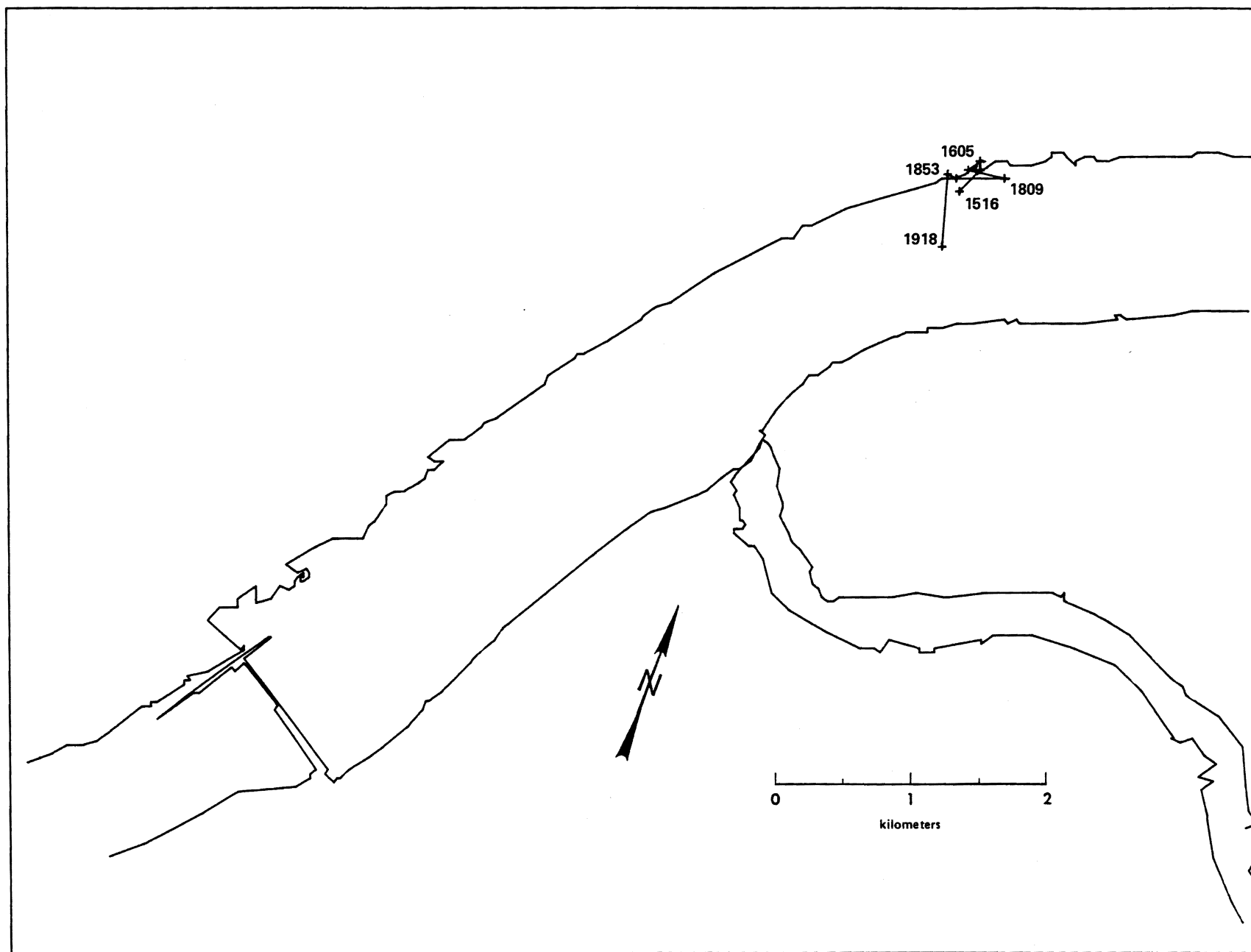
.....

TIME	FLOW (KCF)	PERCENT	DISTANCE	TIME	VELOCITY	DIRECTION	CUMULATIVE	
	TOTAL SPILL	SPILL	(METERS)	SPAN	(M/HR)	(DEG MAG)	DISTANCE	TIME
15:16	190.3	3.2	2					
15:37	190.3	3.2	2	216	0:21	617	25	216 0:21
16:05	193.3	3.2	2	62	0:28	133	340	278 0:49
16:30	193.3	3.2	2	0	0:25	0	-*-	278 1:14
17:04	197.7	3.2	2	106	0:34	187	215	384 1:48
17:40	197.7	3.2	2	267	0:36	445	84	651 2:24
18:09	197.3	3.2	2	0	0:29	0	-*-	651 2:53
18:32	197.3	3.2	2	346	0:23	903	250	997 3:16
18:53	197.3	3.2	2	72	0:21	206	276	1,069 3:37
19:18	260.7	122.1	47	527	0:25	1,265	165	1,596 4:02

#

This fish did not move during daylight hours. As the sun set it made one significant move, the signal decreased and the fish was lost. The track was terminated after an unsuccessful search.

Appendix Figure C12.--Radio tracking data for Fish Code 515.



RELEASE DATE: 18 MAY 1983

INDIVIDUAL FISH CODE: 746

SPECIES: SPRING CHINOOK

LENGTH: 162 MM

```

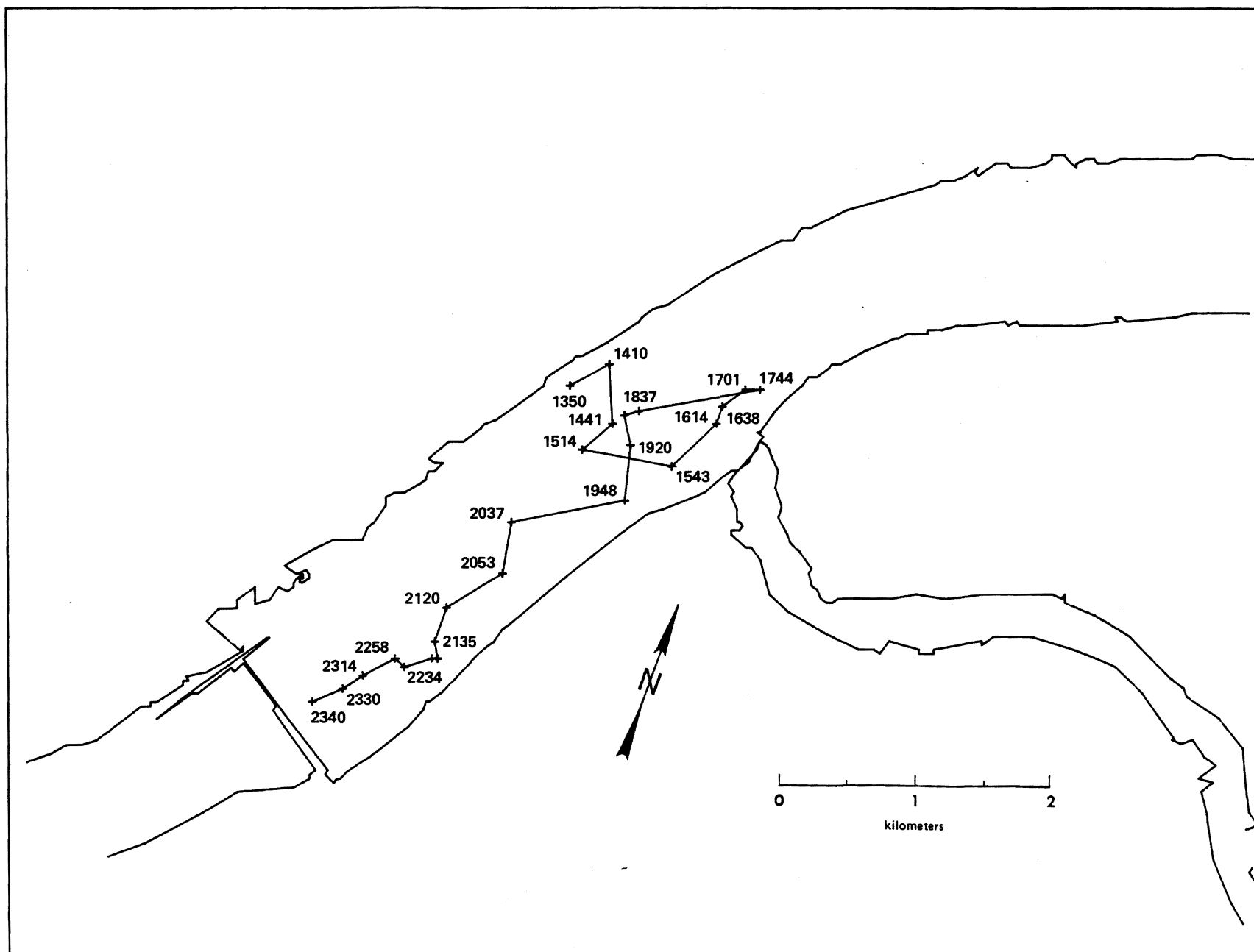
.....
TIME      FLOW (KCFS)  PERCENT  DISTANCE  TIME  VELOCITY  DIRECTION  CUMULATIVE
TOTAL SPILL  SPILL    (METERS)  SPAN    (M/HR)  (DEG MAG)  DISTANCE  TIME
13:50     249.5      3.2      1
14:10     236.3      3.2      1      321    0:20      963      41      321    0:20
14:41     236.3      3.2      1      433    0:31      838     157     754    0:51
15:14     219.2      3.2      1      285    0:33      518     210    1,039  1:24
15:43     219.2      3.2      1      660    0:29     1,366     81    1,699  1:53
16:14     245.9      3.2      1      448    0:31      867     27    2,147  2:24
16:38     245.9      3.2      1      131    0:24      328    360    2,278  2:48
17:01     249.4      3.2      1      213    0:23      556     35    2,491  3:11
17:44     249.4      3.2      1      108    0:43      151     70    2,599  3:54
18:37     242.2      3.4      1      900    0:53     1,019    240    3,499  4:47
19:02     278.0     124.5     45     112    0:25      269    234    3,611  5:12
19:20     278.0     124.5     45     220    0:18      733    149    3,831  5:30
19:48     278.0     124.5     45     404    0:28      866    166    4,235  5:58
20:37     316.6     153.5     48     836    0:49     1,024    240    5,071  6:47
20:53     316.6     153.5     48     376    0:16     1,410    170    5,447  7:03
21:20     331.5     164.7     50     479    0:27     1,064    219    5,926  7:30
21:35     331.5     164.7     50     262    0:15     1,048    180    6,188  7:45
21:50     331.5     164.7     50     125    0:15      500    150    6,313  8:00
22:23     311.7     157.7     51      43    0:33       78    250    6,356  8:33
22:34     311.7     157.7     51     204    0:11     1,113    233    6,560  8:44
22:58     311.7     157.7     51      90    0:24      225    294    6,650  9:08
23:14     281.4     144.4     51     268    0:16     1,005    223    6,918  9:24
23:30     281.4     144.4     51     177    0:16      664    219    7,095  9:40
23:40     281.4     144.4     51     235    0:10     1,410    227    7,330  9:50

```

#

Because of a northwest wind this fish was released closer to the dam and near the Washington shore. The signal was lost for short periods of time during the track. Wave action may have forced the fish to move deeper than normal and because of the wind the boats had to move continually to stay with the fish. This is the second fish that was lost in the restricted zone as it approached the dam after dark.

Appendix Figure C13.--Radio tracking data for Fish Code 746.



RELEASE DATE: 19 MAY 1983

INDIVIDUAL FISH CODE: 474

SPECIES: SPRING CHINOOK

LENGTH: 162 MM

```

.....
TIME      FLOW (KCF)  PERCENT  DISTANCE  TIME  VELOCITY  DIRECTION  CUMULATIVE
TOTAL SPILL SPILL    (METERS) SPAN   (M/HR)   (DEG MAG) DISTANCE  TIME

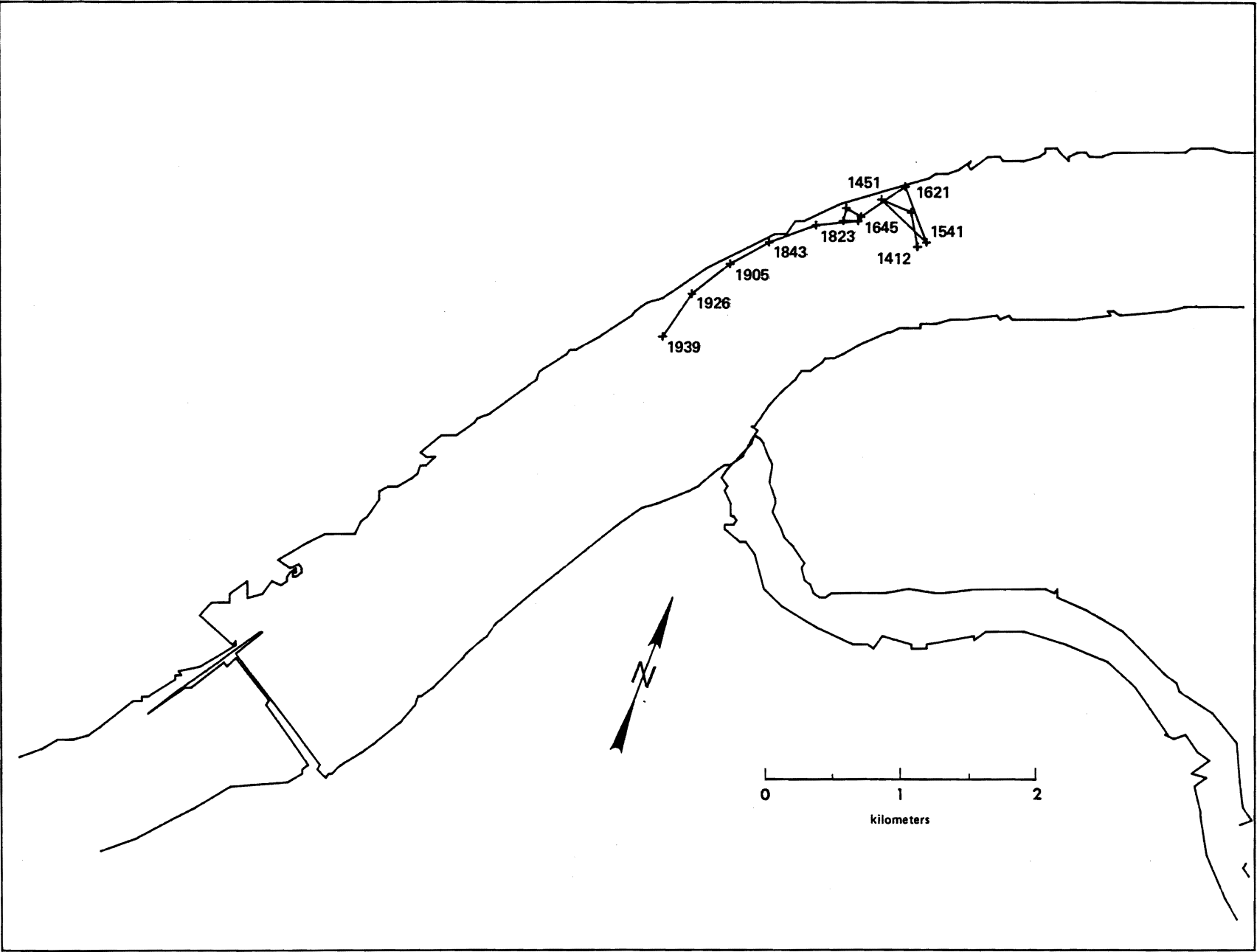
14:12     278.7    3.2      1
14:36     278.7    3.2      1      251    0:24      628      330      251    0:24
14:51     278.7    3.2      1      235    0:15      940      273      486    0:39
15:41     275.2    3.2      1      448    0:50      538      114      934    1:29
16:21     273.9    3.2      1      429    0:40      644      320     1,363    2:09
16:45     273.9    3.2      1      390    0:24      975      217     1,753    2:33
17:11     280.4    3.2      1      124    0:26      286      280     1,877    2:59
17:36     280.4    3.2      1       95    0:25      228      173     1,972    3:24
18:09     278.8     9.3      3      108    0:33      196       70     2,080    3:57
18:23     278.8     9.3      3      304    0:14     1,303      244     2,384    4:11
18:43     278.8     9.3      3      367    0:20     1,101      231     2,751    4:31
19:05     304.9   141.3     46      321    0:22      875      221     3,072    4:53
19:26     304.9   141.3     46      355    0:21     1,014      213     3,427    5:14
19:39     304.9   141.3     46      377    0:13     1,740      195     3,804    5:27

```

#

This fish held up near the release area for two hours after release, and when it did start to move it was eaten by a seagull. In the four years of juvenile tracking at John Day Dam, this is the second fish that seagulls are known to have taken.

