ESTUARINE MANAGEMENT AND RESEARCH ACTIVITIES
MOUTH OF REDWOOD CREEK
1983

Redwood National Park
Crescent City, California
April 1984

INTRODUCTION

Background

During late spring and early summer months, as water discharge in Redwood Creek decreases, a sand berm often builds at the mouth of the creek, forming an embayment east of the beach. By providing habitat for optimal growth and marine acclimation, the embayment is a critical element in the life history of anadromous salmonids, particularly chinook salmon. However, the morphology and productivity of the embayment was adversely altered by the construction of a flood control project on the lower 3.2 miles of Redwood Creek in 1968. In addition as the embayment forms and water level exceeds 5.0 feet above mean sea level, adjacent private farm lands are flooded. Draining of the embayment to prevent flooding removes fish habitat and can prematurely wash fish into the ocean. A detailed discussion of the problem and alternatives are discussed in Management Alternatives for the Redwood Creek Estuary, March 1983, Redwood National Park.

The park undertook active management of the remnant Redwood Creek embayment in 1982 and 1983. Management actions were designed to maintain what little rearing habitat remained and to prevent flooding of private property resulting from natural embayment formation.

Summary Evaluation for 1983

The overall objective of activities undertaken in 1983 was to maintain summertime estuarine habitat for rearing juvenile salmonids while preventing flooding of adjacent private property. Management and research activities included excavation of sand from the necks of the north and south sloughs, installation of temporary drainage culverts in the sand berm at the mouth of the creek, log boom repair, restoration of approximately two acres of wetland, embayment water level control, water quality monitoring, aquatic invertebrate sampling, trapping of downstream migrating juvenile salmon, steelhead, and cutthroat trout, and numbers and growth monitoring of juvenile salmonids utilizing the embayment.

Flooding of private property was prevented. On three occasions embayment water levels exceeded maximum desirable levels, but these events were due to intense sudden rainfall. Nevertheless, management staff immediately lowered water levels to prevent private property damage. Water levels fluctuated greatly and were generally marginal as far as fish habitat was concerned. However, tolerable embayment conditions were maintained so that some habitat was available for juvenile salmonids. Juvenile chinook salmon, steelhead, and cutthroat trout did spend an extended period in the embayment. During this period, rearing salmon and steelhead grew substantially. Such growth enhances their chances of survival during the ocean stage of their life cycle.

Invertebrate fish food production appeared greatest in the north and south sloughs. Relative to the embayment, these areas were not utilized by young rearing salmonids. Invertebrate production in the embayment and its value as salmonid rearing habitat was limited by unstable substrate. Instabilities resulted from tidally influenced water level fluctuations further aggravated by park water level control activities.

Slough necks were excavated to restore embayment volume and to improve fish access to the sloughs. However, even after the excavations several conditions remained which minimized fish access and utilization of the sloughs. A constriction remained in the south slough neck, a 'bridge' was constructed across the north slough neck, and water levels throughout the summer were generally 3.0 feet or less above mean sea level. Furthermore, poor water quality (for example, low dissolved oxygen and high temperatures) prevented large numbers of fish from occupying the sloughs.

Culvert drains were installed in the sand berm at the mouth of the creek to test their efficiency in accommodating part of the stream flow to reduce the frequency of controlled breaching. The temporary drains functioned intermittently for seven days before becoming plugged with sand. The ocean side of the culverts was inadequately anchored to withstand the action of the surf. The culverts had no effect on reducing the frequency of controlled breaching. However, given a proper anchoring system, such drains if installed beyond the sand deposition zone, would probably carry flows throughout the summer. It is still unknown whether this would reduce the need for controlled breaching.

On the long term, wetland restoration activities will have an important effect on the overall productivity of the estuary. Such areas provide biotic energy which drive estuarine systems. When the flood control project (levees and channelization) was completed on Redwood Creek in 1968, approximately 75 percent of the existing wetland/riparian resources were lost. A decrease in productivity and carrying capacity of the estuary was the inevitable result. Wetlands reclaimed in 1982 and 1983 should have a substantial positive effect on restoration of estuarine resources.

Proposed Activities for 1984

1. It is proposed as a short term solution that embayment water levels be regulated by the NPS by controlled breaching.

   Under certain summertime, low flow conditions, embayment water levels can be controlled to prevent flooding of private property while maintaining some juvenile fish habitat. Embayment water level control is an expensive and time consuming method of dealing with the flooding/fish habitat issue. However, as long as adjacent private property can not be permitted to flood by natural embayment formation, water levels must be controlled in a manner which also protects fish habitat as much as possible.

   Water levels will be maintained as close to 5.0 feet above mean sea level as possible. This is the elevation which maximizes fish habitat without flooding adjacent pasturelands.

2. It is proposed that the north and south slough necks be resurveyed.

   A resurvey of the slough necks would identify the degree of winter sediment accumulation in excavated areas. An evaluation could then be made of fish accessibility to the sloughs during 1984.

Recommendations for further sediment removal would follow this evaluation.

3. It is proposed that the park continue to evaluate alternatives to improve circulation patterns in the sloughs.

   Poor summertime water quality in the sloughs will limit fish habitat until circulation patterns are improved. Alternatives to improve water quality, such as installation of gated culverts in the south levee, should be pursued.

4. It is proposed that estuarine water quality, aquatic invertebrate production, downstream migration of juvenile salmonids, and embayment fish numbers and growth rates be monitored.

5. It is proposed that the park fund a Corps of Engineers analysis of estuarine restoration alternatives, including redesign of the levee system.

6. It is proposed the park increase interpretation and public dissemination of information regarding park management activities at the estuary.

MANAGEMENT, RESEARCH AND MONITORING ACTIVITIES IMPLEMENTED IN 1983

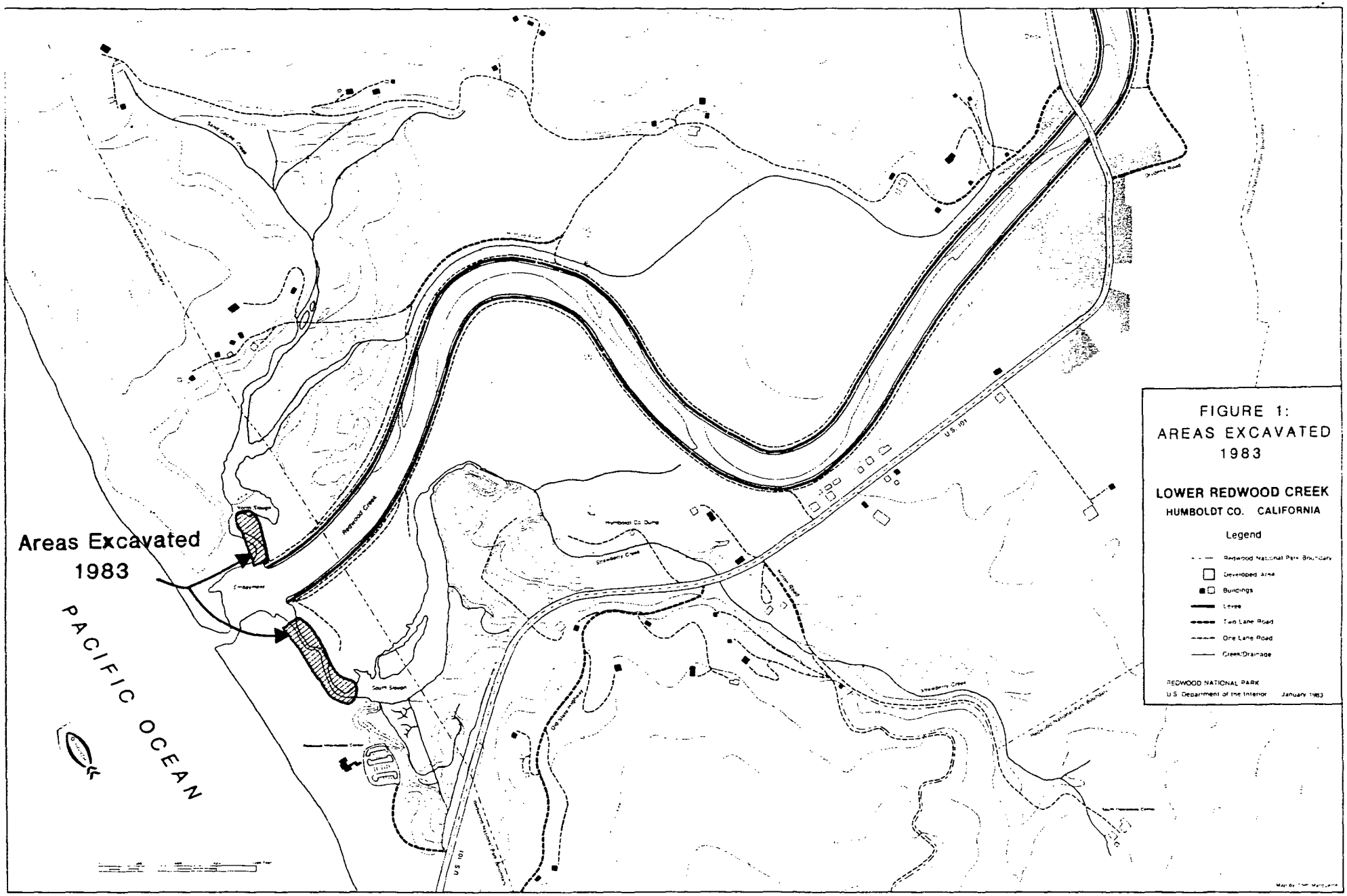
South and North Slough Excavations

Accumulated sand was excavated from the slough necks to restore embayment volume and improve access for juvenile salmonids to the main slough areas. The area excavated is shown in Figure 1. Excavations were accomplished using bulldozers. Profiles were surveyed across the neck areas before and after excavations to document the amount of material removed and to determine final channel configuration. Profile locations are shown in Figure 2.

The first phase of the south slough excavation began June 1 and was completed June 6. It was determined additional sand should be removed and a second excavation occurred between June 16 and June 24. Final channel depths were determined by the surveyed profiles shown in Figures 3 through 8. A constriction remained in the southernmost end of the slough neck as soft bottom material prevented the equipment from working in this area.

Excavation of the north slough neck began June 28 and was completed July 9. Final channel depths were determined by surveyed profiles shown in Figures 9 through 12. On August 18 a portion of the neck was partially filled in to provide a 'bridge' for bulldozer access to the creek mouth for controlled breaching. This material was removed on September 26.

Excavation of the north slough neck hindered access north of the mouth of Redwood Creek by beach users in vehicles. Four wheel drive access had existed since about 1972, when accumulated sand closed the neck of the north slough and provided a ford across the slough. Prior to about 1972, a deep (20+ foot) hole existed in the north slough neck. With the excavations, access was returned to the traditional route up the beach. The excavations brought a number of complaints from beach fishermen.


Areas Excavated
1983
PACIFIC OCEAN
Redwood Creek
Humboldt Co. Dune
Strawberry Creek
South Slough
U.S. 101
FIGURE 1:
AREAS EXCAVATED
1983
LOWER REDWOOD CREEK
HUMBOLDT CO. CALIFORNIA
Legend
Redwood National Park Boundary
Developed Area
Buildings
Levee
Two Lane Road
One Lane Road
Creek/Drainage
REDWOOD NATIONAL PARK
U.S. Department of the Interior
January 1983

