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BIOLOGICAL AND WATER QUALITY MONITORING IN THE RUSSIAN RIVER ESTUARY, 1996 REPORT

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Submitted by
Merritt Smith Consulting
3675 Mt. Diablo Blvd. Suite 120
Lafayette, California 94549
510 284-6490

CONTENTS

I. SUMMARY 1

II. INTRODUCTION 1

BACKGROUND 1

STUDY PROGRAM 2

METHODS 2

Water Quality Monitoring 2

Biological Monitoring: Fish and Macro-Invertebrates 4

Biological Monitoring: Plankton 4

Biological Monitoring: Pinnipeds 4

III. RESULTS 4

NARRATIVE OF BREACHING EVENTS IN 1996 4

WATER QUALITY MONITORING 7

In situ profiles 7

Datasonde records 7

BIOLOGICAL MONITORING 7

Fish and Macro-Invertebrates 7

Plankton 12

Pinnipeds 12

IV. DISCUSSION 12

WATER QUALITY 12

BIOLOGICAL MONITORING 13

V. CONCLUSIONS 13

VI. RECOMMENDATIONS FOR 1997 STUDY 13

V. REFERENCES 14

PERSONAL CONTACTS 14

REFERENCES CITED 14

VI. APPENDIX 15

TABLES

Table 3-1. Proposed Field Study, 1996 7
Table 3-2. Summary of the Field Study Conducted in 1996 8
Table 3-3. Fish Species Caught in the Russian River Estuary, 1996 11
Table 3-4. Total Catch in Otter Trawls in Russian River Estuary, 1996 12
Table 3-5. Total Catch in Beach Seines in Russian River Estuary, 1996. 13

FIGURES

Figure 2-1. Map of the Russian River Estuary, Showing Sampling Stations for 1996 Study. 4
Figure 3-1. Length-frequency of Steelhead Smolts Captured in Beach Seines in Russian River Estuary, 1996. 14

APPENDICES

Appendix A. Water Quality

Appendix A-1. Prebreaching Water Quality Profiles, Event I, 1 July 1996.
Appendix A-2. Postbreaching Water Quality Profiles, Event I, 1 July 1996.
Appendix A-3. Postbreaching Water Quality Profiles, Event II, 5 August 1996.
Appendix A-4. Prebreaching Water Quality Profiles, Event V, 18 September 1996.
Appendix A-5. Day-of-Breaching Water Quality Profiles Near the Mouth of Willow Creek, Event V, 26 September 1966.
Appendix A-6. Postbreaching Water Quality Profiles, Event V, 27 September 1996.
Appendix A-7. Prebreaching Water Quality Profiles, Event VI, 9-10 October 1996.
Appendix A-8. Day-of-Breaching Water Quality Profiles in Willow Creek and in the Russian River Near the Creek Mouth, Event VI, 15 October 1996.
Appendix A-9. Postbreaching Water Quality Profiles, Event VI, 16 October 1996.
Appendix A-10. Postbreaching Water Quality Profiles, Event VII, 9 November 1996.
Appendix A-11. Prebreaching Water Quality Profile, Event I, Station 1.
Appendix A-12. Prebreaching Water Quality Profile, Event I, Station 2.
Appendix A-13. Prebreaching Water Quality Profile, Event I, Station 3.
Appendix A-14. Prebreaching Water Quality Profile, Event I, Station 4.
Appendix A-15. Postbreaching Water Quality Profile, Event I, Station 1.
Appendix A-16. Postbreaching Water Quality Profile, Event I, Station 2.
Appendix A-17. Postbreaching Water Quality Profile, Event I, Station 3.
Appendix A-18. Postbreaching Water Quality Profile, Event I, Station 4.
Appendix A-19. Prebreaching Water Quality Profile, Event VI, Station 1.
Appendix A-20. Prebreaching Water Quality Profile, Event VI, Station 2.
Appendix A-21. Prebreaching Water Quality Profile, Event VI, Station 3.
Appendix A-22. Prebreaching Water Quality Profile, Event VI, Station 4.
Appendix A-23. Postbreaching Water Quality Profile, Event VI, Station 1.
Appendix A-24. Postbreaching Water Quality Profile, Event VI, Station 2.
Appendix A-25. Postbreaching Water Quality Profile, Event VI, Station 3.
Appendix A-26. Postbreaching Water Quality Profile, Event VI, Station 4.
Appendix A-27. Datasonde Record, Station 1, 18-27 September 1996.
Appendix A-28. Datasonde Record, Station 3, 18-27 September 1996.
Appendix A-29. Datasonde Record, Station 4, 18-27 September 1996.
Appendix A-30. Datasonde Record, Station 1, 9 October - 9 November 1996.
Appendix A-31. Datasonde Record, Station 3, 9 October - 9 November 1996.
Appendix A-32. Datasonde Record, Station 4, 15 October - 9 November 1996.

Appendix B. Fish and macroinvertebrates

Appendix B-1. Prebreaching Otter Trawl Catch Summary, Event I, 1 July 1996.
Appendix B-2. Postbreaching Otter Trawl Catch Summary, Event I, 7 July 1996.
Appendix B-3. Postbreaching Otter Trawl Catch Summary, Event II, 5 August 1996.
Appendix B-4. Prebreaching Otter Trawl Catch Summary, Event V, 18 September 1996.
Appendix B-5. Postbreaching Otter Trawl Catch Summary, Event V, 27 September 1996.
Appendix B-6. Prebreaching Otter Trawl Catch Summary, Event VI, 9-10 October 1996.
Appendix B-7. Postbreaching Otter Trawl Catch Summary, Event VI, 16 October 1996.
Appendix B-8. Number of Fish Species in Otter Trawls, Event I--Breached 5 July 1996.
Appendix B-9. Otter Trawl Catch, Event I--Breached 5 July 1996.
Appendix B-10. Number of Fish Species in Otter Trawls, Event II--Breached 3 August 1996.
Appendix B-11. Otter Trawl Catch, Event II--Breached 3 August 1996.
Appendix B-12. Number of Fish Species in Otter Trawls, Event V--Breached 26 September 1996.
Appendix B-13. Otter Trawl Catch, Event V-- Breached 26 September 1996.
Appendix B-14. Number of Fish Species in Otter Trawls, Event VI--Breached 15 October 1996.
Appendix B-15. Otter Trawl Catch, Event VI--Breached 15 October 1996.
Appendix B-16. Postbreaching Beach Seine Catch Summary, Event I, 7 July 1996.

Appendix B-17. Postbreaching Beach Seine Catch Summary, Event II, 5 August 1996.
Appendix B-18. Prebreaching Beach Seine Catch Summary, Event V, 18 September 1996.
Appendix B-19. Postbreaching Beach Seine Catch Summary, Event V, 27 September 1996.
Appendix B-20. Prebreaching Beach Seine Catch Summary, Event VI, 9 October 1996.
Appendix B-21. Postbreaching Beach Seine Catch Summary, Event VI, 16 October 1996.
Appendix B-22. Postbreaching Beach Seine Catch Summary, Event VII, 9 November 1996.
Appendix B-23. Number of Fish Species in Beach Seines, Event I--Breached 5 July 1996.
Appendix B-24. Beach Seine Catch, Event I--Breached 5 July 1996.
Appendix B-25. Number of Fish Species in Beach Seines, Event II--Breached 3 August 1996.
Appendix B-26. Beach Seine Catch, Event II--Breached 3 August 1996.
Appendix B-27. Number of Fish Species in Beach Seines, Event V--Breached 26 September 1996.
Appendix B-28. Beach Seine Catch, Event V--Breached 26 September 1996.
Appendix B-29. Number of Fish Species in Beach Seines, Event VI--Breached 15 October 1996.
Appendix B-30. Beach Seine Catch, Event VI--Breached 15 October 1996.
Appendix B-31. Number of Fish Species in Beach Seines, Event VII--Breached 7 November 1996.
Appendix B-32. Beach Seine Catch, Event VII--Breached 7 November 1996.
Appendix B-33. Fork Lengths (millimeters) of Steelhead Smolts Captured by Beach Seine, 1996.

Appendix C. Plankton

Appendix C-1. Summary of Organisms Caught in Plankton Tows in the Russian River Near Willow Creek, 1996.

Appendix D. Pinnipeds

Appendix D-1. "Breaching of the Russian River and it Effects on Humans and Seals in 1996," by Joseph Mortenson.

Authors

This report was prepared by James C. Roth, Ph.D., Michael H. Fawcett, Ph.D. and David W. Smith, Ph.D.

I. SUMMARY

This report summarizes the results of a field study to evaluate the impact of sandbar breaching at the mouth of the Russian River. The study included water quality sampling, fish and invertebrate sampling, and observations of pinniped numbers and behavior before and after breaching. In 1996 the Russian River estuary mouth first closed June 29, and the sandbar was breached seven times between July and early November. Some aspects of each breaching event were studied by the MSC field team.

Water quality profiles made at deep channel sites showed stratification (saline water overlain by brackish or fresh water). The physical act of breaching is an important agent that promotes renewal of dissolved oxygen in the lower, more saline layer, and tidal exchange during bar-open conditions helps keep the saline layers oxygenated.

A significant finding of a 1992-1993 study (Heckel, 1994) was a wedge of saline, anoxic water killing mysids and fish as it drained from Willow Creek following a breaching event. This did not occur during the 1996 study. The reasons for the difference have not been determined, but may be related to rainfall patterns, summer streamflow, changes in channel morphology, and/or accumulation of dead organic matter in the upper Willow Creek marsh area.

The estuary contains a diverse assemblage of marine, estuarine, and freshwater fish and invertebrate species. The estuary alternates between being a tidal estuary (bar-open) and a coastal lagoon (bar-closed). In several respects, the bar-open state is beneficial to the biota. Among these benefits are the following:

- Tidal exchange helps keep the saline water layers oxygenated, and re-supplies marine plankton used as food by some of the organisms in the estuary.
- Food-rich mud flats and beaches exposed at low tides are available to wading birds and foraging mammals.
- Migrating salmonids and other fishes can enter or leave the estuary at any time. Steelhead smolts were found in the estuary throughout the study period in 1996.
- Harbor seals can use their preferred haulout sites at the mouth and at the snag area between Willow Creek and Sheephouse Creek.

The present management plan of breaching the sandbar when the river rises to 7 to 9 feet at Jenner appears appropriate in light of the findings of the 1992-1993 and 1996 studies.

Several recommendations for improving the study design for 1997 have been identified, as follows:

- Some fish sampling should be done in the interval between breachings to ensure that postbreaching collections are representative of bar-open conditions.
- Prebreaching water quality profiles should be conducted in Willow Creek to determine the need for plankton sampling during the breaching event.
- Datasondes (continuous-recording water quality meters) should be deployed continuously.
- More effective exclusion of humans from the mouth area during breaching operations (and for the rest of the day of breaching) would minimize effects on harbor seals and prevent humans from endangering themselves.
- A Lampara net should be purchased to improve the effectiveness of salmonid sampling during bar-closed conditions.

II. INTRODUCTION

BACKGROUND

A study of the hydrological, biological, and social impacts of artificially breaching the mouth of the Russian River was conducted in 1992-1993 for Sonoma County and the California State Coastal Conservancy under the direction of the Russian River Interagency Task Force. The final report of the study (Heckel, 1994) included selection of a preferred estuary management program which was used as the basis for the Russian River Estuary Management Plan subsequently adopted by the Board of Supervisors. The Management Plan includes biological and water quality monitoring to be conducted during artificial breaching events to support the adopted management approach or provide the basis for modification, as appropriate. Merritt Smith Consulting (MSC) was selected by the Sonoma County Water Agency (SCWA) to implement the monitoring element of the Management Plan during artificial breaching events in 1996 and 1997.

This report presents the results of the 1996 study program and includes some recommended modifications of methodology for the 1997 study program.

STUDY PROGRAM

The study program conducted during 1996 included the following elements:

- Pre- and post-breaching water quality profiles (depth, temperature, salinity, conductivity, and dissolved oxygen) at four stations, and continuous recording of temperature, salinity, and dissolved oxygen near the river bottom at three stations during breaching events.
- Pre- and post-breaching sampling of fish and epibenthic invertebrates at four stations, by means of otter trawl and beach seine, and of planktonic invertebrates at two stations, by means of plankton trawl net.
- Observations of pinniped behavior near the river mouth before, during, and after breaching events.

The station locations are shown in Figure 1. Stations 2, 3, and 4 are at the same locations as the corresponding stations used for biological and water quality sampling in the previous study (Heckel, 1994). However, for Station 1 the MSC team elected to use the deep channel closer to the River mouth and adjacent to the remains of the wooden pier pilings of the old jetty on the south side of the river mouth, rather than the site adjacent to the Visitor Center used as Station 1 in the previous study. We decided that the goals of the study would be best met by locating Station 1 as near as possible to the river mouth.

At Station 1, otter trawls and water quality measurements were made near the jetty in water 8-9 m deep, but the beach seining for Station 1 was conducted at the western tip of Penny Island, about 300 m from the pier pilings. Beach seining was, by necessity, conducted at gently sloping beaches located as close as possible to the designated station locations used for otter trawling and water quality sampling.

At Station 2, beach seining was conducted on the north shore opposite the station location shown in Figure 1 (otter trawls and water quality profiles were taken in the 6-8 m deep channel adjacent to the south shore).

At Station 3, beach seining was conducted on the beach in front of the Ranger's residence just upstream of the mouth of Willow Creek, whereas, water quality sampling was conducted both within the mouth adjacent to the Willow Creek Road bridge and in the deep (4 m) channel adjacent to the east river bank 200 m downstream from the Willow Creek mouth; otter trawling was also conducted in the deep channel. Plankton trawls were conducted in the shallow (1 m) channel leading southward from the Willow Creek mouth, as well as at a control site located about 300 m upstream of the creek mouth, north of the Ranger's residence. A water quality profile was also taken at this control site each time plankton was collected.

At Station 4, otter trawling and water quality sampling were conducted in the deep (14 m) channel adjacent to the rocky cliff on the northwest bank just below the mouth of Sheephouse Creek, while beach seining was done on the southeast bank opposite the mouth of Sheephouse Creek.

METHODS

Water Quality Monitoring

Water quality vertical profiles were conducted at each station each time biological sampling was conducted, plus on one additional occasion in November, when the study team was onsite working on another project. Portable YSI salinity and dissolved oxygen meters were used to obtain *in situ* data on temperature, salinity, conductivity, and dissolved oxygen. The profiles were performed in the deepest part of the channel at each station, to determine whether or not salinity stratification was present. Additionally,

submerged, continuous-recording meters (Hydrolab Datasonde III) were installed in the deep channels at Stations 1, 3, and 4 prior to breaching events in September and October, and left in place for periods of 9 to 31 days. These instruments were used to record temperature, salinity, and dissolved oxygen just above the river bottom.

Biological Monitoring: Fish and Macro-Invertebrates

Otter trawl sampling was conducted in the deep channel at each station to collect slow-moving, benthic fishes and macro-invertebrates (e.g., crabs, shrimp, and mysids). The trawl used is eight feet wide at the mouth, with 1/8 in. (square) mesh throughout. Single tows of four minutes duration were conducted at each station. The trawl was towed at 3-5 mph. behind a 16 ft. aluminum skiff powered by a 25 hp. outboard motor. Owing to the numerous snags found in the Russian River, dragging a net along the bottom frequently results in the net getting entangled on some obstruction. Usually, the net can be pulled free with the catch intact, and our practice in this study was to retain the sample and treat it as a successful trawl if it was at least two minutes duration (repeated trawls in the same narrow channel are undesirable because of the disturbance caused by the first, aborted, trawl). On one occasion, the trawl became thoroughly entangled on a submerged tree at Station 3 and had to be abandoned overnight. It was retrieved the following day. After each successful trawl was completed, the contents of the net were brought aboard and emptied into a large plastic tray filled with water for sorting, counting, and species identification. Nearly all specimens were released alive and unharmed. A small number of invertebrates and juvenile or larval fish (non-salmonids) were preserved for closer examination in the laboratory.

Beach seine sampling was used to capture more agile fishes (especially salmonids) that cannot be caught by otter trawl, as well as mid-water fishes. The beach seine used in this study is 100 ft. long, 8 ft. deep, with an 8 by 8 by 8 ft. bag in the center, and is composed of 3/8 in. mesh knotless nylon netting. The seine was usually deployed by using the boat to pull one end offshore, then around in a half-circle while the other end was held onshore by another person. Both field team members then pulled the net ashore by hand. In some favorable circumstances (firm bottom, low current velocity), the net was deployed by wading, without use of the boat, but there was nothing in the data to indicate that this made any difference in the catches. Captured fish and invertebrates were placed in a water-filled tray for sorting, identifying, and counting prior to release. Captured steelhead smolts were also measured and examined closely for general condition and wild vs. hatchery origin prior to release.

Biological Monitoring: Plankton

Plankton trawls were conducted at Station 3, at the mouth of Willow Creek, and also at another site in the river a short distance upstream of the mouth of Willow Creek (Figure 1). The net used is a standard egg and larval net (50 cm. diameter, with 505 µm. mesh). The plankton net was towed slowly behind the boat, just above the river bottom in shallow (1 m.) water for two minutes. A General Oceanics flowmeter was attached to the mouth of the net to estimate the volume of water sampled. In some cases the flowmeter became fouled by submerged plant material. For this reason, the average volume sampled per minute of tow based on trials without fouling was used to estimate water volumes filtered for all tows.

Biological Monitoring: Pinnipeds

Observations of pinniped (mostly harbor seals) behavior near the traditional haulout site at the river mouth were made before, during, and after breaching events, following the method used by Hanson's team in the previous study (Heckel, 1994). An observer stationed on the bluffs along Highway One made a continuous record of human/pinniped interactions. The day prior to breaching was used to provide a baseline for considering the effects of breaching *per se*. During the day of breaching, seal numbers and behavior were observed before, during, and after breaching. Observations made on the day following breaching were used to indicate the extent of recovery toward prebreaching use of the area.

III. RESULTS

NARRATIVE OF BREACHING EVENTS IN 1996

The study plan that was to be carried out under optimal conditions, and if sufficient numbers of breaching events occurred throughout the seasons from early spring to fall, is outlined in Table 3-1.

The first bar closure and subsequent breaching event in 1996 occurred on June 29, which eliminated the possibility of any early or late spring sampling from the study program. The breaching events that occurred in 1996, along with the study elements conducted in association with each event, are summarized in Table 3-2. Unanticipated events affected implementation of the study plan. Some of the variables that militated against smooth execution of the study plan included delays in obtaining the permits necessary to breach the river mouth, surreptitious breaching by local citizens at unscheduled and unanticipated times, and failed attempts at breaching, owing to unfavorable conditions of tides and wave energy. The first three events (July and August, Table 2) made it clear that scheduling breaching for a certain day was a tenuous proposition. Therefore, beginning with the fourth event, all of the prebreaching efforts (including the prebreaching plankton collections) were conducted several days in advance of the likely breaching day. This change in the study design allowed the team to successfully complete the sampling program for two breaching events, although both events occurred in the fall. Additional details surrounding the individual breaching events are given in the pinniped report, included here as Appendix D. The partial surveys shown in Table 2 for the seventh event were done in conjunction with a different project, i.e., the seventh event was not planned to be studied as part of this program, but the data are included in this report.

Table 3-1. Proposed Field Study, 1996.

Condition	Plankton Tows	Otter Trawls	Beach Seines	Pinneped Obs.	WQ Profiles
Early Spring					
Prebreaching		X	X	X	X
Breaching Day	X[1]			X	X
Postbreaching		X	X	X	X
Late Spring					
Prebreaching		X	X		X
Breaching Day					
Postbreaching		X	X		X
Late Spring					
Prebreaching			X		X
Breaching Day					
Postbreaching			X		X
Early Summer					
Prebreaching			X	X	X
Breaching Day	X[1]			X	X
Postbreaching			X	X	X
Early Summer					
Prebreaching			X		X
Breaching Day					
Postbreaching			X		X
Fall					
Prebreaching		X	X	X	X
Breaching Day				X	X
Postbreaching		X	X	X	X
Fall					
Prebreaching		X	X		X
Breaching Day					
Postbreaching		X	X		X

[1]Plankton collections were originally scheduled to be made on the breaching day, both just before breaching, and 3 hours after breaching.

Table 3-2. Summary of the Field Study Conducted in 1996.						
Condition	**Date**	**Plankton Tows**	**Otter Trawls**	**Beach Seines**	**Pinniped Obs.**	**WQ Profiles**
Event I. Breached by SCWA 5 July 1996						
Prebreaching	1 July		X		X	X
Breaching Day	5 July				X	
Postbreaching	7 July		X	X	X	X
Event II. Breached by Citizens (?) 3 August 1996						
Prebreaching						
Breaching Day	3 August				X	
Postbreaching	5 August	X	X	X	X	X
Event III. Breached by Citizens (?) 27 August 1996						
Prebreaching						
Breaching Day	27 August	(Fish and Water Quality Studies			X	
Postbreaching		Aborted as per SWCA)			X	
Event IV. Breached by Citizens (?) 6 September 1996						
Prebreaching						
Breaching Day	6 September				X	
Postbreaching	8 September				X	
Event V. Breached by SCWA 26 September 1996						
Prebreaching	18 September	X	X	X[2]	X	X[3]
Breaching Day	26 September	X[1]			X	X[3]
Postbreaching	27 September		X	X	X	X[3]
Event VI. Breached by SCWA 15 October 1996						
Prebreaching	9-10 October	X	X	X[2]	X	X[4]
Breaching Day	15 October	X[1]			X	X[4]
Postbreaching	16 October		X	X	X	X[4]
Event VII. Breached by Itself 6 November 1996						
Prebreaching						
Breaching Day						
Postbreaching				X		X[3]

[1]Breaching-day plankton tows were made approximately 3 hours after breaching, as the estuary and Willow Creek drained for the first time.
[2]3 stations
[3]Including datasonde deployment
[4]Datasondes left in place until 9 November

WATER QUALITY MONITORING

In situ profiles

Water quality profiles were made at Stations 1 through 4 on ten dates in 1996. These are listed in Table 3-2. The complete data are given in Appendices A-1 through A-10. Pre- and postbreaching profiles are illustrated graphically for Event I and Event VI; these plots are given in Appendices A-11 through A-26.

As was the case in 1992-1993, prebreaching profiles at the deeper stations showed a stratified system with fresh (or brackish) water overlaying a pocket of saline water. The dissolved oxygen (DO) concentration in the deeper water typically was reduced (Stations 1 and 2) or absent (Station 4--up to 14 m deep). Station 3, being shallower, was not always stratified. Postbreaching profiles at Stations 1 and 2 show that DO was mixed into the saline bottom layer, although the salinity stratification remained (Appendix A-15, A-16). Station 4, being deeper, was not mixed in the bottom layers following the first breaching event (Appendix A-18).

Profiles made later in the summer and fall show reduced surface temperatures, and a thinner freshwater layer over the saline deeper water. Postbreaching profiles for Event VI (Appendix A-23 through A-26) show that DO was well-mixed at Stations 1 through 3 and that the saline and low-DO layer at Station 4 was reduced to depths below 9 m.

Water quality profiles made in and around the mouth of Willow Creek on the day of breaching (as the creek and marsh drained for the first time) showed that the water coming out of the creek was mostly fresh, and not anoxic (although DO was reduced to 2 - 3 ppm--Appendix A-5 and A-8). Thus, a significant finding of the 1992-1993 study--the saline, anoxic water with dead mysids entering the estuary from Willow Creek following breaching--was not found in 1996. Plankton tows made in 1996 (see below) confirm that the marsh/creek water was not salty or anoxic.

Datasonde records

Datasonde records of water quality conditions near the bottom at Stations 1, 3, and 4 (Appendix A-27 through A-32) show that there is a delay of several hours after the berm is breached before water quality changes are apparent near the bottom at the deep stations. The deep layer at Station 4 did not mix following Event IV, as shown in Appendix A-29. Datasondes left in place between breaching episodes also show that the exchange of water in the deep layers of the estuary is most extensive during and immediately following the breaching event, as the estuary drains. This can be regarded as a beneficial event, since the availability of a saline and oxygenated refuge may be critical to adult salmonids which enter the estuary and “hold” there before ascending the creeks to spawn.

BIOLOGICAL MONITORING

Fish and Macro-Invertebrates

A list of all the fish species captured by otter trawl and seine in 1996 is provided in Table 3-3, showing 25 species representing 16 families. Fifteen of these species were also captured in the 1992-1993 estuary study, which reported totals of 24 species in 17 families (Heckel, 1994, Table 8.1). The 1996 otter trawl catch is summarized in Table 3-4. The first five species listed in Table 3-4 are common estuarine species in this region and together comprise 80.6 percent of the total otter trawl catch. Only three of the species shown in Table 3-4 (Sacramento sucker, green sunfish, and Russian River tuleperch) are generally considered to be strictly freshwater species (Moyle, 1976). Threespine stickleback and prickly sculpin may live all or part of their lives in either fresh water, estuaries, or the ocean, and the remaining species are restricted to either estuarine or marine waters.

Complete data from each trawl and station are provided in Appendix Tables B-1 to B-7, which also include the data for invertebrates captured in otter trawls. Otter trawl fish catches for each station and date are displayed graphically in Appendices B-8 to B-15, which also compare pre- versus post-breaching numbers. Analysis of the trawl data provided in Appendix B shows no apparent trends in pre- versus post-breaching species captured, number of species, or number of individuals.