Appendix Figure C14.--Radio tracking data for Fish Code 474.



RELEASE DATE: 20 MAY 1983

INDIVIDUAL FISH CODE: 127

SPECIES: SPRING CHINOOK

LENGTH: 164 MM

.....

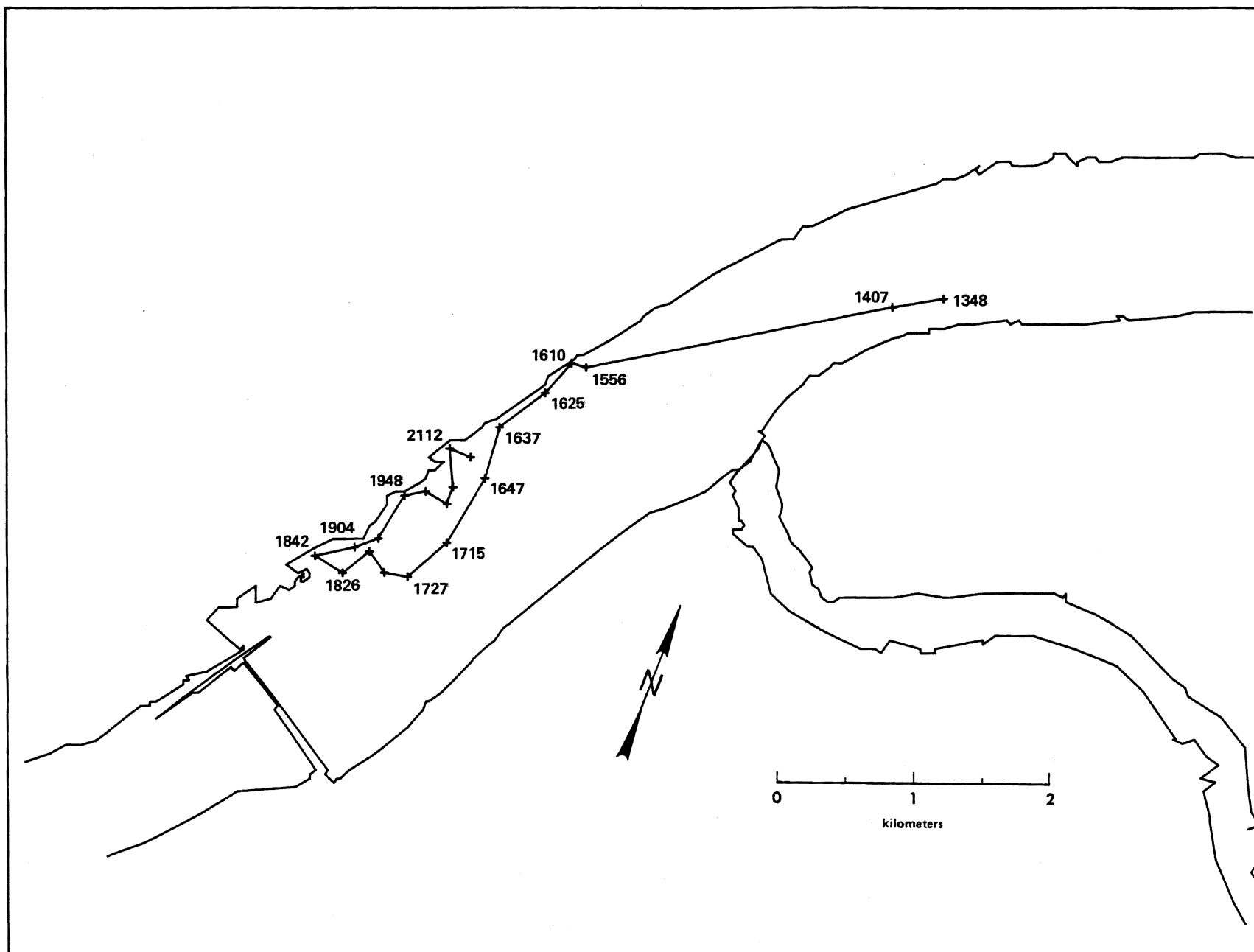
TIME	FLOW (KCFS) TOTAL SPILL	PERCENT SPILL	DISTANCE (METERS)	TIME SPAN	VELOCITY (M/HR)	DIRECTION (DEG MAG)	CUMULATIVE DISTANCE	TIME
13:48	286.8	3.2						
14:07	281.5	3.2	373	0:19	1,178	241	373	0:19
15:56	278.2	3.0	2,269	1:49	1,249	239	2,642	2:08
16:10	261.3	3.2	112	0:14	480	266	2,754	2:22
16:25	261.3	3.2	291	0:15	1,164	202	3,045	2:37
16:37	261.3	3.2	408	0:12	2,040	213	3,453	2:49
16:47	261.3	3.2	386	0:10	2,316	176	3,839	2:59
17:15	270.3	19.0	542	0:28	1,161	191	4,381	3:27
17:27	270.3	19.0	374	0:12	1,870	209	4,755	3:39
17:48	270.3	19.0	176	0:21	503	260	4,931	4:00
18:12	250.8	98.4	188	0:24	470	305	5,119	4:24
18:26	250.8	98.4	248	0:14	1,063	212	5,367	4:38
18:42	250.8	98.4	230	0:16	863	283	5,597	4:54
19:04	258.1	129.0	288	0:22	785	58	5,885	5:16
19:26	258.1	129.0	184	0:22	502	51	6,069	5:38
19:48	258.1	129.0	365	0:22	995	12	6,434	6:00
20:03	270.2	133.0	154	0:15	616	59	6,588	6:15
20:16	270.2	133.0	177	0:13	817	102	6,765	6:28
20:42	270.2	133.0	131	0:26	302	360	6,896	6:54
21:12	275.2	133.9	279	0:30	558	336	7,175	7:24
21:30	275.2	133.9	163	0:18	543	92	7,338	7:42

#

At the time this fish was released the John Day River plume was just downstream from the release site. At the time the second location was taken the fish was in the plume. Shortly after the location was recorded the signal was lost. After the signal was found near the Washington shore we had good signal reception. The fish approached the restricted area before dark and at the time the spill pattern was being changed. The track was terminated when the fish continued upstream after dark.



Appendix Figure C15.--Radio tracking data for Fish Code 127.



RELEASE DATE: 21 MAY 1983

INDIVIDUAL FISH CODE: 627

SPECIES: SPRING CHINOOK

LENGTH: 174 MM

```

.....
TIME      FLOW (KCFS)  PERCENT  DISTANCE  TIME  VELOCITY  DIRECTION  CUMULATIVE
TOTAL SPILL  SPILL    (METERS)  SPAN    (M/HR)    (DEG MAG)  DISTANCE  TIME

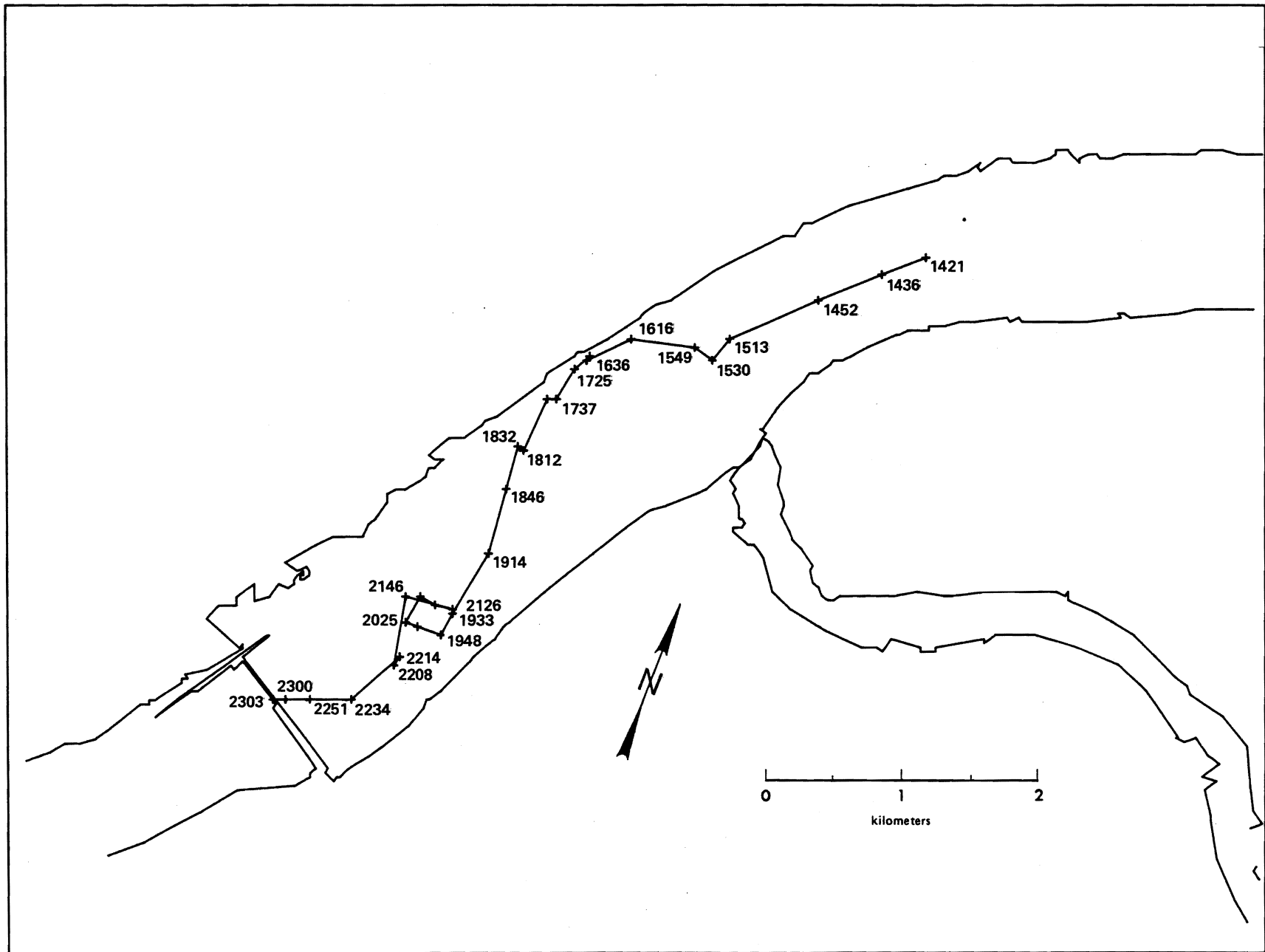
14:21      283.3  120.3    42
14:36      283.3  120.3    42      347      0:15      1,388      229      347      0:15
14:52      283.3  120.3    42      490      0:16      1,838      228      837      0:31
15:13      281.5  120.3    43      706      0:21      2,017      227      1,543    0:52
15:30      281.5  120.3    43      202      0:17        713      200      1,745    1:09
15:49      281.5  120.3    43      159      0:19        502      286      1,904    1:28
16:16      287.7  120.3    42      458      0:27      1,018      258      2,362    1:55
16:36      287.7  120.3    42      359      0:20      1,077      225      2,721    2:15
17:08      253.5  120.3    47       38      0:32        71       15      2,759    2:47
17:25      253.5  120.3    47      142      0:17        501      210      2,901    3:04
17:37      253.5  120.3    47      252      0:12      1,260      191      3,153    3:16
17:53      253.5  120.3    47       65      0:16        244      250      3,218    3:32
18:12      240.1  118.5    49      409      0:19      1,292      185      3,627    3:51
18:32      240.1  118.5    49       53      0:20        159      286      3,680    4:11
18:46      240.1  118.5    49      321      0:14      1,376      176      4,001    4:25
19:14      228.4  118.5    52      481      0:28      1,031      176      4,482    4:53
19:33      228.4  118.5    52      504      0:19      1,592      191      4,986    5:12
19:48      228.4  118.5    52      177      0:15        708      189      5,163    5:27
20:00      228.4  118.5    52      184      0:12        920      270      5,347    5:39
20:25      230.0  120.3    52       92      0:25        221      270      5,439    6:04
20:52      230.0  120.3    52      214      0:27        476      10      5,653    6:31
21:09      256.1  122.0    48      124      0:17        438      100      5,777    6:48
21:26      256.1  122.0    48      133      0:17        469      84      5,910    7:05
21:46      256.1  122.0    48      358      0:20      1,074      265      6,268    7:25
22:08      284.8  143.5    50      501      0:22      1,366      170      6,769    7:47
22:14      284.8  143.5    50       75      0:06        750      15      6,844    7:53
22:34      284.8  143.5    50      464      0:20      1,392      208      7,308    8:13
22:51      284.8  143.5    50      303      0:17      1,069      250      7,611    8:30
23:00      284.8  143.5    50      173      0:09      1,153      250      7,784    8:39
23:03      242.1  127.4    53       86      0:03      1,720      250      7,870    8:42

```

#

This fish showed the typical behavior of the radio tagged fish to the John Day River plume and to the dam. The plume caused the fish to move to the Washington shore and the fish held up just upstream of the restricted zone until after dark. The last monitor record was at 2256.

Appendix Figure C16.--Radio tracking data for Fish Code 627.