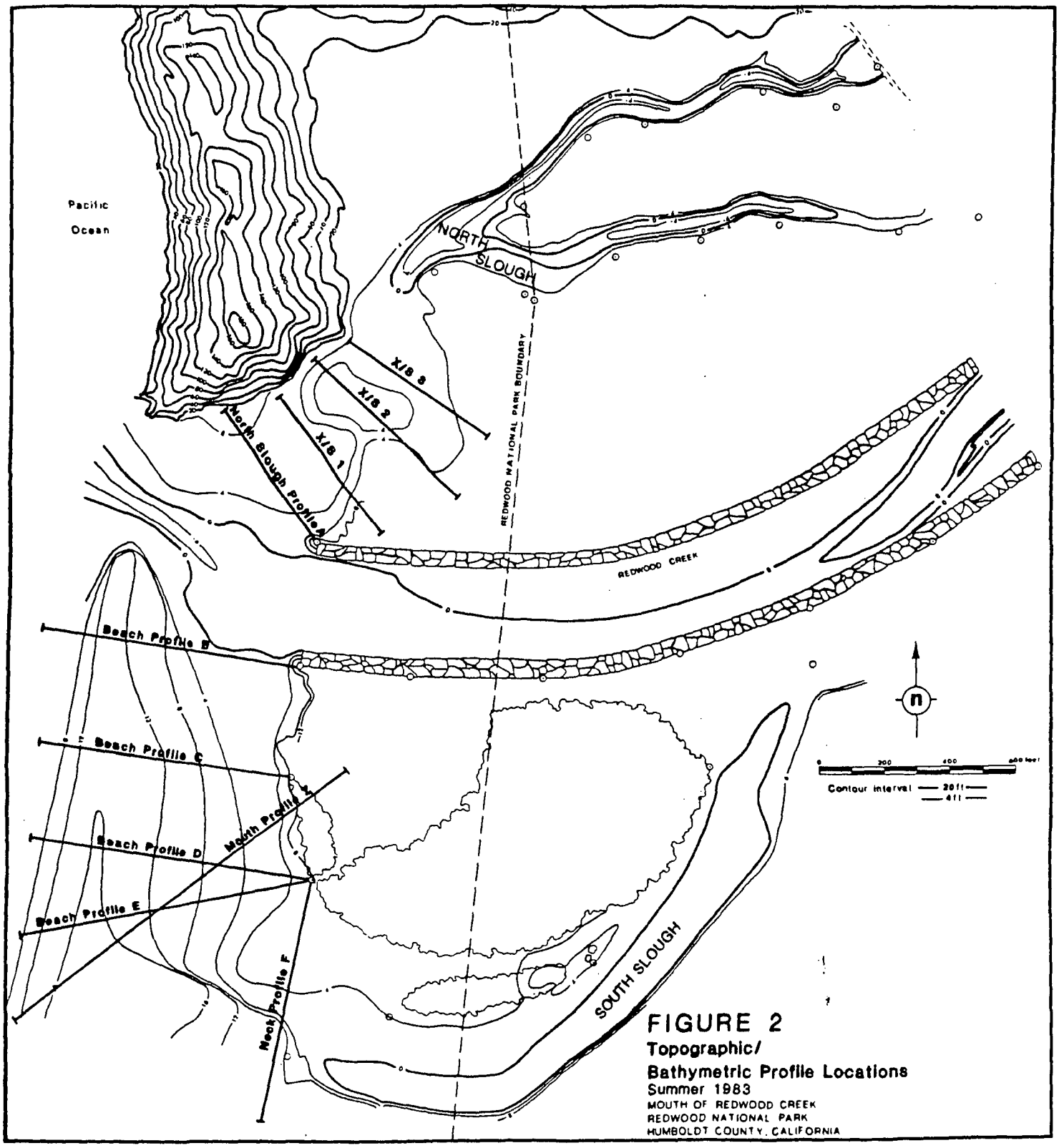


FIGURE 2
Topographic/
Bathymetric Profile Locations
Summer 1983
MOUTH OF REDWOOD CREEK
REDWOOD NATIONAL PARK
HUMBOLDT COUNTY, CALIFORNIA