Fish captured by beach seine in 1996 are summarized in Table 3-5, which shows 17 species captured, with 78 percent of the total represented by the first five species. Beach seining captured more freshwater species (Sacramento sucker, Sacramento squawfish, bluegill, Navarro roach, Russian River tuleperch, and smallmouth bass) than did otter trawls. Complete catch data for beach seines are tabulated in Appendices B-16 to B-22, and are displayed graphically in Appendices B-23 to B-32. In the two events where pre- versus post-breaching data for beach seines can be compared (Events V and VI, Appendices B-27 to B-30), a trend of greater numbers of species and individuals in the post-breaching surveys is apparent. However, the cause of this trend is most likely an artifact of the sampling method; beach seining is clearly more effective at low to moderate water levels than it is when the estuary is flooded, as it always was during the prebreaching surveys. During flooded conditions, the seine was usually being pulled, in part, through what would normally be emergent, or even terrestrial vegetation, which is less likely to be used by fish for foraging or resting than would be areas that are normally submerged. At Station 2, we were unable to find a beach where the seine could even be deployed during high water.

Table 3-3. Fish Species Caught in The Russian River Estuary, 1996

Family	Scientific Name	Common Name
Atherinidae	*Atherinops affinis*	Topsmelt
Bothidae	*Citharichthys sordidus*	Pacific sanddab
Catostomidae	*Catostomus occidentalis*	Sacramento sucker
Centrarchidae	*Lepomis cyanellus*	Green sunfish
	Lepomis macrochirus	Bluegill
	Micropterus dolomieui	Smallmouth bass
Clupeidae	*Clupea harengus pallasii*	Pacific herring
Cottidae	*Cottus asper*	Prickly sculpin
	Leptocottus armatus	Staghorn sculpin
	Scorpaenichthys marmoratus	Cabezon
Cyprinidae	*Lavinia symmetricus navarroensis*	Navarro roach
	Ptychocheilus grandis	Sacramento squawfish
Embiotocidae	*Cymatogaster aggregata*	Shiner surfperch
	Hyperprosopon argenteum	Walleye surfperch
	Hysterocarpus traskii	Russian River tuleperch
Gadidae	*Gadus macrocephalus*	Pacific tomcod
Gasterosteidae	*Gasterosteus aculeatus*	Threespine stickleback
Gobiidae	*Clevelandia ios*	Arrow goby
Hexagrammidae	*Ophiodon elongatus*	Lingcod
Osmeridae	*Hypomesus pretiosus*	Surf smelt
Pleuronectidae	*Isopsetta ischyra*	Hybrid sole
	Parophrys vetulus	English sole
	Platichthys stellatus	Starry flounder
Salmonidae	*Oncorhynchus mykiss*	Steelhead
Syngnathidae	*Syngnathus leptorhynchus*	Bay pipefish

Table 3-4. Total Catch in Otter Trawls in Russian River Estuary, 1996						
Common Name	**Stn 1**	**Stn 2**	**Stn 3**	**Stn 4**	**Total**	**%**
Prickly sculpin	34	17	262	20	333	31.2
Staghorn sculpin	34	18	143	25	220	20.6
Starry flounder	23	22	47	21	113	10.6
Threespine stickleback	0	0	76	32	108	10.1
Shiner surfperch	29	0	4	53	86	8.1
Sacramento sucker	0	0	19	50	69	6.5
Surf smelt	36	5	0	0	41	3.8
English sole	7	7	3	22	39	3.7
Bay pipefish	5	1	8	5	19	1.8
Pacific tomcod	11	1	0	1	13	1.2
Pacific sanddab	12	0	0	0	12	1.1
Hybrid sole	2	2	0	1	5	0.5
Arrow goby	0	3	0	0	3	0.3
Cabezon	1	0	0	0	1	0.1
Green sunfish	0	0	1	0	1	0.1
Lingcod	1	0	0	0	1	0.1
Russian River tuleperch	0	0	0	1	1	0.1
Walleye surfperch	1	0	0	0	1	0.1
total	196	76	563	231	1066	100

Table 3-5. Total Catch in Beach Seines in Russian River Estuary, 1996						
Common Name	**Stn 1**	**Stn 2**	**Stn 3**	**Stn 4**	**Total**	**%**
Topsmelt	205	0	0	0	205	38.8
Threespine stickleback	0	3	24	52	79	15.0
Sacramento sucker	0	2	15	44	61	11.6
Steelhead	3	5	20	5	33	6.3
Surf smelt	4	16	13	0	33	6.3
Pacific herring	0	0	0	25	25	4.7
Starry flounder	6	3	3	12	24	4.5
Prickly sculpin	2	9	0	9	20	3.8
Shiner surfperch	1	7	3	7	18	3.4
Bay pipefish	4	4	0	0	8	1.5
Staghorn sculpin	6	0	0	1	7	1.3
Sacramento squawfish	0	0	5	0	5	0.9
Bluegill	0	3	0	1	4	0.8
Navarro roach	0	0	0	2	2	0.4
Russian River tuleperch	0	0	2	0	2	0.4
English sole	0	0	0	1	1	0.2
Smallmouth bass	0	0	0	1	1	0.2
Total	231	52	85	160	528	100

Steelhead smolts were captured by beach seine at one or more stations on all but one of the sampling days. All appeared to be wild fish, i.e., showed none of the fin deformations or other marks characteristic of hatchery-reared fish. These fish showed the typical silvery coloration that steelhead juveniles undergo as they lose the parr marks and begin to undergo the adaptation to seawater (smoltification). At least three age classes were represented among the smolts, as indicated on Figure 3-1. Russian River steelhead smolts typically comprise at least three age classes (see Fig 3-14, in Roth, et al., 1995). The steelhead data are tabulated in Appendices B-16 to B-22, and the length of each steelhead smolt is listed in Appendix B-33. There was no trend of greater numbers at stations nearest the river mouth (as might be expected if the bar-closed condition were blocking their outmigration). Pre- versus post-breaching comparisons of steelhead numbers can be made only for Events V and VI (App. B-18 to B-21), and are inconclusive (in regard to showing any prebreaching accumulation of fish). The data are too few for rigorous statistical tests, but there was a tendency for smaller (and younger) fish to occur earlier (July and August) than larger fish (September through November). No steelhead smolts were captured close to the river mouth (Station 1) before September 27.

The occurrence of steelhead smolts in the estuary in summer differed from the 1992-1993 study wherein only a single (dead) individual was caught. No juvenile steelhead were released from the Dry Creek hatchery during the study period, the last release having been made in March 1996 (Gunter, pers. comm.).

Macro-invertebrates collected in otter trawls are included in the Appendix (Tables B-1 to B-7). The most common invertebrates collected were the estuarine shrimps *Crangon franciscorum* and *C. nigricauda*, and the mysid *Neomysis mercedis.* Other invertebrates included euryhaline epibenthic species such as *Corophium* and isopods, as well as freshwater snails and corixids. A few *Cancer* crabs (including *C. productus* and *C. jordani* were caught in 1996.

Plankton

Plankton tows were made above and below the mouth of Willow Creek before breaching and on the day of breaching (approximately 3 hours after breaching, as the estuary and the creek drained for the first time) to determine whether the phenomenon observed in 1992-1993 (anoxic water and dead mysids streaming out of the marsh/creek following breaching) would occur in 1996. As discussed above, the marsh/creek water in the summer of 1996 was not anoxic, nor was it saline. Consequently, the plankton tows (catches listed in Appendix C-1) did not contain dead animals, nor did it contain many mysids. Very little plankton at all were collected in tows made in August or October. The pre- and postbreaching surveys made in September (Event V) contained a few more animals. Tows upstream of the creek mouth contained only between 2 and 10 individuals per cubic meter of water, and consisted primarily of isopods, snails, and a few mysids (*Neomysis mercedis*). Tows made downstream of the creek mouth (sampling water from the marsh and creek) in September contained somewhat greater catches (25 to 107 individuals per cubic meter, still low densities). The downstream channel in September contained extensive stands of macrophytes (*Ruppia* and *Myriophyllum*) and macroalgae (*Spirogyra*). Not surprisingly, most of the animals found in the tows were freshwater species associated with vegetation, such as mayfly nymphs (*Callibaetis* sp.), freshwater snails, corixid nymphs, damselfly nymphs and chironomid larvae. A few estuarine species including *Neomysis* and amphipods (*Anisogammarus* and *Corophium*) were also found, as were larval and juvenile threespine sticklebacks. The postbreaching tows had more corixids and fewer mayflies, but were otherwise similar.

Pinnipeds

Detailed observations on harbor seals in the vicinity of the estuary mouth are included in Appendix D, "Breaching of the Russian River and its effects on humans and seals," by Joseph Mortenson. The major findings of the pinniped observations are that harbor seals are much more abundant in the vicinity of the river mouth and in the estuary when the bar is open than when it is closed. Breaching operations (even with a bulldozer) are less disturbing to seals than humans on the beach. Therefore, access of humans to the beach during breaching should be restricted (this is also necessary for safety reasons, as breaching can be sudden and dangerous).

Additional observations made during pre- and postbreaching water quality and fish sampling cruises showed that a small group of seals (6-8 individuals) were typically seen hauled out on snags at low tide between Stations 3 and 4. Seals were rarely seen in the estuary during flooded conditions.

IV. DISCUSSION

WATER QUALITY

In the earlier estuary study (Heckel, 1994), water quality monitoring in the Willow Creek area found that, in late summer, hyper-saline, anoxic water from stratified, stranded pools in the upper marsh area drained from the marsh following a breaching event in October, 1992, when the Jenner gauge level exceeded nine feet prior to breaching. As the water backed up into the marsh prior to breaching, it apparently entered the stratified pools without mixing; then, after breaching, a wedge of anoxic water drained from the pools, killing some fish and many mysids as it exited the marsh and mouth of Willow Creek. The same phenomenon was not observed during the 1996 study, even though the water level at Jenner exceeded nine feet during Event VI in mid-October. The water observed draining from Willow Creek during each event studied in 1996 was neither saline nor anoxic, and no kills of fish or invertebrates were observed. No sampling was conducted in the upper marsh area in 1996, so it is not known whether stratification or anoxic conditions existed there during the summer. The differences between events observed in 1992 and 1996 may be related to differences in winter rainfall amounts and patterns, which could affect channel morphology, summer streamflow (and thus the salinity regime in the estuary), and/or the accumulation of organic matter in the upper marsh area. Decay of organic matter in stratified pools may lead to oxygen depletion.

BIOLOGICAL MONITORING

A few steelhead smolts were captured in beach seines during each breaching event studied in 1996. Given the small area sampled and limited effectiveness of beach seining (compared to other methods, such as gill netting), a substantial number of smolts must have been present in the estuary throughout the summer and fall of 1996. No juveniles were released by the Warm Springs Hatchery during the study period (Gunter, pers. comm.), and all the smolts captured by the MSC team appeared to be wild fish. The difference between these findings and those of the previous study (Heckel, 1994), wherein no steelhead were ever captured in beach seines, have not been determined. The differences could be related to rainfall patterns, variable spawning success, differences in seining technique, or other factors. Smolting steelhead are known to live and feed in estuaries for varying lengths of time before going out to sea, and trapping studies conducted year-round in other streams (e.g., Shapovalov and Taft, 1954) have found that, even though most downstream migration occurs during predictable winter and spring periods every year, some fish migrate during every month of the year.

A number of marine or estuarine fish species use the Russian River estuary and other estuaries along the California coast for either spawning or as nursery areas for larvae and juveniles, including topsmelt (*Atherinops affinis*), jacksmelt (*Atherinopsis californiensis*), Pacific herring (*Clupea harengus*) surf smelt (*Hypomesus pretiosus*), starry flounder (*Platichthys stellatus*), English sole (*Parophrys vetulus*), and Pacific sanddab (*Citharichthys sordidus*). (Biological studies of nearby Estero Americano and Estero de San Antonio are reported in Commins, et al., 1996). Adults or juveniles of these and other species may be moving in or out of the estuary at various times of the year, and so may be affected by the opening and closing of the river mouth. In general, keeping the mouth open all of the time, or preventing it from remaining closed for long periods, would probably benefit these species.

V. CONCLUSIONS

The 1996 studies confirm most of the conclusions made following the earlier study (Heckel, 1994). The estuary has in general a biota which is adapted to survival in an environment which alternates between being a tidal estuary and a coastal lagoon. In several respects the bar-open state is more beneficial to the local biota:

- Tidal exchange helps keep saline water layers oxygenated
- Food-rich mud flats and beaches exposed at low tides are available to wading birds
- An open mouth provides an avenue for migrating salmonids and other fishes
- An open mouth allows harbor seals to use their preferred haulout sites near the mouth and at the snag sites between Stations 3 and 4. However, increased use of the estuary by harbor seals during bar-open conditions could also be viewed as a negative impact (increased predation on salmonids and other fishes).
- Steelhead smolts were found in the lower Russian River estuary from July through November 1996, and breaching provides an intermittent avenue to the sea.

In addition to confirming many findings of the 1992-1993 study, the 1996 study suggests that the breaching event itself may be beneficial in that as the estuary drains following breaching, DO is replenished to stratified pockets of saline water which are important as a refuge for marine species, especially adult salmonids on their way upstream, which "hold" in the estuary in fall and winter.

Two negative aspects of sandbar breaching noted in the 1992-1993 study (anoxic water draining from Willow Creek marsh; and juvenile surfsmelt carried out to sea) were not found in the 1996 study. Reasons for the year-to-year differences are not understood, but may include the winter rainfall amount and pattern, which in turn may affect the channel morphology, timing, and frequency of bar closure and the quantity of organic matter in the Willow Creek channel (which would decay and deplete oxygen).

The present management plan of breaching the sandbar when the river rises to 7 to 9 feet appears appropriate based on the 1992-1993 and 1996 study results.

VI. RECOMMENDATIONS FOR 1997 STUDY

Several recommendations for improving the study for 1997 have been identified as follows:

- Postbreaching surveys made in 1996 were done within a day or two of breaching, but datasonde traces show that the influence of breaching can extend over several days. Some fish sampling made a few days after bar-open conditions were reestablished would help to confirm that fish distributions under tidal conditions are similar to those during and immediately after breaching.

- Water quality profiles in Willow Creek as part of the prebreaching surveys to determine whether a saline, anoxic zone has developed will show whether plankton collections should be included in the subsequent day-of-breaching survey.
- Datasonde deployments should be extended throughout the interval between successive breaches.
- More effective exclusion of humans from the beach during breaching operations would minimize effects on harbor seals and increase visitor safety.
- A Lampara net (which operates somewhat like a purse seine) should be purchased and used in the fish sampling, as it would allow more effective sampling of salmonids during flooded (prebreaching) conditions.

V. REFERENCES

PERSONAL CONTACTS

Bill Cox, California Department of Fish and Game
Rex Grady, California State Parks
Mike Wisehart, California State Parks
Brian Hickey, California State Parks
Royce Gunter, California Department of Fish and Game

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VI. APPENDIX

Appendix A-1. Prebreaching Water Quality Profiles, Event I, 1 July 1996

Depth Meters	Station 1(1600 hr PDT) Temp °C	Sal °/oo	Cond μmho	D. O. ppm	Station 2 (1745 hr PDT) Temp °C	Sal °/oo	Cond μmho	D. O. ppm	Station 3 (1815 hr PDT) Temp °C	Sal °/oo	Cond μmho	D. O. ppm	Station 4 (1848 hr PDT) Temp °C	Sal °/oo	Cond μmho	D. O. ppm
0	22.9	1.4		7.6	23.0	1.0		8.4	23.5	0.7		8.4	23.8	0.6	550	7.5
1	21.5	2.0		7.7	22.7	1.0		8.3	23.5	0.7		7.5	23.7	0.6	580	7.4
2	20.0	6.5		8.3	21.0	2.5		8.4	23.5	0.9		7.6	23.0	0.6	600	7.4
3					17.0	22.1		8.5								
4	13.7	25.8		6.4	14.9	27.0		4.8					17.5	25.0	33800	3.3
5					14.7	28.0		4.0								
6	13.0	27.0		6.0									17.0	25.5	34000	2.6
7																
8	13.2	27.8		4.0									16.0	25.5	34000	0.3
9																
10													16.0	26.0	34200	0.4

Appendix A-2. Postbreaching Water Quality Profiles, Event I, 7 July 1996

Depth Meters	Station 1 (1130 hr PDT)				Station 2 (1300 hr PDT)				Station 3 (1550 hr PDT)				Station 4 (1425 hr PDT)			
	Temp ^{o}C	Sal $^{o}/_{oo}$	Cond µmho	D. O. ppm	Temp ^{o}C	Sal $^{o}/_{oo}$	Cond µmho	D. O. ppm	Temp ^{o}C	Sal $^{o}/_{oo}$	Cond µmho	D. O. ppm	Temp ^{o}C	Sal $^{o}/_{oo}$	Cond µmho	D. O. ppm
0	21.0	5.3	8500	6.8	23.0	2.2	3180	6.2	20.0	0.5	402	7.2	23.3	0.8	101	7.2
1	21.0	5.9	9200	6.8	21.5	5.5	8300	5.8	19.6	0.5	402	6.3	23.0	0.8	101	6.8
2	15.9	21.8	21200	7.6	14.5	26.0	32700	8.2					23.0	0.8	102	6.4
3	13.0	27.7	33200	8.4	13.5	27.2	33200	8.3					22.5	1.1	145	6.2
4	12.1	29.8	34500	9.0	13.5	27.0	33500	8.2					18.3	23.1	32400	2.0
5	12.0	31.5	35000	8.9												
6													16.1	26.0	38800	0.2
7																
8													16.1	26.2	39500	0.2
9																
10																

Appendix A-3. Postbreaching Water Quality Profiles, Event II, 5 August 1996

Depth Meters	Station 1 (1120 hr PDT)				Station 2 (1218 hr PDT)				Station 3 (1402 hr PDT)				Station 4 (1435 hr PDT)			
	Temp °C	Sal °/oo	Cond μmho	D. O. ppm	Temp °C	Sal °/oo	Cond μmho	D. O. ppm	Temp °C	Sal °/oo	Cond μmho	D. O. ppm	Temp °C	Sal °/oo	Cond μmho	D. O. ppm
0	20.0	5.0	8000	7.4	21.6	3.0	4700	7.0	22.0	2.2	3180	7.1	22.5	1.5	1950	7.0
1	18.0	11.8	12000	6.4	21.0	3.5	5200	6.9	21.3	2.5	3500	7.0	22.5	1.5	2420	7.1
2	14.5	25.2	31800	4.8	15.7	25.3	32800	4.0	17.5	26.3	35300	2.7	22.0	2.0	2620	7.0
3	12.3	27.0	32200	5.4	15.0	26.0	33000	3.7	17.5	28.5	38000	1.6	19.0	28.0	37000	3.2
4	11.8	27.9	32500	5.8	15.0	27.9	35300	1.0					17.0	28.5	37500	1.7
5	11.5	28.0	30000	5.8									17.0	28.5	37500	1.6
6	11.9	28.0	33200	5.6									17.0	28.5	37500	1.6
7																
8													16.5	28.5	37500	1.5
9																
10													17.0	28.5	37500	1.2

Appendix A-4. Prebreaching Water Quality Profiles, Event V, 18 September 1996

	Station 1 (1030 hr PDT)				Station 2 (1200 hr PDT)				Station 3 (1330 hr PDT)				Station 4 (1455 hr PDT)			
Depth Meters	Temp °C	Sal °/oo	Cond µmho	D. O. ppm	Temp °C	Sal °/oo	Cond µmho	D. O. ppm	Temp °C	Sal °/oo	Cond µmho	D. O. ppm	Temp °C	Sal °/oo	Cond µmho	D. O. ppm
0	17.0	3.0	4200	9.0	19.2	1.1	1610	8.4	19.0	1.1	1900	8.8	20.5	0.3	520	8.9
1	17.0	4.0	5500	9.1	18.8	2.0	3000	8.6	19.0	1.3	1970	8.2	20.0	0.4	530	8.9
2	17.0	4.5	6300	10.8	18.5	6.5	9700	8.6	19.0	6.5	10200	9.0	19.5	7.5	11600	9.0
3	17.5	26.9	36000	10.5	18.9	24.9	34700	7.7	18.5	25.7	34900	8.2	19.8	26.5	37000	7.6
4	16.5	28.2	36800	11.0	17.0	27.5	37000	5.5					19.0	27.8	38300	6.7
5	15.5	29.1	37000	8.7	16.5	28.3	37000	2.5					18.3	28.0	38000	2.8
6	14.9	30.1	37800	5.5									17.9	28.5	38200	2.4
7																
7.5	14.5	30.8	38000	7.5												
8													17.0	28.6	37900	0.1
9																
10													16.5	28.7	37800	0.1

Appendix A-5. Day-of-Breaching Water Quality Profiles Near the Mouth of Willow Creek, Event V, 26 September 1996

	Above Creek (1705 hr PDT)				In Creek Mouth (1605 hr PDT)				Below Creek (1630 hr PDT)			
Depth Meters	Temp °C	Sal °/oo	Cond µmho	D. O. ppm	Temp °C	Sal °/oo	Cond µmho	D. O. ppm	Temp °C	Sal °/oo	Cond µmho	D. O. ppm
0	18.0	0.7	1020	8.6	17.0	10.0	1180	2.9	19.5	1.8	2530	8.1
1	18.5	2.9	4300	8.5	17.0	1.0	1200	2.8	19.5	2.0	2950	8.2
2					17.0	1.0	1200	2.4	20.0	2.7	3870	8.4
3									20.0	3.6	4800	8.5
4									18.5	28.0	38100	1.9
5												
6												
7												
8												
9												
10												

Appendix A-6. Postbreaching Water Quality Profiles, Event V, 27 September 1996

Depth Meters	Station 1 (0845 hr PDT) Temp °C	Sal $^{o}/_{oo}$	Cond µmho	D. O. ppm	Station 2 (1400 Hr PDT) Temp °C	Sal $^{o}/_{oo}$	Cond µmho	D. O. ppm	Station 3 (1330 hr PDT) Temp °C	Sal $^{o}/_{oo}$	Cond µmho	D. O. ppm	Station 4 (1205 hr PDT) Temp °C	Sal $^{o}/_{oo}$	Cond µmho	D. O. ppm
0	17.5	3.6	5100	7.8	18.0	4.4	6800	7.5	18.2	3.3	4400	7.7	19.0	1.9	2500	7.4
1	17.0	11.5	14000	8.0	16.0	23.5	31200	7.0	18.0	10.0	14000	7.2	18.7	2.0	3050	7.5
2	15.0	19.0	25000	8.6	15.0	25.5	33000	7.5	16.0	25.0	32900	5.6	18.5	2.1	2950	7.4
3	14.2	23.0	29500	8.2	15.0	26.3	33800	7.5	16.0	25.0	32900	5.6	18.5	2.2	3200	7.4
4	13.5	27.3	33000	9.0	15.0	27.0	34300	5.6					17.5	3.0	3950	7.4
5	13.5	27.7	33900	8.6	15.5	29.1	37100	0.2					18.5	24.5	34500	1.6
6					15.5	29.0	37000	0.2					18.0	27.5	36600	0.2
7					15.3	29.1	37000	0.2					17.5	28.2	36600	0.1
8													17.0	28.6	37000	0.1
9													16.5	28.9	37000	0.1
10													16.5	28.8	37000	0.1

Appendix A-7. Prebreaching Water Quality Profiles, Event VI, 9-10 October 1996

	Station 1 (1435 hr PDT 9 Oct)				Station 2 (1545 hr PDT 9 Oct)				Station 3 (1710 hr PDT 9 Oct)				Station 4 (1310 hr PDT 10 Oct)			
Depth Meters	Temp °C	Sal ‰	Cond µmho	D. O. ppm	Temp °C	Sal ‰	Cond µmho	D. O. ppm	Temp °C	Sal ‰	Cond µmho	D. O. ppm	Temp °C	Sal ‰	Cond µmho	D. O. ppm
0	17.5	3.0	4000	10.0	18.5	2.0	2750	10.0	18.5	1.5	2030	10.1	19.0	0.9	960	9.4
1	17.5	3.1	4000	10.0	18.5	2.5	3400	10.2	18.5	1.5	2030	10.1	19.0	0.9	980	9.8
2	16.5	15.7	21800	12.2	18.2	12.5	18000	11.5	18.8	11.7	15700	10.4	19.0	5.0	7000	10.0
3	15.1	26.0	33300	12.2	17.5	25.8	35000	10.8	18.0	25.4	35200	9.4	18.5	25.3	36000	9.5
4	15.0	28.2	35500	10.0	16.0	28.2	36500	7.8	16.5	27.2	36500	7.4	18.0	27.5	37000	7.9
5	14.5	29.0	36500	7.4	14.7	28.5	36200	5.5					17.0	27.5	36400	5.2
6	14.0	29.4	36500	6.0	14.5	28.7	36000	4.0					16.5	27.7	36200	3.6
7	14.0	29.0	36200	5.9	14.5	28.0	36000	4.0								
8	14.0	29.0	36200	5.8									16.0	27.8	36000	3.9
9																
10													16.0	27.5	36000	3.5

Appendix A-8. Day-of-Breaching Water Quality Profiles in Willow Creek and in the Russian River Near the Creek Mouth, Event VI, 15 October 1996