RELEASE DATE: 22 MAY 1983

INDIVIDUAL FISH CODE: 267

SPECIES: COHO

LENGTH: 152 MM

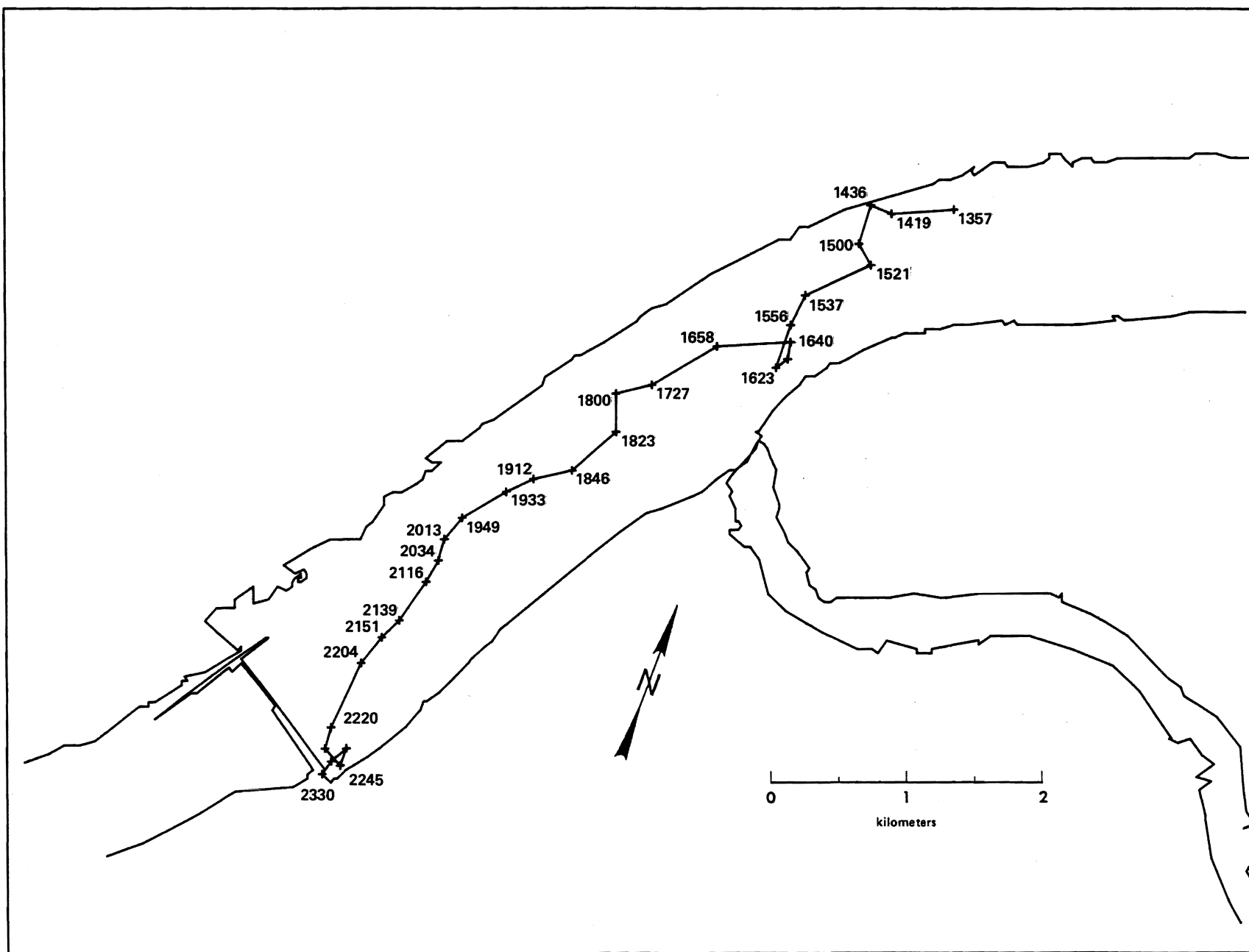
.....

TIME	FLOW (KCFS)	PERCENT	DISTANCE	TIME	VELOCITY	DIRECTION	CUMULATIVE	
	TOTAL SPILL	SPILL	(METERS)	SPAN	(M/HR)	(DEG MAG)	DISTANCE	TIME
13:57	320.7	121.5	38					
14:19	313.0	150.4	48					
14:36	313.0	150.4	48	455	0:22	1,241	246	455 0:22
15:00	313.0	150.4	48	163	0:17	575	272	618 0:39
15:21	315.6	150.4	48	291	0:24	728	177	909 1:03
15:37	315.6	150.4	48	177	0:21	506	131	1,086 1:24
15:56	315.6	150.4	48	522	0:16	1,958	226	1,608 1:40
16:23	309.4	150.4	49	242	0:19	764	187	1,850 1:59
16:40	309.4	150.4	49	327	0:27	727	180	2,177 2:26
16:58	309.4	150.4	49	106	0:17	374	35	2,283 2:43
17:27	310.6	150.4	48	125	0:18	417	350	2,408 3:01
18:00	310.6	150.4	48	541	0:29	1,119	247	2,949 3:30
18:23	286.9	150.4	52	551	0:33	1,002	220	3,500 4:03
18:46	286.9	150.4	52	267	0:23	697	237	3,767 4:26
19:12	297.6	150.4	51	278	0:23	725	160	4,045 4:49
19:33	297.6	150.4	51	427	0:26	985	210	4,472 5:15
19:49	297.6	150.4	51	288	0:21	823	238	4,760 5:36
20:13	299.8	150.4	50	216	0:16	810	225	4,976 5:52
20:34	299.8	150.4	50	373	0:24	933	220	5,349 6:16
20:54	299.8	150.4	50	202	0:21	577	200	5,551 6:37
21:16	302.3	148.1	49	160	0:20	480	176	5,711 6:57
21:39	302.3	148.1	49	177	0:22	483	189	5,888 7:19
21:51	302.3	148.1	49	339	0:23	884	195	6,227 7:42
22:04	268.0	140.9	53	179	0:12	895	207	6,406 7:54
22:20	268.0	140.9	53	239	0:13	1,103	199	6,645 8:07
22:32	268.0	140.9	53	511	0:16	1,916	185	7,156 8:23
22:45	268.0	140.9	53	160	0:12	800	176	7,316 8:35
22:54	268.0	140.9	53	164	0:13	757	119	7,480 8:48
23:13	242.3	139.9	58	131	0:09	873	360	7,611 8:57
23:30	242.3	139.9	58	142	0:19	448	210	7,753 9:16
				113	0:17	399	195	7,866 9:33

#

This is one of two coho salmon that were released when chinook salmon were not available. This fish avoided the John Day River plume and slowed when it got to the restricted zone. It crossed the river (Washington to Oregon) during a period of high spill, and it passed downstream via the Oregon shore Fishladder.

Appendix Figure C17.--Radio tracking data for Fish Code 267.



RELEASE DATE: 23 MAY 1983

INDIVIDUAL FISH CODE: 928

SPECIES: COHO

LENGTH: 179 MM

```

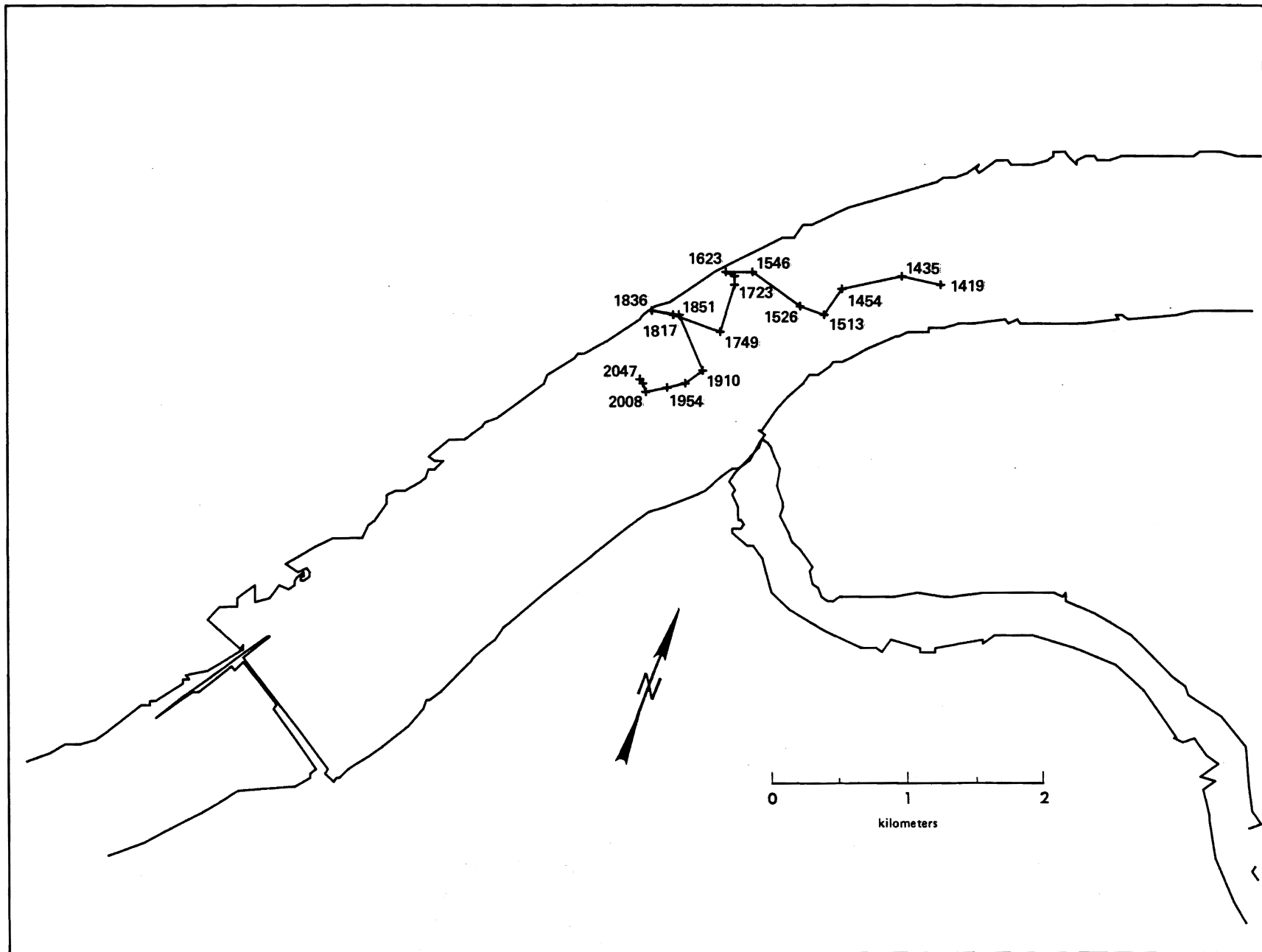
.....
TIME      FLOW (KCFS)  PERCENT  DISTANCE  TIME  VELOCITY  DIRECTION  CUMULATIVE
TOTAL SPILL  SPILL    (METERS)  SPAN    (M/HR)    (DEG MAG)  DISTANCE  TIME

14:19      276.9   35.2    13
14:35      276.9   35.2    13      288    0:16    1,080      263      288    0:16
14:54      276.9   35.2    13      442    0:19    1,396      238      730    0:35
15:13      265.5   35.2    13      226    0:19      714      195      956    0:54
15:26      265.5   35.2    13      184    0:13      849      270     1,140    1:07
15:46      265.5   35.2    13      425    0:20    1,275      286     1,565    1:27
16:23      254.3   64.0    25      195    0:37      316      250     1,760    2:04
16:53      254.3   64.0    25       72    0:30      144       96     1,832    2:34
17:23      261.3  120.3    46       62    0:30      124      160     1,894    3:04
17:49      261.3  120.3    46      356    0:26      822      178     2,250    3:30
18:17      272.8  130.0    48      367    0:28      786      270     2,617    3:58
18:36      272.8  130.0    48      154    0:19      486      262     2,771    4:17
18:51      272.8  130.0    48      197    0:15      788       79     2,968    4:32
19:10      277.7  129.6    47      437    0:19    1,380      137     3,405    4:51
19:28      277.7  129.6    47      159    0:18      530      215     3,564    5:09
19:54      277.7  129.6    47      133    0:26      307      237     3,697    5:35
20:08      315.8  154.0    49      154    0:14      660      239     3,851    5:49
20:22      315.8  154.0    49       65    0:14      279      321     3,916    6:03
20:47      315.8  154.0    49       38    0:25       91      305     3,954    6:28
#

```

This coho salmon showed a strong avoidance of the John Day River plume. It was holding upstream of the plume at sunset when the track was abandon due to no downstream movement. Passage at the dam was recorded by the spillway monitors at 0420 on 24 May.

Appendix Figure C18.--Radio tracking data for Fish Code 928.



RELEASE DATE: 24 MAY 1983

INDIVIDUAL FISH CODE: 766

SPECIES: STEELHEAD

LENGTH: 165 MM

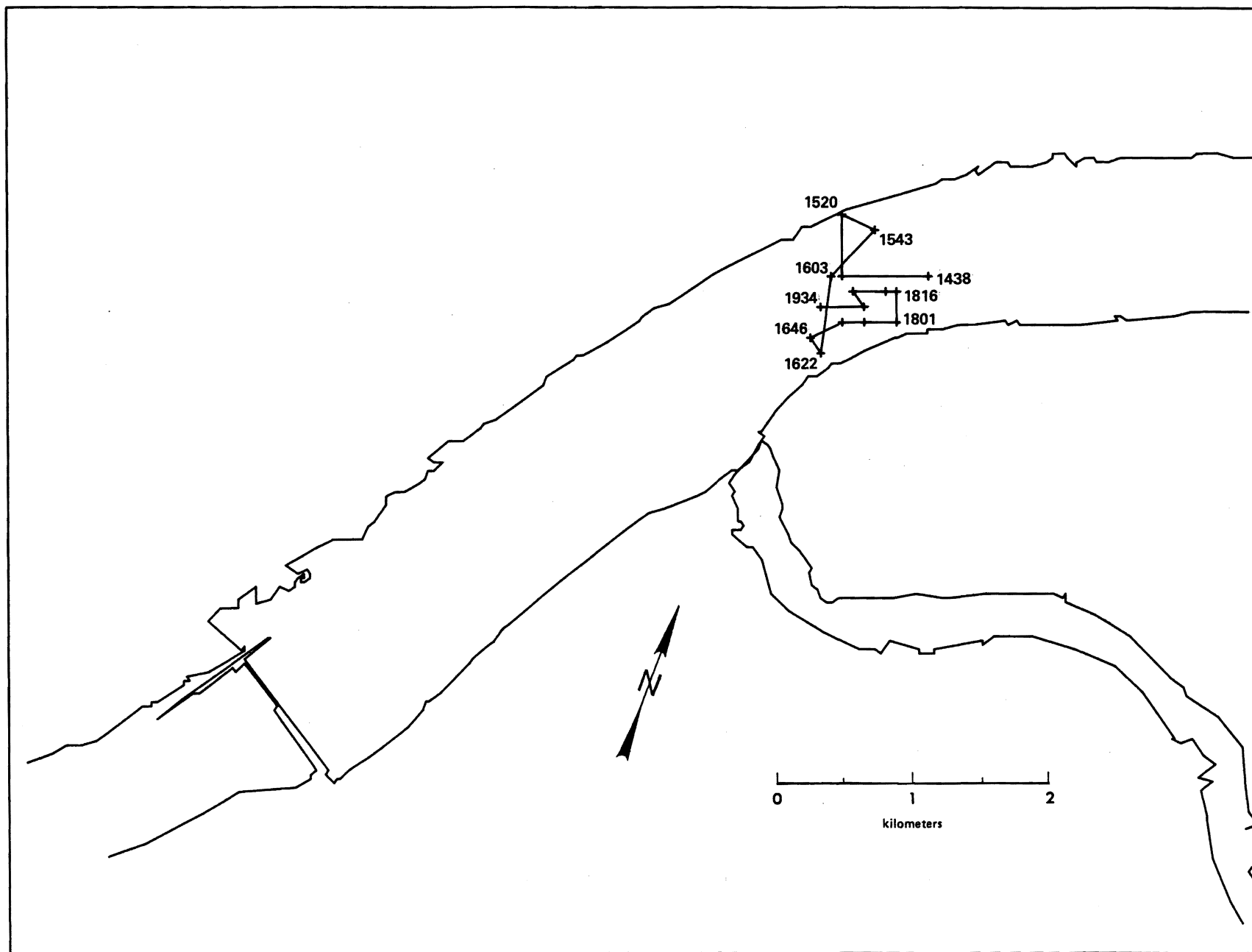
.....									
TIME	FLOW (KCFS)		PERCENT	DISTANCE	TIME	VELOCITY	DIRECTION	CUMULATIVE	
	TOTAL	SPILL	SPILL	(METERS)	SPAN	(M/HR)	(DEG MAG)	DISTANCE	TIME
14:38	334.8	119.5	36						
15:00	334.8	119.5	36	585	0:22	1,595	247	585	0:22
15:20	331.6	119.5	36	433	0:20	1,299	337	1,018	0:42
15:43	331.6	119.5	36	246	0:23	642	85	1,264	1:05
16:03	320.2	119.5	37	503	0:20	1,509	197	1,767	1:25
16:22	320.2	119.5	37	468	0:19	1,478	168	2,235	1:44
16:46	320.2	119.5	37	72	0:24	180	276	2,307	2:08
17:10	266.4	119.5	45	255	0:24	638	49	2,562	2:32
17:30	266.4	119.5	45	144	0:20	432	45	2,706	2:52
18:01	265.1	119.5	45	259	0:31	501	70	2,965	3:23
18:16	265.1	119.5	45	185	0:15	740	340	3,150	3:38
18:33	265.1	119.5	45	124	0:17	438	280	3,274	3:55
18:54	265.1	119.5	45	255	0:21	729	229	3,529	4:16
19:10	300.6	149.6	50	92	0:16	345	90	3,621	4:32
19:34	300.6	149.6	50	330	0:24	825	239	3,951	4:56

#

This was the first steelhead release in 1983. Besides indicating why we prefer to track chinook salmon, this fish was in and out of the John Day River plume while closest to the Oregon shore. Passage of the dam was recorded by the spillway monitors at 1734 on 25 May.