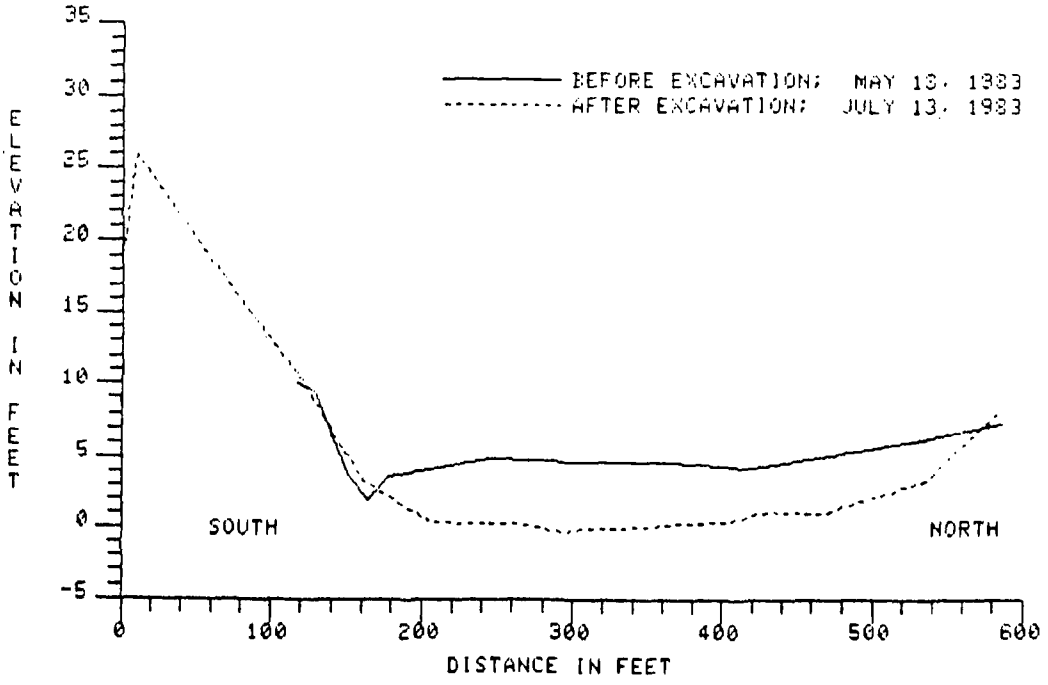


FIGURE 3: NECK PROFILE F

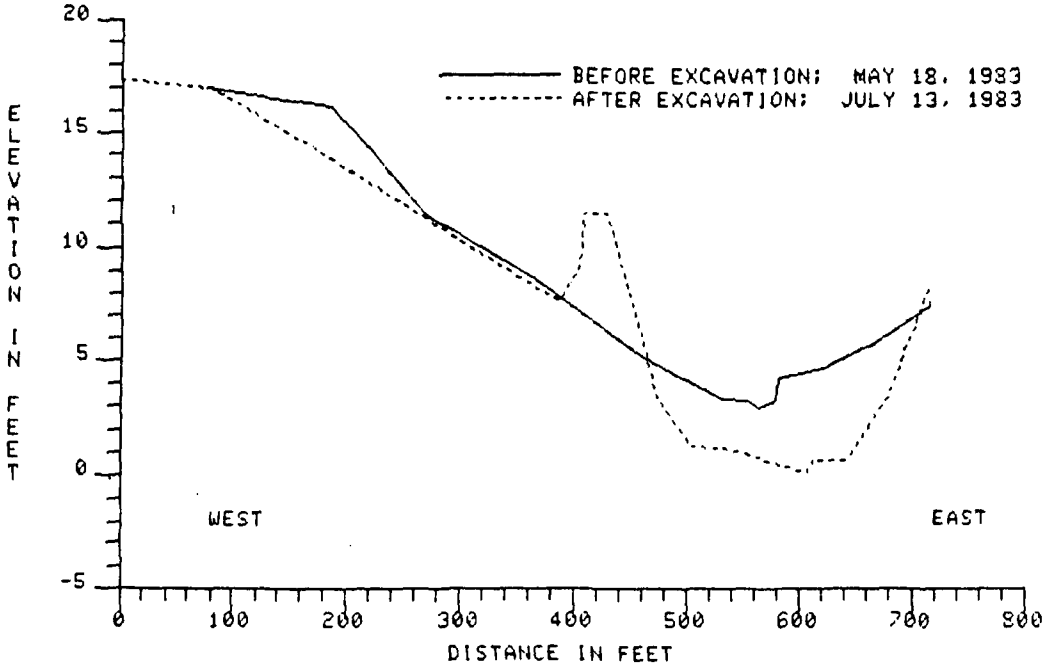


FIGURE 4: BEACH PROFILE E

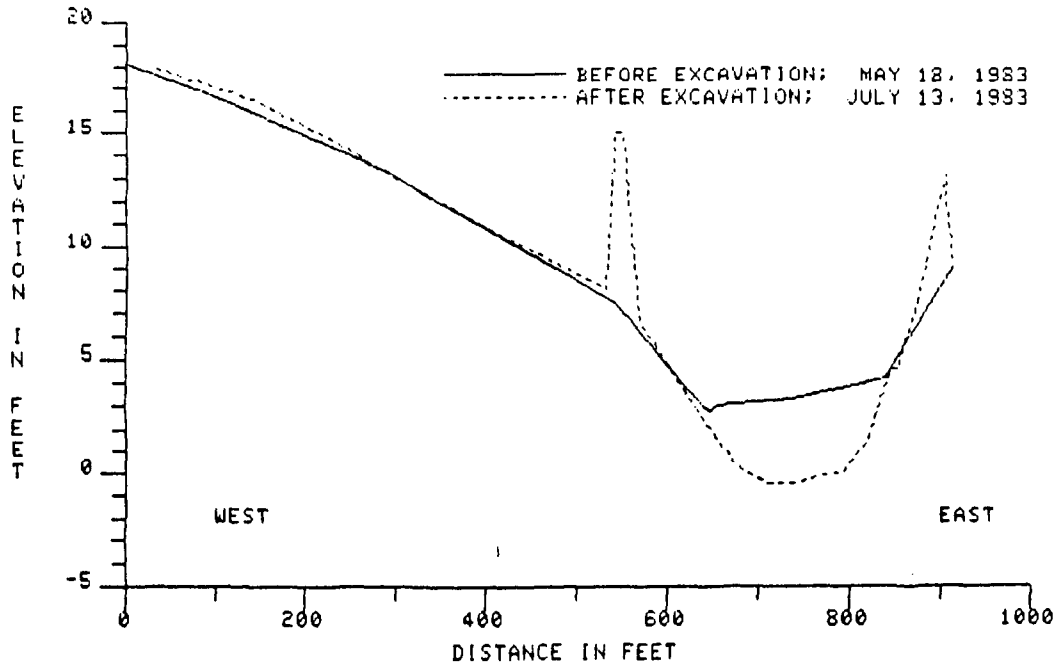


FIGURE 5: MOUTH PROFILE Z

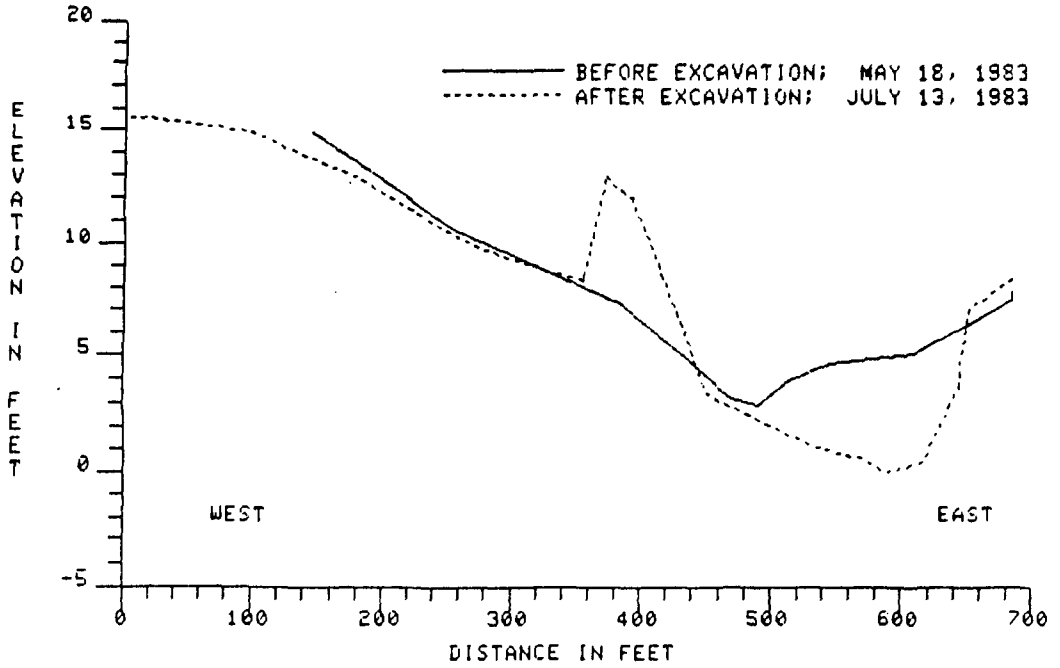


FIGURE 6: BEACH PROFILE D

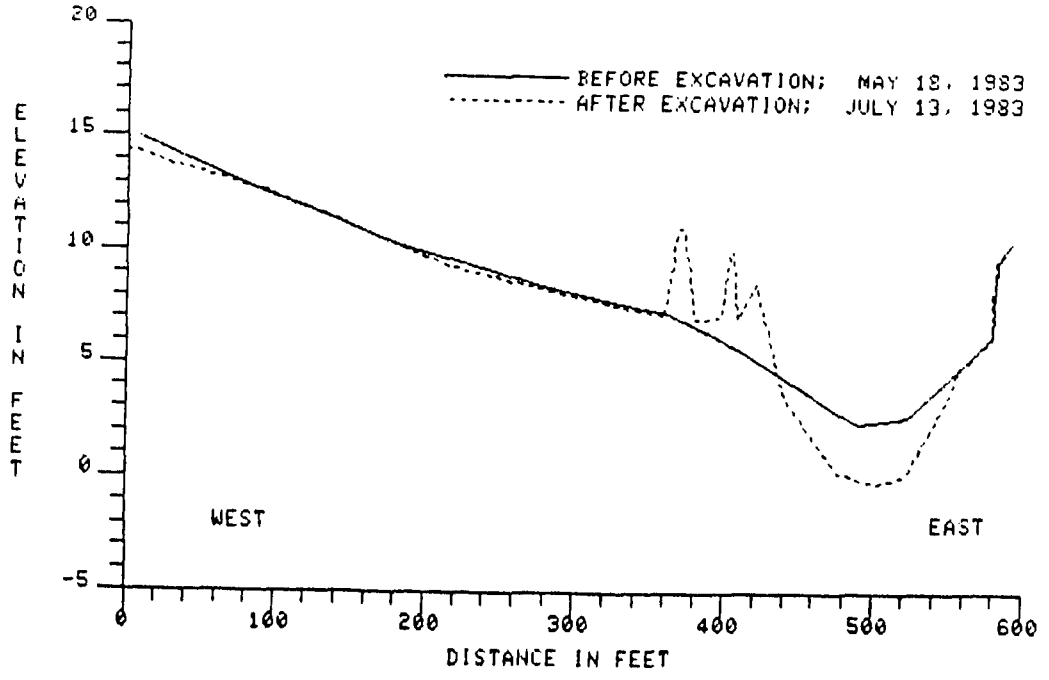


FIGURE 7: BEACH PROFILE C

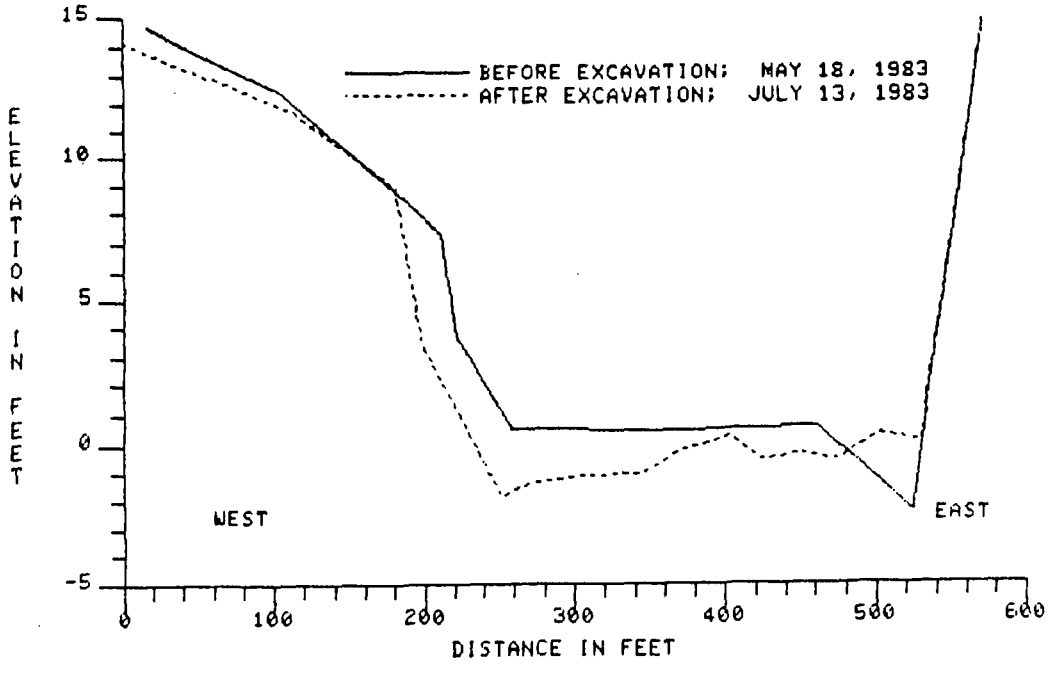


FIGURE 8: BEACH PROFILE B

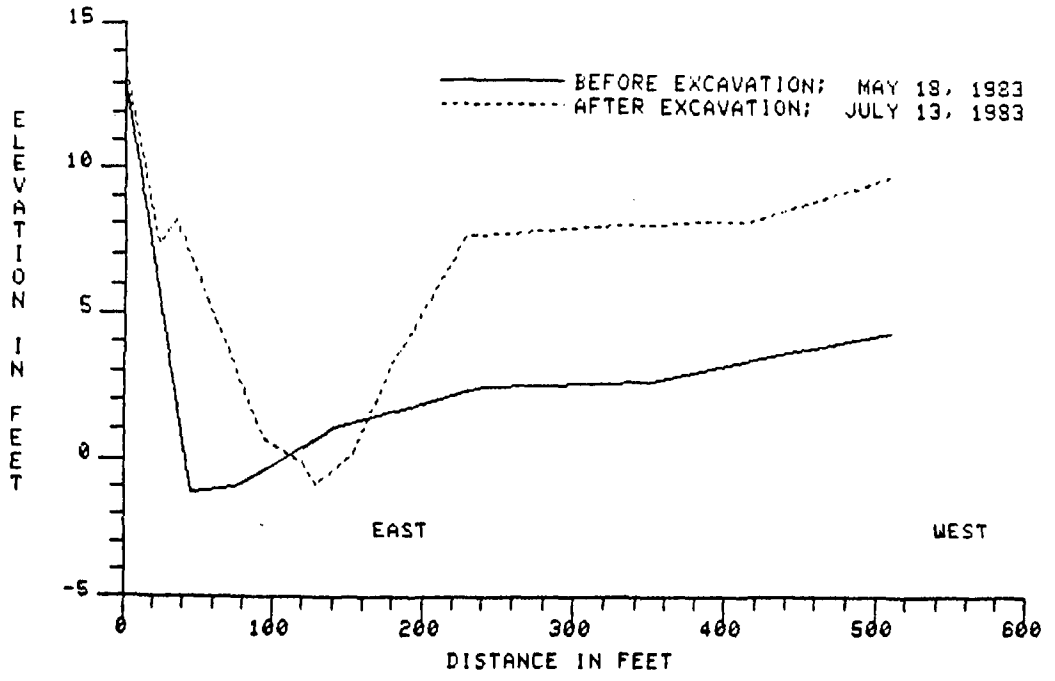


FIGURE 9: NORTH SLOUGH PROFILE A

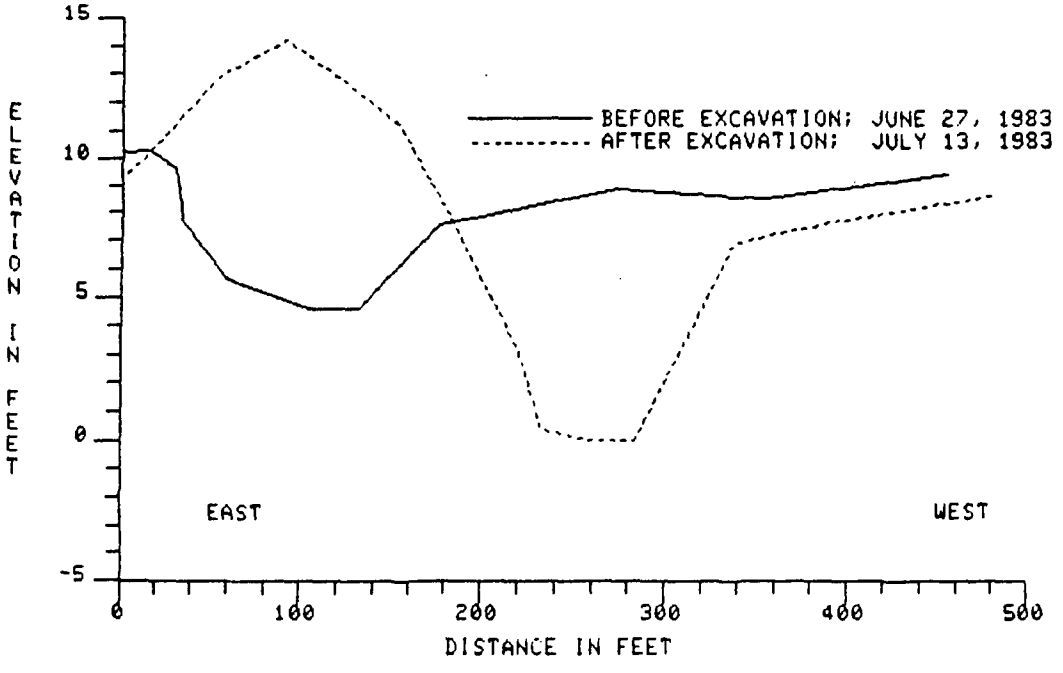


FIGURE 10: X/S 1

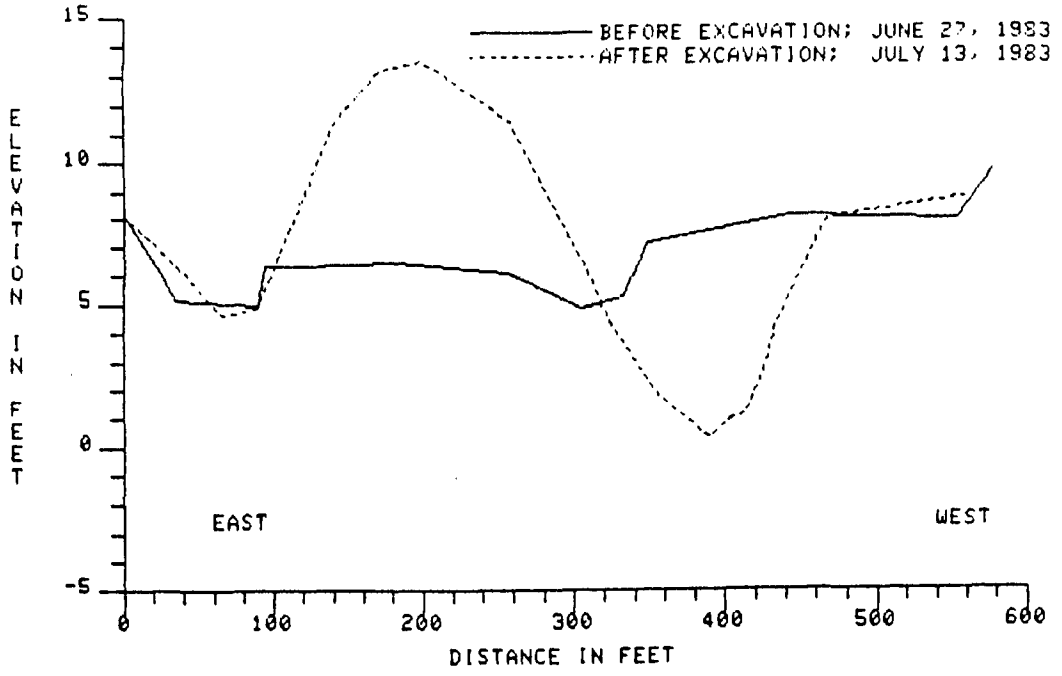


FIGURE 11: X/S 2

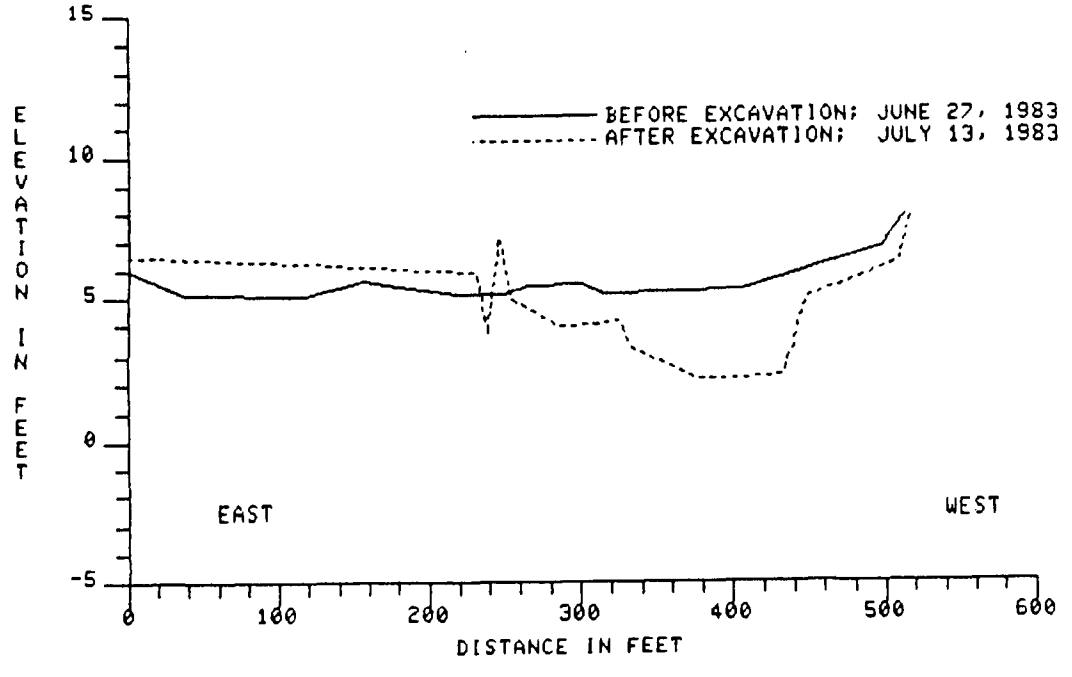


FIGURE 12: X/S 3

Culvert Installation

Culvert drains were installed in the berm at the mouth of the creek to test if they could accommodate part of the stream flow to reduce the frequency of controlled breaching.