	150 m up Creek (1645 hr PDT)				Above Creek (1800 hr PDT)				In Creek Mouth (1730 hr PDT)				Below Creek (1705 hr PDT)			
Depth Meters	Temp °C	Sal °/oo	Cond µmho	D. O. ppm	Temp °C	Sal °/oo	Cond µmho	D. O. ppm	Temp °C	Sal °/oo	Cond µmho	D. O. ppm	Temp °C	Sal °/oo	Cond µmho	D. O. ppm
0	15.2	0.7	820	3.1					15.0	0.7		3.2	18.0	0.7	780	8.4
0.5					16.5	0.9	860	9.5								
1	15.0	0.7	850	2.8									18.0	0.7	780	8.4
2	15.0	0.7	850	2.8									18.0	0.7	800	8.4
2.8	15.0	0.7	850	2.8												
3													18.0	2.0	2540	8.5
4													17.5	26.8	36000	3.7
5													15.5	28.0	36000	2.6
5.5													15.5	27.9	35700	2.5
6																
7																
8																
9																
10																

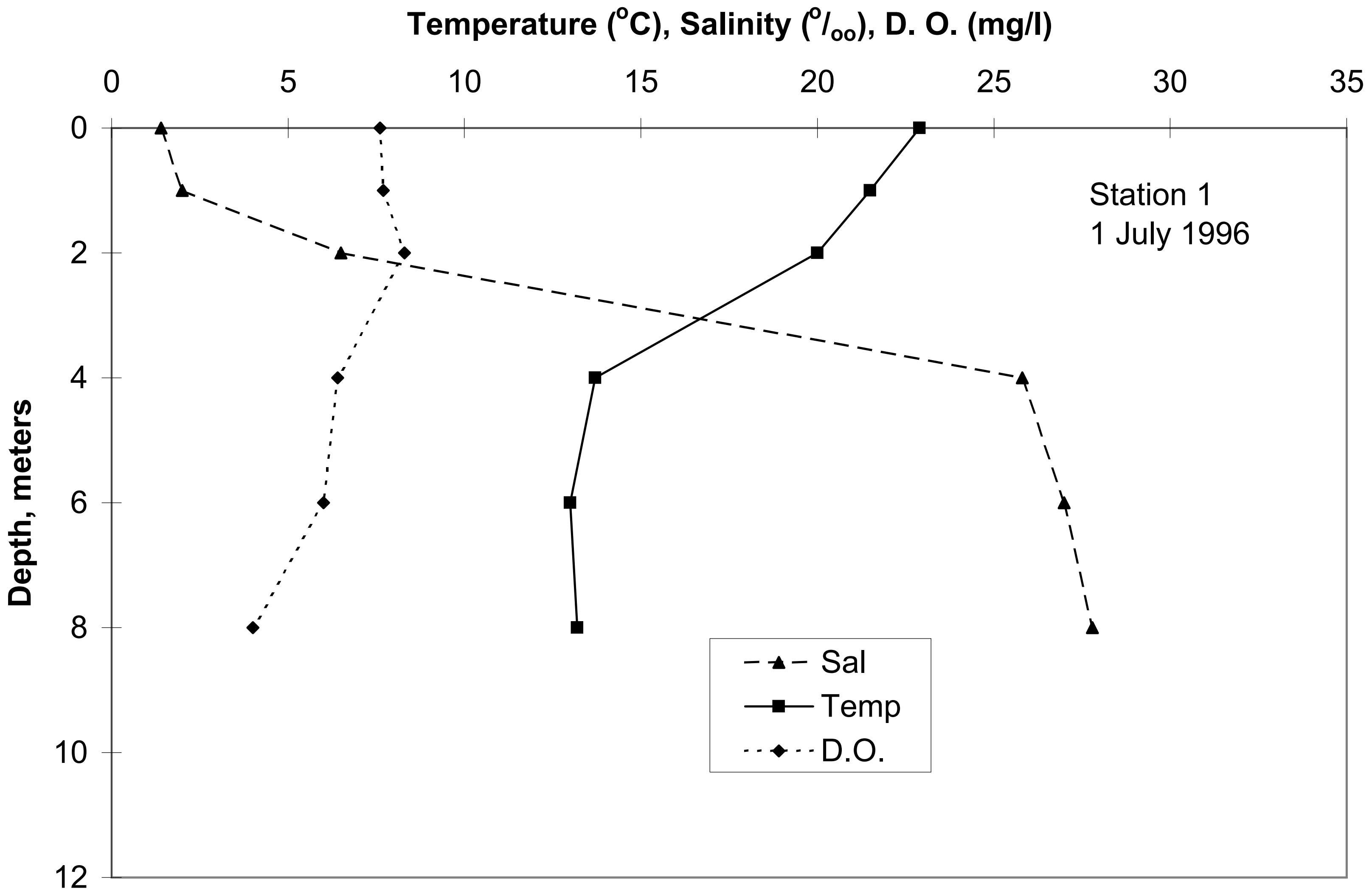
Appendix A-9. Postbreaching Water Quality Profiles, Event VI, 16 October 1996

	Station 1 (1455 hr PDT)				Station 2 (1340 hr PDT)				Station 3 (1255 hr PDT)				Station 4 (1209 hr PDT)			
Depth Meters	Temp °C	Sal ‰	Cond µmho	D. O. ppm	Temp °C	Sal ‰	Cond µmho	D. O. ppm	Temp °C	Sal ‰	Cond µmho	D. O. ppm	Temp °C	Sal ‰	Cond µmho	D. O. ppm
0	13.0	23.5	28500	6.7	16.0	5.6	7800	8.3	17.0	2.7	3550	8.3	15.5	1.9	2320	8.0
1	11.5	29.1	34000	6.7	13.2	23.0	28900	7.1	15.0	15.5	19000	7.3	15.5	2.0	2470	8.0
2	11.5	29.7	34400	6.6	12.3	26.3	31500	7.0	14.0	21.2	27000	7.1	15.5	2.1	2550	8.1
3	11.4	29.7	34600	6.6	12.0	27.0	32000	7.0	14.0	21.5	27300	7.1	15.5	2.2	2640	8.1
3.5									14.1	21.2	27300	7.1				
4	11.3	29.7	34500	6.6	12.0	27.0	32000	7.0					15.5	2.2	2750	8.1
5	11.3	29.7	34600	6.6	12.0	27.0	32000	7.0					15.3	2.2	2750	8.1
6	11.5	29.7	34600	6.6	12.1	26.8	32200	7.0					15.2	2.2	2690	8.1
7	11.8	29.4	34500	6.6	12.2	26.7	32000	7.0					15.2	2.2	2790	8.0
8													15.2	2.3	2830	7.8
9													15.0	2.7	3260	7.2
10													14.9	21.7	28300	1.5

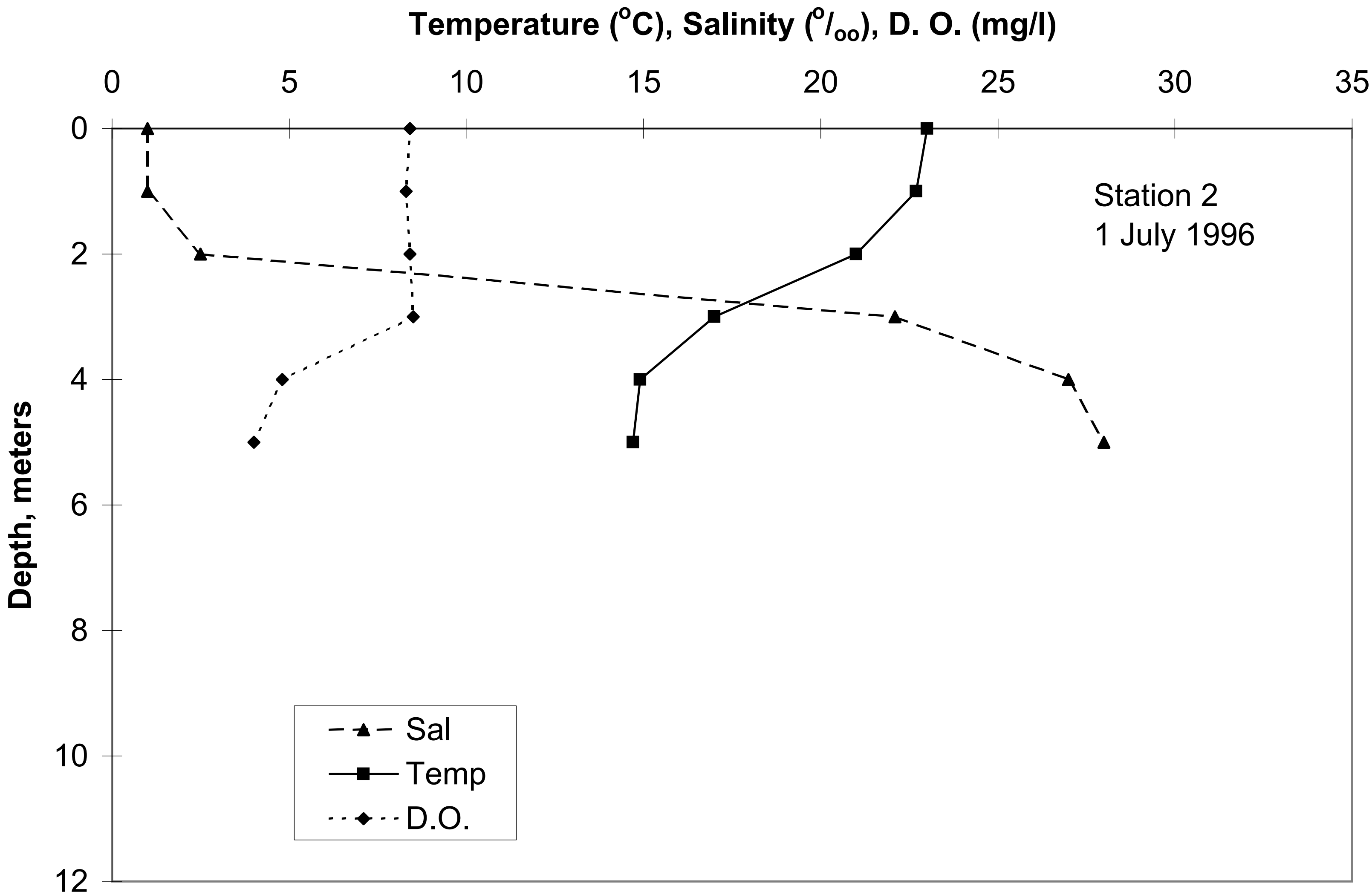
Appendix A-10. Postbreaching Water Quality Profiles, Event VII, 9 November 1996

Depth	Station 1 (1320 hr PST)				Station 2 (1615 hr PST)				Station 3 (1600 hr PST)				Station 4 (1440 hr PST)			
Meters	Temp °C	Sal ‰	Cond µmho	D. O. ppm	Temp °C	Sal ‰	Cond µmho	D. O. ppm	Temp °C	Sal ‰	Cond µmho	D. O. ppm	Temp °C	Sal ‰	Cond µmho	D. O. ppm
0	12.0	19.3	23500	9.8	12.4	9.2	11800	10.2	13.0	7.2	9600	10.5	12.5	3.5	4200	10.4
1	11.7	23.0	27700	9.7	12.0	12.2	15800	9.9	13.0	8.0	10500	10.4	12.5	4.8	6000	10.4
2	11.5	28.0	32900	9.5	11.5	27.6	32400	8.6	13.0	25.3	31700	9.4	12.0	17.0	19500	9.0
3	11.0	30.3	35300	9.3	11.5	29.0	34000	8.6					11.5	26.2	31200	8.5
4	11.0	30.7	35500	9.3	11.5	29.0	34000	8.6					11.6	26.6	31500	8.5
5	11.5	31.0	35700	9.4	12.0	28.3	34000	8.6					11.5	27.0	31600	8.5
6	11.7	32.0	35700	9.3									11.8	26.7	31600	8.5
7													12.0	26.0	31200	8.5
8																
9																
10																

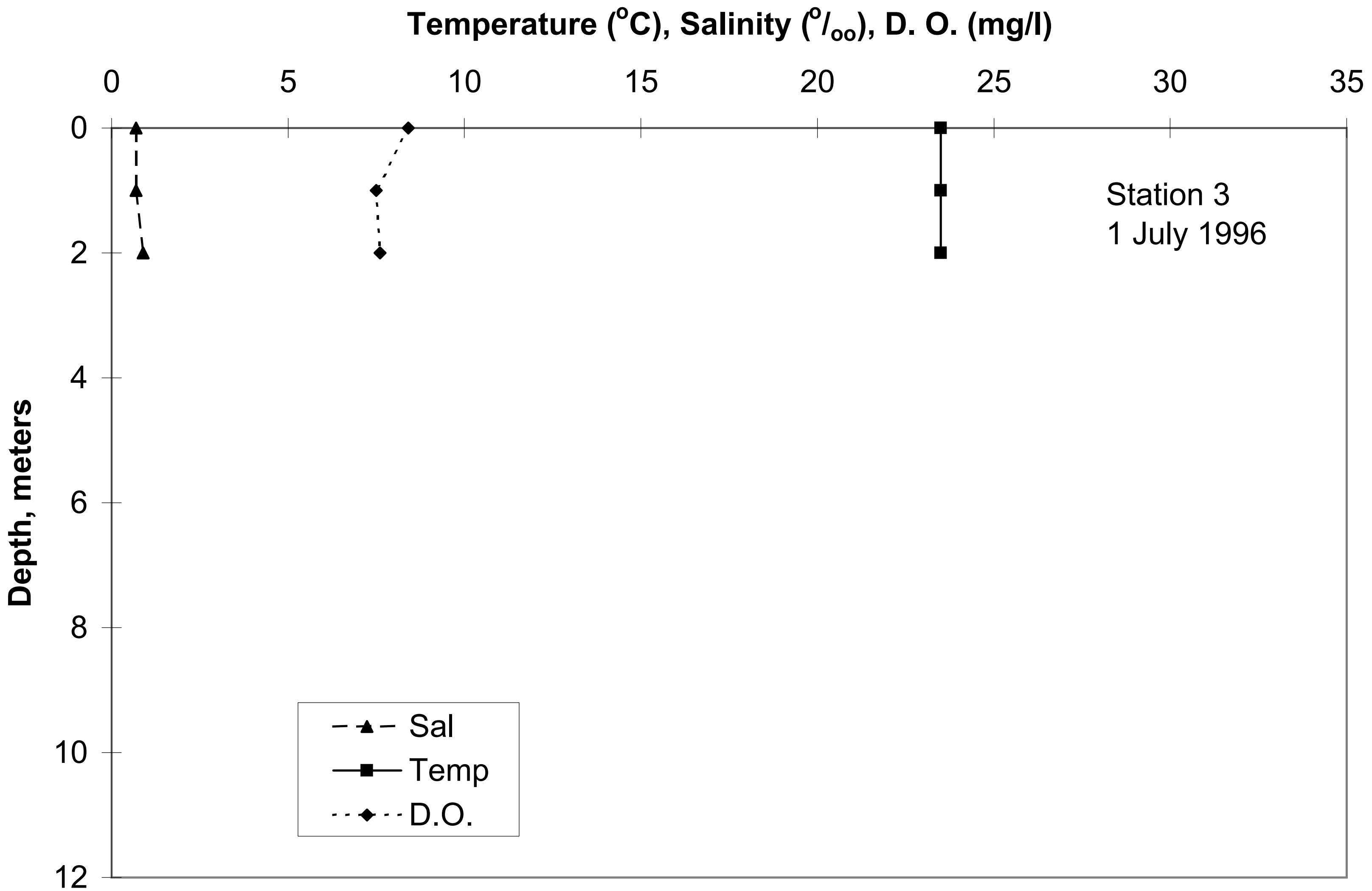
Appendix A-11. Prebreaching Water Quality Profile, Event I, Station 1



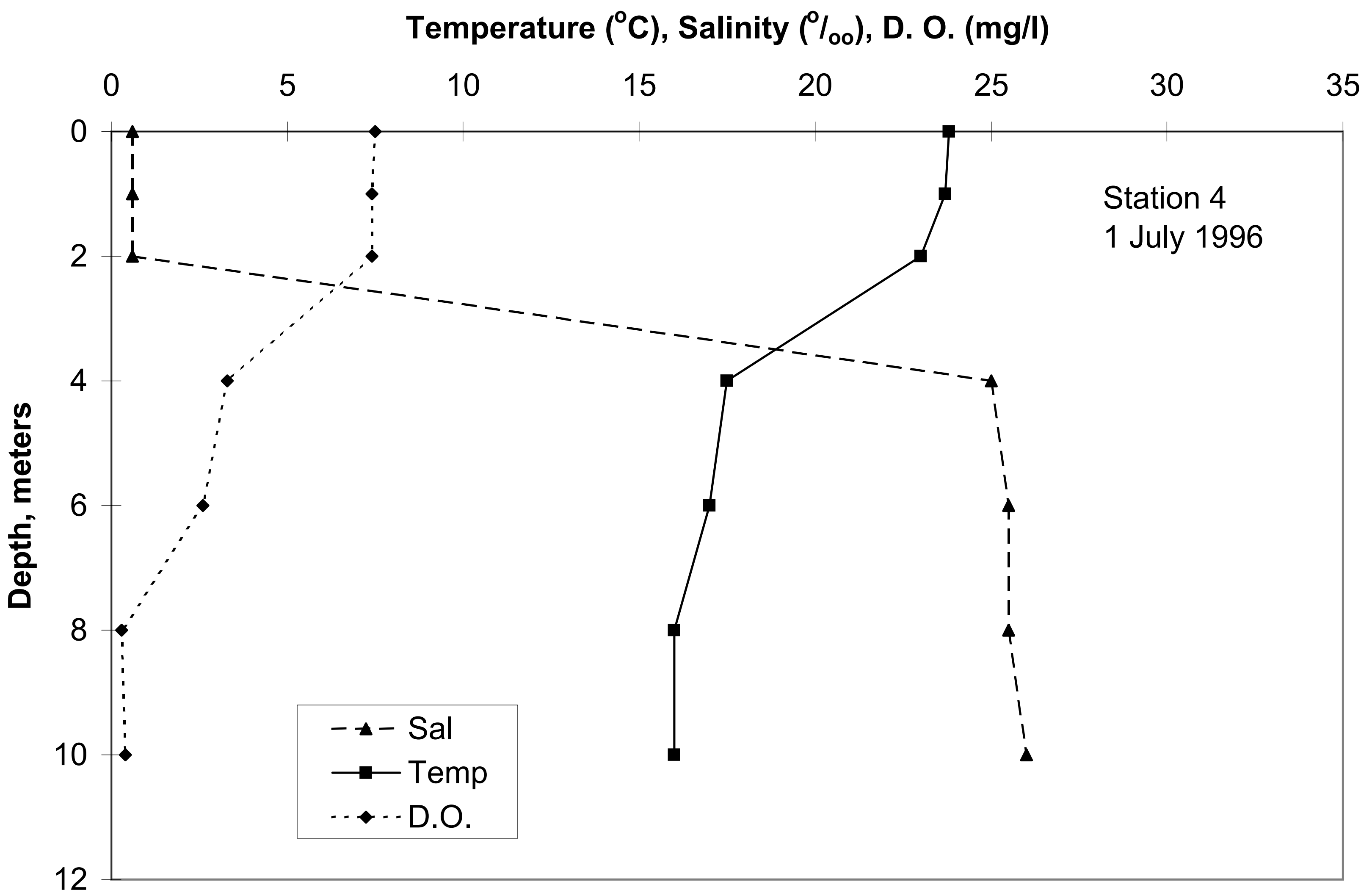
Appendix A-12. Prebreaching Water Quality Profile, Event I, Station 2



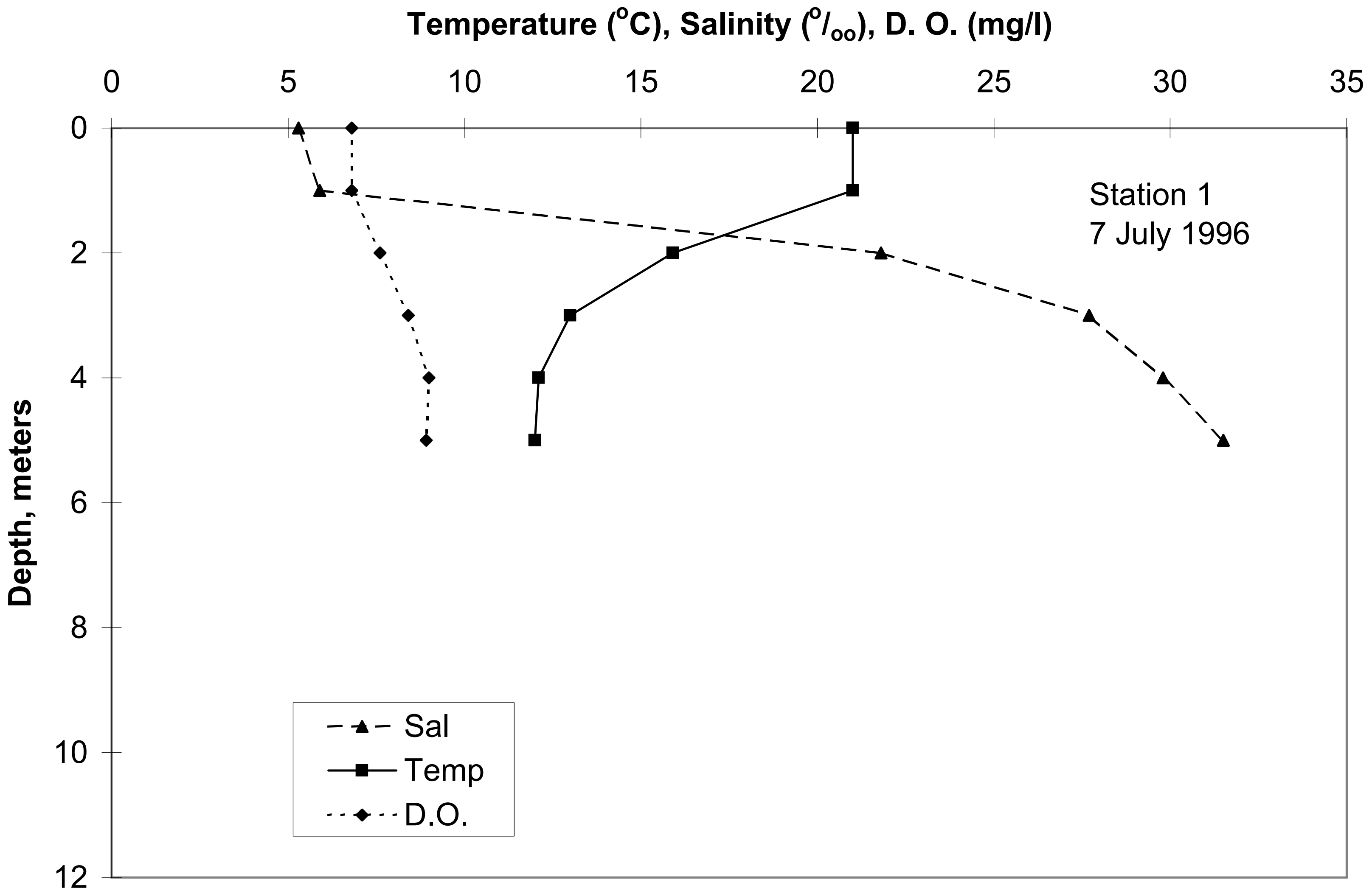
Appendix A-13. Prebreaching Water Quality Profile, Event I, Station 3



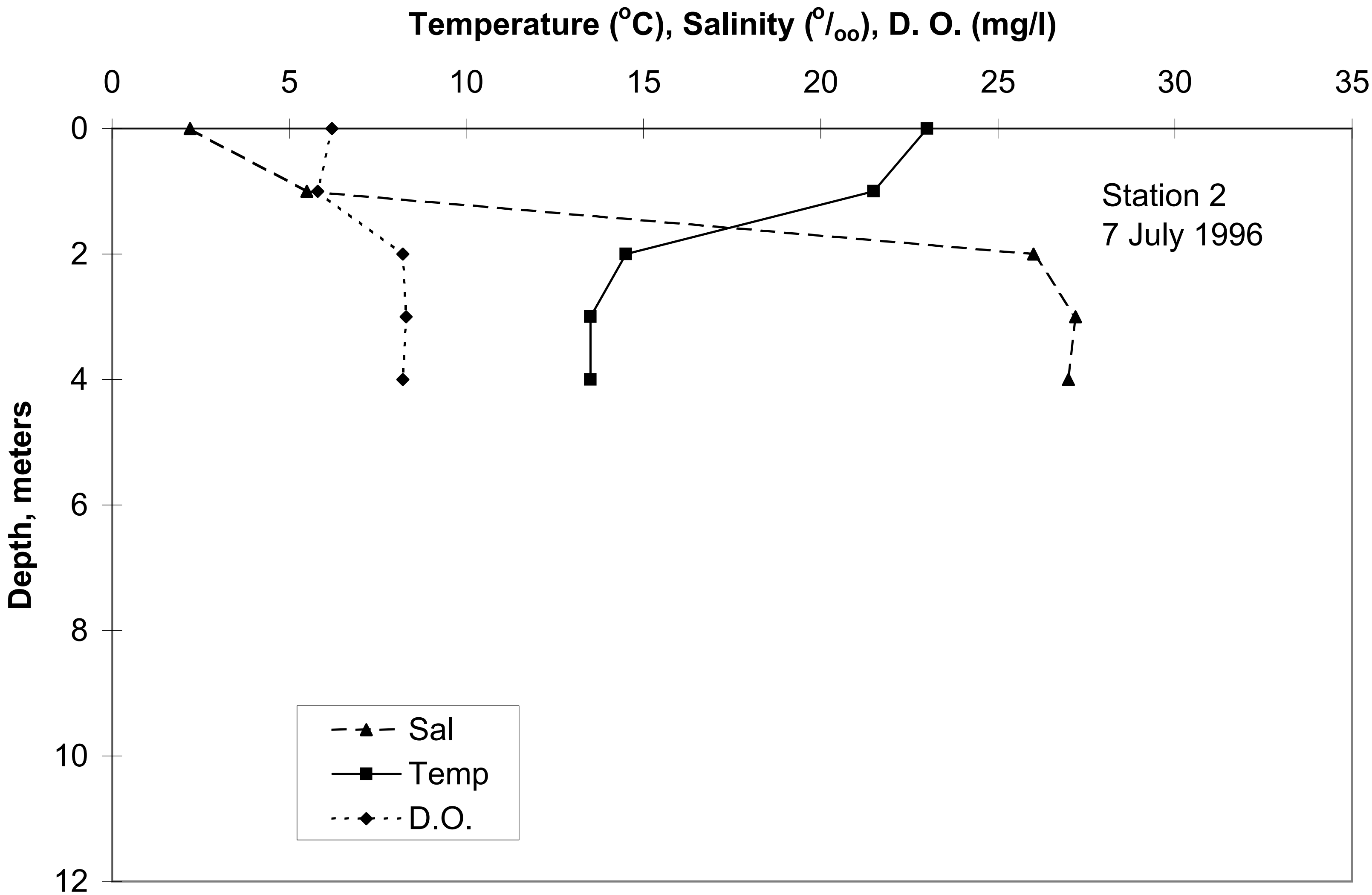
Appendix A-14. Prebreaching Water Quality Profile, Event I, Station 4