Appendix Figure C19.--Radio tracking data for Fish Code 766.



RELEASE DATE: 25 MAY 1983

INDIVIDUAL FISH CODE: 144

SPECIES: SPRING CHINOOK

LENGTH: 159 MM

```

.....
TIME      FLOW (KCFS)  PERCENT  DISTANCE  TIME  VELOCITY  DIRECTION  CUMULATIVE
TOTAL    SPILL    SPILL    (METERS)  SPAN  (M/HR)    (DEG MAG)  DISTANCE  TIME

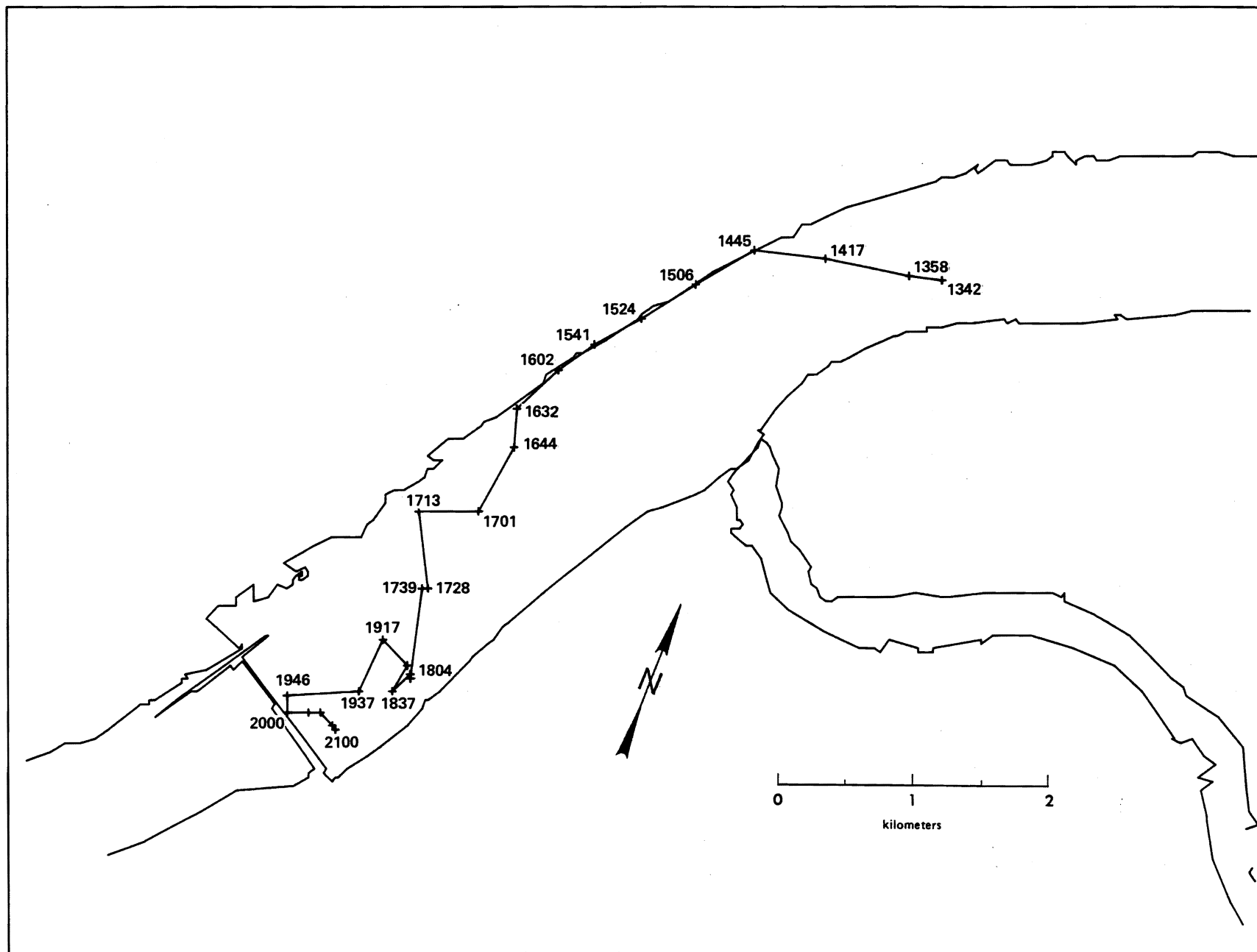
13:42      349.4   121.9    35
13:58      349.4   121.9    35      240    0:16      900      258      240    0:16
14:17      335.3   121.9    36      618    0:19     1,952     262      858    0:35
14:45      335.3   121.9    36      523    0:28     1,121     257     1,381    1:03
15:06      332.6   121.9    37      498    0:21     1,423     220     1,879    1:24
15:24      332.6   121.9    37      461    0:18     1,537     218     2,340    1:42
15:41      332.6   121.9    37      392    0:17     1,384     222     2,732    1:59
16:02      330.3   121.5    37      319    0:21       911     215     3,051    2:20
16:32      330.3   121.5    37      411    0:30       822     208     3,462    2:50
16:44      330.3   121.5    37      279    0:12     1,395     165     3,741    3:02
17:01      366.5   150.1    41      531    0:17     1,874     189     4,272    3:19
17:13      366.5   150.1    41      432    0:12     2,160     250     4,704    3:31
17:28      366.5   150.1    41      559    0:15     2,236     154     5,263    3:46
17:39      366.5   150.1    41       43    0:11       235     250     5,306    3:57
17:55      366.5   150.1    41      654    0:16     2,453     168     5,960    4:13
18:04      262.1   150.4    57       31    0:09       207     340     5,991    4:22
18:37      262.1   150.4    57      179    0:33       325     207     6,170    4:55
18:54      262.1   150.4    57      214    0:17       755       10     6,384    5:12
19:17      335.8   172.9    51      253    0:23       660     297     6,637    5:35
19:37      335.8   172.9    51      409    0:20     1,227     185     7,046    5:55
19:46      335.8   172.9    51      520    0:09     3,467     247     7,566    6:04
20:00      335.8   172.9    51      123    0:14       527     160     7,689    6:18
20:24      364.5   180.5    50      151    0:24       378       70     7,840    6:42
20:29      364.5   180.5    50       86    0:05     1,032       70     7,926    6:47
20:45      364.5   180.5    50      127    0:16       476     117     8,053    7:03
21:00      364.5   180.5    50       38    0:15       152     125     8,091    7:18

```

#

This fish moved downstream very rapidly. It moved to the Washington shore to avoid the plume and held up at the upstream edge of the restricted zone. This was the third chinook salmon that was lost in the restricted zone after dark. The track was terminated after an unsuccessful search. The spillway monitor last recorded the tag signal at 2329 on 25 May.

Appendix Figure C20.--Radio tracking data for Fish Code 144.



RELEASE DATE: 3 JUNE 1983

INDIVIDUAL FISH CODE: 133

SPECIES: STEELHEAD

LENGTH: 165 MM

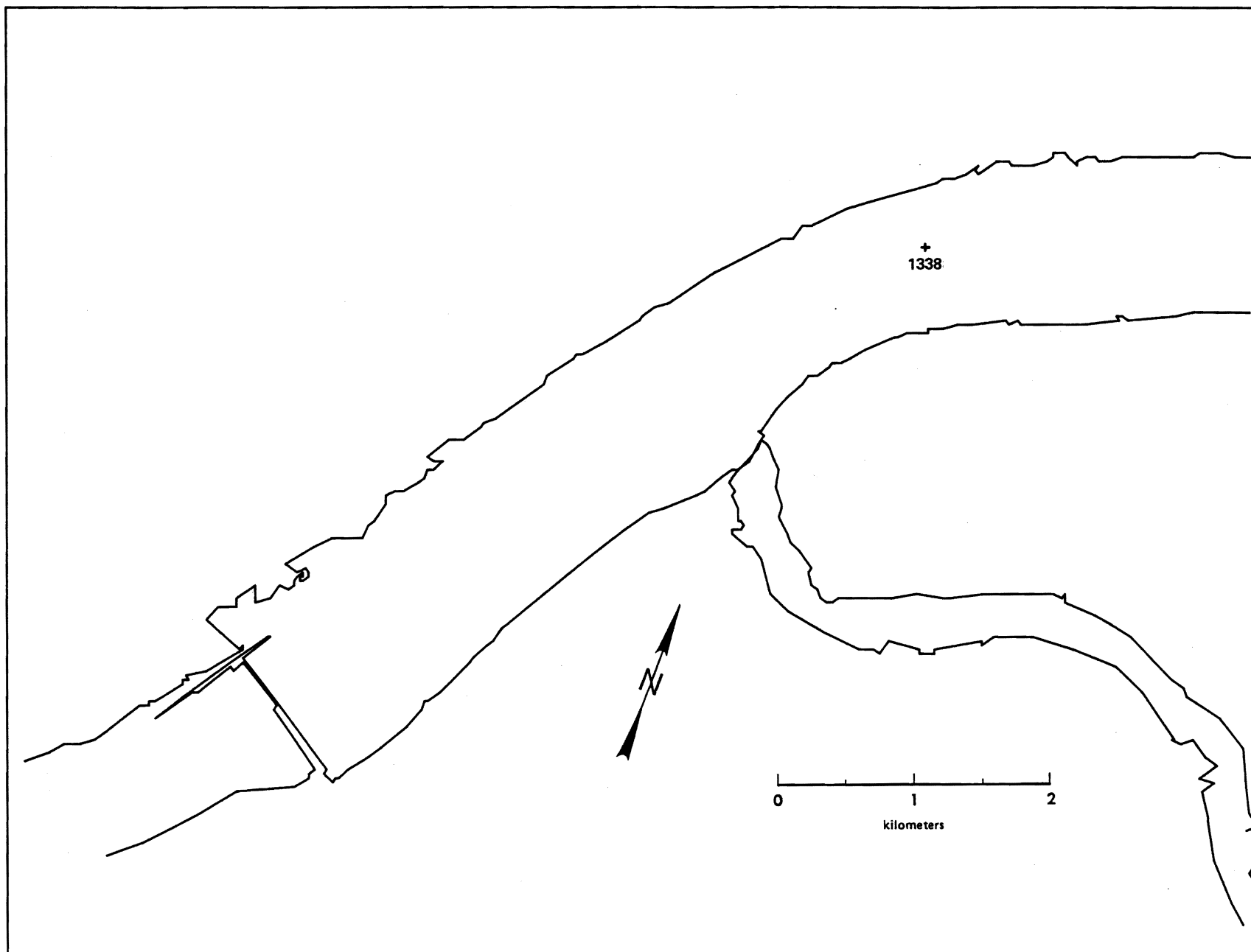
.....

TIME	FLOW (KCFS)	PERCENT	DISTANCE	TIME	VELOCITY	DIRECTION	CUMULATIVE
	TOTAL	SPILL	(METERS)	SPAN	(M/HR)	(DEG MAG)	DISTANCE TIME
13:38	384.9	190.0	49				
13:40	384.9	190.0	49	0	0:02	0	0:02

#

This fish appeared to dive immediately upon release and was never heard again during two hours of searching. The search was called off when the wind increased the wave height and the crew's safety became an overriding concern.

Appendix Figure C21.--Radio tracking data for Fish Code 133.



RELEASE DATE: 5 JUNE 1983

INDIVIDUAL FISH CODE: 667

SPECIES: STEELHEAD

LENGTH: 189 MM

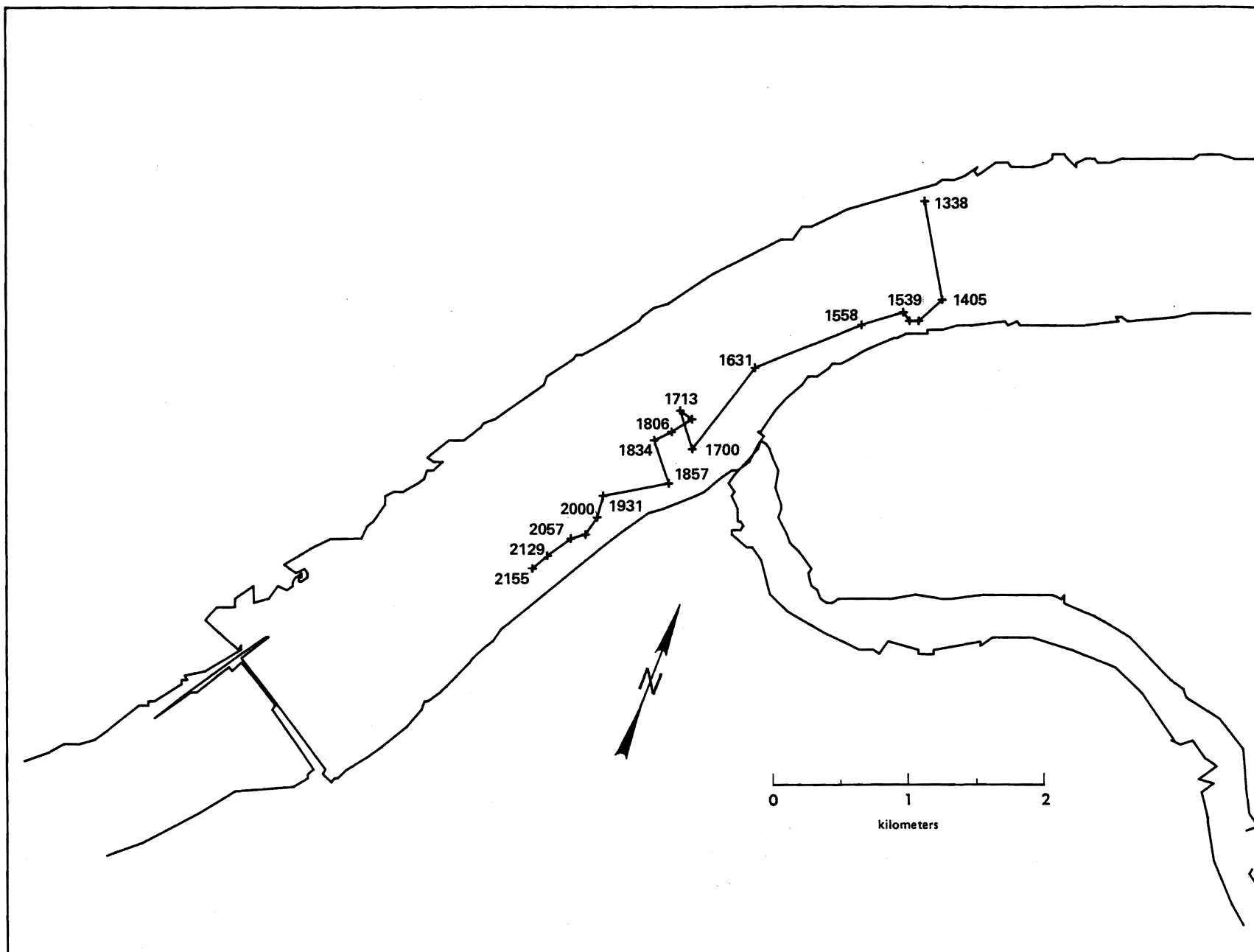
.....