A 24-inch drain and 36-inch drain were installed July 6 and 7. Installation work required use of a park backhoe, contract bulldozer, and manual labor. Within a few days, the culvert drains had suffered considerable damage on the oceanside. Waves, sand deposition and undercutting resulted in the loss of several culvert sections. The drains carried water intermittently until July 14 when they were completely buried by sand on the oceanside. The culverts were removed from the berm on September 12.

Log Boom Repair

New anchors were installed on the west end of the log boom constructed during October 1981. The boom prevents woody debris from entering the north slough. This debris often settles on adjacent private lands during high water.

The new anchors consisted of two, four-foot sections of 24-inch culvert attached to the west end of the cable, buried eight feet deep. The work required approximately four hours on September 9.

Wetland Restoration

Wetlands were reclaimed at the old California Pacific Mill site. Approximately two acres were restored, from September 19 to November 21. Fill was removed and drainages established continuous with those of existing wetlands (natural and restored).

The area was excavated to a depth of approximately 5.0 feet above mean sea level and is now subject to periodic flooding.

Embayment Water Level Control

The objective was to maintain embayment water levels to protect adjacent private lands from flooding while retaining sufficient water to provide habitat for juvenile salmonids. Water levels were to be maintained as high as possible without exceeding 5.0 feet above mean sea level, which is the point pastures begin to flood. An operations plan was developed by Resources Management Division outlining objectives, methods, and responsibilities.

Water levels were manipulated by controlled breaching a total of 22 times from June 1 through October 5 using either manual labor and/or heavy equipment. On only three days did water levels exceed 5.0 feet above mean sea level, the highest being 5.24 feet. These occurrences followed heavy rains but were promptly remedied by controlled breaching. There were no private landowner complaints about excess water.

To carry out slough excavations and culvert installations it was necessary for the park to lower embayment water levels. This resulted in water levels that often represented poor quality juvenile salmonid habitat. On four occasions

heavy equipment was utilized to slow or stop embayment outflow in an attempt to raise water levels and prevent loss of critical habitat.

In conjunction with embayment water level control, a record of water levels and other observations was maintained by Resources Management. Entries included water levels, outflow channel configuration, wind and sea conditions, time spent, and other comments. A total of 327 record entries were made from April 18 to November 2.

Water Quality Studies

Monitoring was conducted to determine if and when estuarine (embayment and sloughs) water quality was limiting for juvenile salmonids. Twelve monitoring sites were established in the north and south sloughs and the embayment. Parameters measured included conductivity, temperature, salinity, and dissolved oxygen. A vertical profile from surface to bottom was determined for each parameter, at each station, 14 different times from July 7 through November 17. Poorest water quality was observed in the sloughs where temperatures and dissolved oxygen reached levels that were limiting to salmonids. In the embayment, water temperature occasionally increased to undesirable levels but was never limiting. These elevated temperatures usually accompanied low embayment water levels. Dissolved oxygen was consistently adequate in the embayment.

The embayment alternated between a fresh and brackish water system. High tides and ocean overwash caused short periods when brackish conditions prevailed. A dense salt water layer was maintained on the slough bottoms throughout the summer. A salt water layer also existed on the embayment bottom. Its depth varied with tide, ocean conditions, and mouth configuration.

Aquatic Invertebrate Sampling

Aquatic invertebrates were sampled to determine abundance and areas of greatest density. Sampling methods included the use of small artifical substrate baskets, plankton net tows, and plastic bottom samplers. Suspended artificial substrate baskets were used to sample the slough areas whereas plastic bottom samplers were used in the excavated neck of the south slough and the embayment. Plankton net tows were made in sloughs and the embayment at artificial and plastic substrate sampler sites. A total of 78 samples was collected from July 21 to November 17.

These samples are presently being analyzed. However, visual inspection of samples suggests greatest invertebrate density in the north and south sloughs.

Fish Migration and Estuary Utilization

This program was directed at identifying the timing and extent of juvenile salmonid downstream migration, and numbers and growth of juvenile salmonids utilizing the embayment.

Trapping of downstream migrating fish began on April 28 and continued through August 11. Trapping was conducted from approximately 5:00 p.m. to 9:00 a.m. one night each week on both Prairie Creek and Redwood Creek. Trapped fish were identified, counted, measured, and scale samples were collected.

Embayment fish populations were estimated by seining and marking captured fish. The ratio of marked versus unmarked fish captured two days later was utilized in calculating population estimates. Six estimates were made from June 29 to October 18. During the same period growth was monitored 11 times by seining and measuring each fish captured. On each of these sampling days approximately 20 fish (10 steelhead and 10 salmon) were sacrificed for stomach analyses and for determination of food habits. Scales were collected from 30 individuals of each species.

Downstream migration of juvenile chinook salmon showed three equal peaks, late May, mid June, and early July. Chinook migration ended by July 28. Peak downmigration of juvenile steelhead and cutthroat trout occurred in late June and mid May respectively. Downstream migrant trapping was terminated after chinook downmigration ceased. It is assumed that some low level of steelhead migration continued past this date.

The major area utilized by juvenile salmonids was the embayment. Fish avoided the saltwater layer on the embayment bottom and area adjacent to the ocean berm during periods of overwash, preferring water of lower salinity. Few fish utilized the sloughs. Population estimates and growth for juvenile chinook salmon and steelhead trout are shown in Figures 13 and 14. These figures show downstream migrating salmonids found favorable habitat in the estuary as soon as an embayment began to form. A decline in chinook on July 13 (Figure 13) was probably the result of inadequate habitat. This was associated with frequent water level fluctuations and low embayment water levels (averaging only 1.9 feet above mean sea level) which occurred during the preceding two weeks. Downstream migration continued. By July 27 numbers of young chinook had again increased. Water levels from July 13 to July 27 averaged 2.9 feet above mean sea level. More habitat was available and fish remained in the embayment. During this entire period the mouth of the creek remained open. Increases in fish numbers therefore indicate preferential rearing. That is, the embayment was the preferred habitat as compared to the ocean. Sudden decline in chinook numbers on September 13 was the result of fish entering the ocean and was caused by intense rainfall, increased streamflow, controlled breaching at the mouth, and subsequent lowered embayment water levels. Downstream migration of chinook had ended by this date and numbers remained low.

Juvenile salmon growth in the estuary during the summer was significant (see Figure 13). Fork length averaged 81.8 mm on June 29 and 119.6 mm on October 18.

Patterns of estuarine use by juvenile steelhead trout (Figure 14) were similar to that of salmon. That is, when habitat was available, steelhead spent an extended period in the estuary. Unlike salmon, downmigration of juvenile steelhead continued throughout the summer. The influence of streamflow on steelhead downstream migration was apparent on July 13 and September 13. Both dates were preceded by rains and increased streamflow. While fish numbers increased, average size decreased substantially with an influx of smaller fish. As numbers declined average size again increased probably indicating loss of the smaller fish from the embayment. Following September 29 both the numbers and average size of fish declined. Larger fish, having completed the smolting process, entered the ocean.