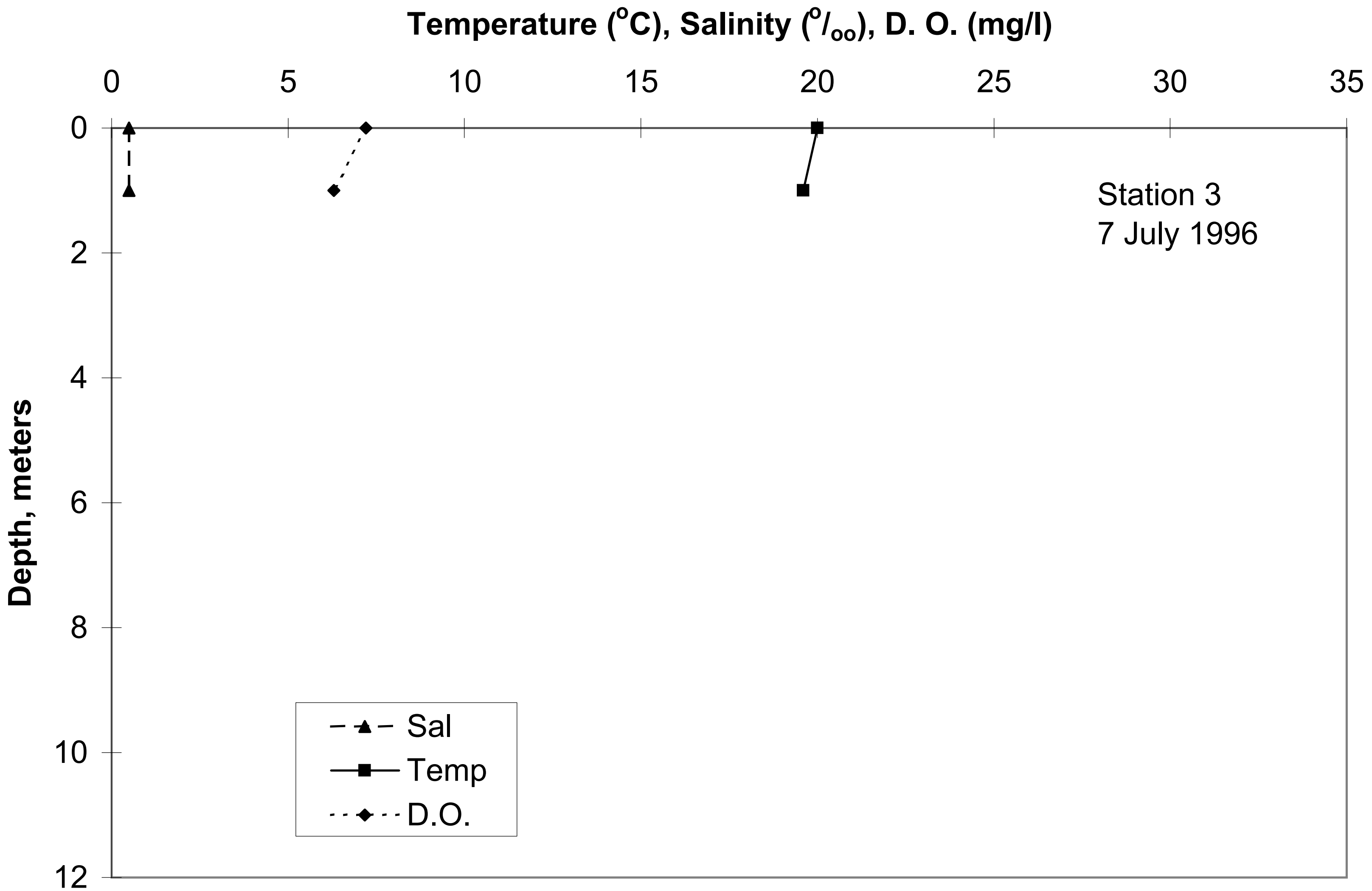
Appendix A-15. Postbreaching Water Quality Profile, Event I, Station 1



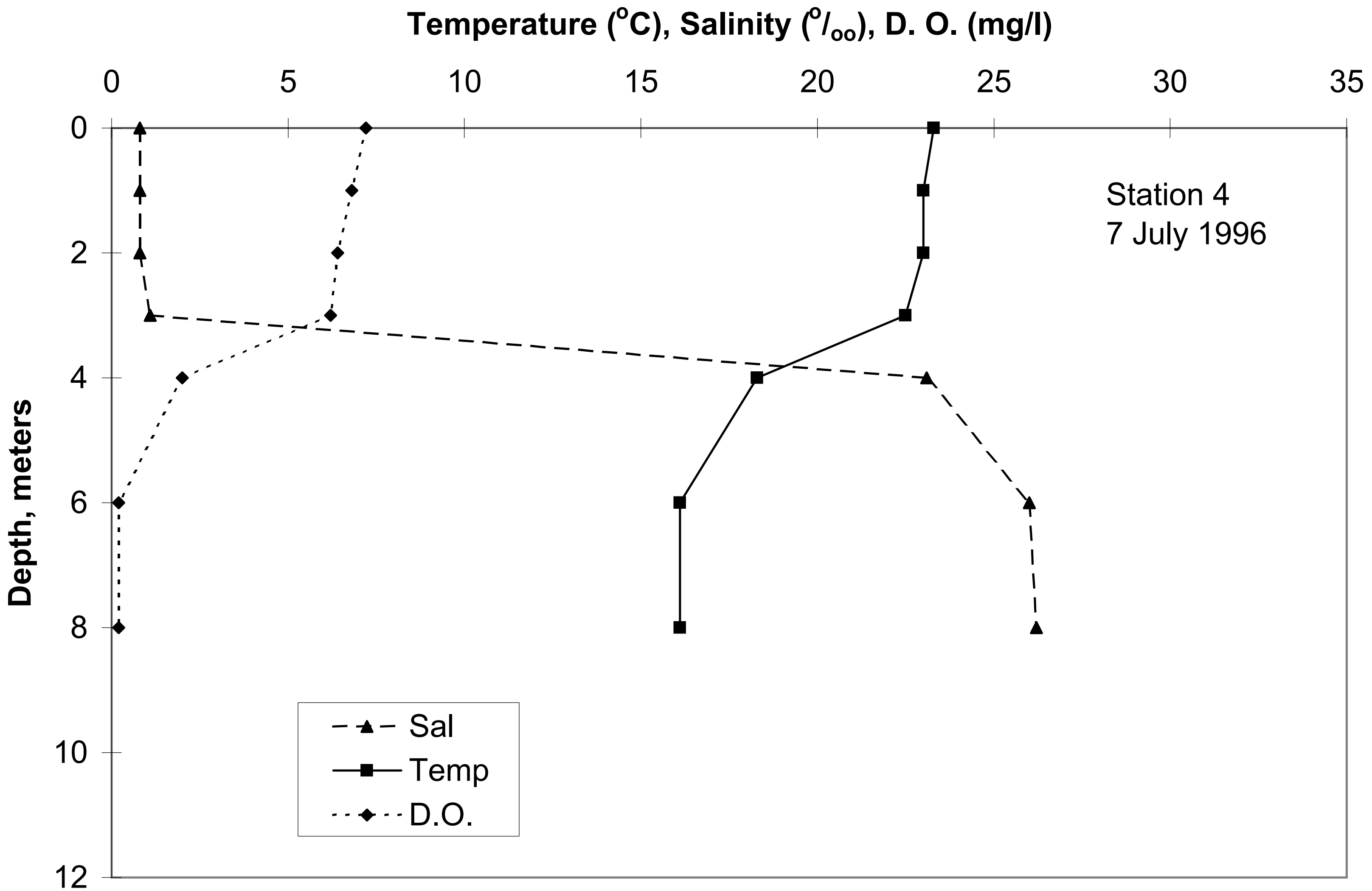
Appendix A-16. Postbreaching Water Quality Profile, Event I, Station 2



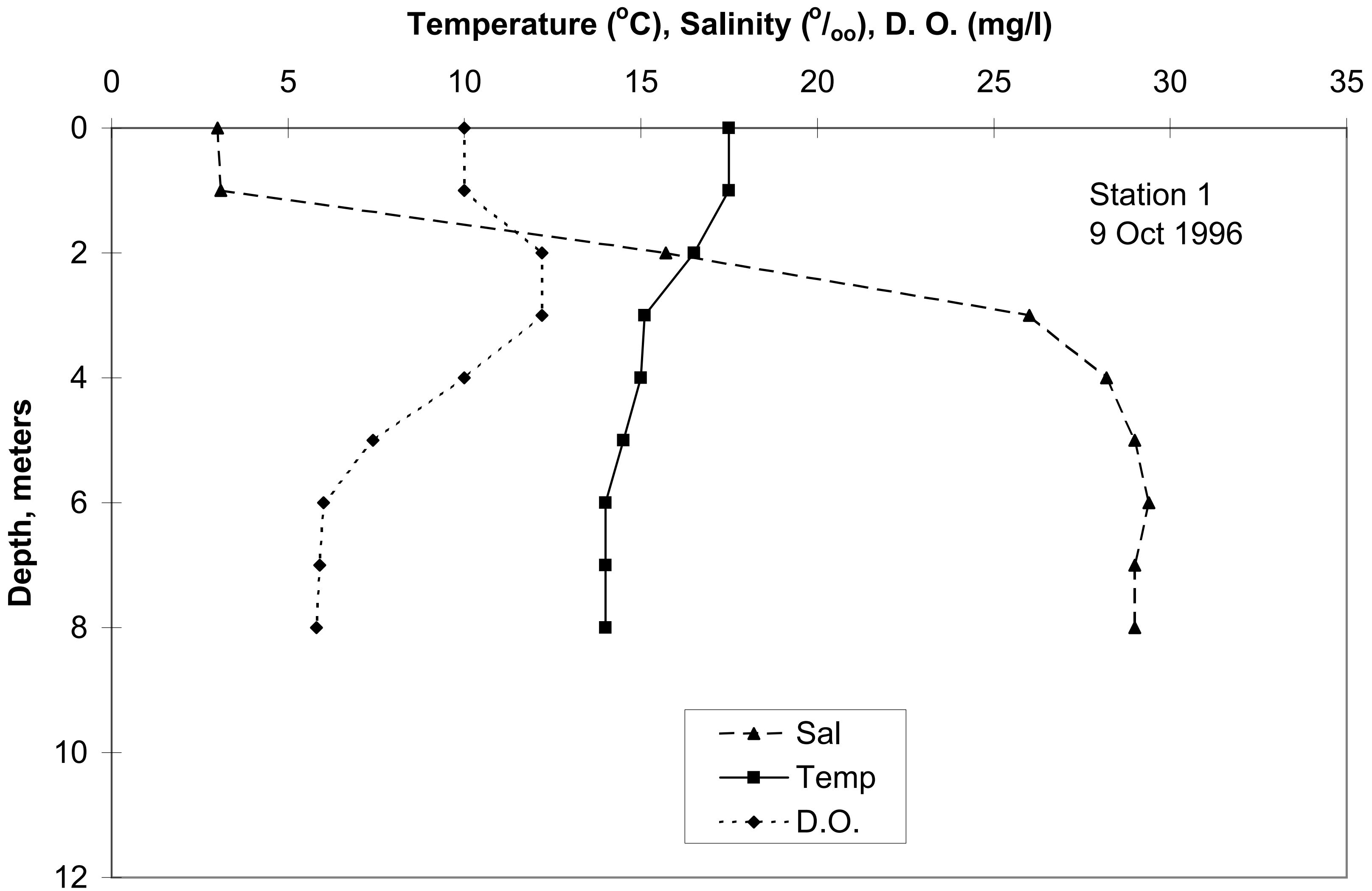
Appendix A-17. Postbreaching Water Quality Profile, Event I, Station 3



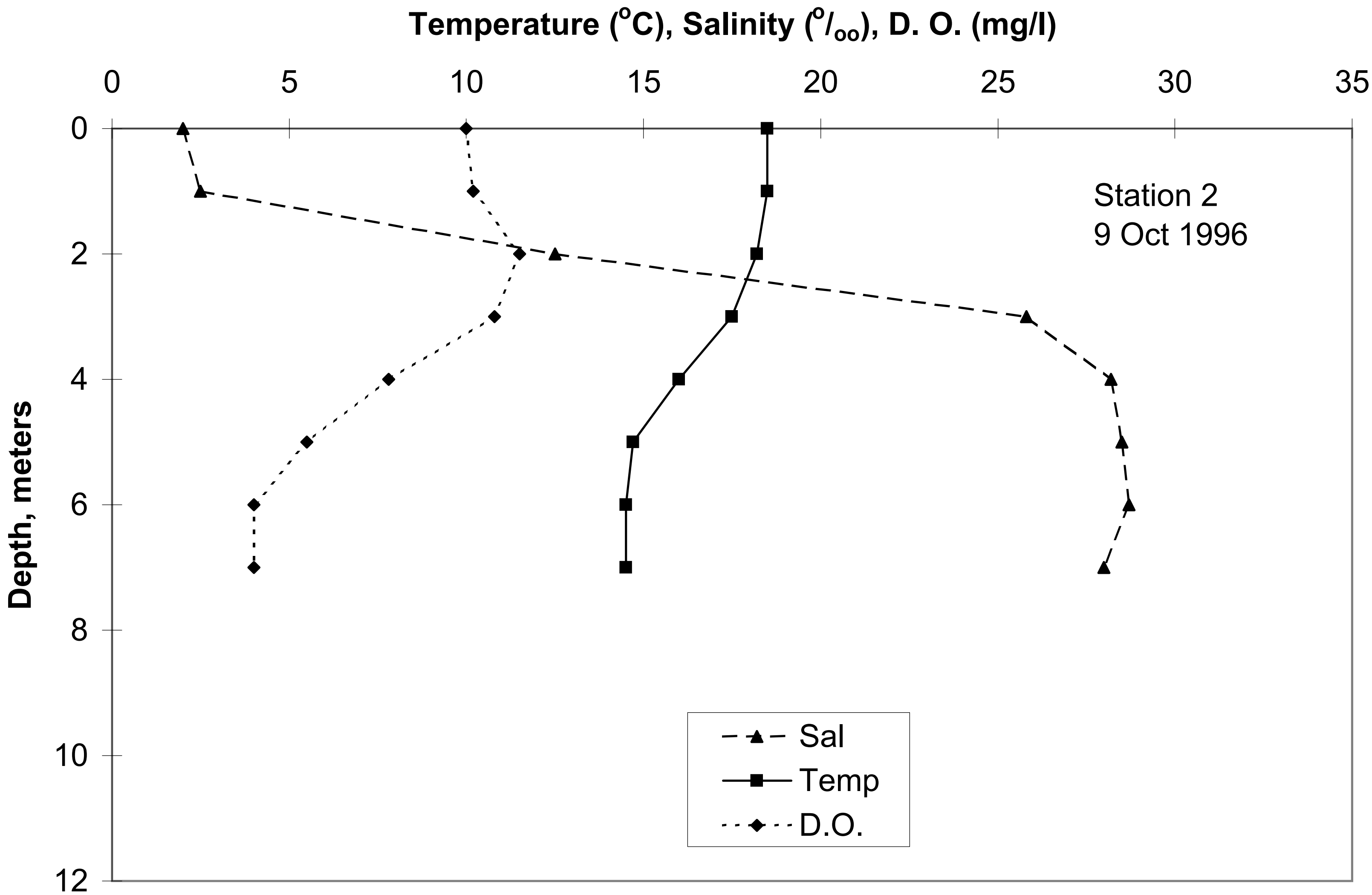
Appendix A-18. Postbreaching Water Quality Profile, Event I, Station 4



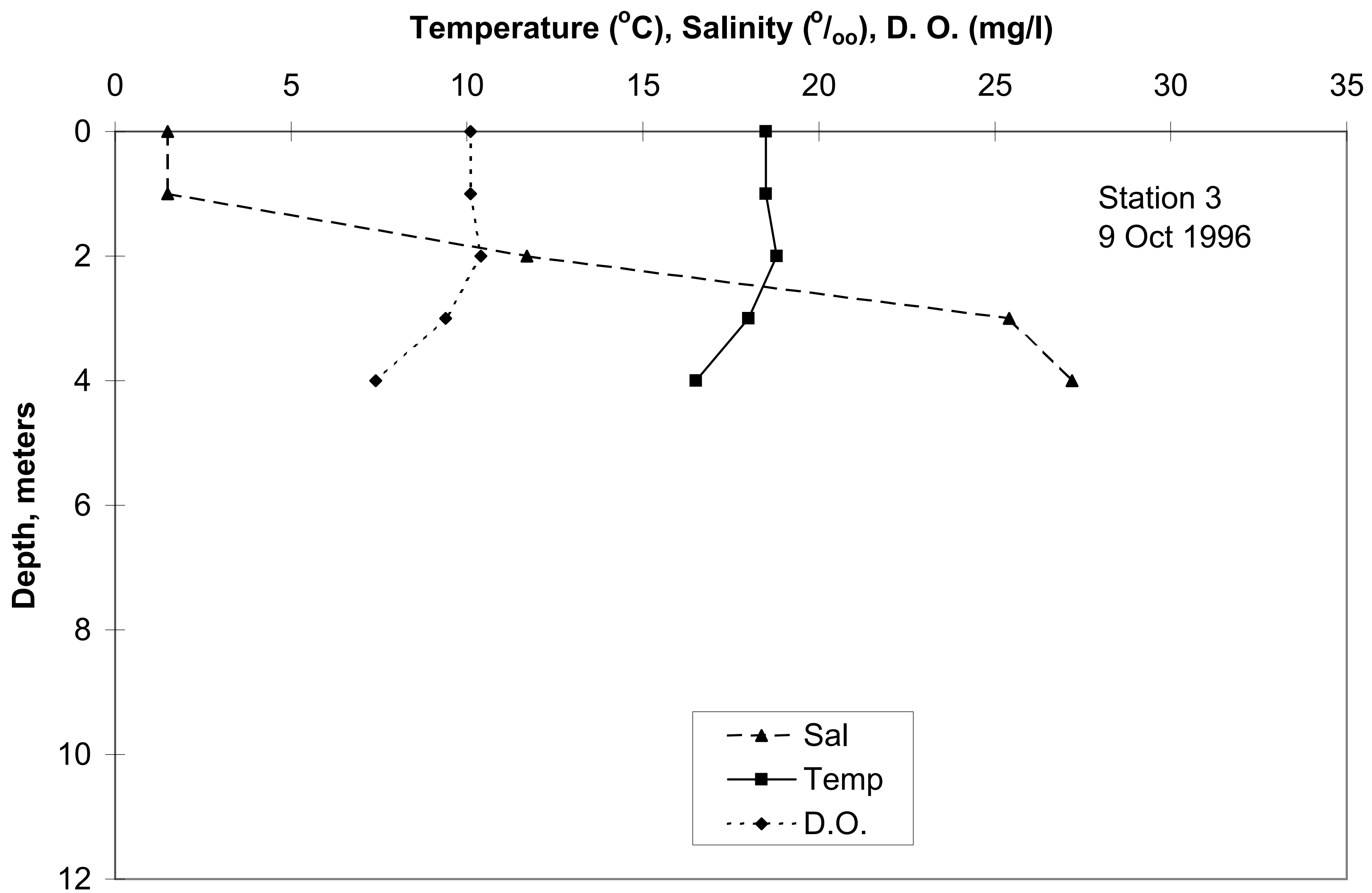
Appendix A-19. Prebreaching Water Quality Profile, Event VI, Station 1



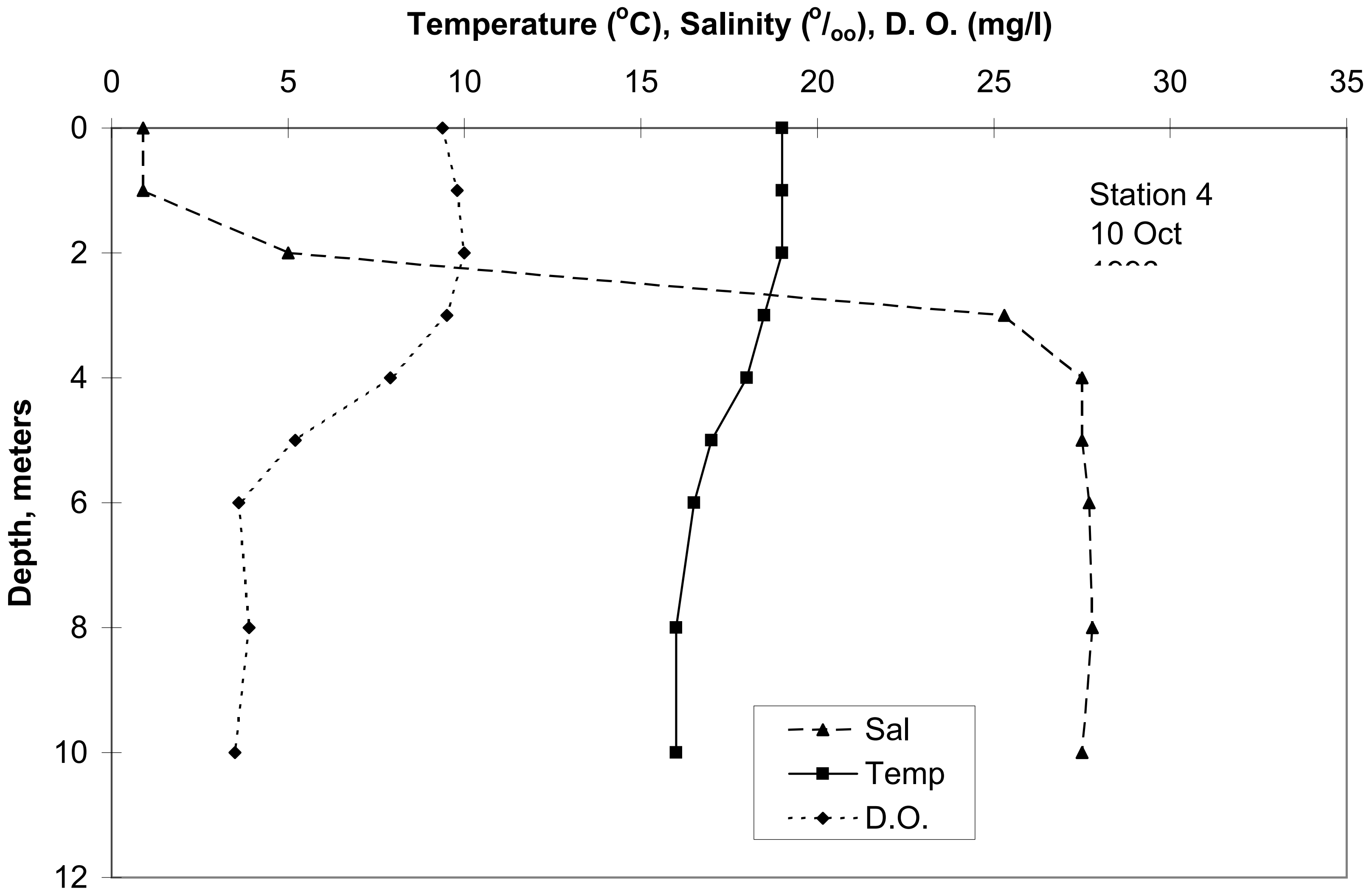
Appendix A-20. Prebreaching Water Quality Profile, Event VI, Station 2