TIME	FLOW (KCFS)		PERCENT	DISTANCE	TIME	VELOCITY	DIRECTION	CUMULATIVE	
	TOTAL	SPILL	SPILL	(METERS)	SPAN	(M/HR)	(DEG MAG)	DISTANCE	TIME
13:38	354.5	180.5	51						
14:05	358.0	180.5	50	722	0:27	1,604	150	722	0:27
14:36	358.0	180.5	50	232	0:31	449	208	954	0:58
15:08	358.6	180.5	50	65	0:32	122	250	1,019	1:30
15:39	358.6	180.5	50	75	0:31	145	305	1,094	2:01
15:58	358.6	180.5	50	317	0:19	1,001	233	1,411	2:20
16:31	359.2	181.3	50	837	0:33	1,522	229	2,248	2:53
17:00	359.2	181.3	50	742	0:29	1,535	198	2,990	3:22
17:13	359.2	183.6	51	291	0:13	1,343	323	3,281	3:35
17:36	359.2	183.6	51	106	0:23	277	106	3,387	3:58
18:06	360.5	183.6	51	177	0:30	354	219	3,564	4:28
18:34	360.5	183.6	51	144	0:28	309	225	3,708	4:56
18:57	360.5	183.6	51	327	0:23	853	141	4,035	5:19
19:31	361.8	183.6	51	485	0:34	856	239	4,520	5:53
20:00	361.8	183.6	51	160	0:29	331	176	4,680	6:22
20:26	360.4	183.4	51	151	0:26	348	195	4,831	6:48
20:57	360.4	183.4	51	112	0:31	217	234	4,943	7:19
21:29	359.0	183.6	51	213	0:32	399	215	5,156	7:51
21:55	359.0	183.6	51	142	0:26	328	210	5,298	8:17

#

This steelhead was not a problem to track, but moved downstream very slowly. It showed no avoidance behavior when it entered the John Day River plume and it eventually passed through the powerhouse. The track was terminated because of the slow movement. The powerhouse monitors recorded the downstream passage at 0515 on 7 June.

Appendix Figure C22.--Radio tracking data for Fish Code 667.



RELEASE DATE: 6 JUNE 1983

INDIVIDUAL FISH CODE: 246

SPECIES: SPRING CHINOOK

LENGTH: 180 MM

```

.....
TIME      FLOW (KCFS)  PERCENT  DISTANCE  TIME  VELOCITY  DIRECTION  CUMULATIVE
TOTAL SPILL  SPILL    (METERS)  SPAN    (M/HR)  (DEG MAG)  DISTANCE  TIME

14:15     373.8  184.2    49
14:30     373.8  184.2    49          144    0:15      576        276          144    0:15
14:53     373.8  184.2    49          448    0:23      1,169      207          592    0:38
15:13     372.4  190.0    51          666    0:20      1,998      198         1,258    0:58
15:41     372.4  190.0    51        1,011    0:28      2,166      213         2,269    1:26
16:03     371.9  190.8    51          541    0:22      1,475      247         2,810    1:48
16:29     371.9  190.8    51          867    0:26      2,001      232         3,677    2:14
17:36     375.3  178.9    48          837    1:07        750      229         4,514    3:21
18:02     378.9  177.3    47          440    0:26      1,015      193         4,954    3:47
18:28     378.9  177.3    47          589    0:26      1,359      180         5,543    4:13
18:45     378.9  177.3    47          616    0:17      2,174      197         6,159    4:30
18:59     378.9  177.3    47          327    0:14      1,401      192         6,486    4:44
19:03     372.1  177.3    48           38    0:04        570      125         6,524    4:48
19:20     372.1  177.3    48          144    0:17      508      225         6,668    5:05

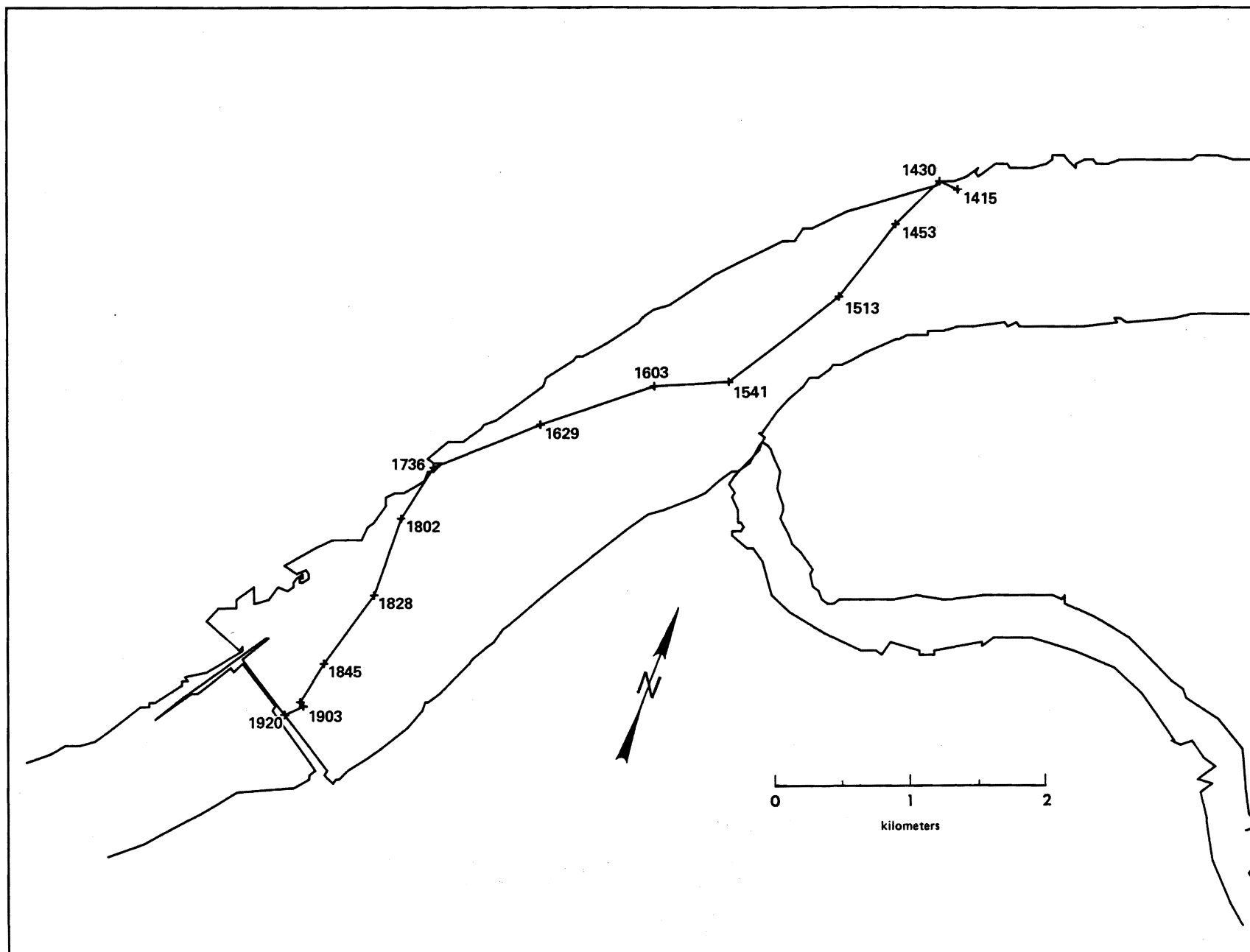
```

#

This fish reacted to the John Day River plume, but did not hold up above the restricted zone during its approach. Spill during the period that the fish crossed from the Washington shore to the powerhouse may not have been effective because of daylight behavior patterns near the dam (an area not concentrated upon during any of the work at John Day Dam).



Appendix Figure C23.--Radio tracking data for Fish Code 246.



RELEASE DATE: 7 JUNE 1983

INDIVIDUAL FISH CODE: 575

SPECIES: STEELHEAD

LENGTH: 175 MM

```

.....
TIME      FLOW (KCFS)  PERCENT  DISTANCE  TIME  VELOCITY  DIRECTION  CUMULATIVE
TOTAL SPILL  SPILL    (METERS)  SPAN    (M/HR)    (DEG MAG)  DISTANCE  TIME

13:39      341.7  119.5    35
14:11      345.4  160.9    47          431    0:32      808        225          431    0:32
14:35      345.4  160.9    47          225    0:24      563        234          656    0:56
15:03      356.2  170.0    48          485    0:28     1,039       239       1,141    1:24
15:35      356.2  170.0    48          815    0:32     1,528       239       1,956    1:56
16:05      351.9  163.1    46          709    0:30     1,418       238       2,665    2:26
16:28      351.9  163.1    46          466    0:23     1,216       191       3,131    2:49
16:53      351.9  163.1    46          851    0:25     2,042       212       3,982    3:14
17:22      357.4  154.5    43        1,098    0:29     2,272       177       5,080    3:43
17:43      357.4  154.5    43          156    0:21      446       348       5,236    4:04
18:01      351.8  156.7    45          391    0:18     1,303       211       5,627    4:22
18:17      351.8  156.7    45           95    0:16      356       173       5,722    4:38
18:40      351.8  156.7    45          554    0:23     1,445       199       6,276    5:01
19:10      347.3  150.2    43          142    0:30      284       210       6,418    5:31

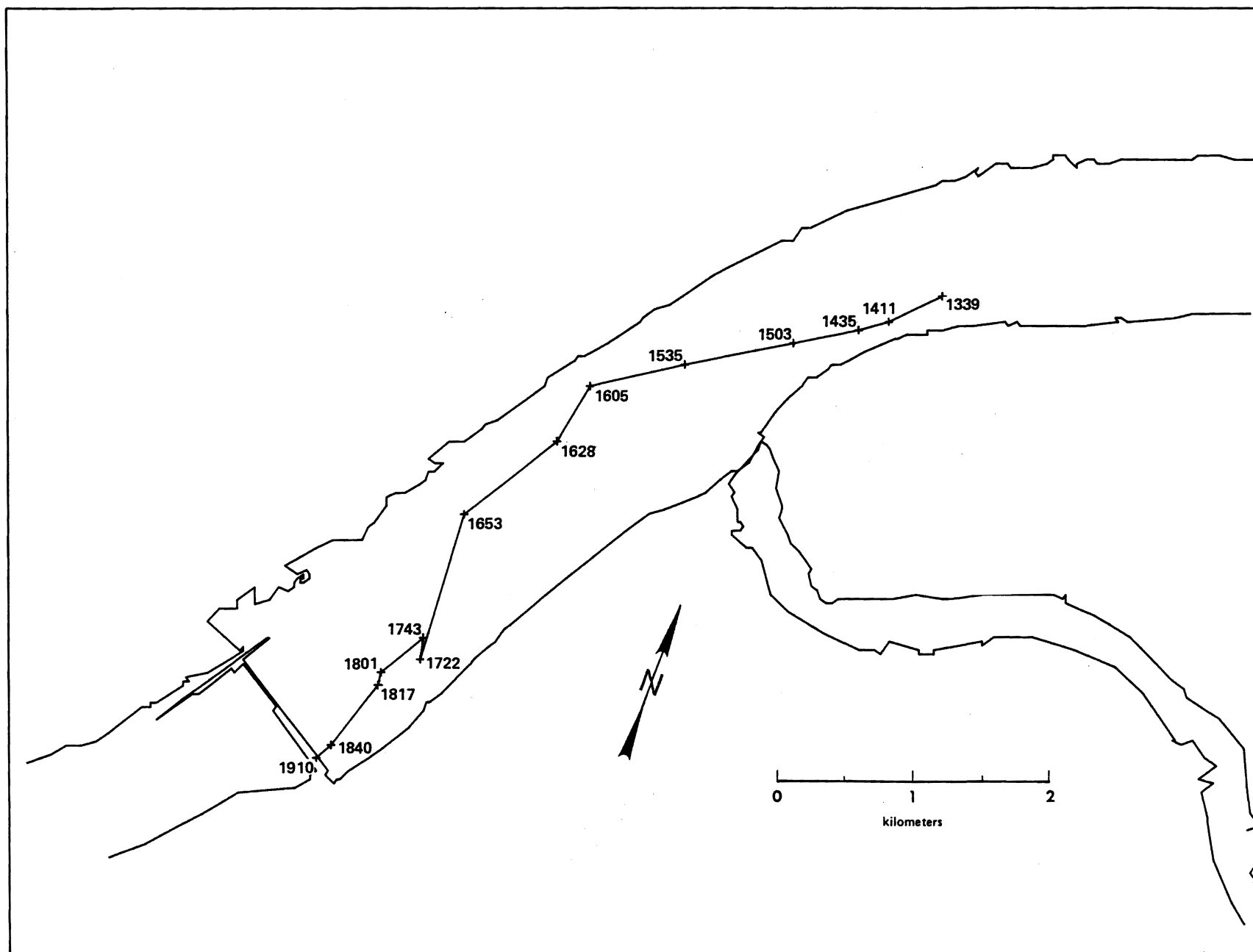
```

#

This is one steelhead that was influenced by the John Day River plume. It also showed an avoidance behavior as it approached the restricted zone, but it continued downstream for a daylight passage. The cross over from the Washington side to the powerhouse side under high spill was observed here and with one chinook salmon, both during daylight periods.

163

Appendix Figure C24.--Radio tracking data for Fish Code 575.



RELEASE DATE: 8 JUNE 1983

INDIVIDUAL FISH CODE: 728

SPECIES: STEELHEAD

LENGTH: 172 MM

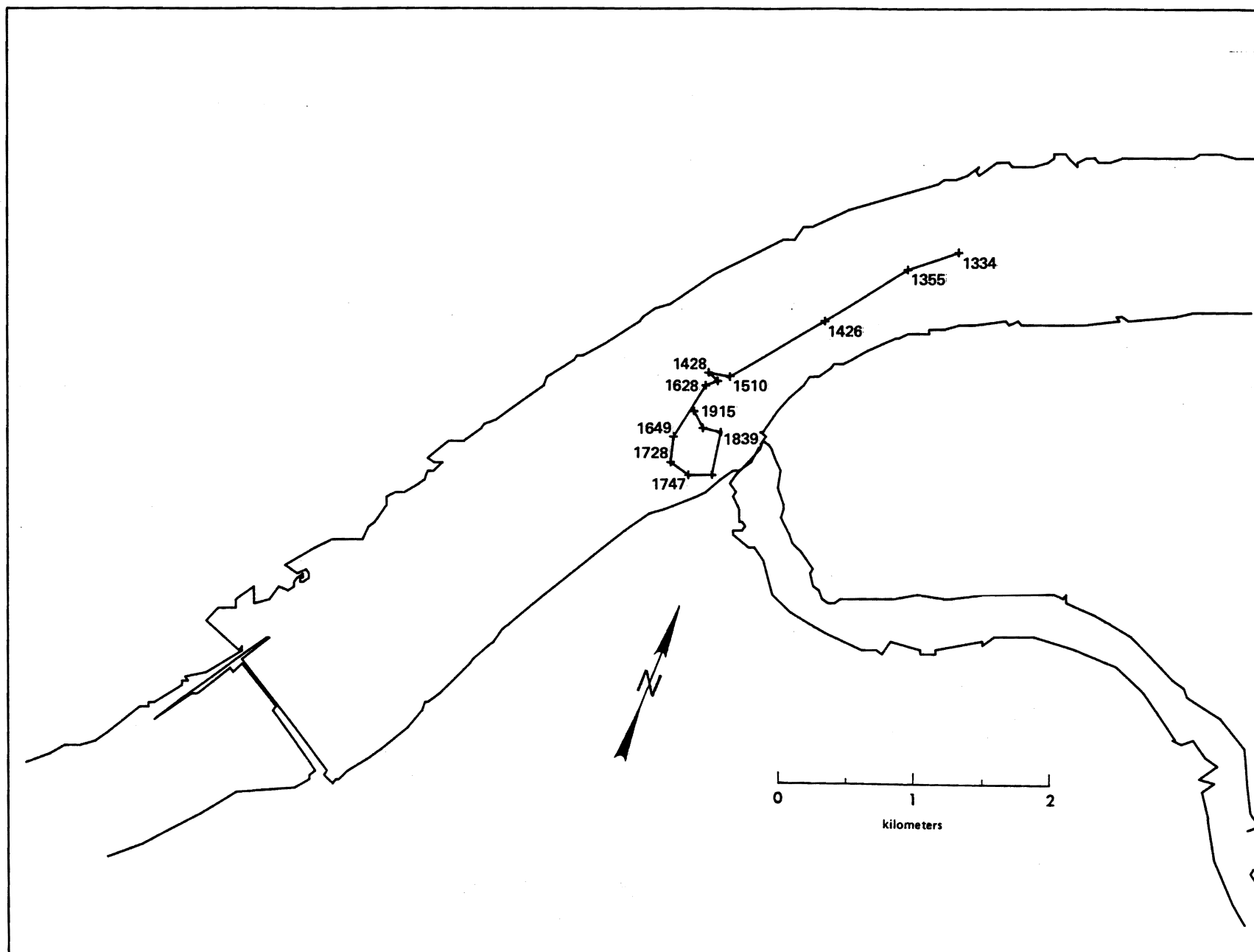
.....