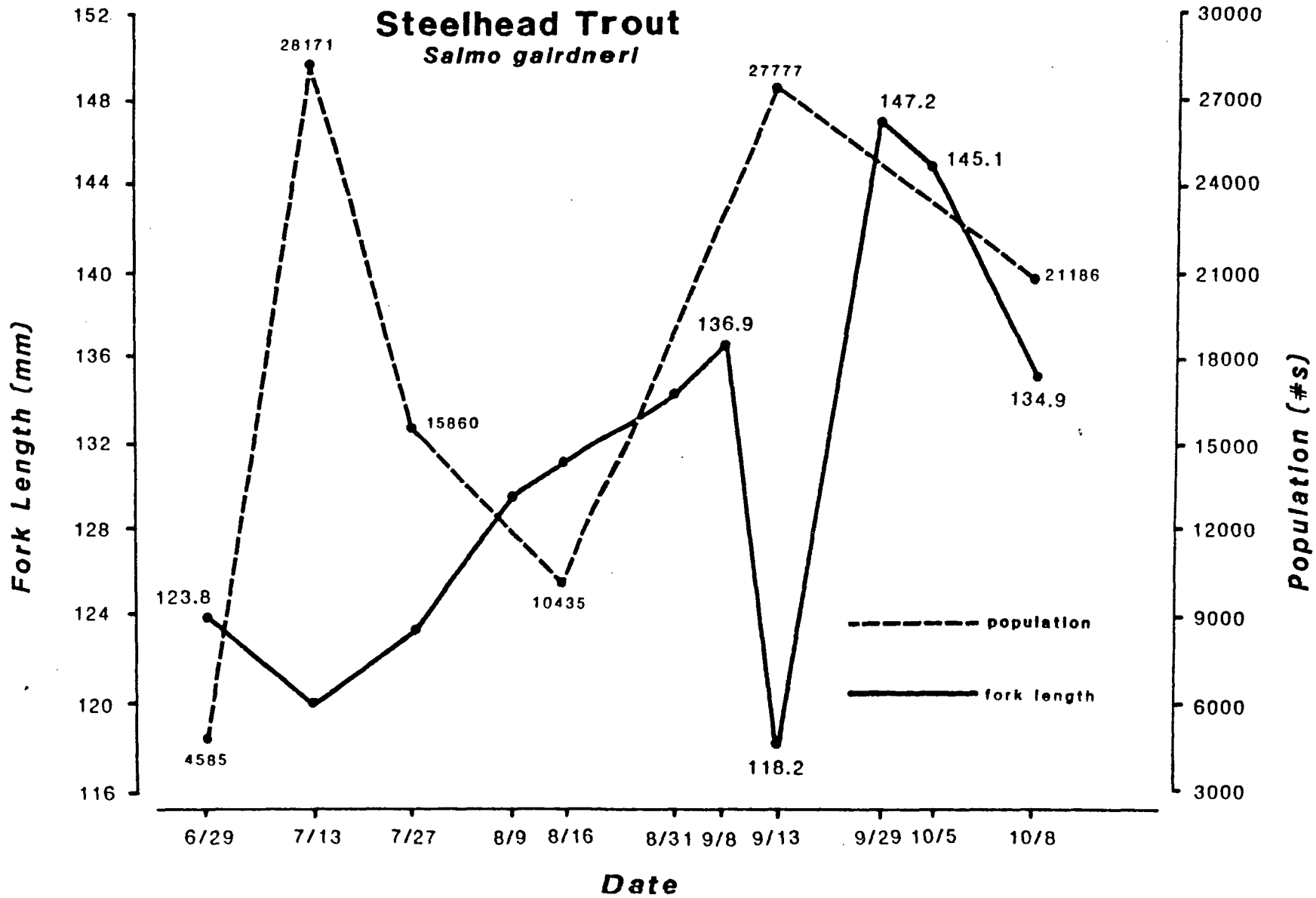


FIGURE 14: Population estimates and growth of steelhead trout, summer 1983

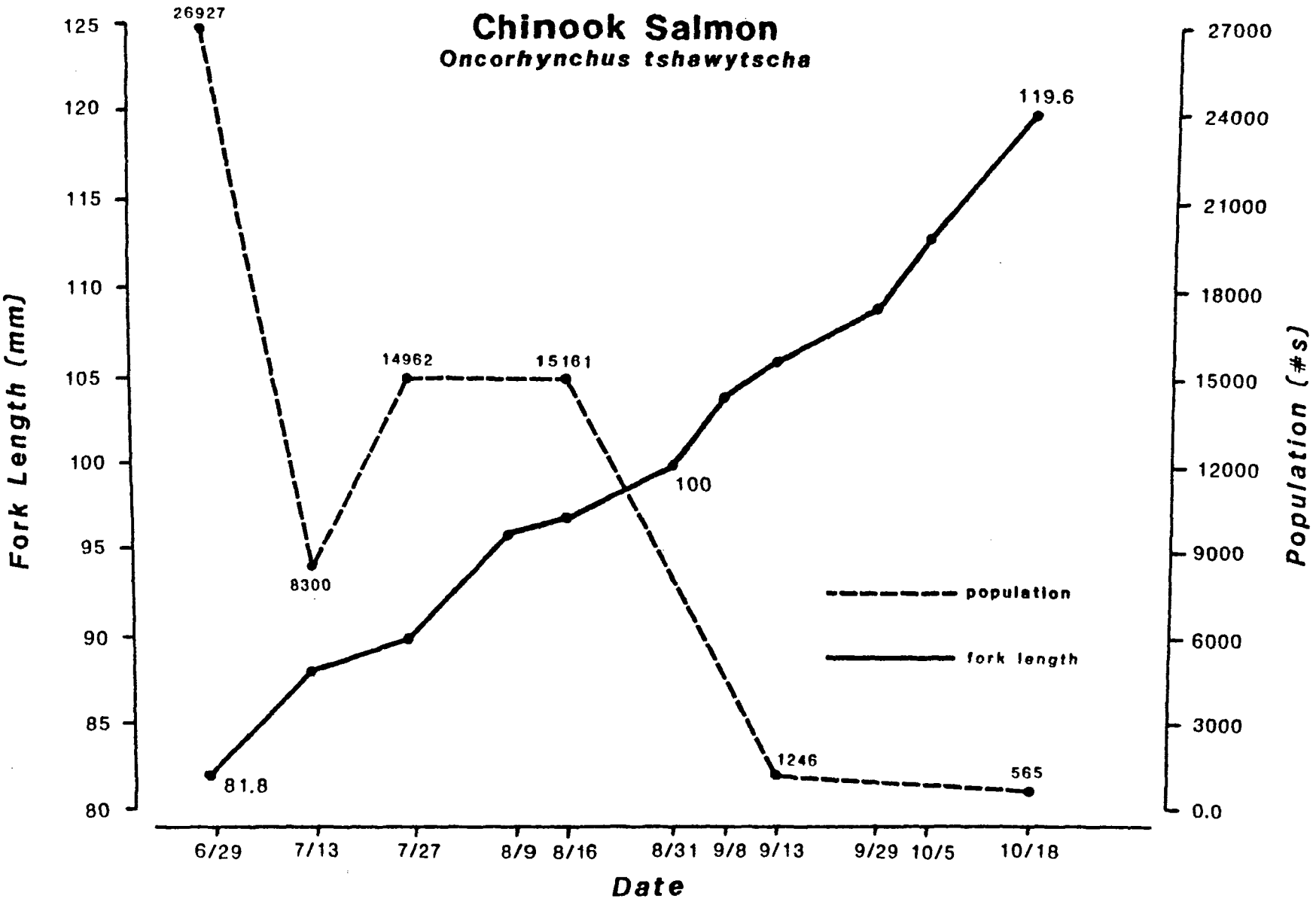


FIGURE 13: Population estimates and growth of chinook salmon, summer 1983

1983 Cost Summary

Management Activities

Slough Excavations	$20,386
Culvert Drain Installation	5,339
Log Boom Repair	386
Water Level Control and Monitoring	9,430
Total	$35,541

Research and Monitoring

Water Quality Monitoring	2,670
Aquatic Invertebrate Monitoring	4,935
Fish Trapping, Population and Growth Monitoring	16,150
Total	$23,755

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INTRODUCTION

Background

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The park has actively managed the remnant Redwood Creek embayment since 1982. Management actions were designed to maintain what little rearing habitat remained and to prevent flooding of private property resulting from natural embayment formation.

Summary Evaluation for 1984

The overall objective of activities undertaken in 1984 was to maintain summertime estuarine habitat for rearing juvenile salmonids while preventing flooding of adjacent private property. Management and research activities included topographic and bathymetric surveys, log boom repair, embayment water level control, water quality monitoring, aquatic invertebrate sampling, trapping of downstream migrating juvenile salmon, steelhead, and cutthroat trout, and numbers and growth monitoring of juvenile salmonids utilizing the embayment.

Flooding of private property was prevented. Water levels fluctuated greatly and were generally marginal as far as fish habitat was concerned. However, tolerable embayment conditions were maintained so that some habitat was available for juvenile salmonids. Juvenile chinook salmon, steelhead, and cutthroat trout did spend an extended period in the embayment. During this period, rearing salmon and steelhead grew substantially. Such growth enhances their chances of survival during the ocean stage of their life cycle.

Invertebrate fish food production appeared greatest in the north and south sloughs. Relative to the embayment, these areas were not utilized by young rearing salmonids. Invertebrate production in the embayment and its value as salmonid rearing habitat was limited by unstable substrate. Bottom instability resulting from tidally influenced water level fluctuations was further aggravated by park water level control activities.

Slough necks excavated in 1983 to restore embayment volume and to improve fish access to the sloughs were resurveyed. The resurvey shows that sand deposition has occurred in the areas of excavation although the channel bottoms of the slough necks remain considerably below pre-excavation levels.

However, fish utilization of the sloughs was limited by poor water quality (for example, low dissolved oxygen and high temperatures).

Proposed Activities for 1985

1. It is proposed as a short term solution that embayment water levels be regulated by the NPS by controlled breaching.

   Under certain summertime, low flow conditions, embayment water levels can be controlled to prevent flooding of private property while maintaining some juvenile fish habitat. Embayment water level control is an expensive and time consuming method of dealing with the flooding/fish habitat issue. However, as long as adjacent private property can not be permitted to flood by natural embayment formation, water levels must be controlled in a manner which also protects fish habitat as much as possible.

   Water levels will be maintained as close to 5.0 feet above mean sea level as possible. This is the elevation which maximizes fish habitat without flooding adjacent pasturelands.

2. It is proposed that the north and south slough necks be resurveyed.

   A resurvey of the slough necks would identify the degree of winter sediment accumulation in excavated areas. An evaluation could then be made of fish accessibility to the sloughs during 1985. Recommendations for further sediment removal would follow this evaluation.

3. It is proposed that the park continue to evaluate alternatives to improve circulation patterns in the sloughs.

   Poor summertime water quality in the sloughs will limit fish habitat until circulation patterns are improved. Alternatives to improve water quality, such as installation of gated culverts in the south levee, should be pursued.

4. It is proposed that estuarine water quality, and embayment fish numbers and growth rates be monitored.

5. It is proposed the park increase interpretation and public dissemination of information regarding park management activities at the estuary.

MANAGEMENT, RESEARCH AND MONITORING ACTIVITIES IMPLEMENTED IN 1984

South and North Slough Resurvey

Accumulated sand was excavated from the slough necks to restore embayment volume and improve access for juvenile salmonids to the main slough areas in 1983. The area excavated is shown in Figure 1. Profiles were surveyed across the neck areas before and after excavations to document the amount of material removed and to determine final channel configuration. Profile locations are shown in Figure 2. These profiles were resurveyed in 1984 as shown in Figures 3 through 12.

The resurvey shows the excavated channels have undergone some readjustment and filling with sand. Sand deposition was greatest near the mouths of both sloughs, however, channel bottom elevations are still lower at these sites than farther up each neck. Therefore, sediment accumulation at the slough mouths is not yet a problem and is likely to fluctuate both higher and lower in future years.

Circulation between each slough and the mouth of Redwood Creek is controlled by the highest channel-bottom elevation in the connecting neck. This "limiting elevation" limits circulation and fish movement when the backwater of Redwood Creek falls near or below that level. Limiting elevations remain considerably below pre-excavation levels:

Limiting Elevations (above mean sea level)

	May, 1983 (Before Excavation)	July, 1983 (After Excavation)	July, 1984 (After First Winter)
South Slough	3.0	0	1.0
North Slough	5.0	2.0	2.0

Log Boom Repair

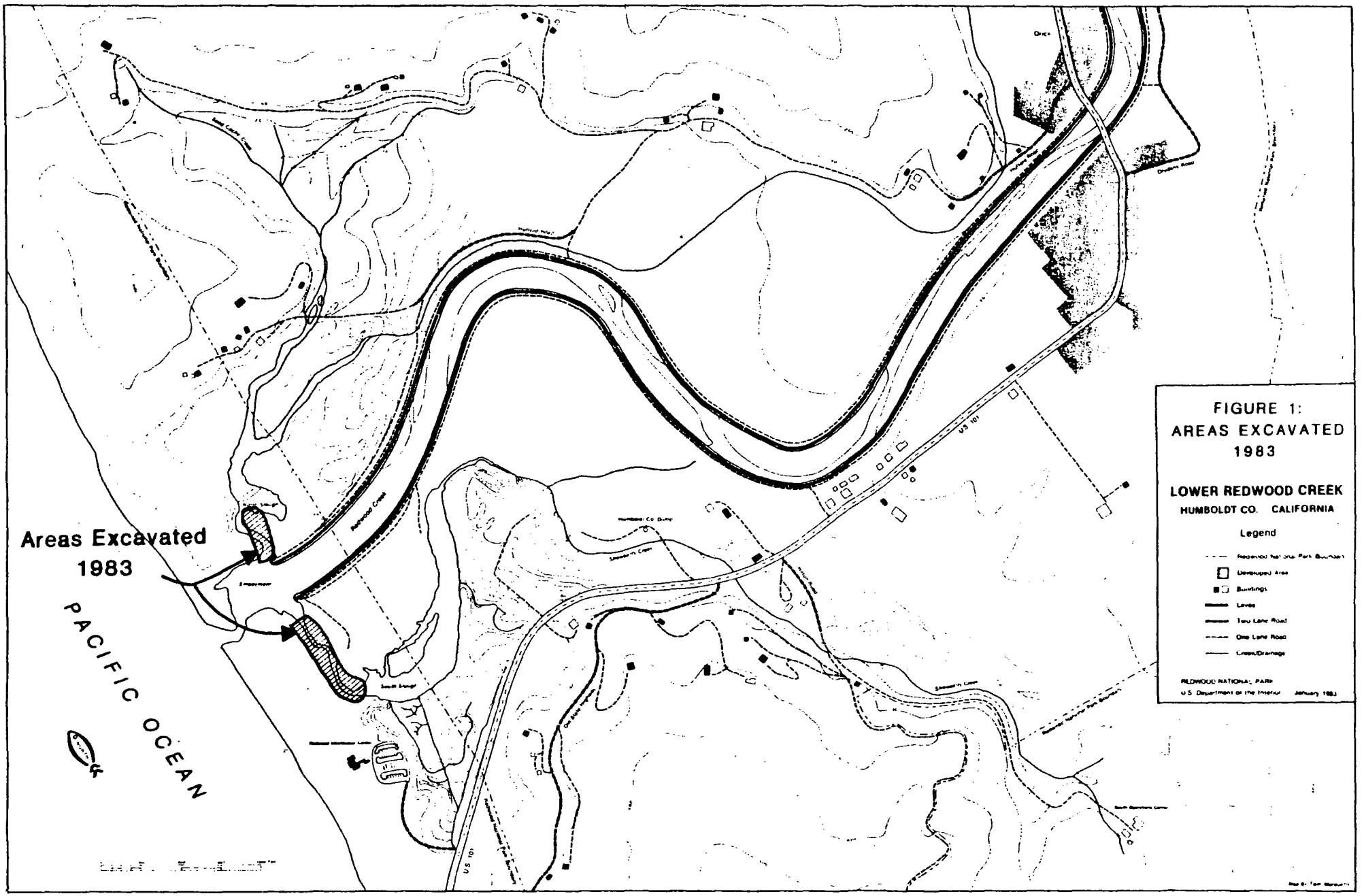
Repair was necessary to one of the anchors on the east end of the log boom. Constructed during October 1981, the boom prevents woody debris from entering the north slough. This debris often settles on adjacent private lands during high water.

Embayment Water Level Control

The objective was to maintain embayment water levels to protect adjacent private lands from flooding while retaining sufficient water to provide habitat for juvenile salmonids. Water levels were to be maintained as high as possible without exceeding 5.0 feet above mean sea level, when pastures begin to flood. An operations plan was developed by Resources Management Division outlining objectives, methods, and responsiblities.

Water levels were manipulated by controlled breaching a total of 19 times from July 22 through October 26 using either manual labor and/or heavy equipment.