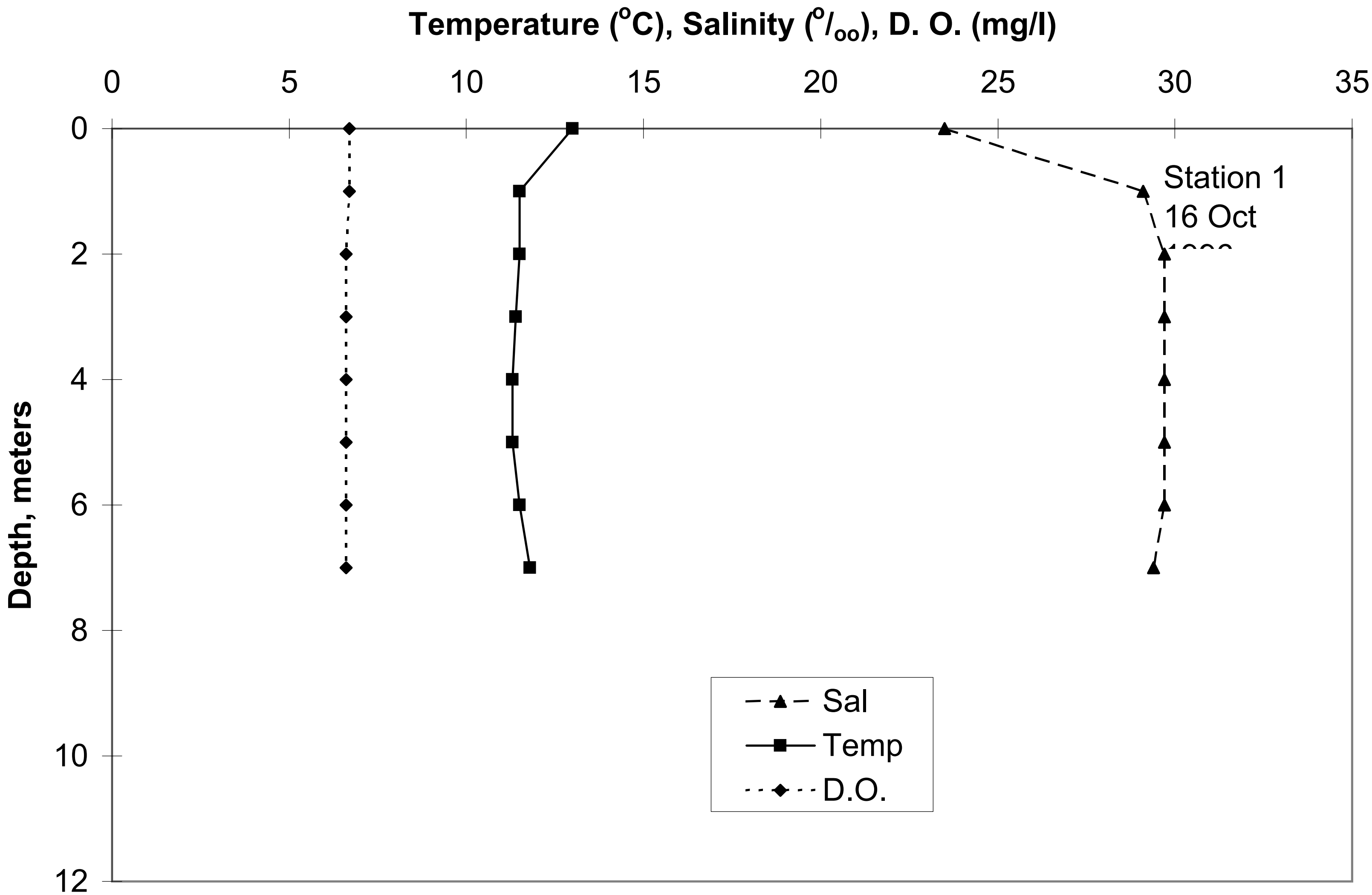
Appendix A-21. Prebreaching Water Quality Profile, Event VI, Station 3



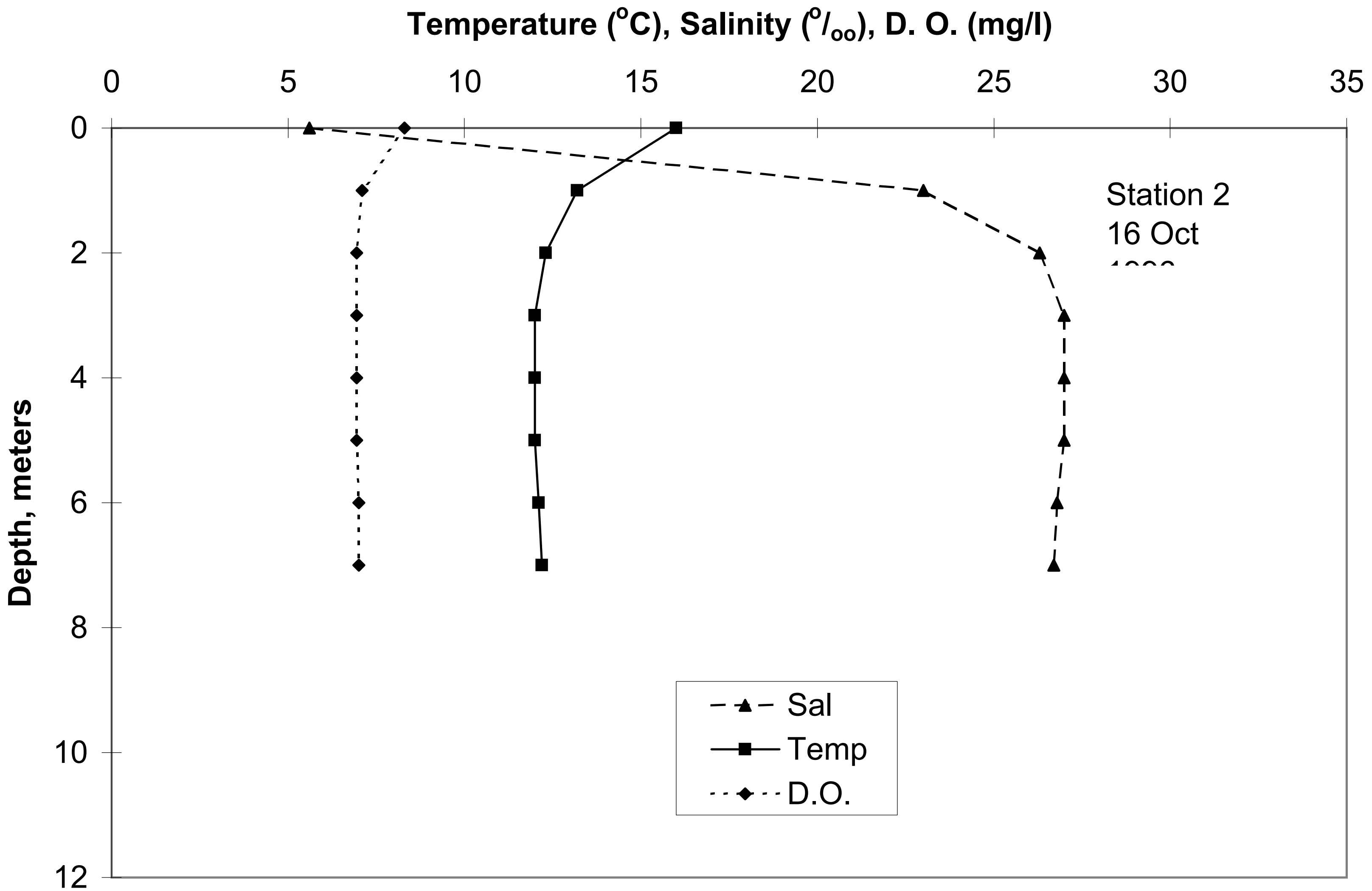
Appendix A-22. Prebreaching Water Quality Profile, Event VI, Station 4



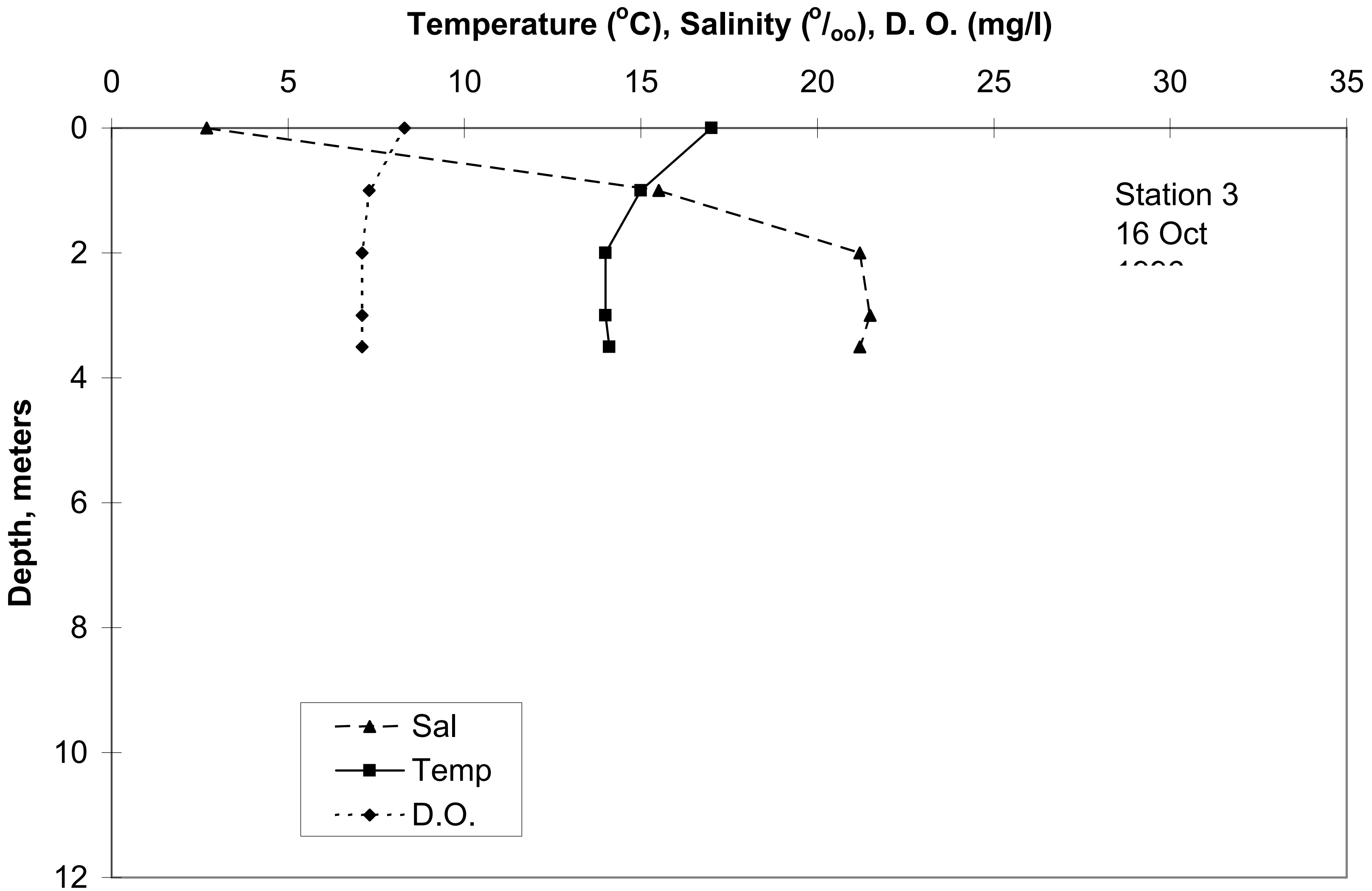
Appendix A-23. Postbreaching Water Quality Profile, Event VI, Station 1



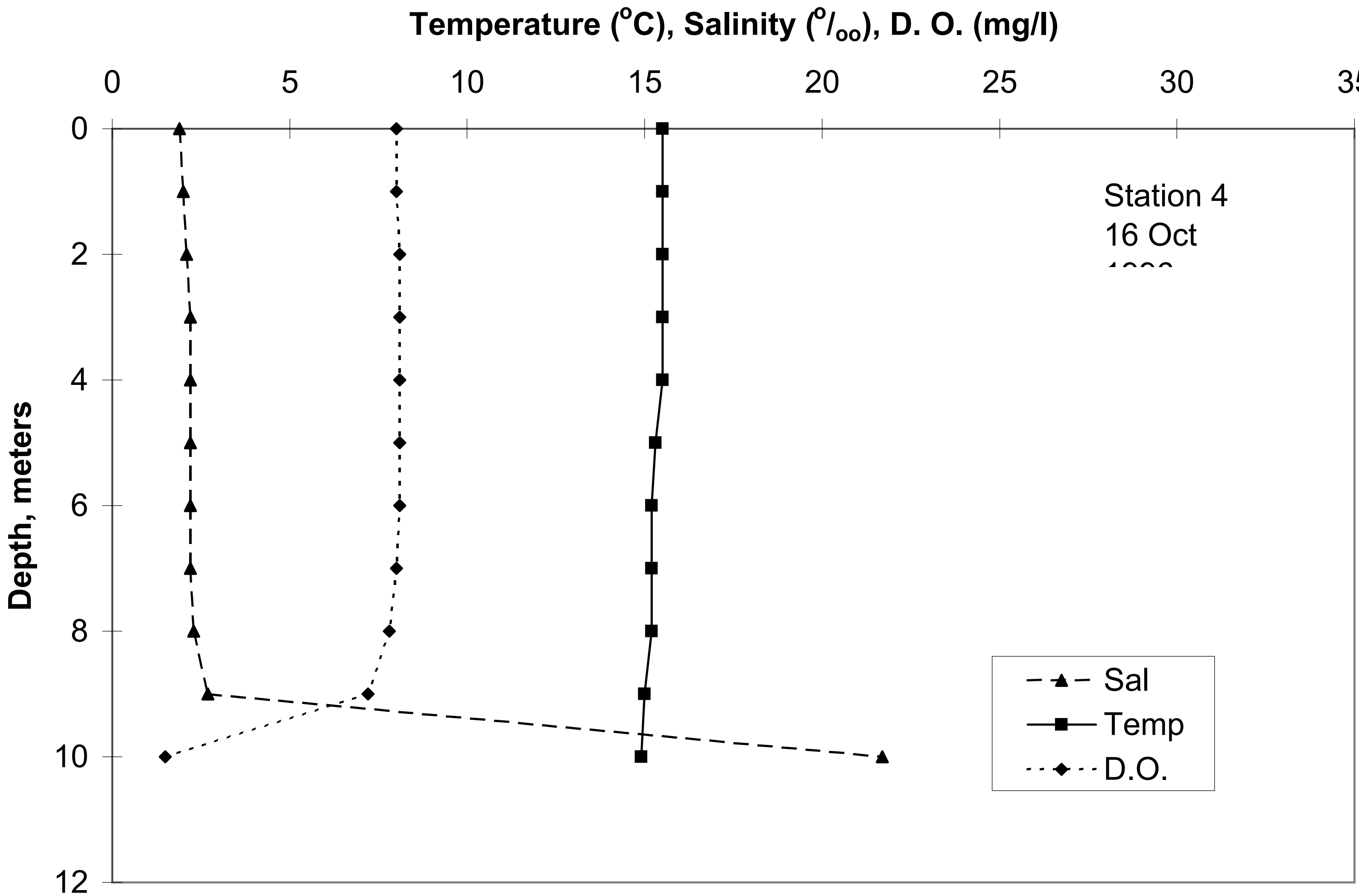
Appendix A-24. Postbreaching Water Quality Profile, Event VI, Station 2



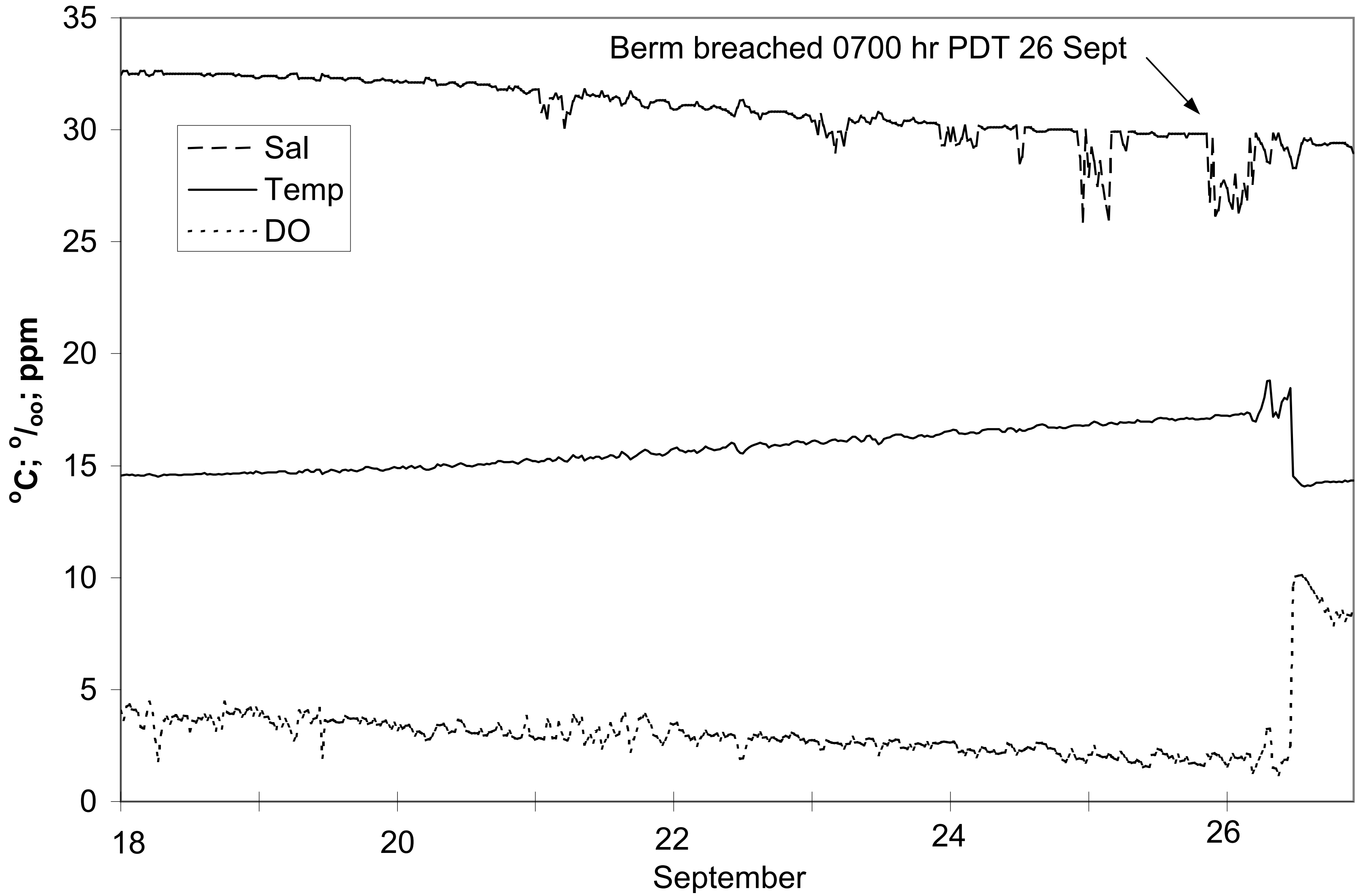
Appendix A-25. Postbreaching Water Quality Profile, Event VI, Station 3



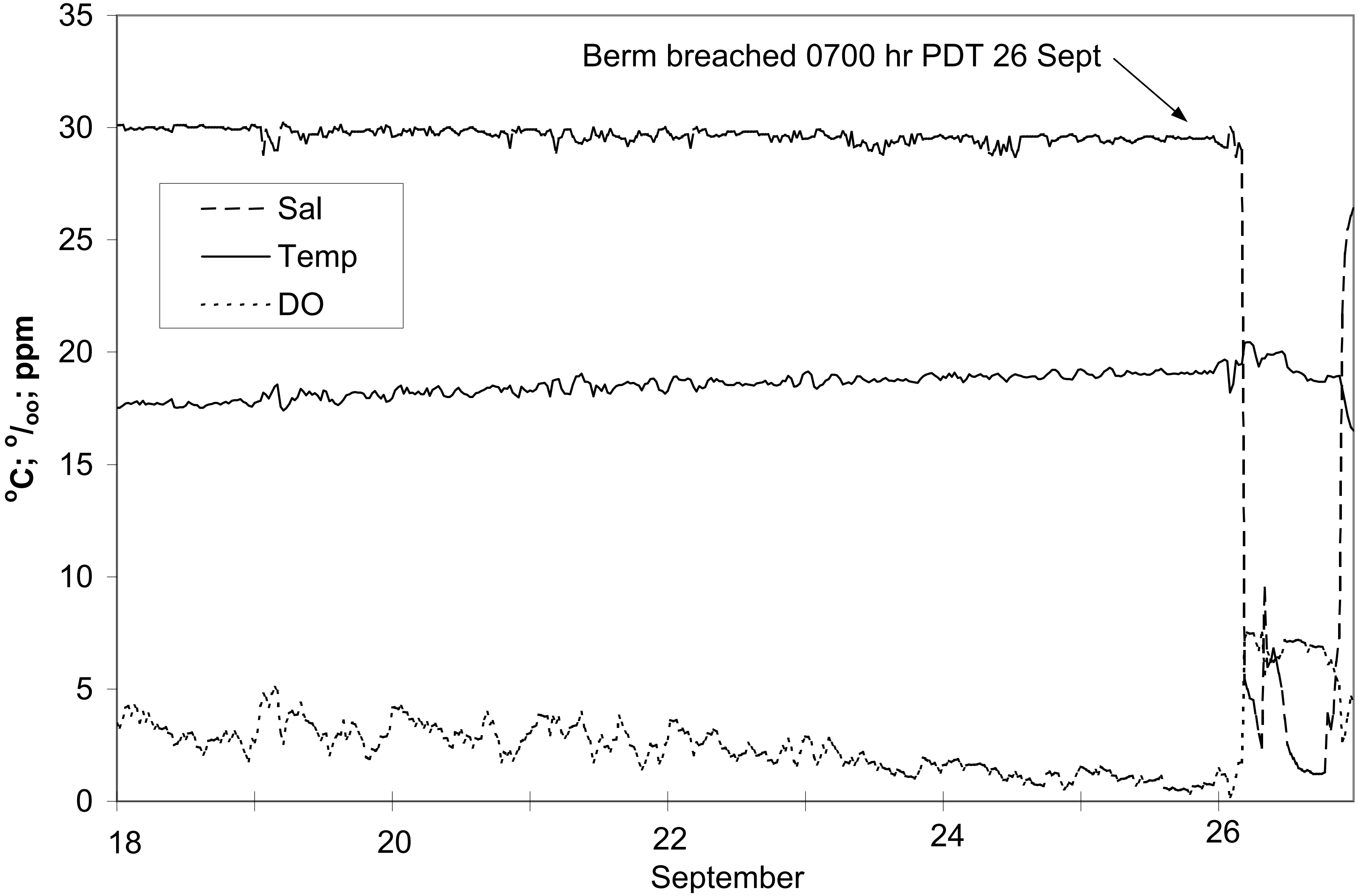
Appendix A-26. Postbreaching Water Quality Profile, Event VI, Station 4



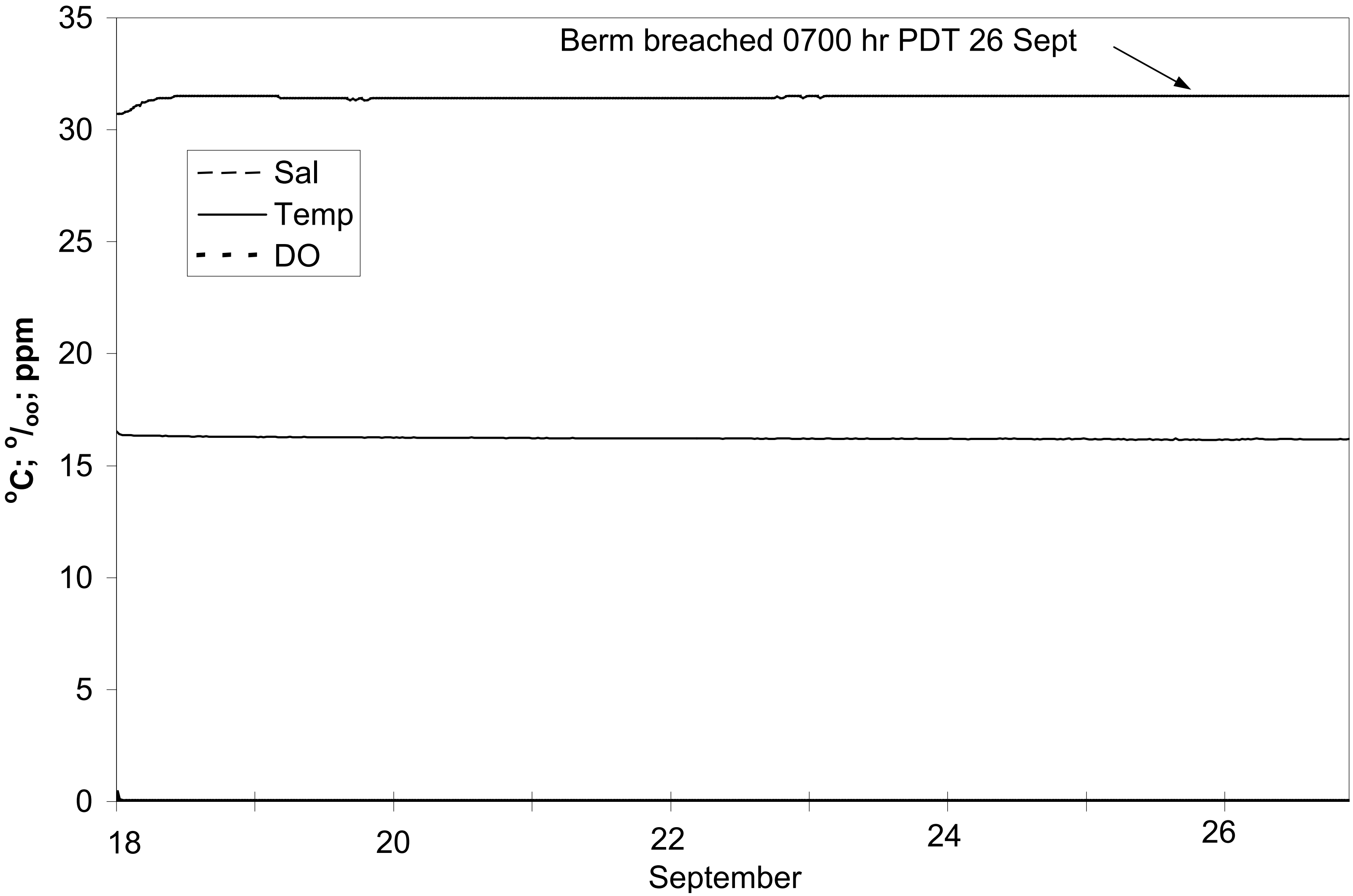
Appendix A-27. Datasonde Record, Station 1, 18-27 Sept 1996