TIME	FLOW (KCFS) TOTAL SPILL	PERCENT SPILL	DISTANCE (METERS)	TIME SPAN	VELOCITY (M/HR)	DIRECTION (DEG MAG)	CUMULATIVE DISTANCE	TIME
13:34	344.8	92.8	27					
13:55	344.8	92.8	27				388	0:21
14:26	353.1	145.0	41	0:31	1,374	219	1,098	0:52
15:10	343.4	161.3	47	0:44	1,091	220	1,898	1:36
15:28	343.4	161.3	47	0:18	513	262	2,052	1:54
15:59	343.4	161.3	47	0:31	174	114	2,142	2:25
16:28	351.6	169.4	48	0:29	190	231	2,234	2:54
16:49	351.6	169.4	48	0:21	1,257	193	2,674	3:15
17:28	351.6	169.4	48	0:39	286	167	2,860	3:54
17:47	351.6	169.4	48	0:19	502	106	3,019	4:13
18:15	350.5	169.4	48	0:28	371	70	3,192	4:41
18:39	350.5	169.4	48	0:24	788	352	3,507	5:05
19:00	350.5	169.4	48	0:21	380	264	3,640	5:26
19:15	353.4	169.6	48	0:15	556	312	3,779	5:41

#

This fish moved downstream from the release site until it reached the mouth of the John Day River. After holding for a short period it entered the plume and went into a holding pattern. With no downstream movement and worsening wave conditions the track was abandoned.

Appendix Figure C25.--Radio tracking data for Fish Code 728.



RELEASE DATE: 9 JUNE 1983

INDIVIDUAL FISH CODE: 146

SPECIES: STEELHEAD

LENGTH: 177 MM

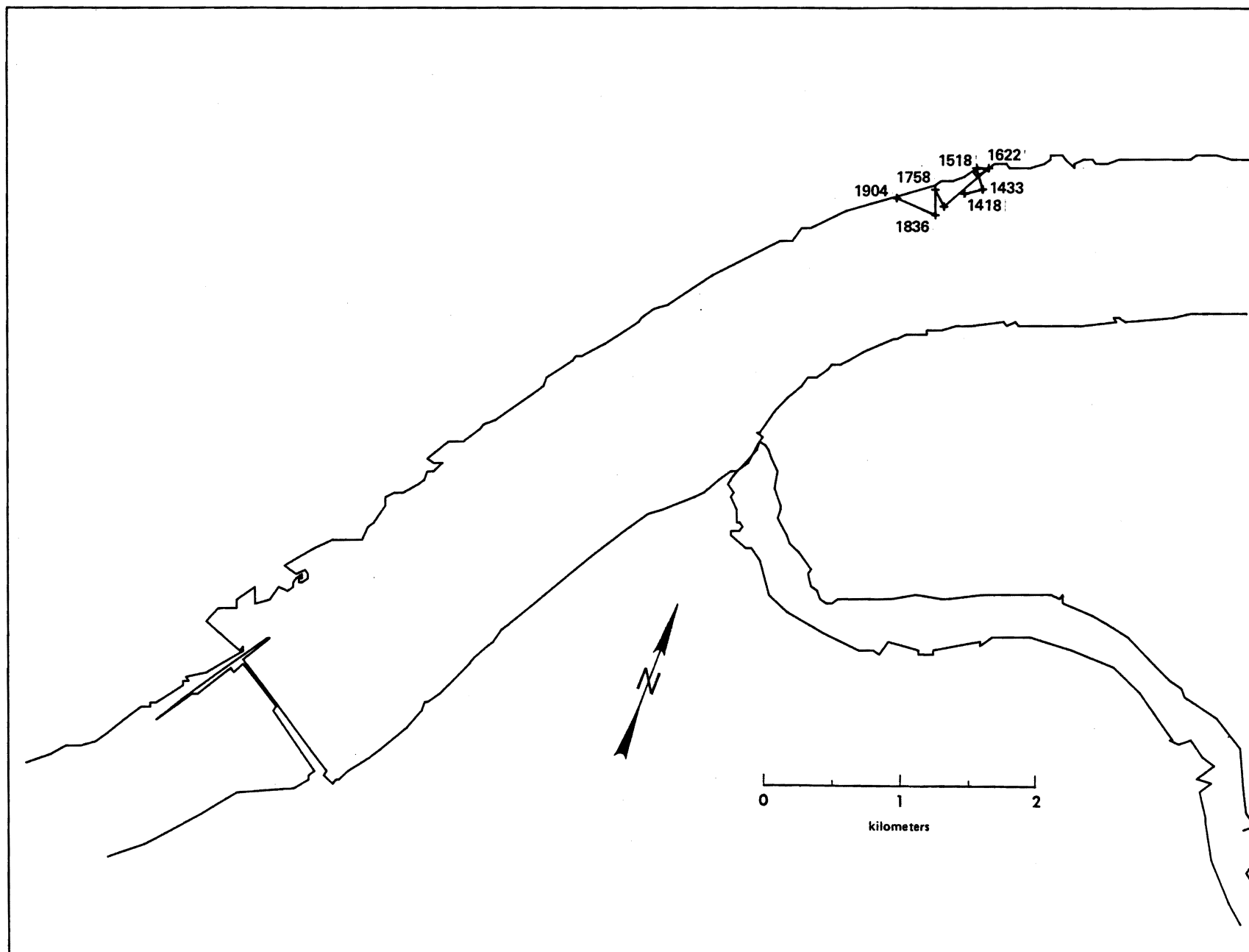
.....

TIME	FLOW (KCFS)	PERCENT	DISTANCE	TIME	VELOCITY	DIRECTION	CUMULATIVE	
	TOTAL	SPILL	(METERS)	SPAN	(M/HR)	(DEG MAG)	DISTANCE	TIME
14:18	343.0	147.7	43					
14:33	343.0	147.7	43	133	0:15	532	57	133 0:15
15:18	345.8	175.0	51	160	0:45	213	325	293 1:00
16:22	353.3	182.1	52	0	1:04	0	-*-	293 2:04
16:46	353.3	182.1	52	86	0:24	215	70	379 2:28
17:27	345.3	173.8	50	427	0:41	625	210	806 3:09
17:58	345.3	173.8	50	139	0:31	269	312	945 3:40
18:36	301.8	2.2	1	185	0:38	292	160	1,130 4:18
19:04	347.6	121.7	35	307	0:28	658	274	1,437 4:46

#

This steelhead did not make significant movement toward the dam during any period of the track. The track was terminated when light conditions made it impossible to obtain position locations.

Appendix Figure C26.--Radio tracking data for Fish Code 146.



RELEASE DATE: 15 JUNE 1983

INDIVIDUAL FISH CODE: 363

SPECIES: SPRING CHINOOK

LENGTH: 150 MM

.....

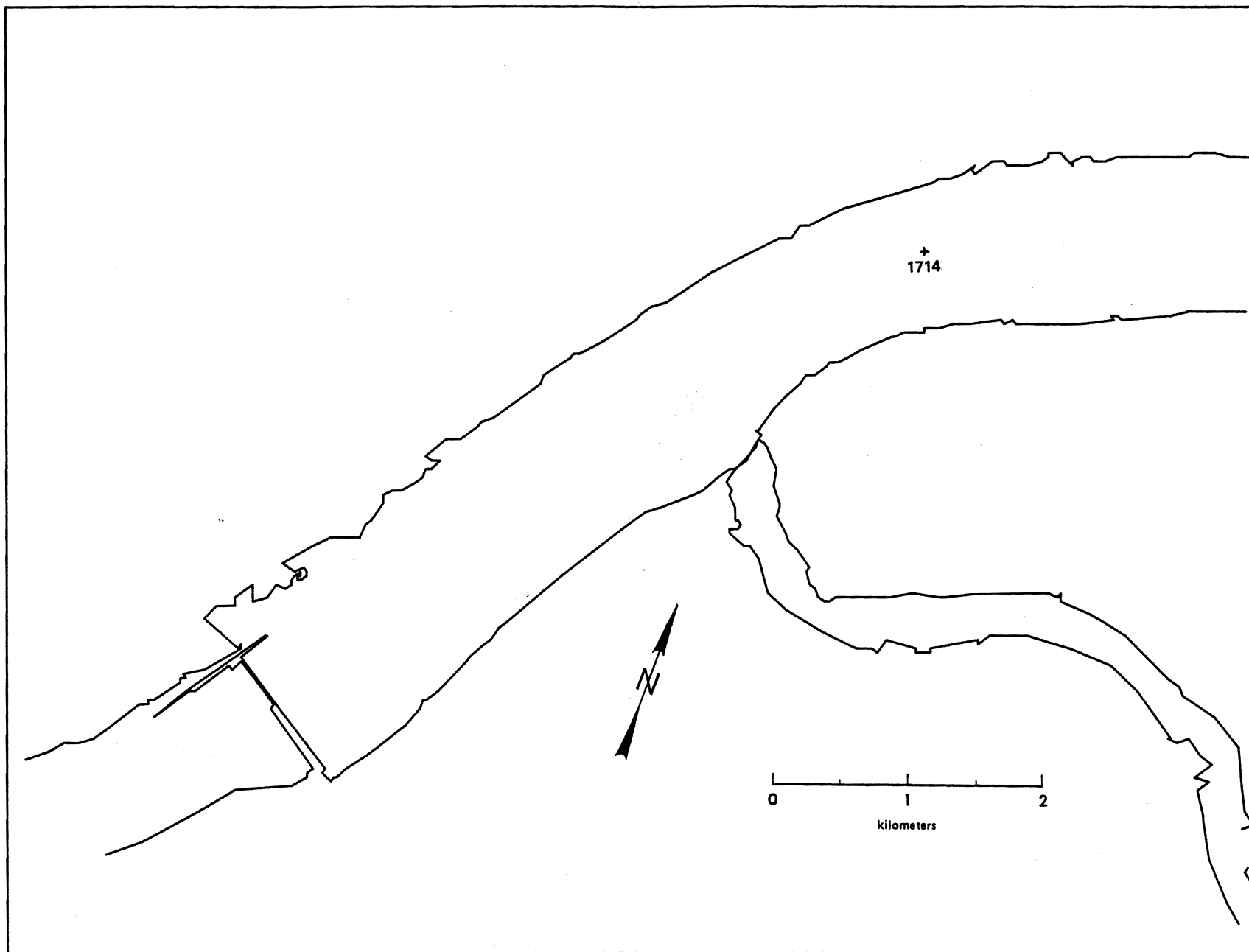
TIME	FLOW (KCFS) TOTAL	SPILL	PERCENT SPILL	DISTANCE (METERS)	TIME SPAN	VELOCITY (M/HR)	DIRECTION (DEG MA3&	CUMULATIVE DISTANCE	TIME
17:14	252.1	0.0	0						
17:15	252.1	0.0	0	0	0:01	0	-*-	0	0:01

#

This fish was released in a high wind situation to test the effect of wave action on arrival time at the dam. Radio tracking was not attempted. No record of passage was recorded by the monitors on the face of the dam.



Appendix Figure C27.--Radio tracking data for Fish Code 363.



RELEASE DATE: 16 JUNE 1983

INDIVIDUAL FISH CODE: 527

SPECIES: STEELHEAD

LENGTH: 173 MM

```

.....
TIME      FLOW (KCFS)  PERCENT  DISTANCE  TIME  VELOCITY  DIRECTION  CUMULATIVE
TOTAL SPILL  SPILL    (METERS)  SPAN    (M/HR)  (DEG MAG)  DISTANCE  TIME

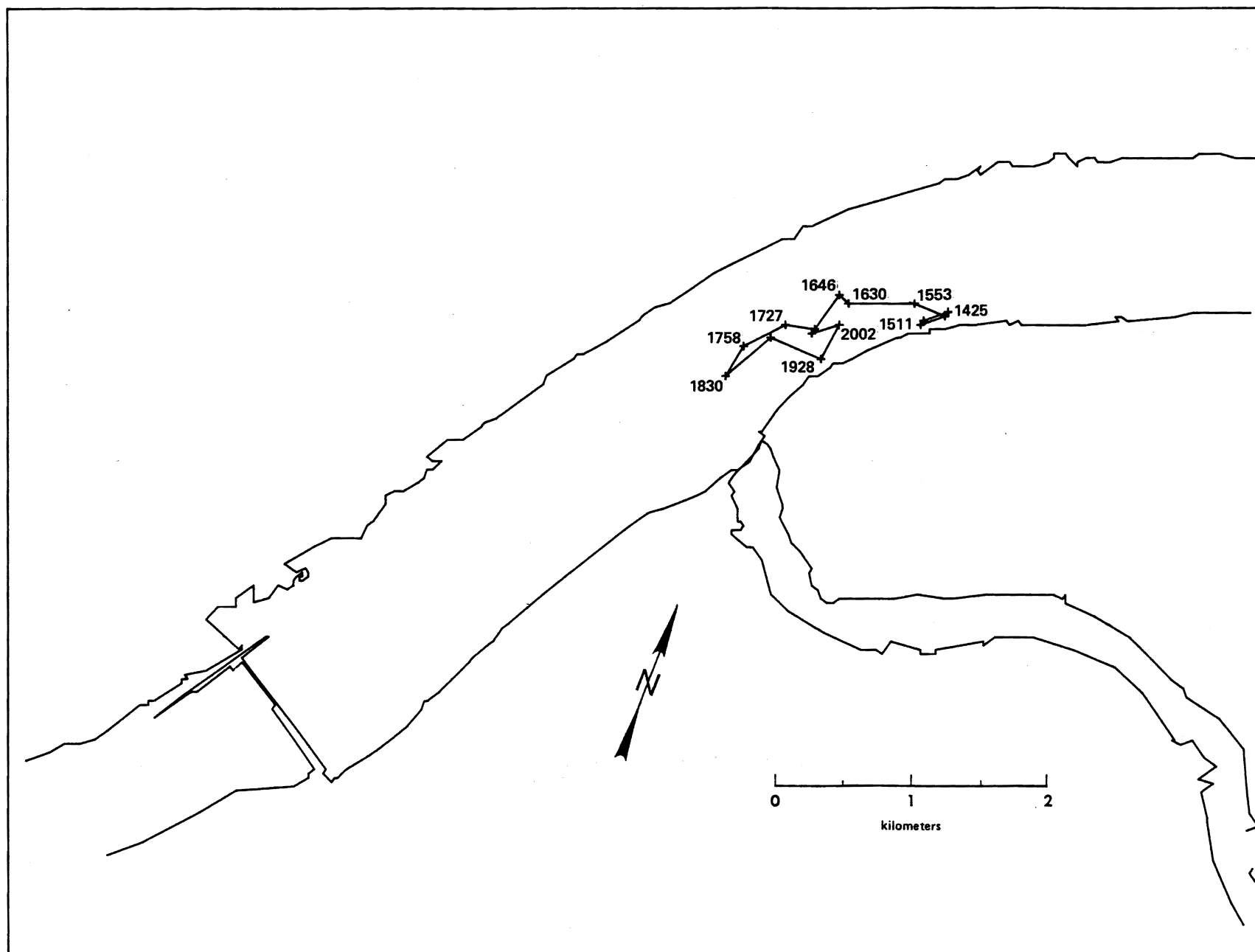
14:25     270.3      0.0      0
14:43     270.3      0.0      0      184    0:18      613      231      184      0:18
15:11     275.6      0.0      0      38     0:28      81       195      222      0:46
15:26     275.6      0.0      0      184    0:15     736      51       406      1:01
15:53     275.6      0.0      0      235    0:27     522     273      641      1:28
16:30     271.9      0.0      0      476    0:37     772     250     1,117     2:05
16:46     271.9      0.0      0      90     0:16     338     294     1,207     2:21
17:07     268.6      0.0      0      301    0:21     860     195     1,508     2:42
17:27     268.6      0.0      0      218    0:20     654     258     1,726     3:02
17:58     268.6      0.0      0      340    0:31     658     223     2,066     3:33
18:30     264.2      0.0      0      252    0:32     473     191     2,318     4:05
19:03     241.9      3.3      1      427    0:33     776      30     2,745     4:38
19:28     241.9      3.3      1      399    0:25     958      93     3,144     5:03
20:02     296.2    142.2     48      279    0:34     492       8     3,423     5:37
20:31     296.2    142.2     48      204    0:29     422     233     3,627     6:06