In conjuction with embayment water level control, a record of water levels and other observations was maintained by Resources Management. Entries included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Undeveloped Area
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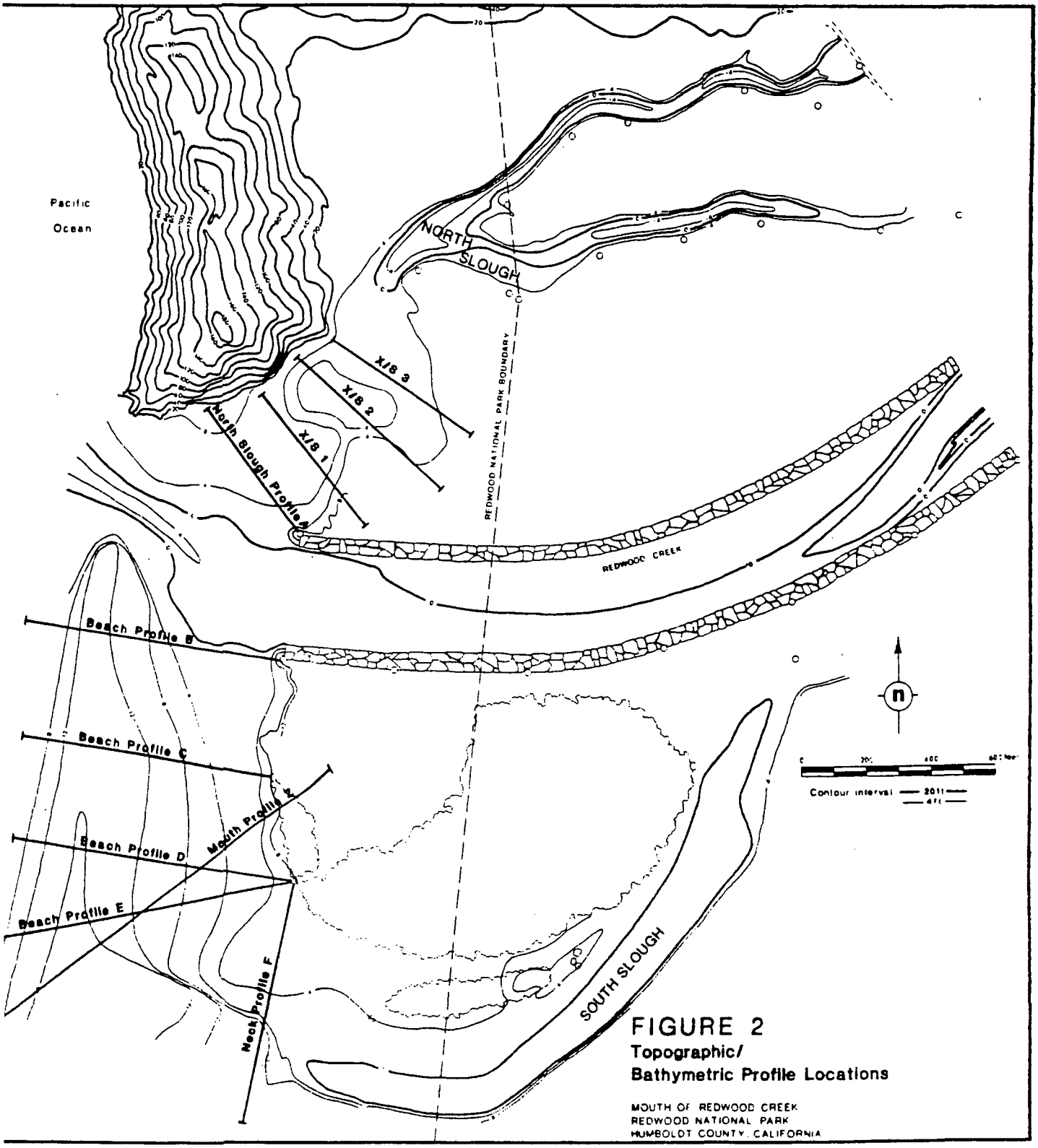