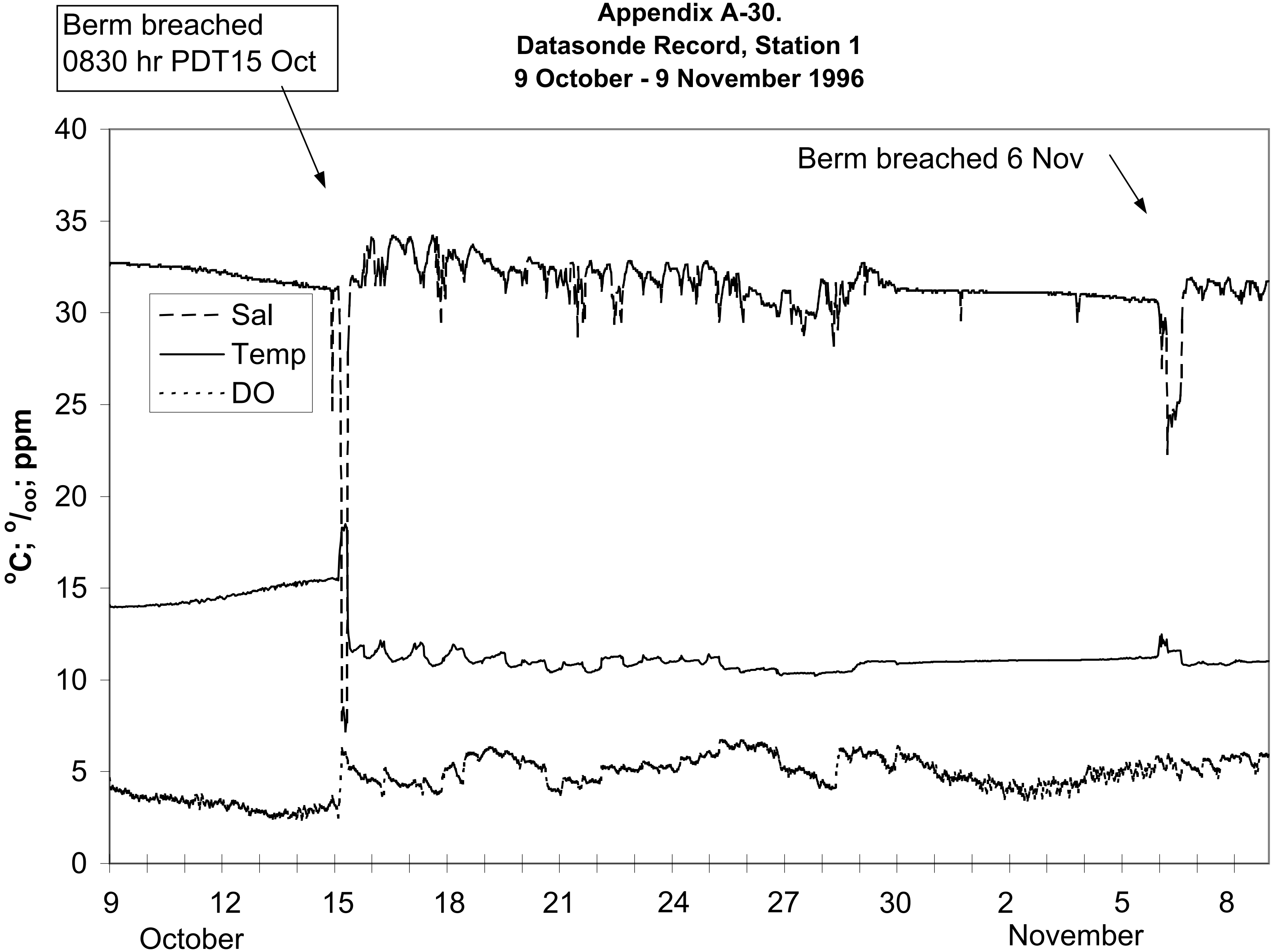
Appendix A-28. Datasonde Record, Station 3 18-27 Sept 1996



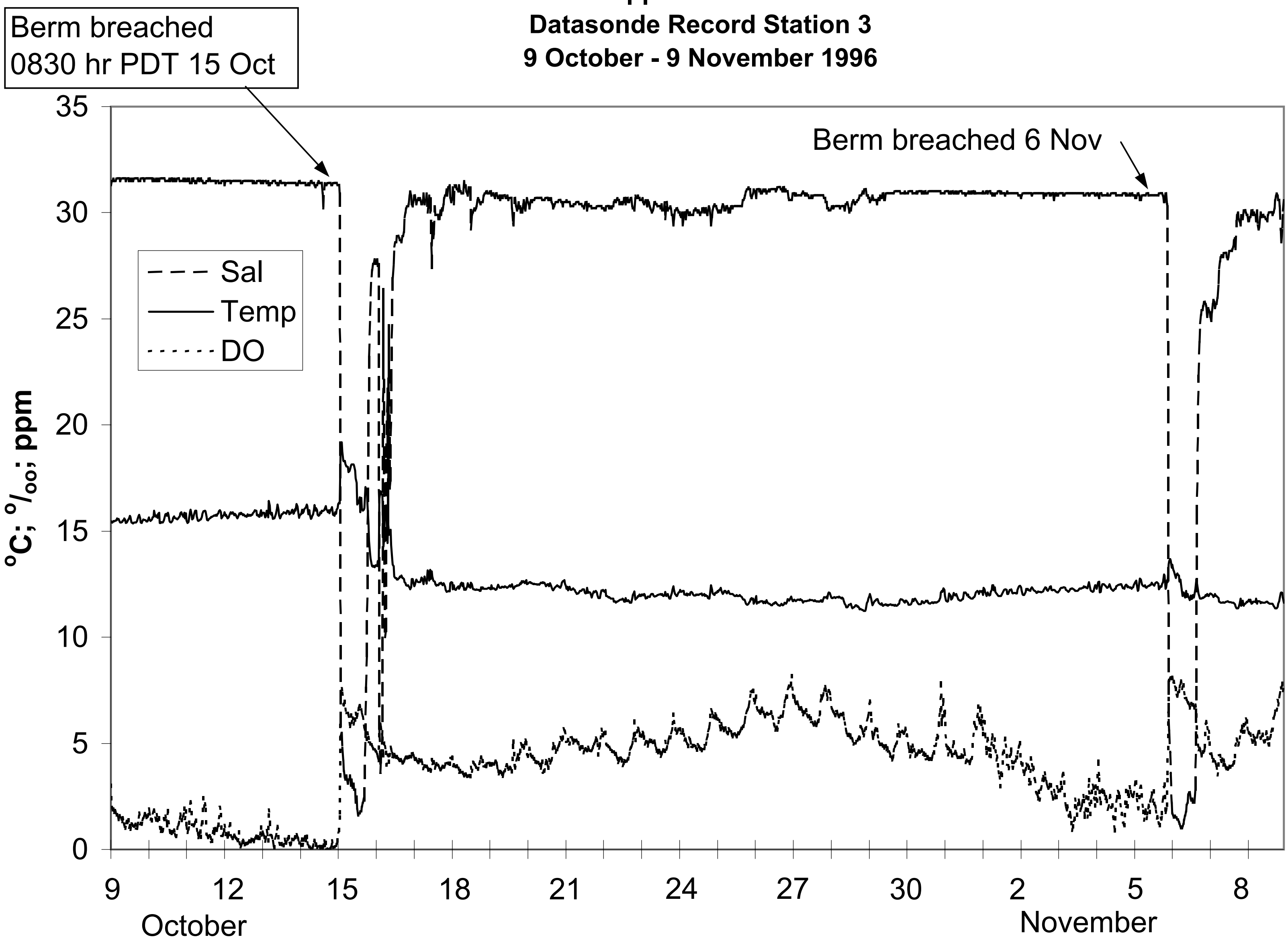
Appendix A-29. Datasonde Record, Station 4 18-27 Sept 1996



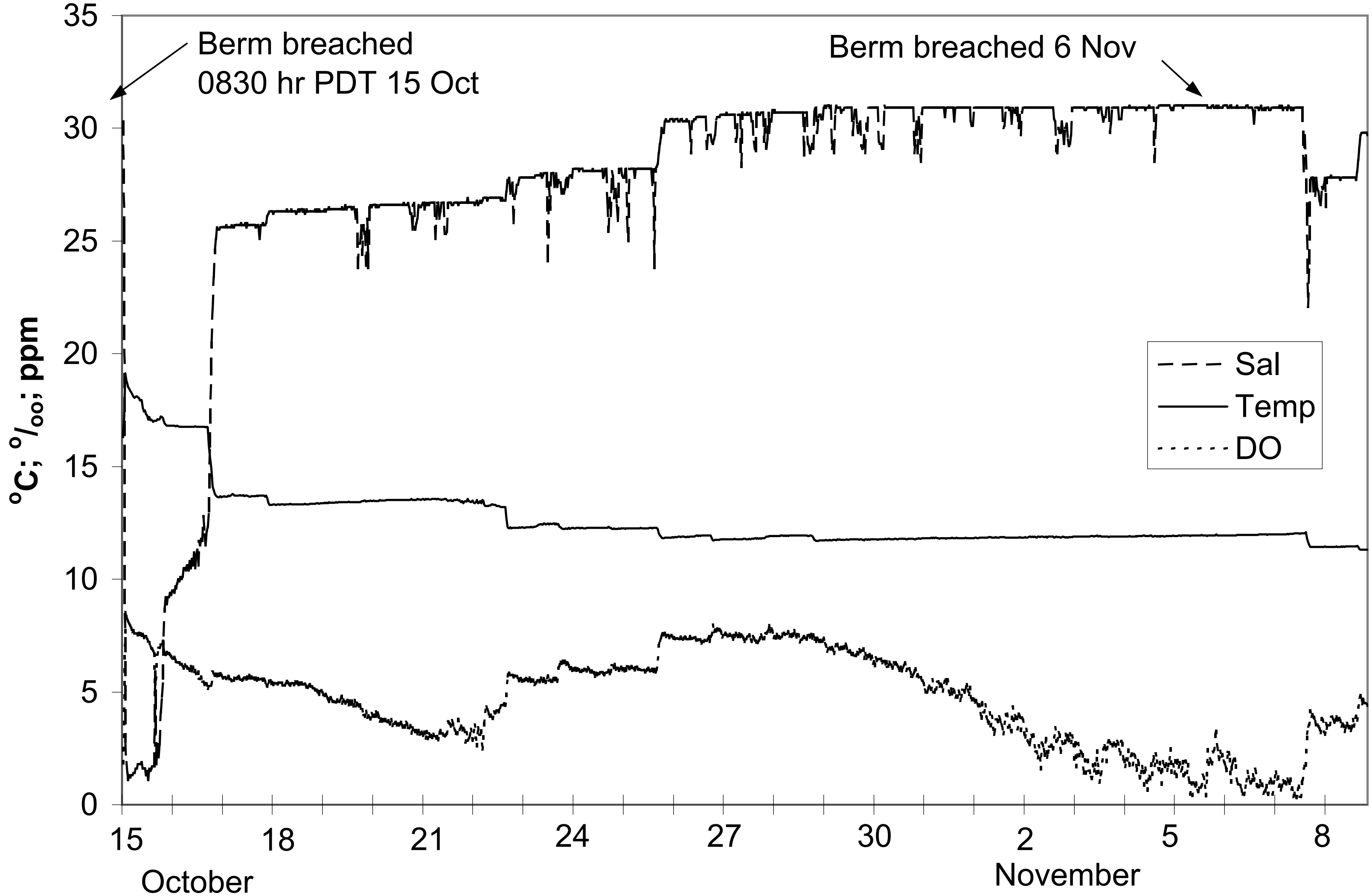
Appendix A-30.
Datasonde Record, Station 1
9 October - 9 November 1996



Appendix A-31.
Datasonde Record Station 3
9 October - 9 November 1996



Appendix A-32.
Datasonde Record Station 4
15 October - 9 November 1996



Appendix B-1. Prebreaching Otter Trawl Catch Summary, Event I, 1 July 1996

	1-Jul-96							
	Station 1 4-min tow 1530 hr PDT		Station 2 3-min tow 2025 hr PDT		Station 3 4-min tow 2000 hr PDT		Station 4 3.5 min 1915 hr PDT	
Common Name	No.	CPU	No.	CPU	No.	CPU	No.	CPU
Topsmelt								
Pacific sanddab	2	0.5						
Sacramento sucker							49	14
Green sunfish								
Bluegill								
Smallmouth bass								
Pacific herring								
Prickly sculpin	1	0.25			1	0.25		
Staghorn sculpin	16	4	8	2.667	7	1.75	12	3.429
Cabezon								
Navarro roach								
Sacramento squawfish								
Shiner surfperch								
Walleye surfperch								
Russian River tuleperch							1	0.286
Pacific tomcod								
Threespine stickleback					7	1.75		
Arrow goby			2	0.667				
Lingcod								
Surf smelt								
Hybrid sole	2	0.5	2	0.667			1	0.286
English sole			7	2.333	1	0.25	22	6.286
Starry flounder	8	2	5	1.667	1	0.25	3	0.857
Steelhead								
Bay pipefish								
Number of fish species	5		5		5		6	
Total fish	29	7.25	24	8	17	4.25	88	25.14

Invertebrates								
Crangon franciscorum			100					
Crangon nigricauda								
Neomysis mercedis			xxx		x		xxx	
Other invertebrates*					efhm		g	

Appendix B-2. Postbreaching Otter Trawl Catch Summary, Event I, 7 July 1996

	7-Jul-96							
	Station 1 4-min tow 1200 hr PDT		Station 2 2.7 min 1315 hr PDT		Station 3 2.5 min 1600 hr PDT		Station 4 2.25 min 1425 hr PDT	
Common Name	No.	CPU	No.	CPU	No.	CPU	No.	CPU
Topsmelt								
Pacific sanddab								
Sacramento sucker								
Green sunfish								
Bluegill								
Smallmouth bass								
Pacific herring								
Prickly sculpin			1	0.37	1	0.4	1	0.444
Staghorn sculpin	2	0.5	8	2.963	26	10.4		
Cabezon								
Navarro roach								
Sacramento squawfish								
Shiner surfperch								
Walleye surfperch								
Russian River tuleperch								
Pacific tomcod								
Threespine stickleback								
Arrow goby			1	0.37				
Lingcod								
Surf smelt								
Hybrid sole								
English sole								
Starry flounder			5	1.852	17	6.8	2	0.889
Steelhead								
Bay pipefish								
Number of fish species	1		4		3		2	
Total fish	2	0.5	15	5.556	44	17.6	3	1.333

Invertebrates								
Crangon franciscorum	1		55		1			
Crangon nigricauda							1	
Neomysis mercedis			xx		xx		x	
Other invertebrates*	ab						hk	

Appendix B-3. Postbreaching Otter Trawl Catch Summary, Event II, 5 August 1996

	5-Aug-96							
	Station 1 4-min tow 1200 hr PDT		Station 2 4-min tow 1300 hr PDT		Station 3 2.5 min 1400 hr PDT		Station 4 4-min tow 1440 hr PDT	
Common Name	No.	CPU	No.	CPU	No.	CPU	No.	CPU
Topsmelt								
Pacific sanddab								
Sacramento sucker					17	6.8		
Green sunfish								
Bluegill								
Smallmouth bass								
Pacific herring								
Prickly sculpin	6	1.5	2	0.5				
Staghorn sculpin					109	43.6	13	3.25
Cabezon								
Navarro roach								
Sacramento squawfish								
Shiner surfperch					3	1.2	48	12
Walleye surfperch								
Russian River tuleperch								
Pacific tomcod								
Threespine stickleback					6	2.4		
Arrow goby								
Lingcod	1	0.25						
Surf smelt								
Hybrid sole								
English sole	1	0.25			1	0.4		
Starry flounder	1	0.25			17	6.8	9	2.25
Steelhead								
Bay pipefish					2	0.8	1	0.25
Number of fish species	4		1		7		4	
Total fish	9	2.25	2	0.5	155	62	71	17.75

Invertebrates								
Crangon franciscorum	x		27		13		5	
Crangon nigricauda	x				1		14	
Neomysis mercedis			x		xxx			
Other invertebrates*			i		fi		i	

Appendix B-4. Prebreaching Otter Trawl Catch Summary, Event V, 18 September 1996

	18-Sep-96							
	Station 1 4-min tow 1100 hr PDT		Station 2 3.5 min 1245 hr PDT		Station 3 3.5 min 1400 hr PDT		Station 4 4-min tow 1515 hr PDT	
Common Name	No.	CPU	No.	CPU	No.	CPU	No.	CPU
Topsmelt								
Pacific sanddab	1	0.25						
Sacramento sucker					2	0.571		
Green sunfish					1	0.286		
Bluegill								
Smallmouth bass								
Pacific herring								
Prickly sculpin	8	2	6	1.714	125	35.71	4	1
Staghorn sculpin	4	1			1	0.286		
Cabezon	1	0.25						
Navarro roach								
Sacramento squawfish								
Shiner surfperch					1	0.286		
Walleye surfperch								
Russian River tuleperch								
Pacific tomcod	3	0.75						
Threespine stickleback					60	17.14	4	1
Arrow goby								
Lingcod								
Surf smelt								
Hybrid sole								
English sole	3	0.75			1	0.286		
Starry flounder	5	1.25	3	0.857			1	0.25
Steelhead								
Bay pipefish	1	0.25			2	0.571		
Number of fish species	8		2		8		3	
Total fish	26	6.5	9	2.571	193	55.14	9	2.25

Invertebrates								
Crangon franciscorum	135		6		3		3	
Crangon nigricauda					1			
Neomysis mercedis			x		xxx			
Other invertebrates*	djl						g	

Appendix B-5. Postbreaching Otter Trawl Catch Summary, Event V, 27 September 1996

	27-Sep-96							
	Station 1 4-min tow 0915 hr PDT		Station 2 4-min tow 2025 hr PDT		Station 3 1:45 min 2000 hr PDT		Station 4 4-min tow 1240 hr PDT	
Common Name	No.	CPU	No.	CPU	No.	CPU	No.	CPU
Topsmelt								
Pacific sanddab								
Sacramento sucker								
Green sunfish								
Bluegill								
Smallmouth bass								
Pacific herring								
Prickly sculpin	4	1	2	0.5	118	67.43	3	0.75
Staghorn sculpin	12	3	1	0.25				
Cabezon								
Navarro roach								
Sacramento squawfish								
Shiner surfperch	29	7.25						
Walleye surfperch	1	0.25						
Russian River tuleperch								
Pacific tomcod	8	2					1	0.25
Threespine stickleback					3	1.714		
Arrow goby								
Lingcod								
Surf smelt	1	0.25						
Hybrid sole								
English sole	1	0.25						
Starry flounder	1	0.25	1	0.25	7	4	1	0.25
Steelhead								
Bay pipefish			1	0.25	4	2.286	1	0.25
Number of fish species	8		4		4		4	
Total fish	57	14.25	5	1.25	132	75.43	6	1.5

Invertebrates								
Crangon franciscorum	11		2		3		28	
Crangon nigricauda	1							
Neomysis mercedis					xx			
Other invertebrates*	dl							

Appendix B-6. Prebreaching Otter Trawl Catch Summary, Event VI, 9-10 October 1996

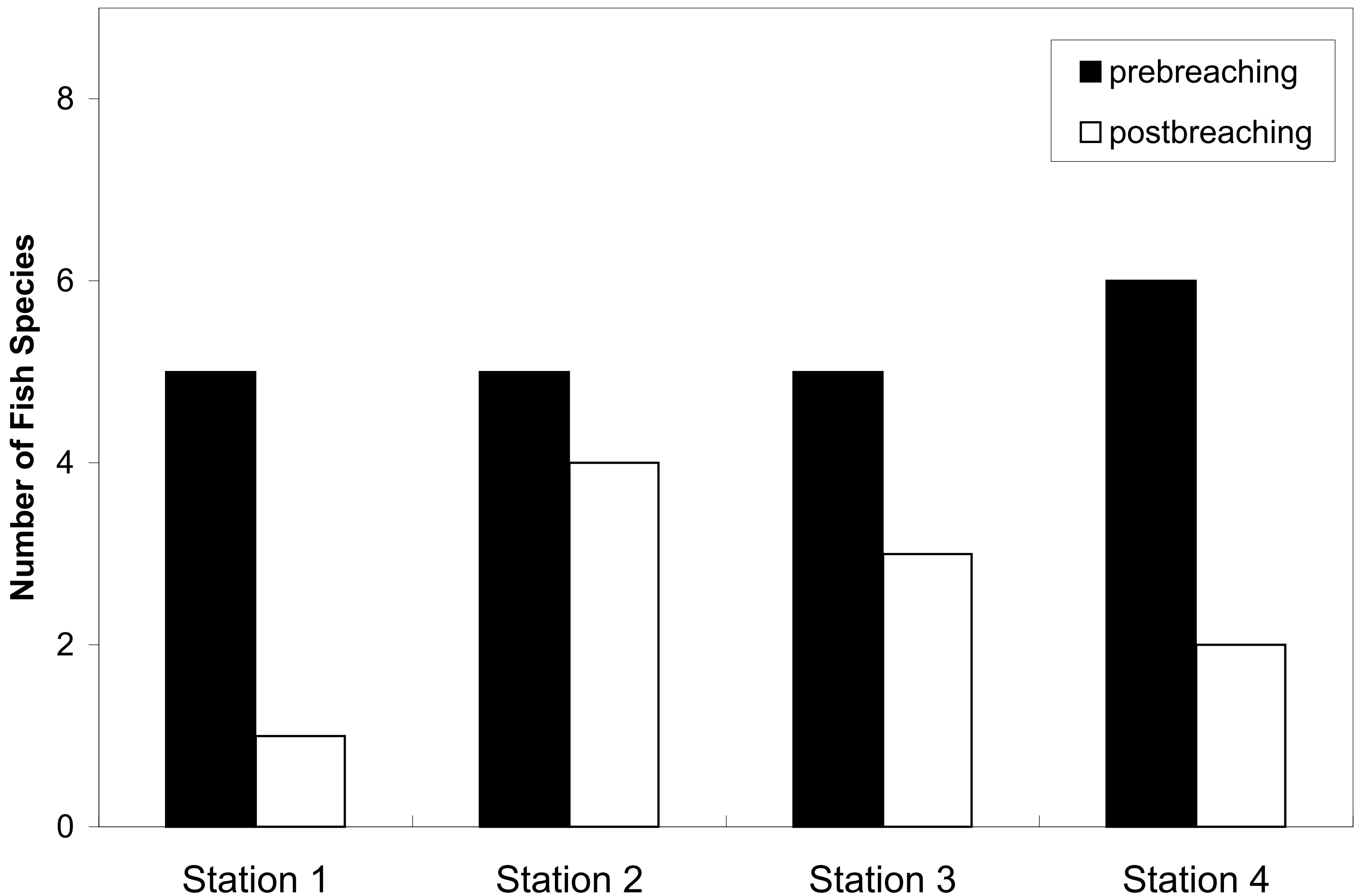
	9-10-Oct-96							
	Station 1 4-min tow 9-Oct 1555 hr PDT		Station 2 4-min tow 9-Oct 1630 hr PDT		Station 3 4-min tow 10-Oct 1130 hr PDT		Station 4 4-min tow 10-Oct 1230 hr PDT	
Common Name	No.	CPU	No.	CPU	No.	CPU	No.	CPU
Topsmelt								
Pacific sanddab	7	1.75						
Sacramento sucker								
Green sunfish								
Bluegill								
Smallmouth bass								
Pacific herring								
Prickly sculpin			1	0.25	3	0.75	5	1.25
Staghorn sculpin			1	0.25				
Cabezon								
Navarro roach								
Sacramento squawfish								
Shiner surfperch							5	1.25
Walleye surfperch								
Russian River tuleperch								
Pacific tomcod			1	0.25				
Threespine stickleback								
Arrow goby								
Lingcod								
Surf smelt	35	8.75	5	1.25				
Hybrid sole								
English sole	2	0.5						
Starry flounder	7	1.75	7	1.75	4	1	3	0.75
Steelhead								
Bay pipefish							3	0.75
Number of fish species	4		5		2		4	
Total fish	51	12.75	15	3.75	7	1.75	16	4
Invertebrates								
Crangon franciscorum	65		130		72		90	
Crangon nigricauda			1		1		5	
Neomysis mercedis	x				x			
Other invertebrates*								