```

#

This steelhead reacted to the John Day River plume but did not move to the Washington shore or downstream. The track was abandoned because light conditions did not permit adequate position readings. The powerhouse monitors recorded downstream passage at 0503 on 18 June.

Appendix Figure C28.--Radio tracking data for Fish Code 527.



RELEASE DATE: 17 JUNE 1983

INDIVIDUAL FISH CODE: 126

SPECIES: SPRING CHINOOK

LENGTH: 149 MM

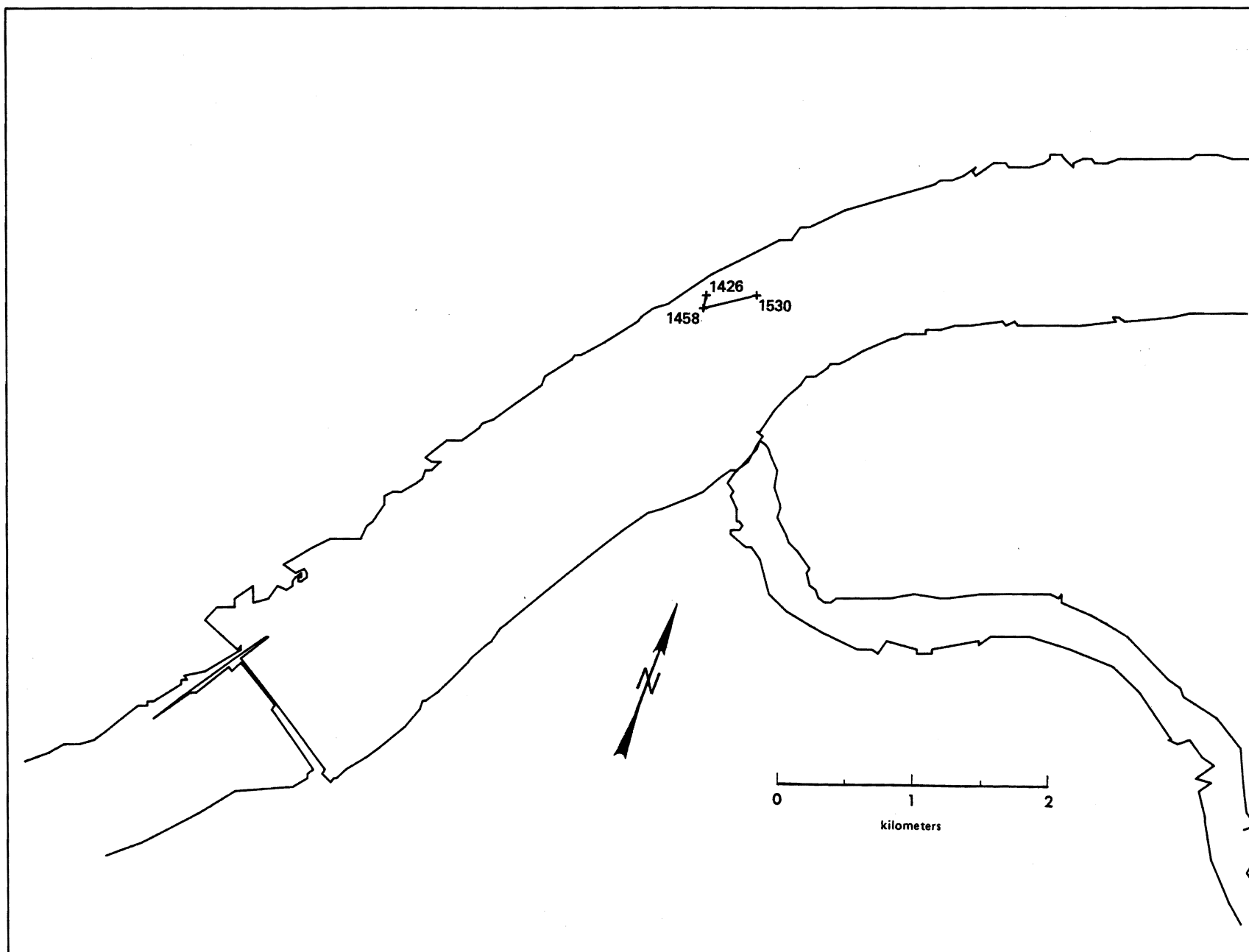
.....

TIME	FLOW (KCFS) TOTAL	PERCENT SPILL	DISTANCE (METERS)	TIME SPAN	VELOCITY (M/HR)	DIRECTION (DEG MAG)	CUMULATIVE DISTANCE	TIME
14:26	273.7	0.0	0					
14:58	273.7	0.0	95	0:32	178	173	95	0:32
15:30	277.4	0.0	400	0:32	750	57	495	1:04

#

The release site for this fish was moved downstream and close to the Washington shore because of bad wave conditions further upstream. When weather conditions got worse and the fish moved upstream the track was terminated for the crew's safety.

Appendix Figure C29.--Radio tracking data for Fish Code 126.



RELEASE DATE: 18 JUNE 1983

INDIVIDUAL FISH CODE: 228

SPECIES: STEELHEAD

LENGTH: 183 MM

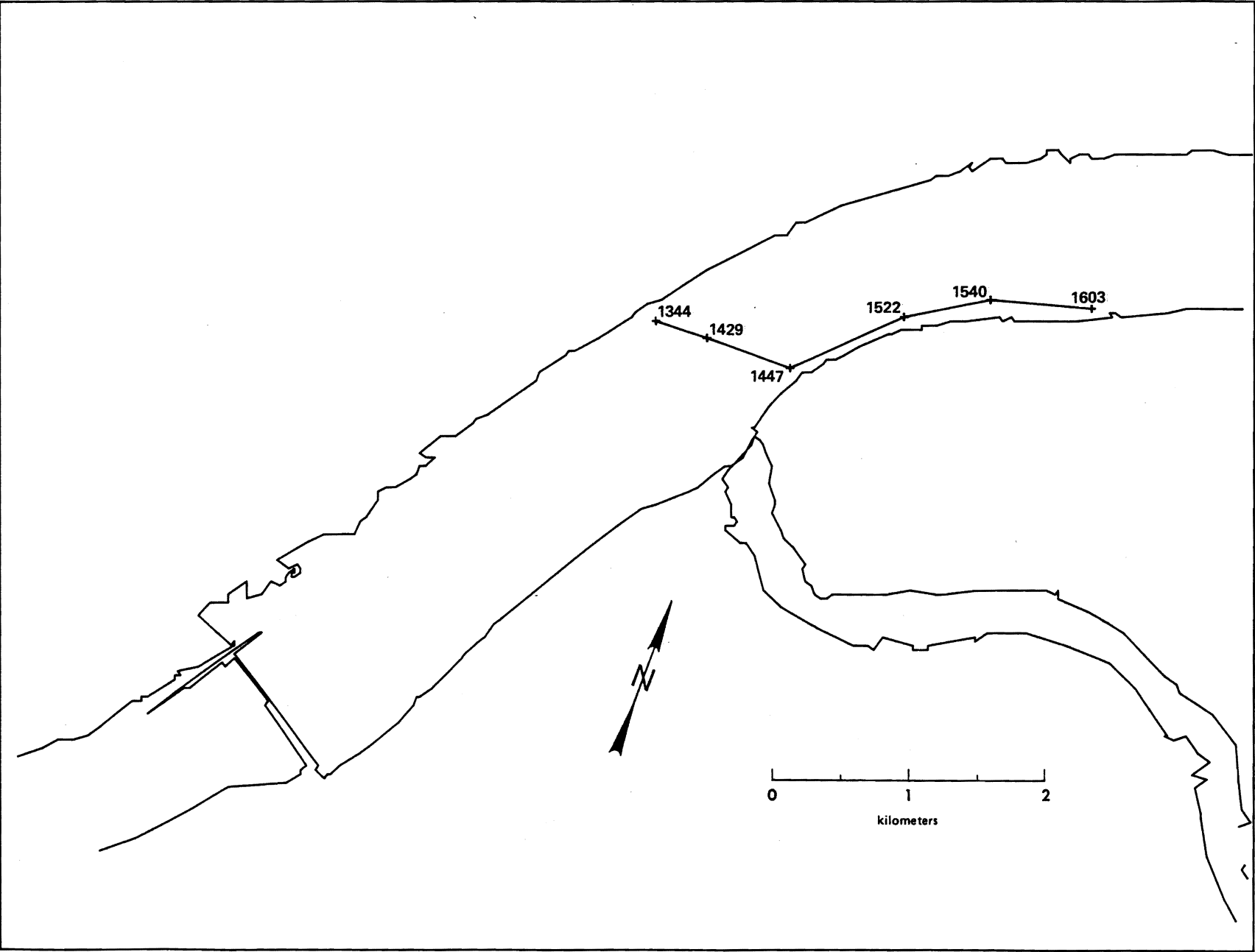
.....

TIME	FLOW (KCFS)	PERCENT	DISTANCE	TIME	VELOCITY	DIRECTION	CUMULATIVE	
	TOTAL SPILL	SPILL	(METERS)	SPAN	(M/HR)	(DEG MAG)	DISTANCE	TIME
13:44	258.7	0.0	0					
14:29	252.7	0.0	0					
14:47	252.7	0.0	0					
15:22	258.6	0.0	0					
15:40	258.6	0.0	0					
16:03	253.7	0.0	0					
			388	0:45	517	89	388	0:45
			643	0:18	2,143	90	1,031	1:03
			901	0:35	1,545	46	1,932	1:38
			639	0:18	2,130	59	2,571	1:56
			738	0:23	1,925	75	3,309	2:19

#

This fish was released downstream from the normal release area because of rough water. When it crossed to the Oregon shore and upstream the Oregon shore provided protection from the wind. At 1603 the battery in the smaller tracking boat failed and the track was terminated. The spillway monitors recorded the downstream passage at 0022 on 22 June.

Appendix Figure C30.--Radio tracking data for Fish Code 228.



RELEASE DATE: 19 JUNE 1983

INDIVIDUAL FISH CODE: 867

SPECIES: SPRING CHINOOK

LENGTH: 150 MM

.....