FIGURE 2

Topographic/
Bathymetric Profile Locations

MOUTH OF REDWOOD CREEK
REDWOOD NATIONAL PARK
HUMBOLDT COUNTY, CALIFORNIA

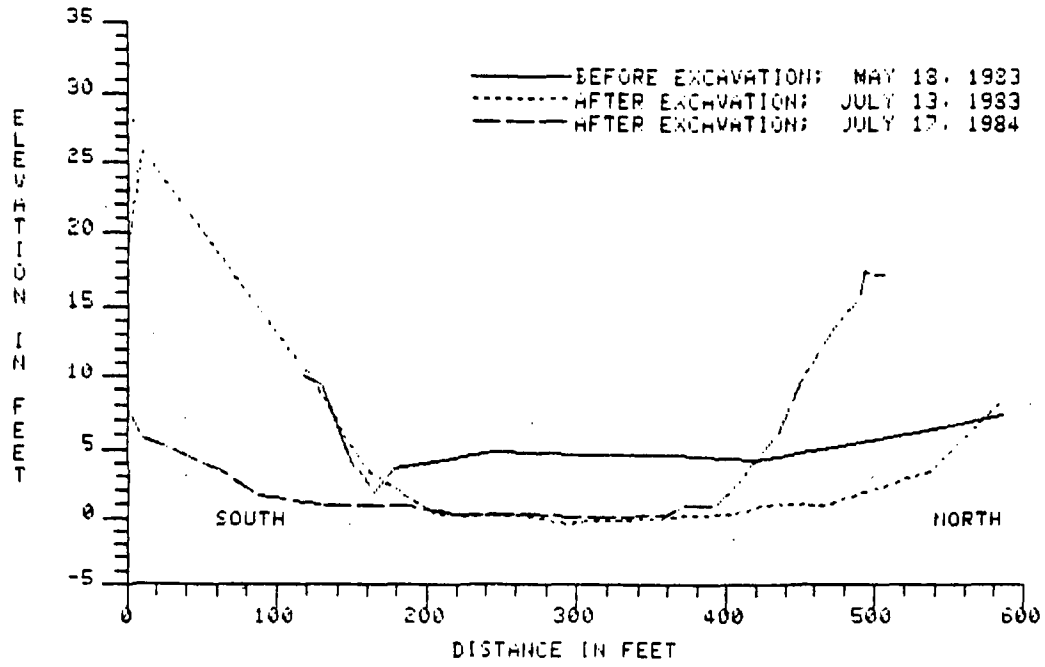

FIGURE 3: NECK PROFILE F

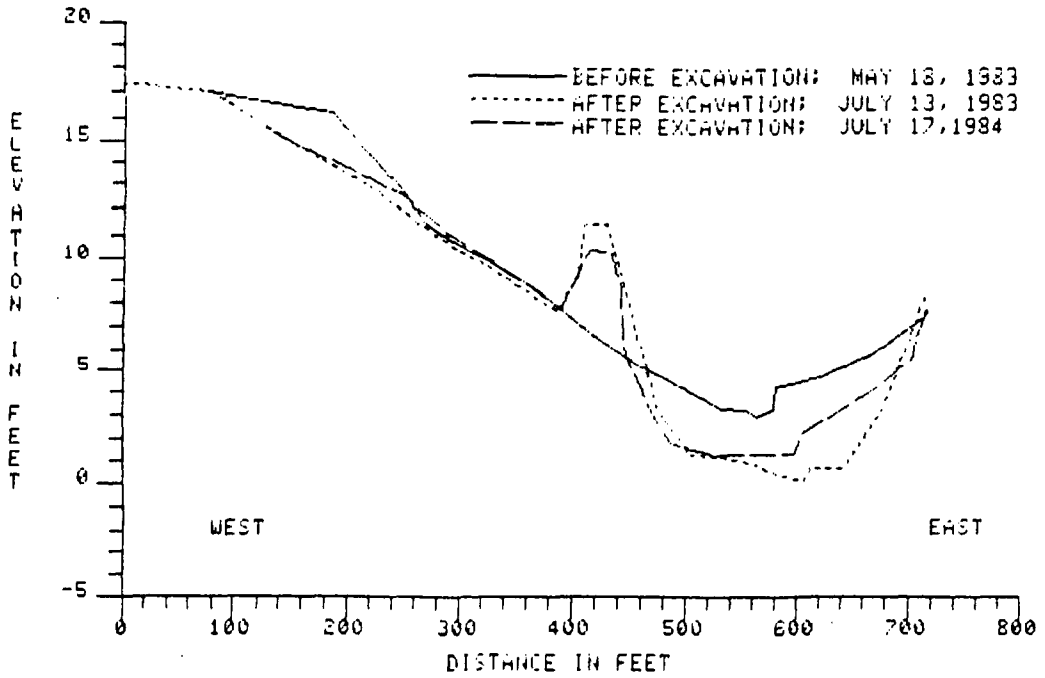

FIGURE 4: BEACH PROFILE E

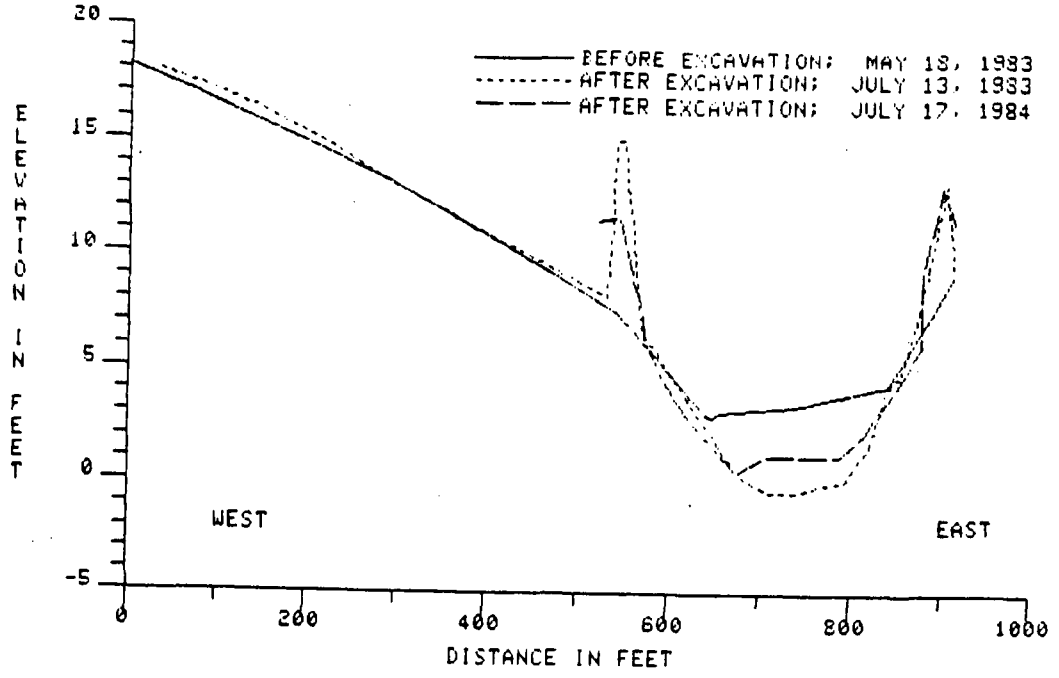

FIGURE 5: MOUTH PROFILE Z

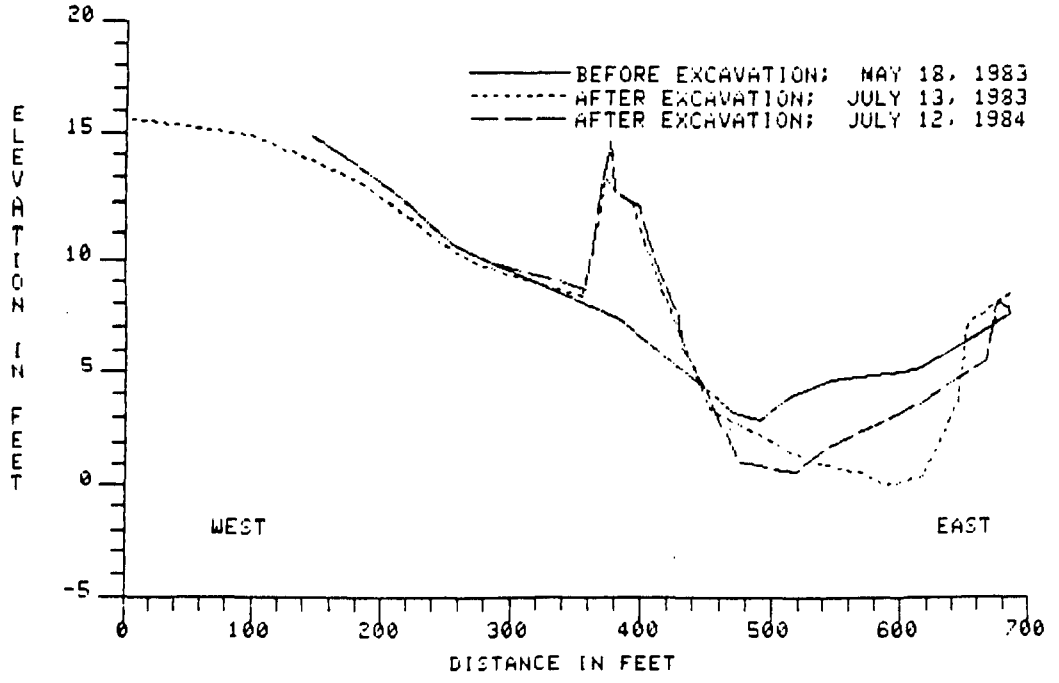

FIGURE 6: BEACH PROFILE D

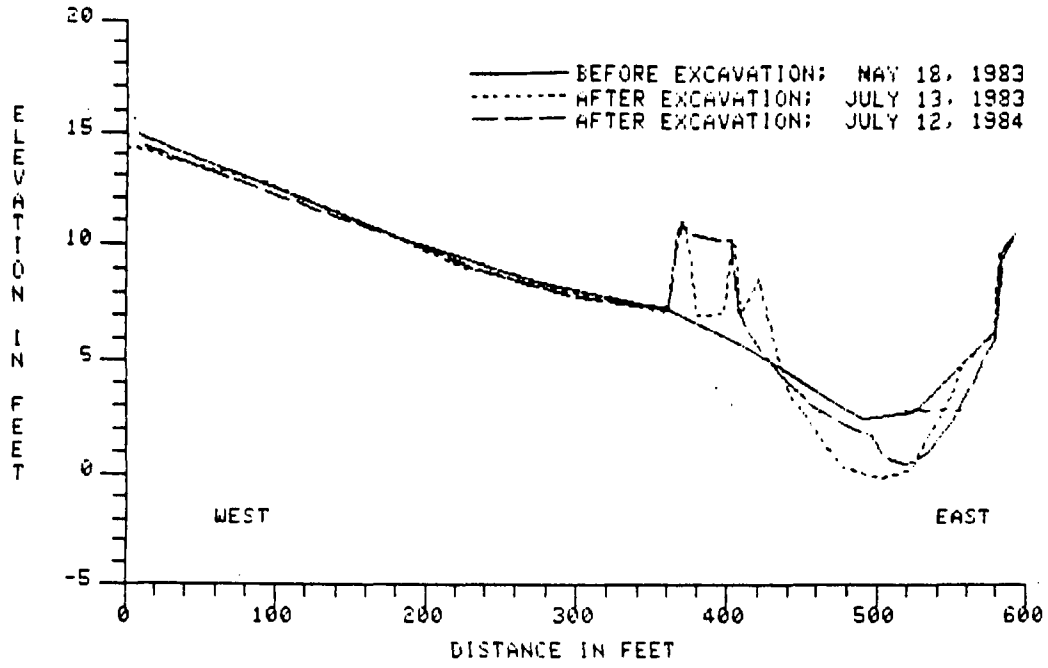

FIGURE 7: BEACH PROFILE C

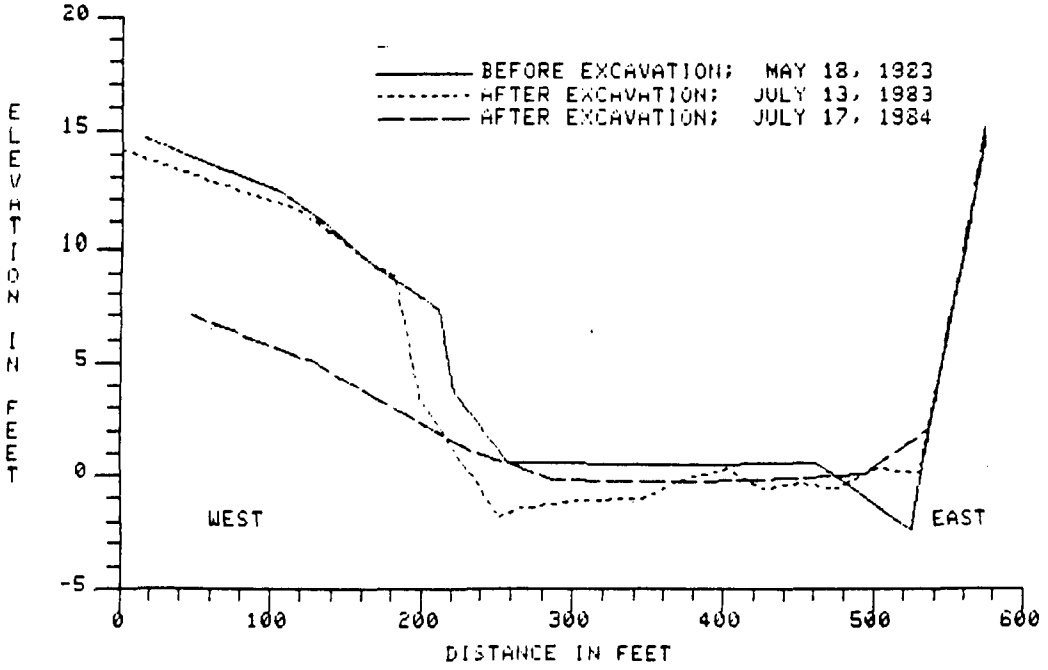

FIGURE 8: BEACH PROFILE B

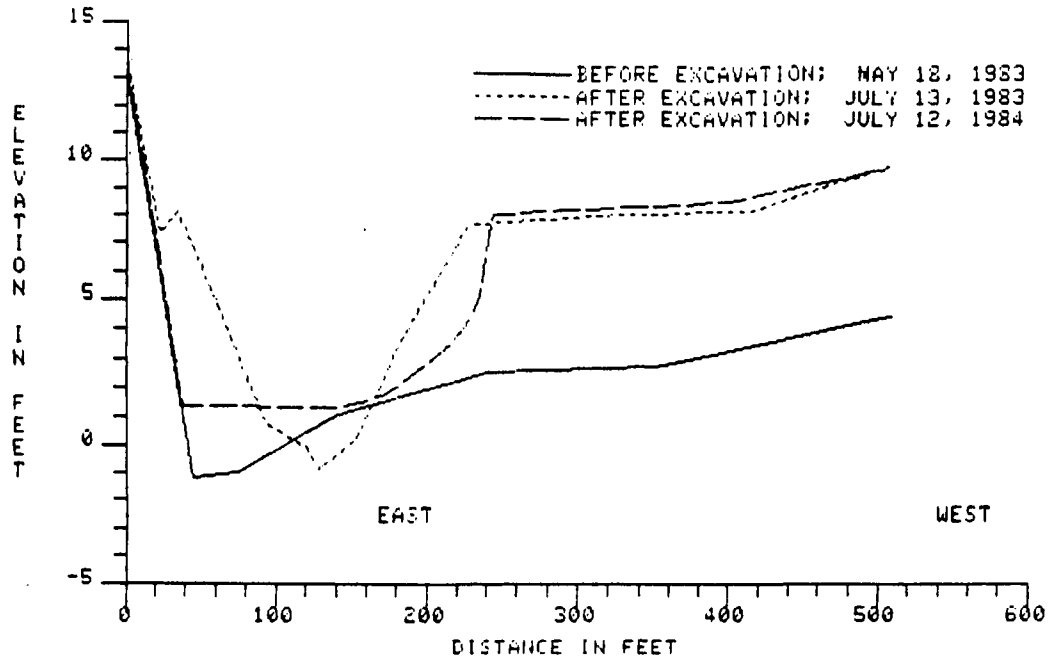

FIGURE 9: NORTH SLOUGH PROFILE A

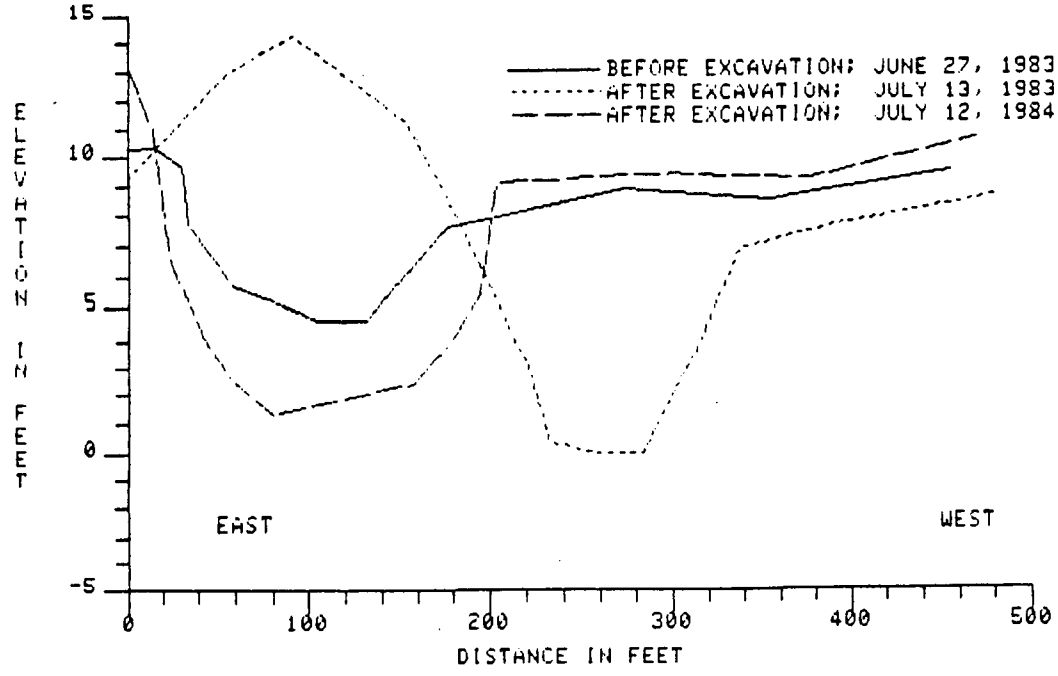

FIGURE 10: X-S 1

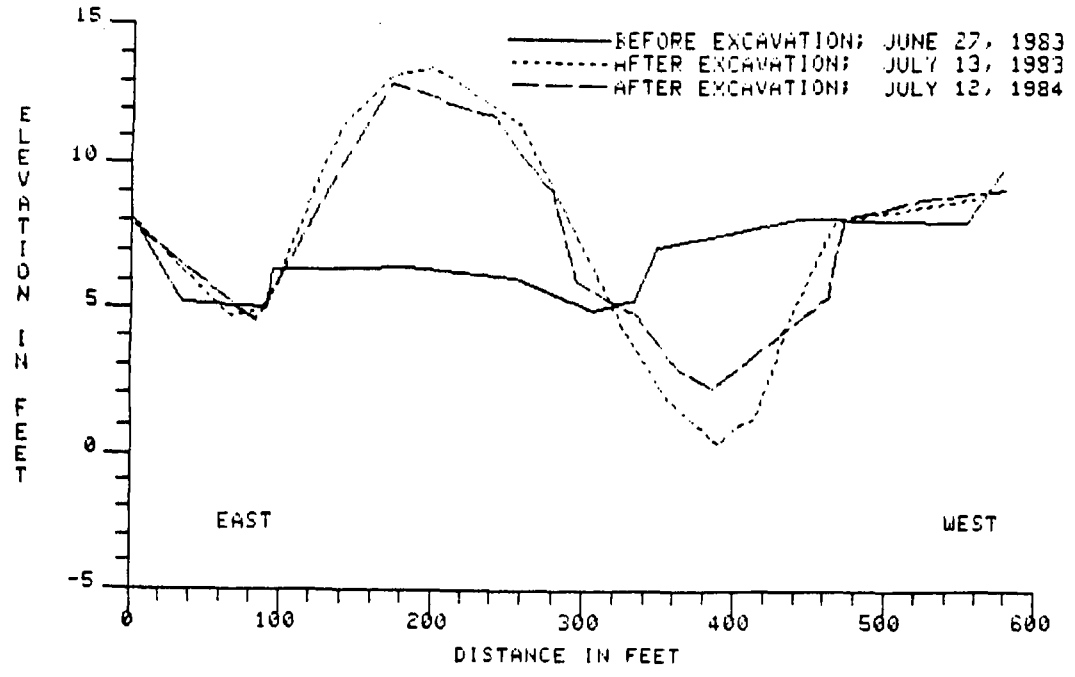

FIGURE 11: X/S 2

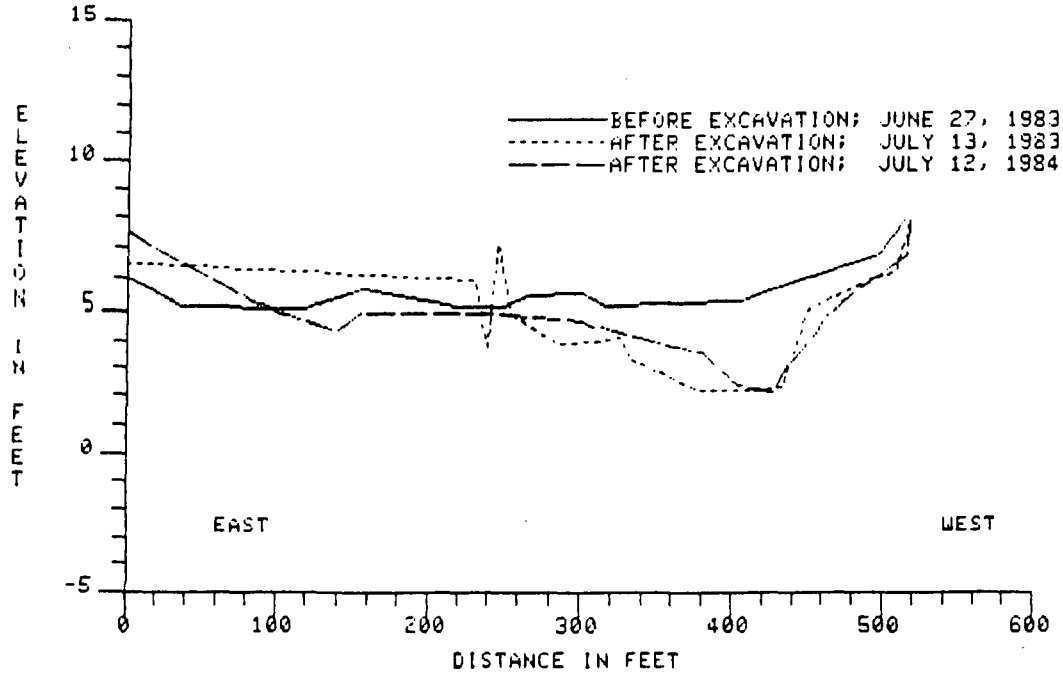

FIGURE 12: X/S 3

water levels, outflow configuration, wind and sea conditions, time spent, and other comments. A total of 301 observations were recorded from June 1 to November 15.