Appendix B-7. Postbreaching Otter Trawl Catch Summary, Event VI, 16 October 1996

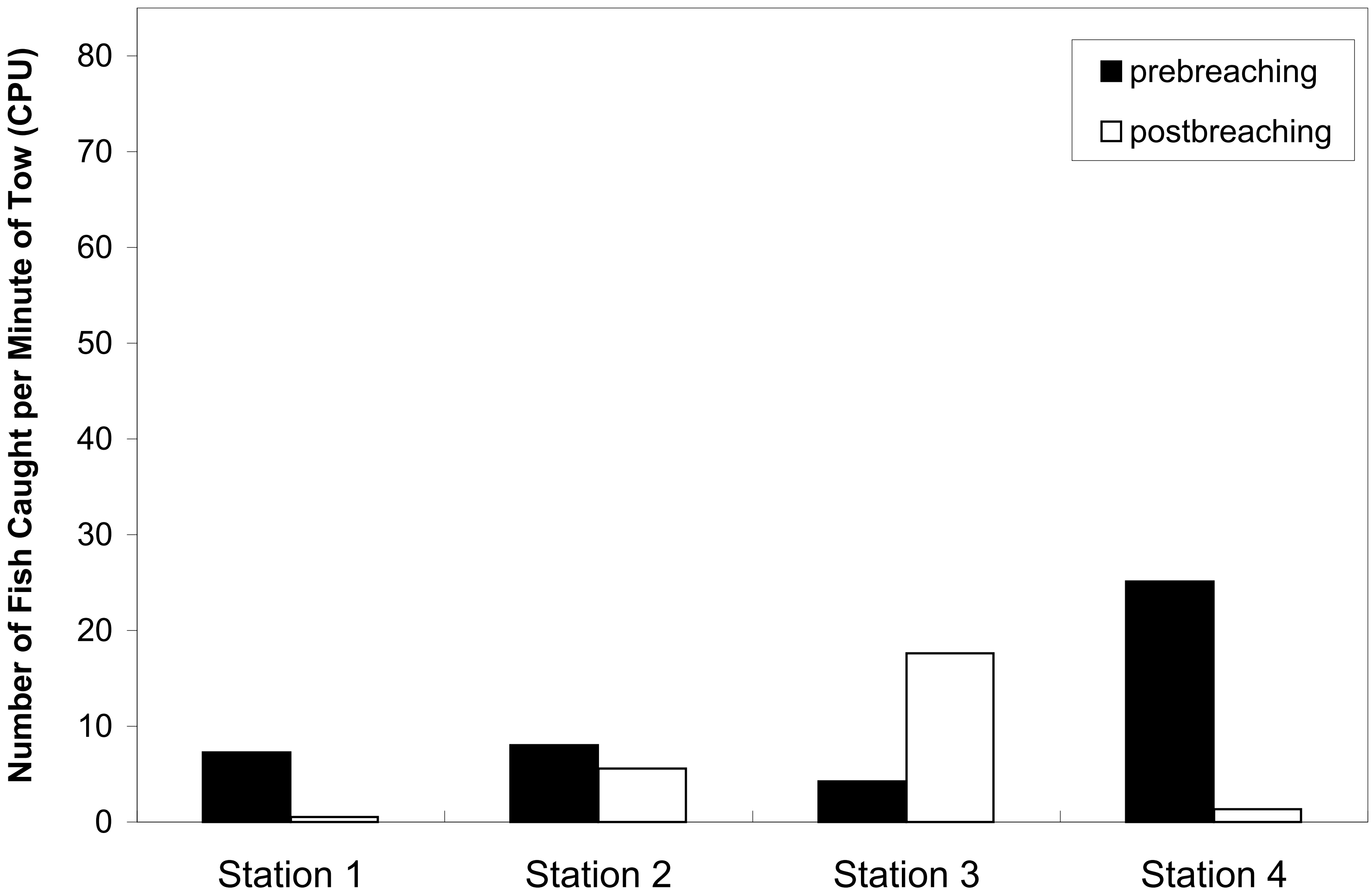
	16-Oct-06							
	Station 1 4-min tow 1445 hr PDT		Station 2 4-min tow 1400 hr PDT		Station 3 2-min tow 1300 hr PDT		Station 4 4-min tow 1135 hr PDT	
Common Name	No.	CPU	No.	CPU	No.	CPU	No.	CPU
Topsmelt								
Pacific sanddab	2	0.5						
Sacramento sucker							1	0.25
Green sunfish								
Bluegill								
Smallmouth bass								
Pacific herring								
Prickly sculpin	15	3.75	5	1.25	14	7	7	1.75
Staghorn sculpin								
Cabezon								
Navarro roach								
Sacramento squawfish								
Shiner surfperch								
Walleye surfperch								
Russian River tuleperch								
Pacific tomcod								
Threespine stickleback							28	7
Arrow goby								
Lingcod								
Surf smelt								
Hybrid sole								
English sole								
Starry flounder	1	0.25	1	0.25	1	0.5	2	0.5
Steelhead								
Bay pipefish	4	1						
Number of fish species	4		2		2		4	
Total fish	22	5.5	6	1.5	15	7.5	38	9.5

Invertebrates								
Crangon franciscorum	87		160		22		7	
Crangon nigricauda	1							
Neomysis mercedis	xxx		xx		x			
Other invertebrates*	c		i					

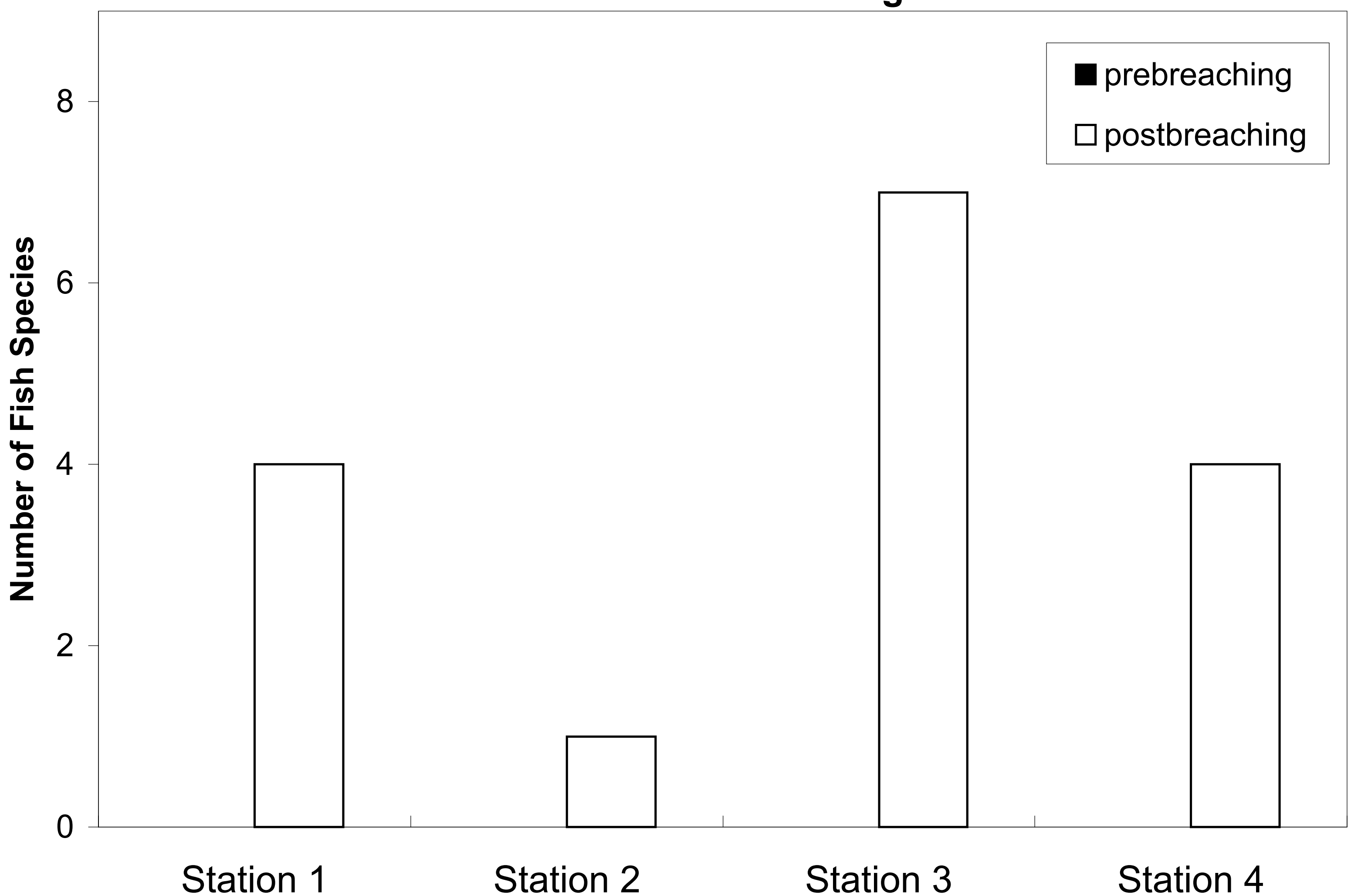
Appendix B-8
Number of Fish Species in Otter Trawls
Event I--Breached 5 July 1996

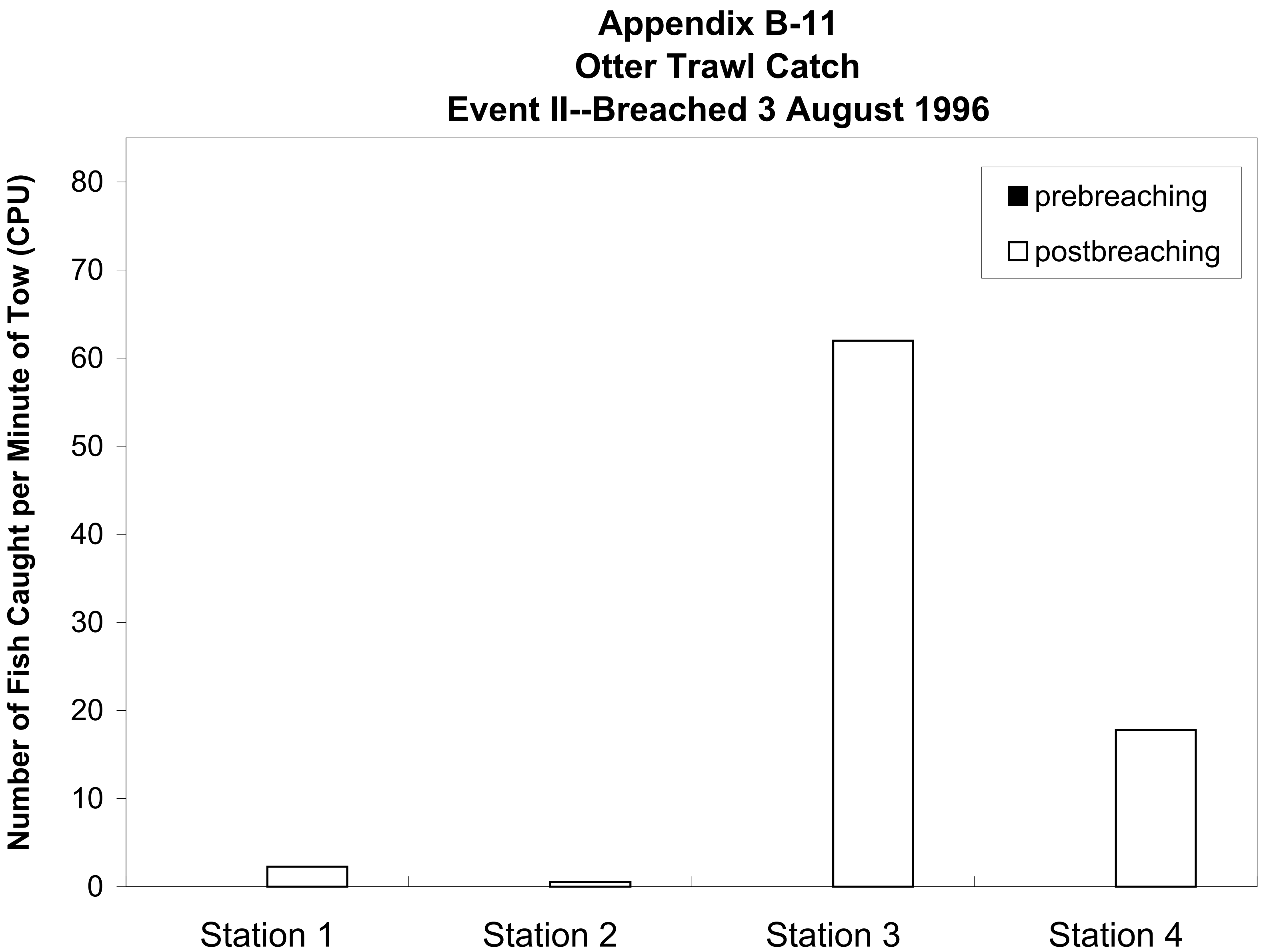


Appendix B-9
Otter Trawl Catch
Event I--Breached 5 July 1996

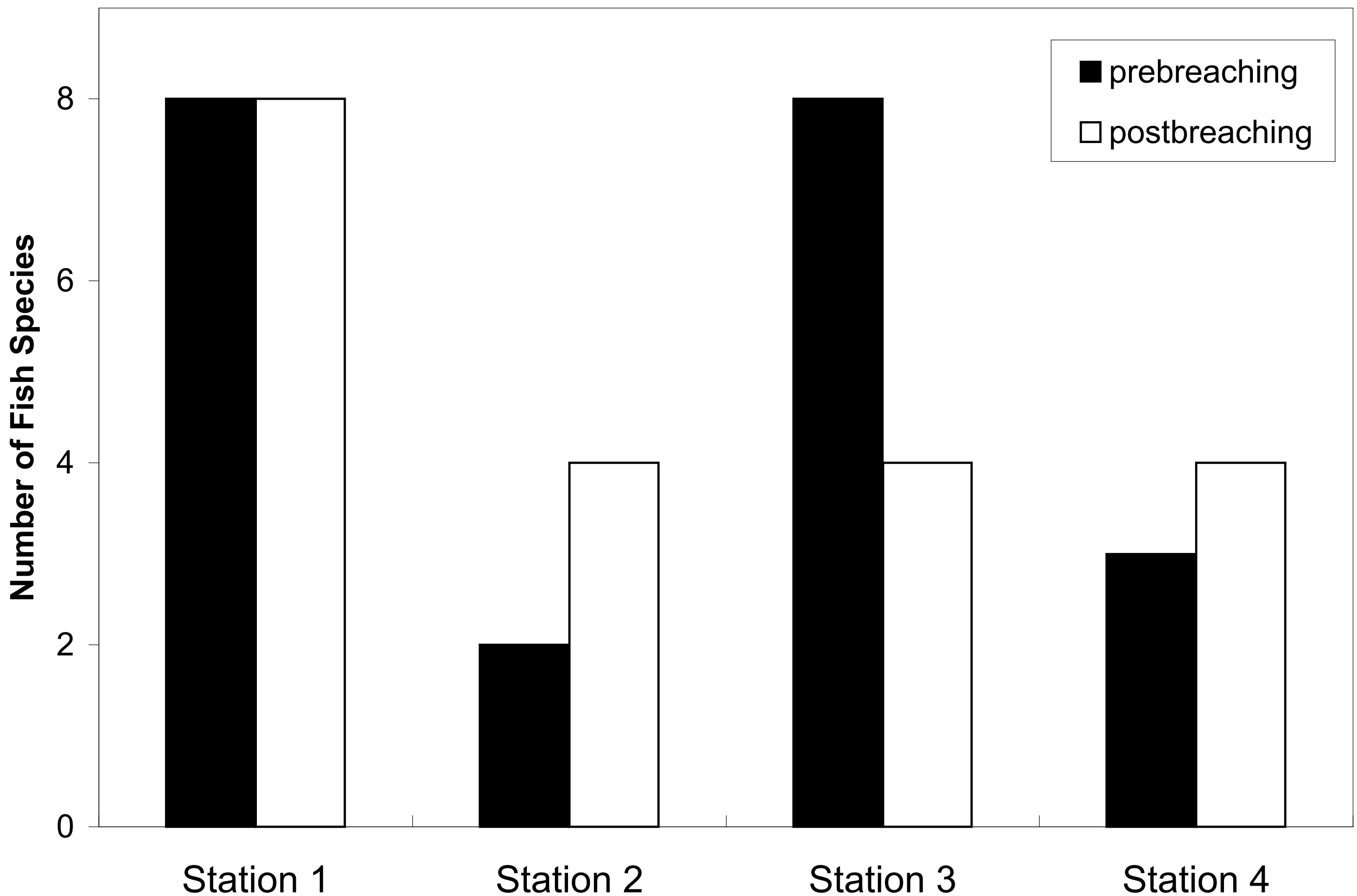


Appendix B-10
Number of Fish Species in Otter Trawls
Event II--Breached 3 August 1996

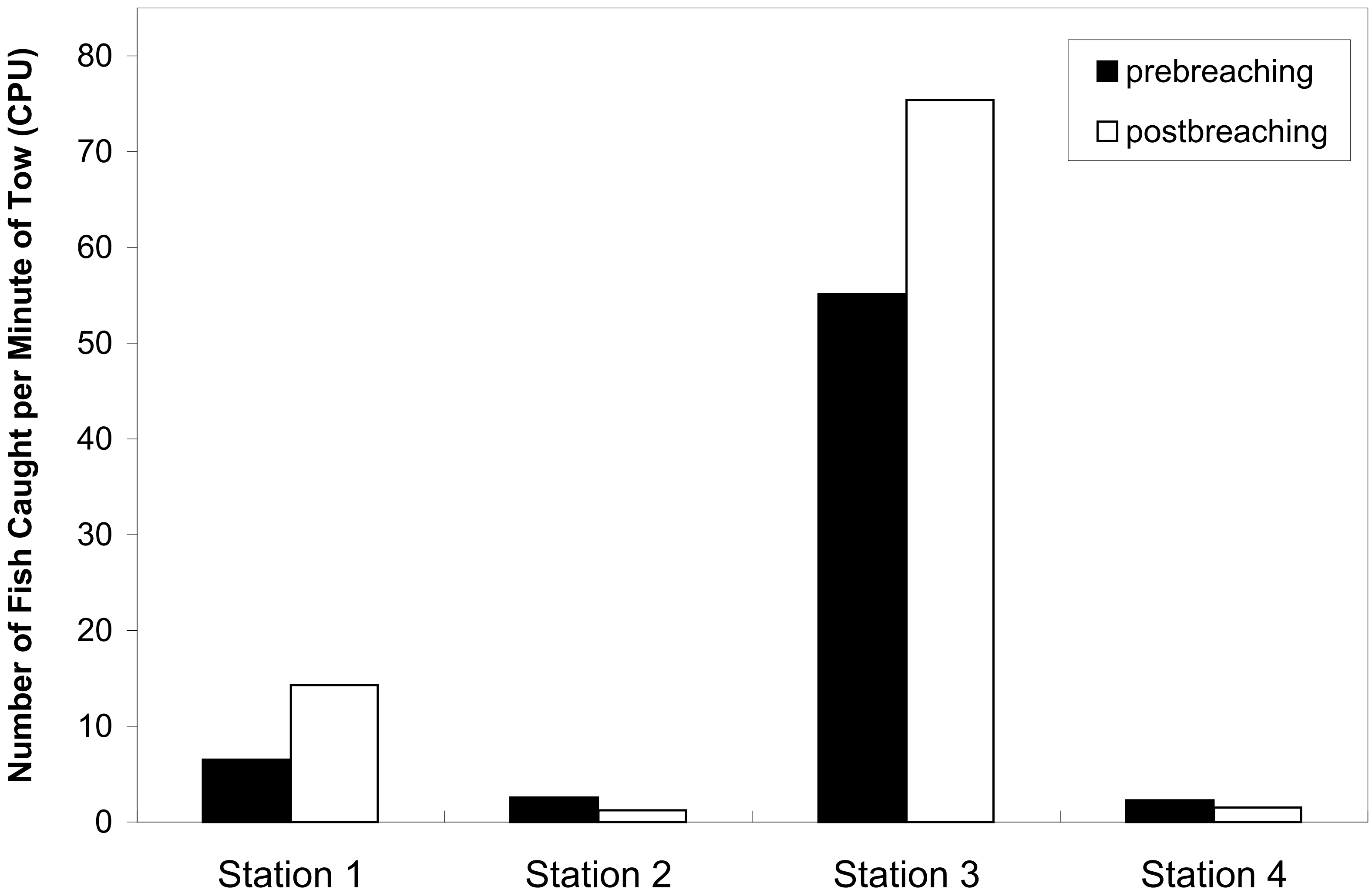



Appendix B-11
Otter Trawl Catch
Event II--Breached 3 August 1996
Number of Fish Caught per Minute of Tow (CPU)
0
10
20
30
40
50
60
70
80
prebreaching
postbreaching
Station 1
Station 2
Station 3
Station 4

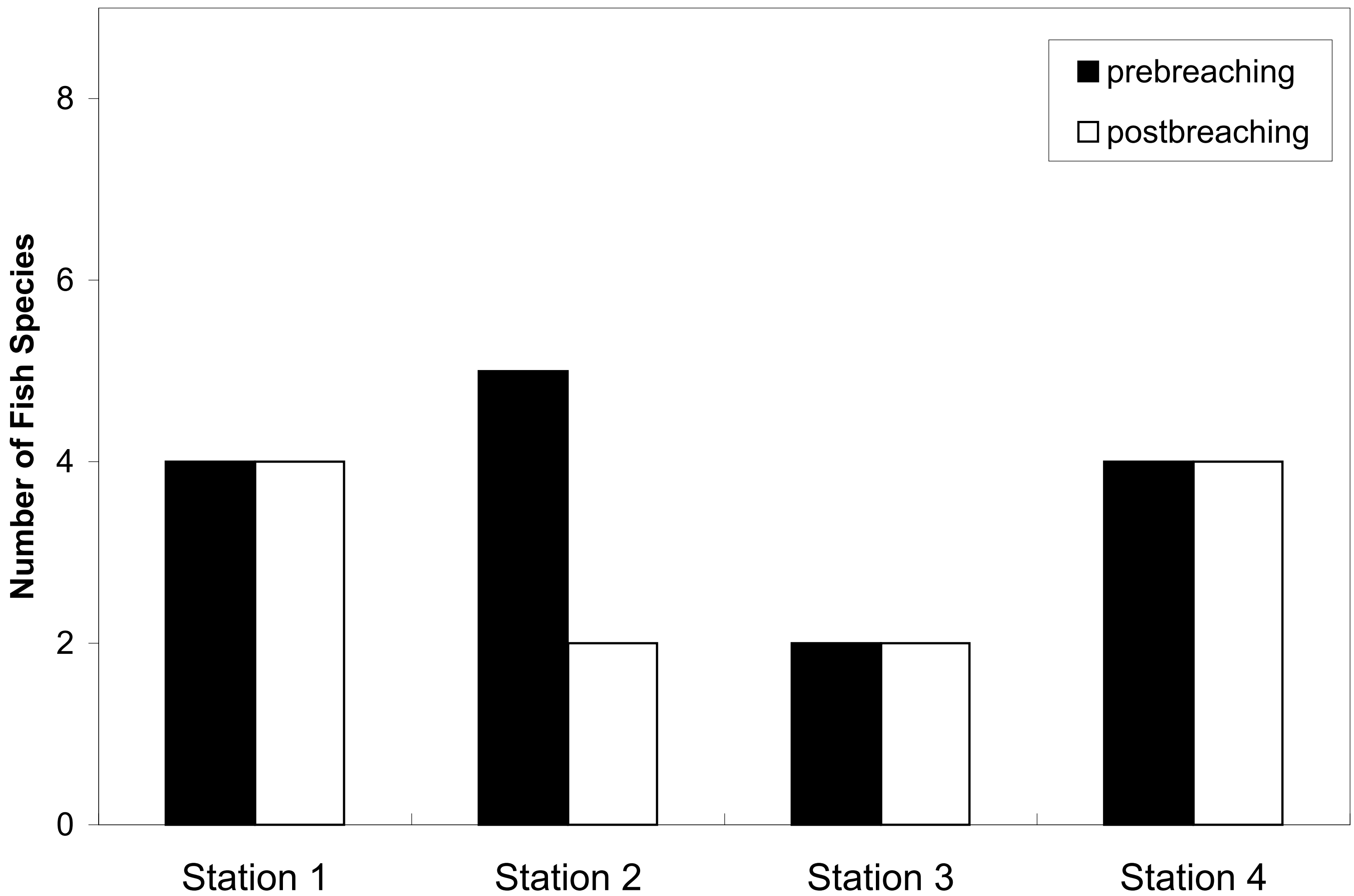
Appendix B-12
Number of Fish Species in Otter Trawls
Event V--Breached 26 September 1996