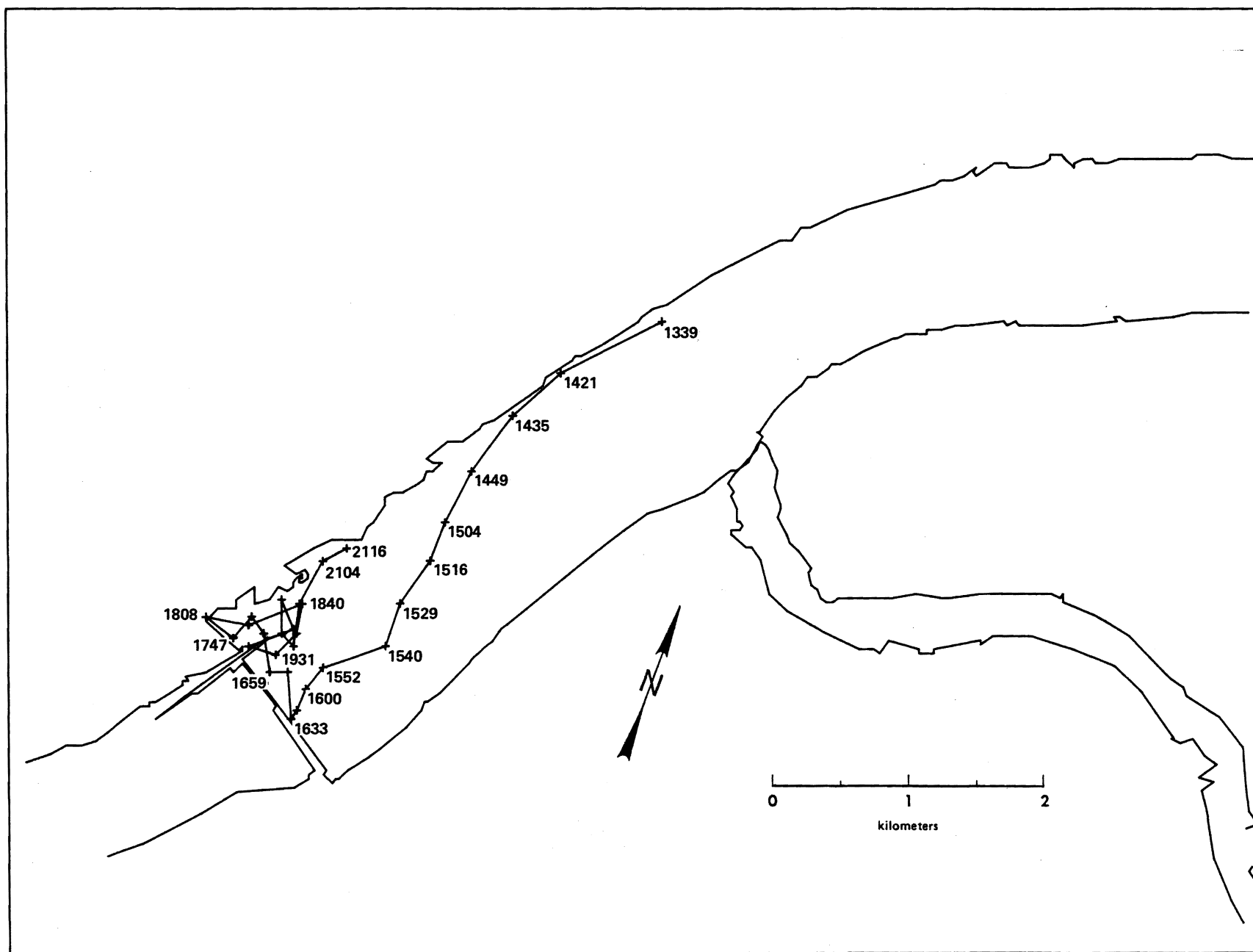
TIME	FLOW (KCFS)	PERCENT	DISTANCE	TIME	VELOCITY	DIRECTION	CUMULATIVE	
	TOTAL SPILL	SPILL	(METERS)	SPAN	(M/HR)	(DEG MAG)	DISTANCE	TIME
13:39	235.6	0.0	0					
14:21	232.6	0.0	0	823	0:42	1,176	223	823 0:42
14:35	232.6	0.0	0	464	0:14	1,989	208	1,287 0:56
14:49	232.6	0.0	0	503	0:14	2,156	197	1,790 1:10
15:04	228.7	0.0	0	418	0:15	1,672	188	2,208 1:25
15:16	228.7	0.0	0	298	0:12	1,490	181	2,506 1:37
15:29	228.7	0.0	0	377	0:13	1,740	195	2,883 1:50
15:40	228.7	0.0	0	327	0:11	1,784	180	3,210 2:01
15:52	228.7	0.0	0	480	0:12	2,400	231	3,690 2:13
16:00	228.7	0.0	0	202	0:08	1,515	200	3,892 2:21
16:06	228.1	0.0	0	167	0:06	1,670	183	4,059 2:27
16:33	228.1	0.0	0	75	0:27	167	195	4,134 2:54
16:51	228.1	0.0	0	340	0:18	1,133	337	4,474 3:12
16:59	228.1	0.0	0	130	0:08	975	250	4,604 3:20
17:10	226.7	0.0	0	281	0:11	1,533	331	4,885 3:31
17:33	226.7	0.0	0	151	0:23	394	305	5,036 3:54
17:47	226.7	0.0	0	202	0:14	866	200	5,238 4:08
18:08	226.6	0.0	0	248	0:21	709	289	5,486 4:29
18:27	226.6	0.0	0	309	0:19	976	82	5,795 4:48
18:40	226.6	0.0	0	419	0:13	1,934	49	6,214 5:01
19:00	226.6	0.0	0	220	0:20	660	172	6,434 5:21
19:11	224.4	0.1	0	216	0:11	1,178	205	6,650 5:32
19:31	224.4	0.1	0	204	0:20	612	268	6,854 5:52
19:47	224.4	0.1	0	347	0:16	1,301	49	7,201 6:08
20:07	250.5	117.3	47	233	0:20	699	318	7,434 6:28
20:19	250.5	117.3	47	247	0:12	1,235	160	7,681 6:40
20:28	250.5	117.3	47	127	0:09	847	117	7,808 6:49
20:45	250.5	117.3	47	312	0:17	1,101	348	8,120 7:06
21:04	256.4	128.2	50	354	0:19	1,118	9	8,474 7:25
21:16	256.4	128.2	50	196	0:12	980	42	8,670 7:37

#

The release site was moved because of bad weather, but the fish moved downstream. The reaction of this fish to the dam during daylight was to move to the Washington shore. The spillway monitors recorded the downstream passage at 0032 on 20 June.



Appendix Figure C31.--Radio tracking data for Fish Code 867.



RELEASE DATE: 20 JUNE 1983

INDIVIDUAL FISH CODE: 327

SPECIES: STEELHEAD

LENGTH: 187 MM

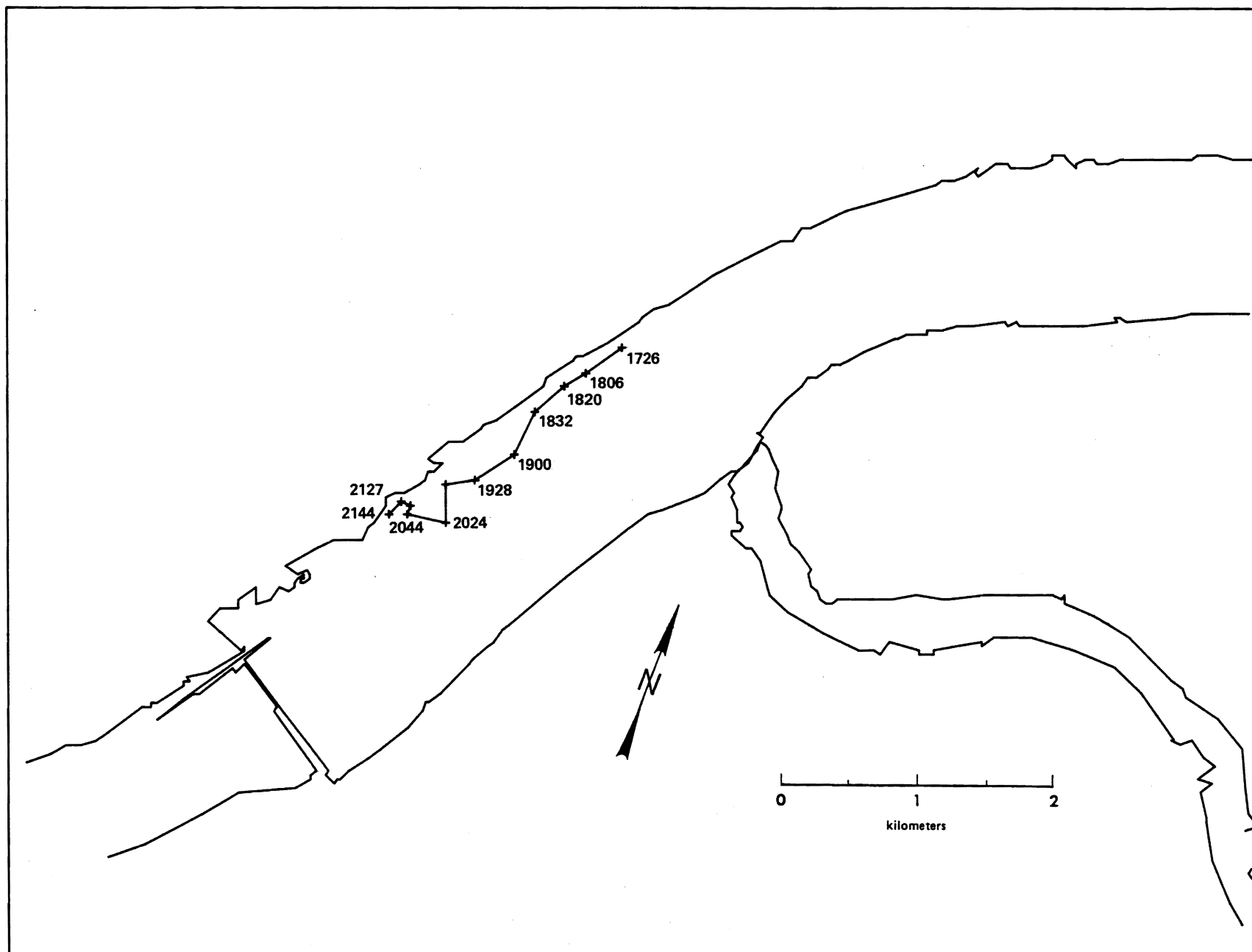
.....

TIME	FLOW (KCFS)	PERCENT	DISTANCE	TIME	VELOCITY	DIRECTION	CUMULATIVE	
	TOTAL SPILL	SPILL	(METERS)	SPAN	(M/HR)	(DEG MAG)	DISTANCE	TIME
17:26	275.4	0.0	0					
18:06	245.6	0.0	0					
18:20	245.6	0.0	0	319	0:40	479	319	0:40
18:32	245.6	0.0	0	177	0:14	759	496	0:54
19:00	245.6	0.0	0	285	0:12	1,425	781	1:06
19:28	245.6	0.0	0	344	0:28	737	1,125	1:34
19:28	202.2	0.0	0	337	0:28	722	1,462	2:02
19:53	202.2	0.0	0	218	0:25	523	1,680	2:27
20:24	283.6	131.5	46	278	0:31	538	1,958	2:58
20:44	283.6	131.5	46	288	0:20	864	2,246	3:18
21:08	297.0	148.8	50	65	0:24	163	2,311	3:42
21:27	297.0	148.8	50	72	0:19	227	2,383	4:01
21:44	297.0	148.8	50	127	0:17	448	2,510	4:18

#

High winds and rough water caused us to release the fish closer to the dam. Tag problems with an earlier released fish was the reason for the late release time. The fish moved very slowly and was not progressing downstream when the track was terminated.

Appendix Figure C32.--Radio tracking data for Fish Code 327.



RELEASE DATE: 22 JUNE 1983

INDIVIDUAL FISH CODE: 170

SPECIES: STEELHEAD

LENGTH: 173 MM

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.....
TIME      FLOW (KCFS)  PERCENT  DISTANCE  TIME  VELOCITY  DIRECTION  CUMULATIVE
TOTAL SPILL  SPILL    (METERS)  SPAN    (M/HR)    (DEG MAG)  DISTANCE  TIME

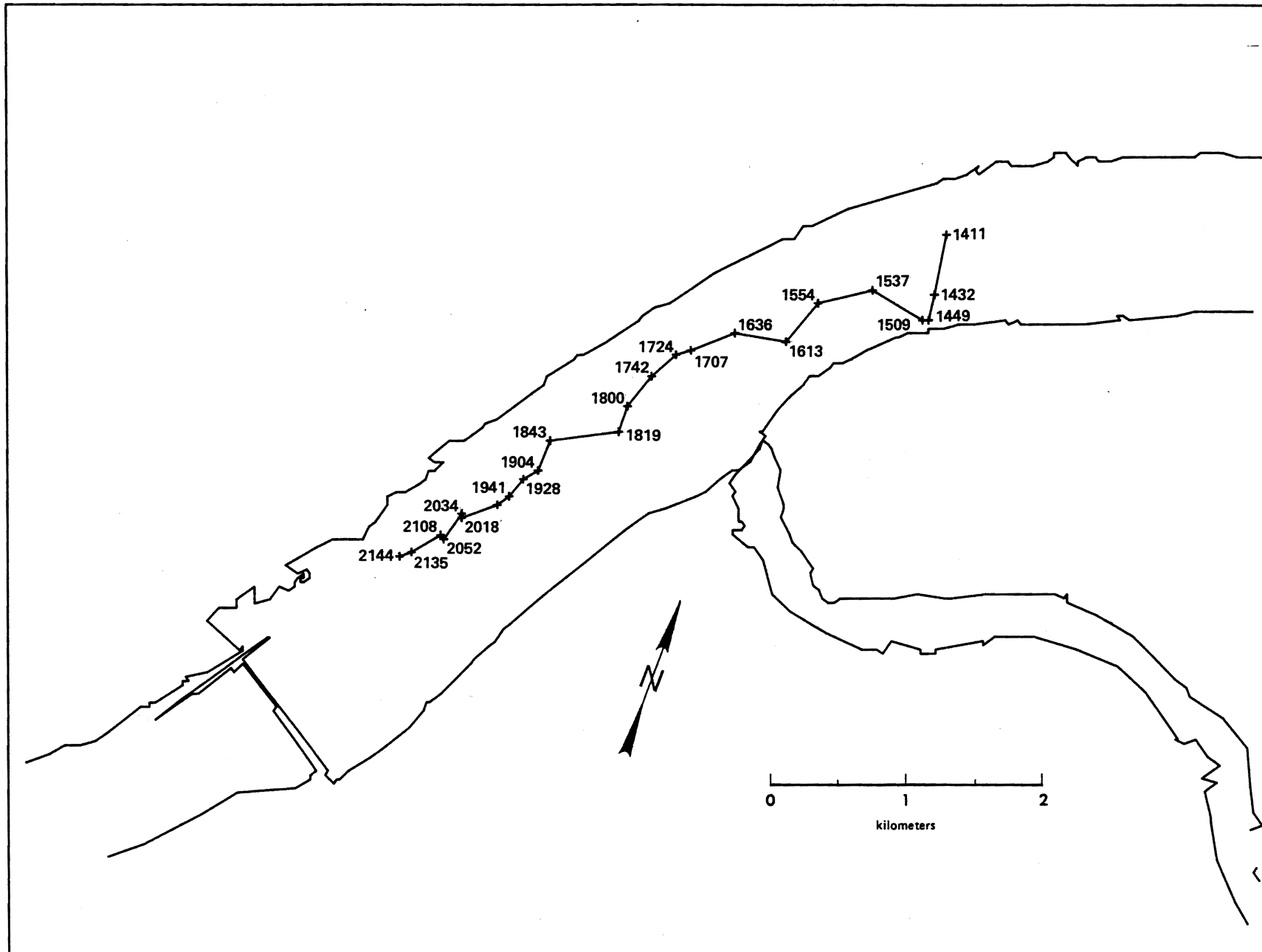
14:11     253.2     3.2      1
14:32     253.2     3.2      1      441    0:21     1,260     172      441    0:21
14:49     253.2     3.2      1      190    0:17      671     173      631    0:38
15:09     252.3     3.2      1       43    0:20      129     250      674    0:58
15:37     252.3     3.2      1      426    0:28      913     281     1,100   1:26
15:54     252.3     3.2      1     400    0:17     1,412     237     1,500   1:43
16:13     252.6     3.2      1      366    0:19     1,156     201     1,866   2:02
16:36     252.6     3.2      1      373    0:23      973     260     2,239   2:25
17:07     252.5     3.2      1      347    0:31      672     229     2,586   2:56
17:24     252.5     3.2      1      112    0:17      395     234     2,698   3:13
17:42     252.5     3.2      1      232    0:18      773     208     2,930   3:31
18:00     252.5     3.2      1      277    0:18      923     199     3,207   3:49
18:19     250.6     3.2      1      196    0:19      619     180     3,403   4:08
18:43     250.6     3.2      1     501    0:24     1,253     243     3,904   4:32
19:04     220.3     3.2      1      233    0:21      666     182     4,137   4:53
19:28     220.3     3.2      1      124    0:24      310     220     4,261   5:17
19:41     220.3     3.2      1      164    0:13      757     201     4,425   5:30
19:59     220.3     3.2      1      106    0:18      353     215     4,531   5:48
20:18     263.3     60.3     23      276    0:19      872     231     4,807   6:07
20:34     263.3     60.3     23       31    0:16      116     340     4,838   6:23
20:52     263.3     60.3     23      226    0:18      753     195     5,064   6:41
21:08     288.8     79.2     27       38    0:16      143     305     5,102   6:57
21:35     288.8     79.2     27      249    0:27      553     220     5,351   7:24
21:44     288.8     79.2     27       92    0:09      613     231     5,443   7:33

```

#

This was the last track of the season. The fish moved downstream at a very slow rate and the track was abandoned when movement did not increase after dark. The tag was recorded by the spillway monitors at 0738 on 23 June, but was not counted as a passage because the spill gates were on the sill at the time and the monitors were removed from the dam.

Appendix Figure C33.--Radio tracking data for Fish Code 170.



## **APPENDIX D**

### **Budget Summary**

# BUDGET SUMMARY

Personal Services and Benefits	\$224.7
Travel and Transportation of Persons	10.1
Transportation of Things	7.4
Rent, Communications, and Utilities	10.2
Printing and Reproduction	0.1
Other Services	6.5
Supplies and Materials	46.2
Equipment	12.7
Support Costs (including DOC overhead)	<u>93.5</u>
TOTAL	\$411.4 K