Water Quality Studies

Monitoring was conducted to determine if and when estuarine (embayment and sloughs) water quality was limiting for juvenile salmonids. Twelve monitoring sites were established in the north and south sloughs and the embayment. Parameters measured included conductivity, temperature, salinity, and dissolved oxygen. A vertical profile from surface to bottom was determined for each parameter, at each station, 9 different times from June 6 through October 25. Poorest water quality was observed in the sloughs, where temperatures and dissolved oxygen reached levels that were limiting to salmonids. In the embayment, water temperature occasionally increased to undesirable levels, but was never limiting. These elevated temperatures usually accompanied low embayment water levels. Dissolved oxygen was consistently adequate in the embayment.

The embayment alternated between a fresh and brackish water system. High tides and ocean overwash caused short periods when brackish conditions prevailed. A dense salt water layer remained on the slough bottoms throughout the summer. A salt water layer also existed on the embayment bottom, but its depth varied with tide, ocean conditions, and mouth configuration.

Aquatic Invertebrate Sampling

Aquatic invertebrates were sampled to determine abundance and areas of greatest density. Sampling methods included the use of small artificial substrate baskets and plastic bottom samplers. Suspended artificial substrate baskets were used to sample the slough areas while plastic bottom samplers were used in the neck of the south slough and the embayment. A total of 27 samples were collected from June 27 to October 12.

These samples have not been analyzed. However, visual inspection of samples suggests greatest invertebrate density in the north and south sloughs. Samples collected in 1983 were analyzed in spring 1984 and confirmed estimates of greatest invertebrate density in the sloughs for summer 1983.

Fish Migration and Estuary Utilization

This program was directed at identifying the timing and extent of juvenile salmonid downstream migration, and numbers and growth of juvenile salmonids utilizing the embayment.

Trapping of downstream migrating fish began on May 7 and continued through August 1. Trapping was conducted from approximately 5:00 p.m. to 9:00 a.m. one night each week on both Prairie Creek and Redwood Creek. Trapped fish were identified, counted, measured, and scale samples were collected. Embayment fish populations were estimated by seining and marking captured fish. The ratio of marked versus unmarked fish captured two days later was utilized in calculating population estimates. Four estimates were made from June 18 to September 11. Growth was monitored 11 times by seining and measuring each fish captured from May 21 to October 18. On each of these sampling days approximately 20 fish (10 steelhead and 10 salmon) were

sacrificed for stomach analyses and for determination of food habits. Scales were collected from 30 individuals of each species.

Downstream migration of juvenile chinook salmon peaked in late June. Chinook migration ended by July 16. Peak down migration of juvenile steelhead and cutthroat trout occurred in late June and mid-May respectively. Downstream migrant trapping was terminated after chinook downmigration ceased. It is assumed that a low level of steelhead migration continued past this date.

The major area utilized by juvenile salmonids was the embayment. Fish avoided the saltwater layer on the embayment bottom and area adjacent to the ocean berm during periods of overwash, preferring water of lower salinity. Few fish utilized the sloughs. Population estimates and growth for juvenile chinook salmon and steelhead trout are shown in Figures 13 and 14. These figures show downstream migrating salmonids found favorable habitat in the estuary as soon as an embayment began to form. A decline in chinook through July (Figure 13) was probably the result of inadequate habitat associated with frequent water level fluctuations and low embayment water levels.

Unlike 1982 and 1983, the majority of chinook had entered the ocean by early September. The shortened 1984 rearing period may have been influenced by an influx of small steelhead trout (Figure 14) and resultant displacement of chinook.

Juvenile salmon growth in the estuary during the summer was significant (see Figure 13). Fork length averaged 63.8 mm on May 21 and 123 mm on October 18.

Patterns of estuarine use by juvenile steelhead trout (Figure 14) were similar to that of salmon. That is, when habitat was available, steelhead spent an extended period in the estuary. Unlike salmon, downmigration of juvenile steelhead continued throughout the summer. On August 14, the steelhead population increased dramatically, but average size decreased, indicating an influx of smaller fish. As numbers declined, average size again increased probably indicating loss of the smaller fish from the embayment.

1984 Cost Summary

Management Activities

Log Boom Repair	$ 225
Water Level Control and Monitoring	11,418
Total	$11,643

Research and Monitoring

Resurvey of Excavated Areas	$ 520
Water Quality Monitoring	1,288
Aquatic Invertebrate Monitoring/Analysis	4,400
Fish Trapping, Population and Growth Monitoring	7,668
Total	$13,876

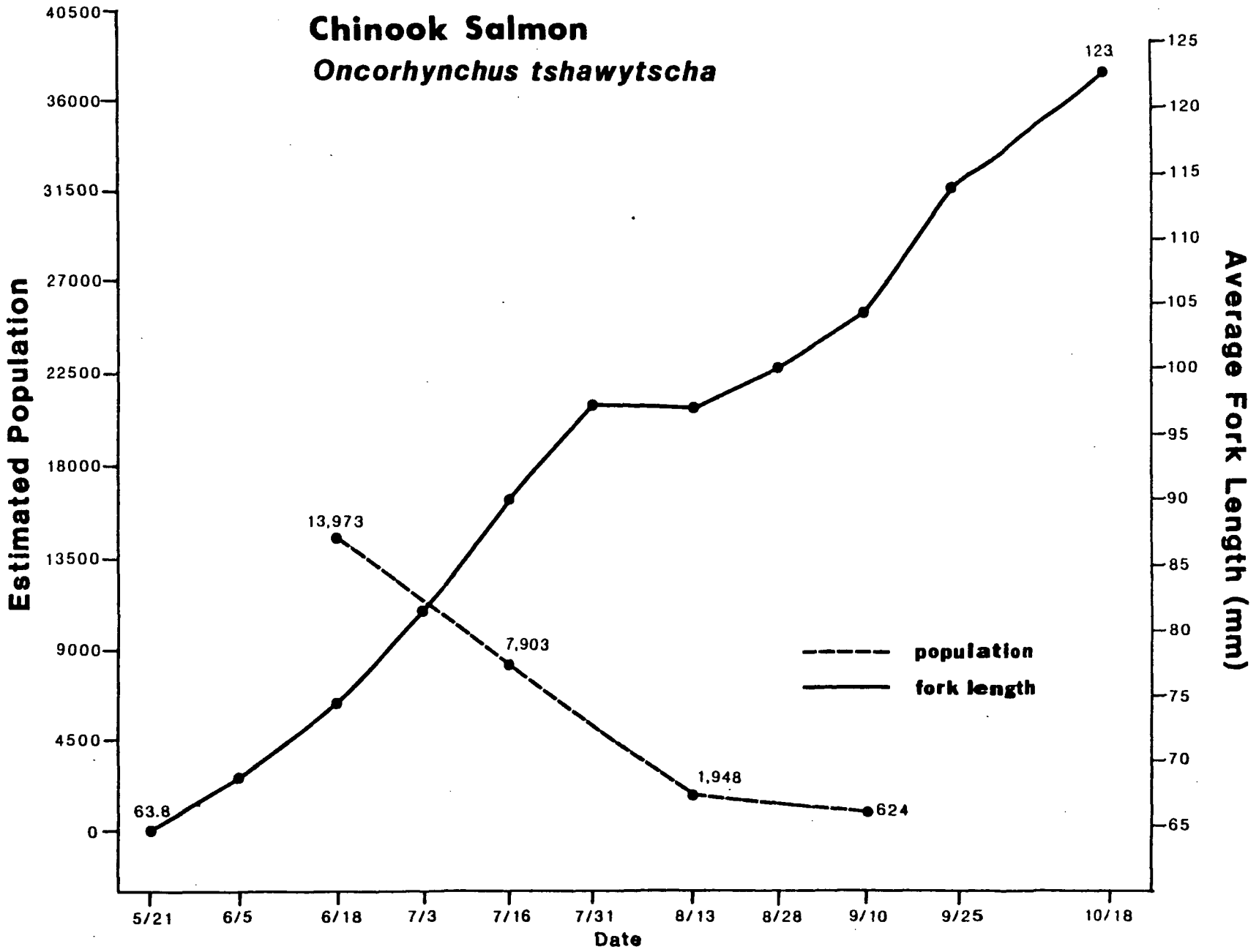

Figure 13: Population estimates and growth of chinook salmon, summer 1984

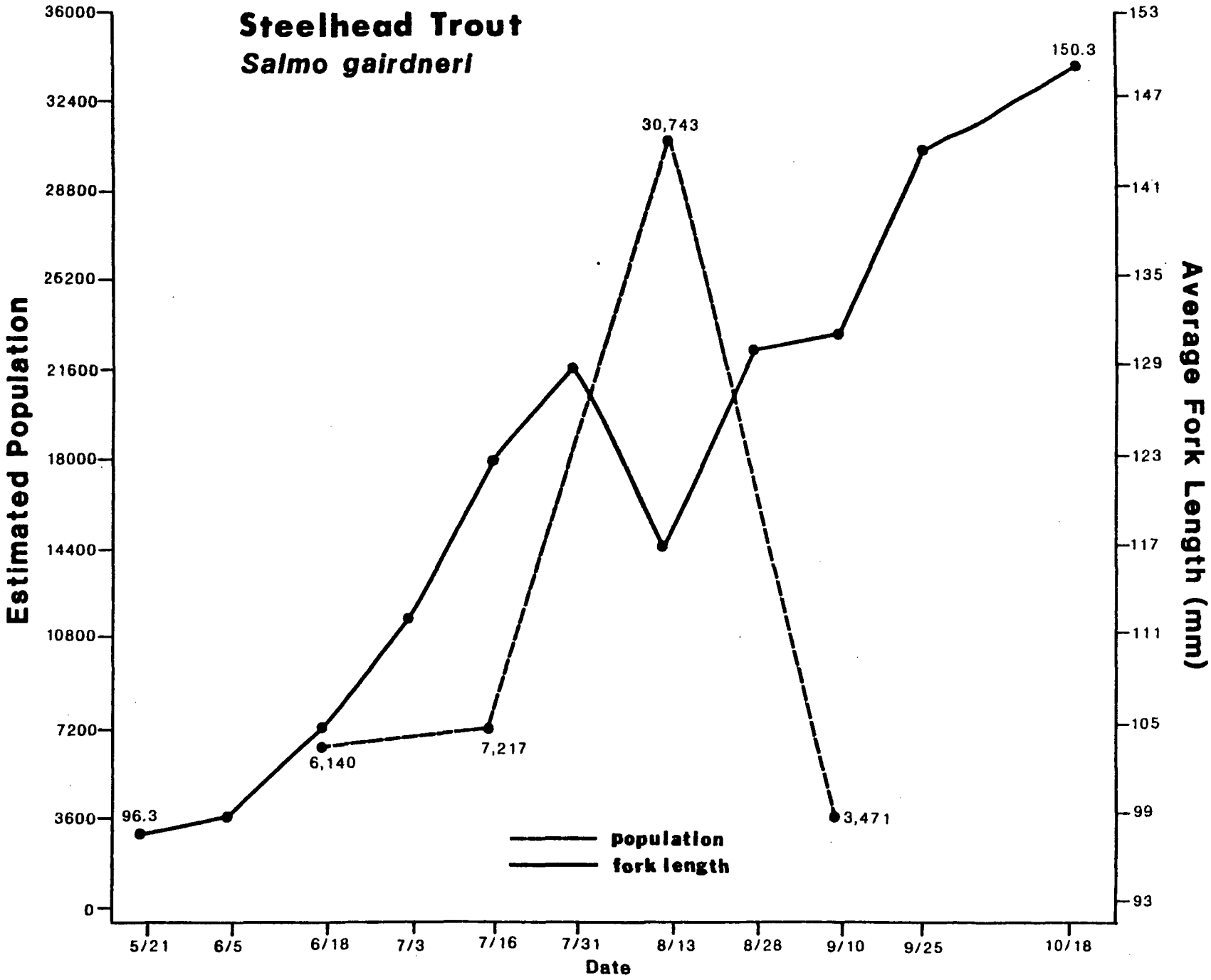

Figure 14: Population estimates and growth of steelhead trout, summer 1984