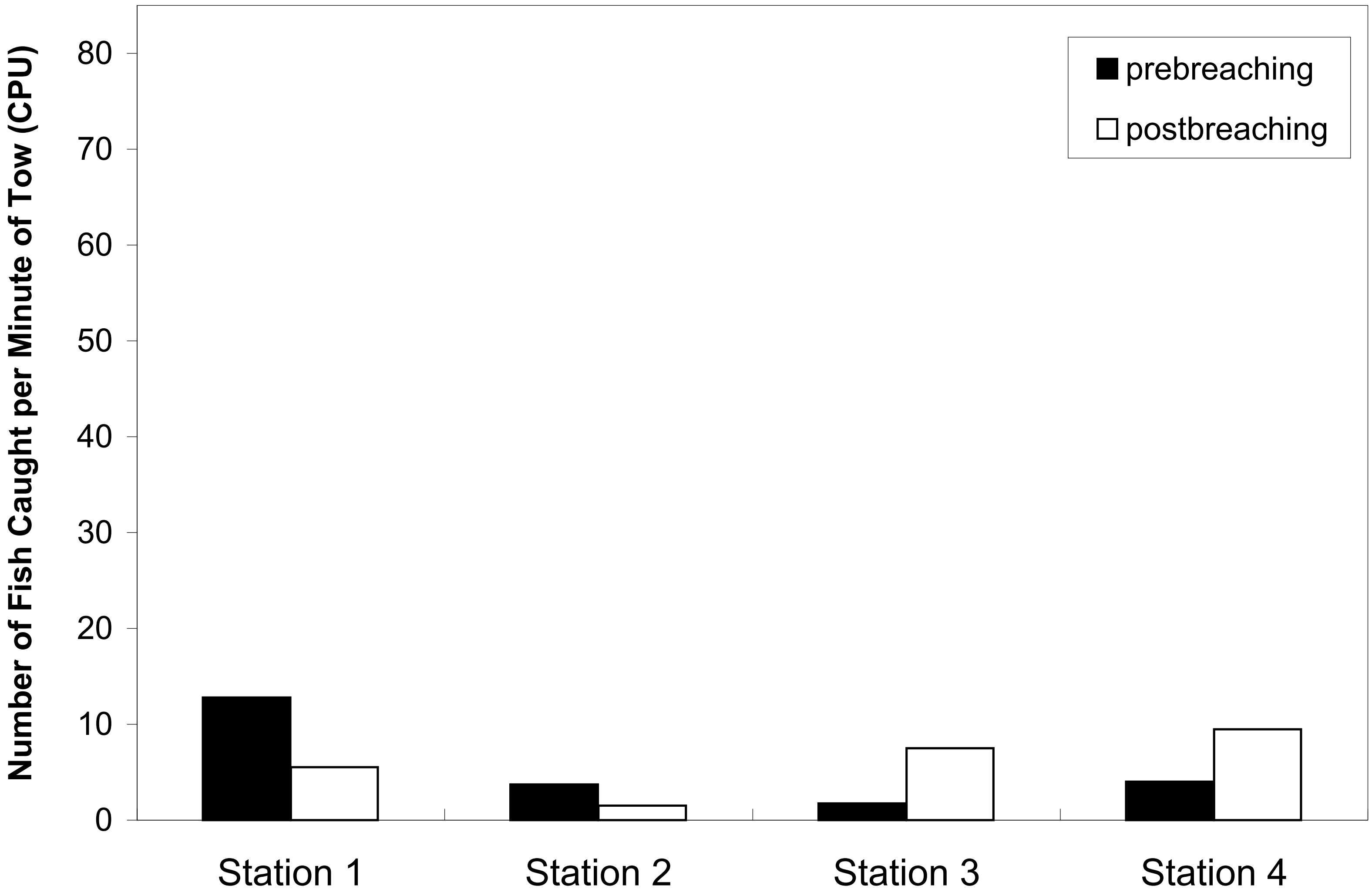
Appendix B-13
Otter Trawl Catch
Event V--Breached 26 September 1996



Appendix B-14
Number of Fish Species in Otter Trawls
Event VI--Breached 15 October 1996



Appendix B-15
Otter Trawl Catch
Event VI--Breached 15 October 1996



Appendix B-16. Postbreaching Beach Seine Catch Summary, Event I, 7 July 1996

	7-Jul-96			
	Stn 1 1225 hr PDT	Stn 2 1400 hr PDT	Stn 3 1630 hr PDT	Stn 4 1515 hr PDT
Topsmelt				
Pacific sanddab				
Sacramento sucker				
Green sunfish				
Bluegill				
Smallmouth bass				
Pacific herring				
Prickly sculpin				
Staghorn sculpin	4			
Cabezon				
Navarro roach				
Sacramento squawfish				
Shiner surfperch	1	1		
Walleye surfperch				
Russian River tuleperch			1	
Pacific tomcod				
Threespine stickleback				
Arrow goby				
Lingcod				
Surf smelt			1	
Hybrid sole				
English sole				
Starry flounder	6	2		1
Steelhead			9	4
Bay pipefish				
Number of fish species	3	2	3	2
Total fish	11	3	11	5

Appendix B-17. Postbreaching Beach Seine Catch Summary, Event II, 5 August 1996

	5-Aug-96			
	Stn 1 1725 hr PDT	Stn 2 1650 hr PDT	Stn 3 1615 hr PDT	Stn 4 1545 hr PDT
Topsmelt				
Pacific sanddab				
Sacramento sucker				37
Green sunfish				
Bluegill				
Smallmouth bass				
Pacific herring				25
Prickly sculpin				
Staghorn sculpin	2			1
Cabezon				
Navarro roach				
Sacramento squawfish				
Shiner surfperch		6	3	7
Walleye surfperch				
Russian River tuleperch			1	
Pacific cod				
Threespine stickleback			9	1
Arrow goby				
Lingcod				
Surf smelt	4			
Hybrid sole				
English sole				1
Starry flounder			1	10
Steelhead		4	2	
Bay pipefish				
Number of fish species	2	2	5	7
Total fish	6	10	16	82

Apppendix B-18. Prebreaching Beach Seine Catch Summary, Event V, 18 September 1996

	18-Sep-96			
	Stn 1 1130 hr PDT	Stn 2 no seine	Stn 3 1415 hr PDT	Stn 4 1530 hr PDT
Topsmelt				
Pacific sanddab				
Sacramento sucker			1	1
Green sunfish				
Bluegill				
Smallmouth bass				
Pacific herring				
Prickly sculpin				
Staghorn sculpin				
Cabezon				
Navarro roach				
Sacramento squawfish				
Shiner surfperch				
Walleye surfperch				
Russian River tuleperch				
Pacific tomcod				
Threespine stickleback				
Arrow goby				
Lingcod				
Surf smelt				
Hybrid sole				
English sole				
Starry flounder				
Steelhead				
Bay pipefish				
Number of fish species	0		1	1
Total fish	0		1	1

Appendix B-19. Postbreaching Beach Seine Catch Summary, Event V, 27 September 1996

	27-Sep-96			
	Stn 1 1000 hr PDT	Stn 2 1030 hr PDT	Stn 3 1100 hr PDT	Stn 4 1120 hr PDT
Topsmelt				
Pacific sanddab				
Sacramento sucker		1		6
Green sunfish				
Bluegill				
Smallmouth bass				
Pacific herring				
Prickly sculpin	2			
Staghorn sculpin				
Cabezon				
Navarro roach				
Sacramento squawfish			1	
Shiner surfperch				
Walleye surfperch				
Russian River tuleperch				
Pacific tomcod				
Threespine stickleback		1	1	
Arrow goby				
Lingcod				
Surf smelt				
Hybrid sole				
English sole				
Starry flounder				
Steelhead	1			
Bay pipefish	1			
Number of fish species	3	2	2	1
Total fish	4	2	2	6

Appendix B-20. Prebreaching Beach Seine Catch Summary, Event VI, 9 October 1996

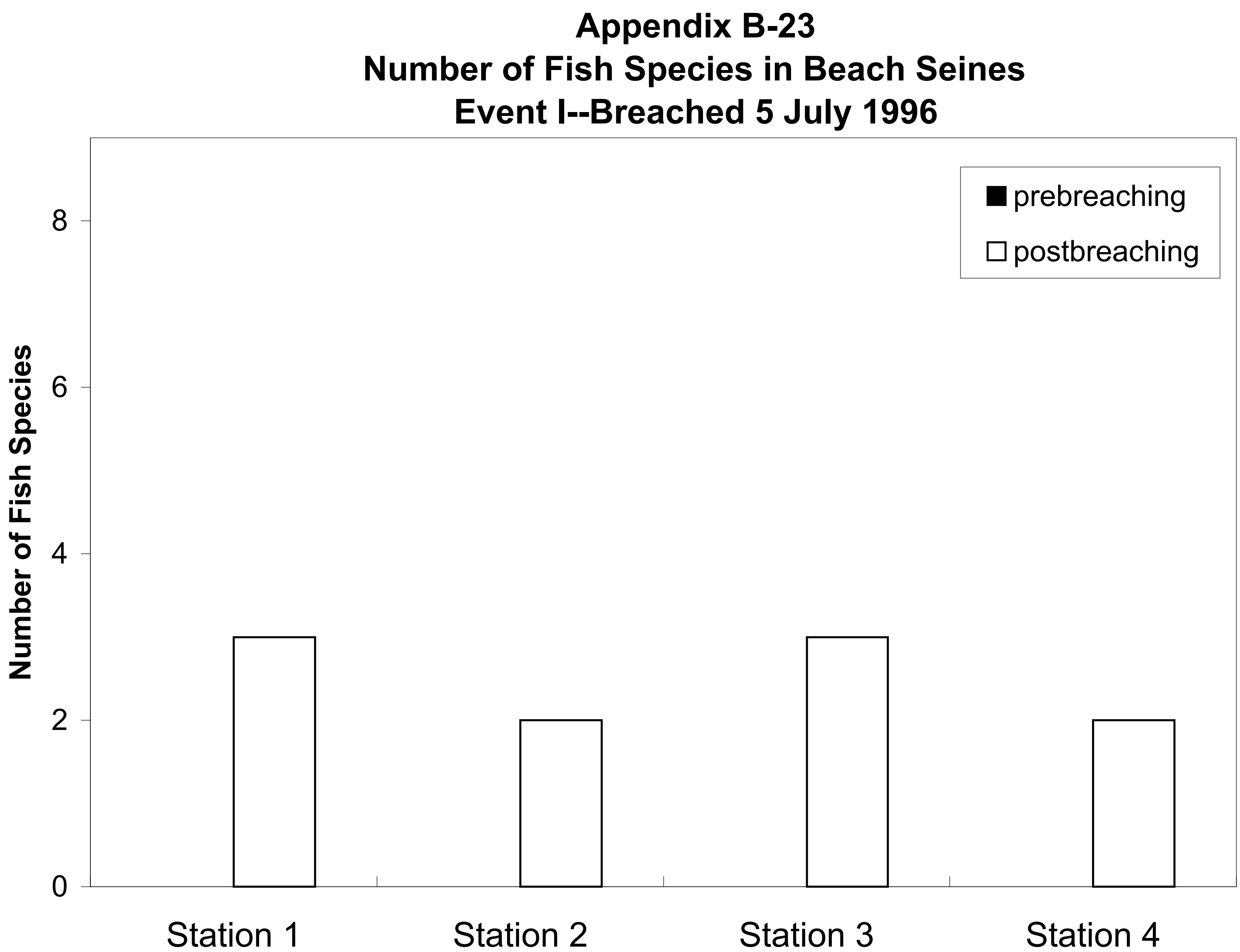
	9-Oct-96			
	Stn 1 1520 hr PDT	Stn 2 no seine	Stn 3 1730 hr PDT	Stn 4 1800 hr PDT
Topsmelt				
Pacific sanddab				
Sacramento sucker				
Green sunfish				
Bluegill				
Smallmouth bass				
Pacific herring				
Prickly sculpin				
Staghorn sculpin				
Cabezon				
Navarro roach				
Sacramento squawfish				
Shiner surfperch				
Walleye surfperch				
Russian River tuleperch				
Pacific tomcod				
Threespine stickleback				1
Arrow goby				
Lingcod				
Surf smelt				
Hybrid sole				
English sole				
Starry flounder			1	
Steelhead	1		7	1
Bay pipefish				
Number of fish species	1		2	2
Total fish	1		8	2

Appendix B-21. Postbreaching Beach Seine Catch Summary, Event VI, 16 October 1996

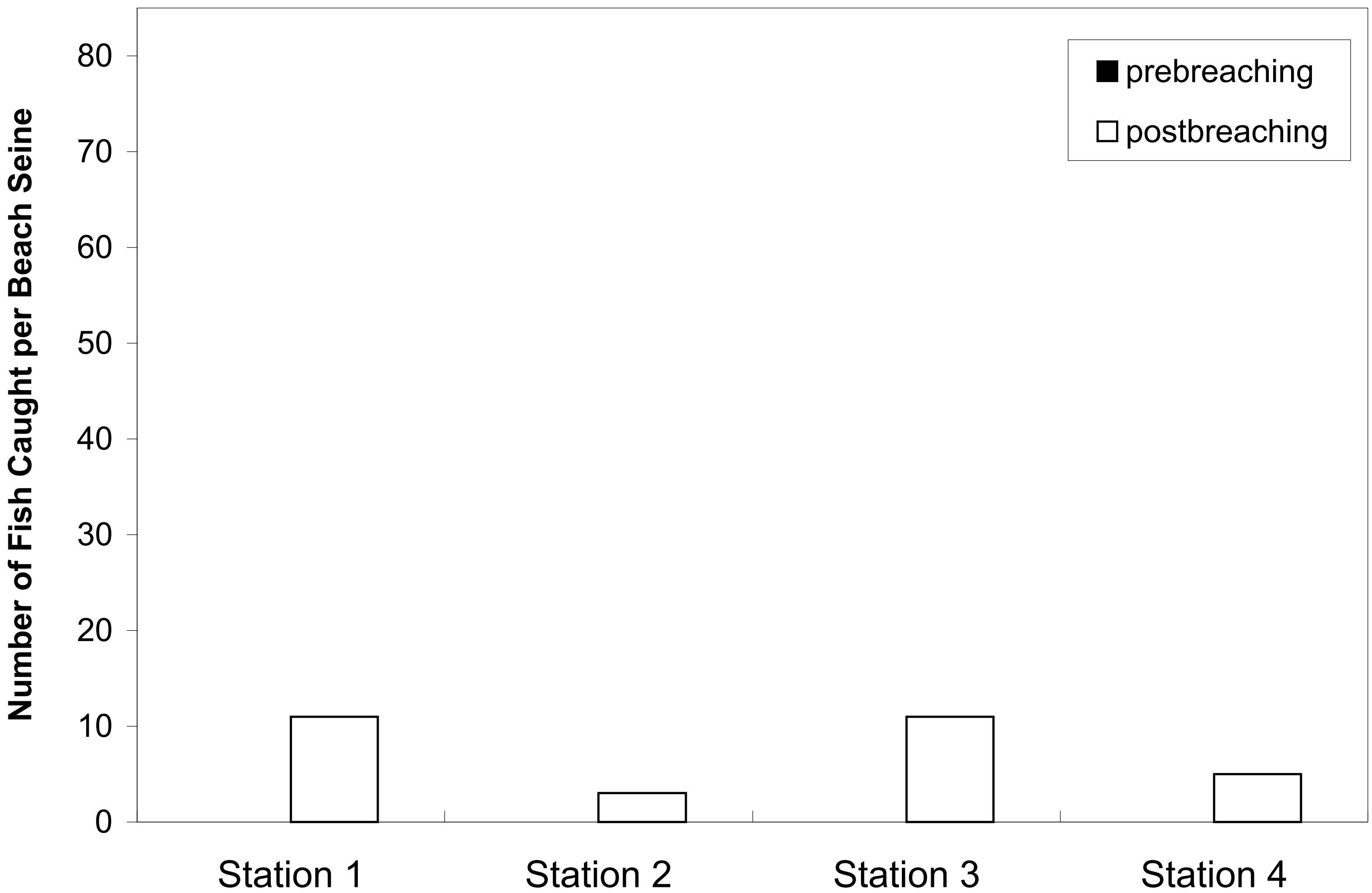
	16-Oct-96			
	Stn 1 0820 hr PDT	Stn 2 0930 hr PDT	Stn 3 1000 hr PDT	Stn 4 1055 hr PDT
Topsmelt				
Pacific sanddab				
Sacramento sucker		1	14	
Green sunfish				
Bluegill		3		1
Smallmouth bass				1
Pacific herring				
Prickly sculpin		3		8
Staghorn sculpin				
Cabezon				
Navarro roach				
Sacramento squawfish			4	
Shiner surfperch				
Walleye surfperch				
Russian River tuleperch				
Pacific tomcod				
Threespine stickleback			14	
Arrow goby				
Lingcod				
Surf smelt		16	12	
Hybrid sole				
English sole				
Starry flounder			1	1
Steelhead	1	1		
Bay pipefish	3	4		
Number of fish species	2	6	5	4
Total fish	4	28	45	11

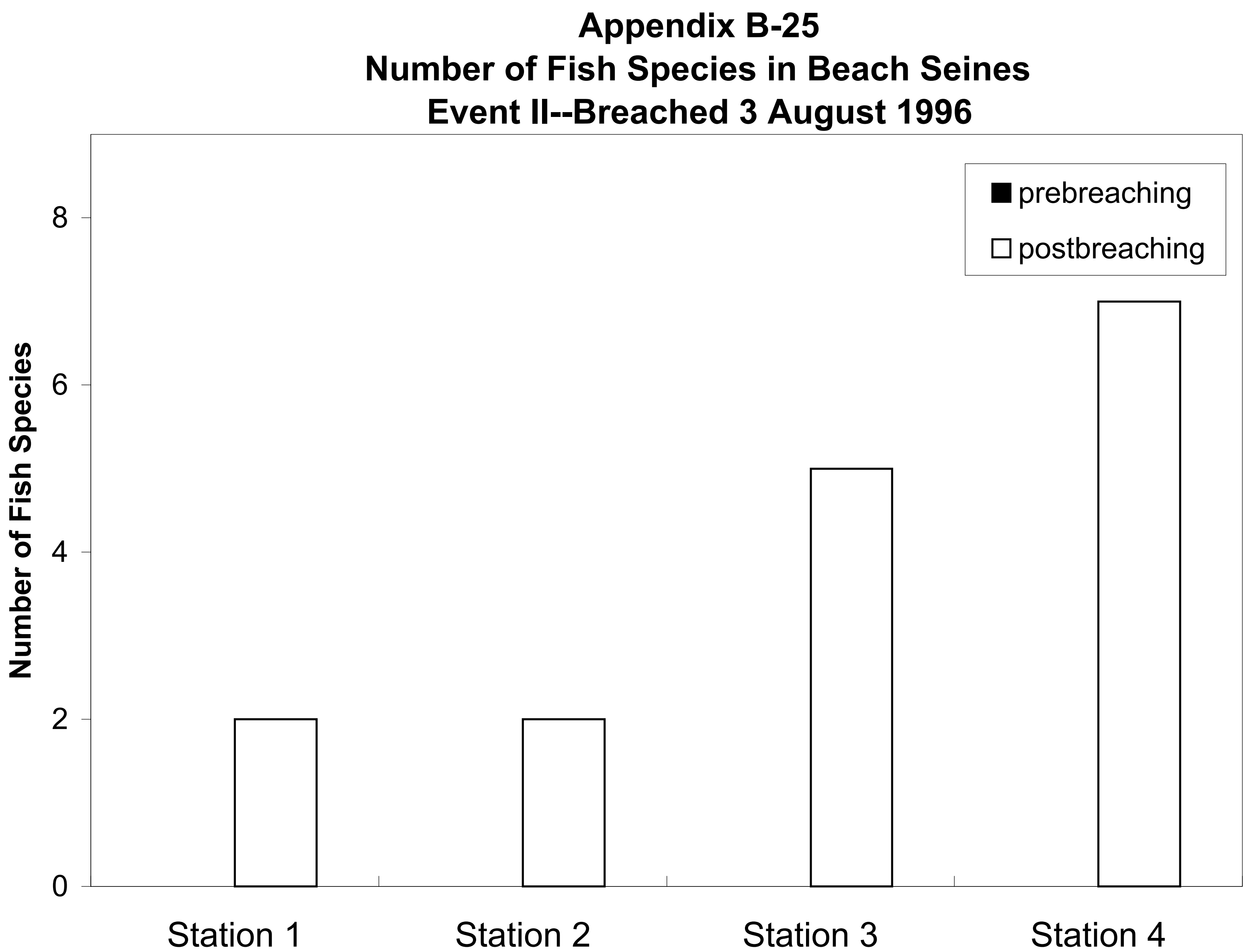
Appendix B-22. Postbreaching Beach Seine Catch Summary, Event VII, 9 November 1996

	9-Nov-96			
	Stn 1 1400 hr PST	Stn 2 1620 hr PST	Stn 3 1545 hr PST	Stn 4 1500 hr PST
Topsmelt	205			
Pacific sanddab				
Sacramento sucker				
Green sunfish				
Bluegill				
Smallmouth bass				
Pacific herring				
Prickly sculpin		6		1
Staghorn sculpin				
Cabezon				
Navarro roach				2
Sacramento squawfish				
Shiner surfperch				
Walleye surfperch				
Russian River tuleperch				
Pacific tomcod				
Threespine stickleback		2		50
Arrow goby				
Lingcod				
Surf smelt				
Hybrid sole				
English sole				
Starry flounder		1		
Steelhead			2	
Bay pipefish				
Number of fish species	1	3	1	3
Total fish	205	9	2	53


Appendix B-23
Number of Fish Species in Beach Seines
Event I--Breached 5 July 1996
prebreaching
postbreaching
Number of Fish Species
0
2
4
6
8
Station 1
Station 2
Station 3
Station 4

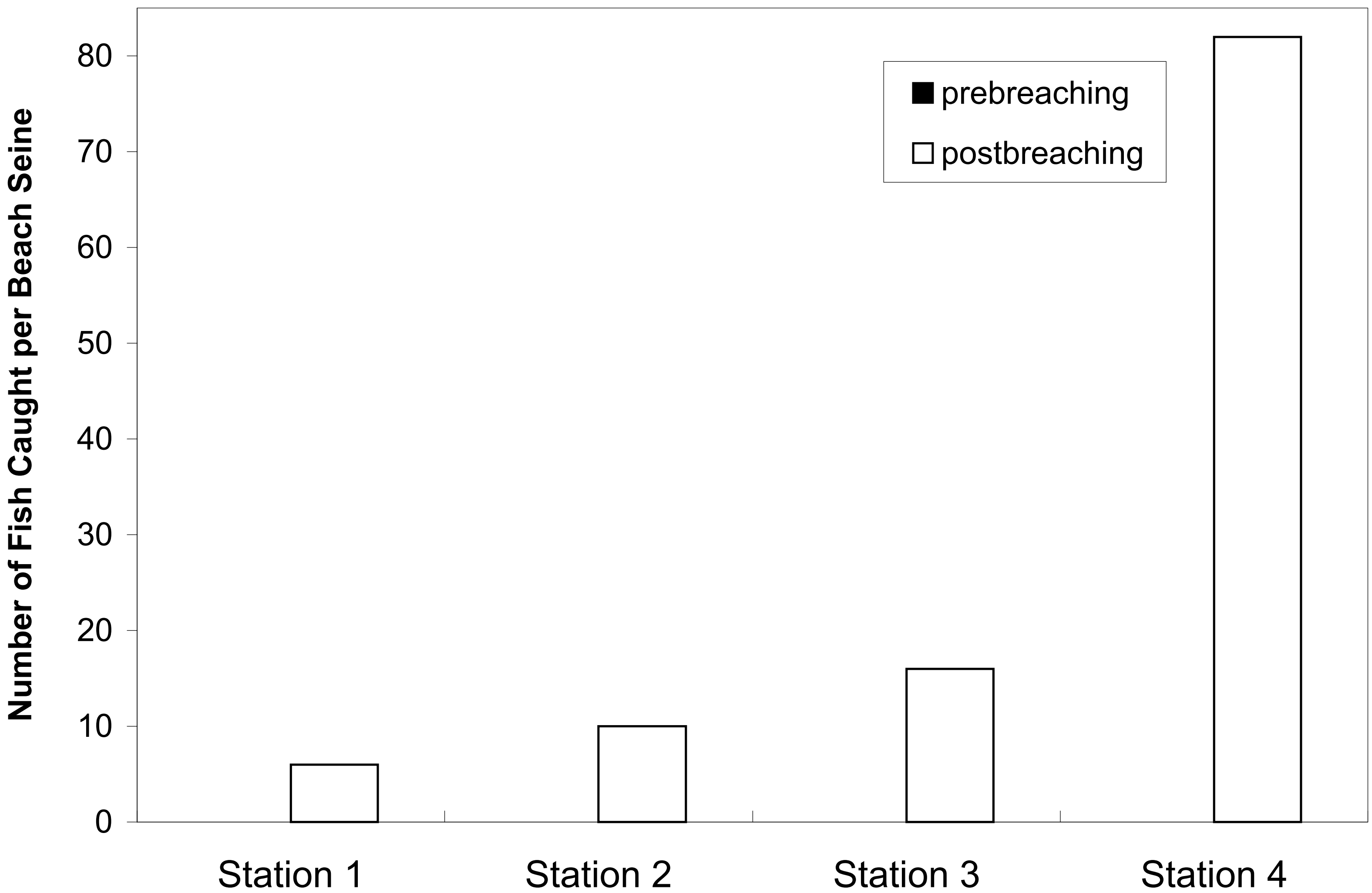
Appendix B-24
Beach Seine Catch
Event I--Breached 5 July 1996



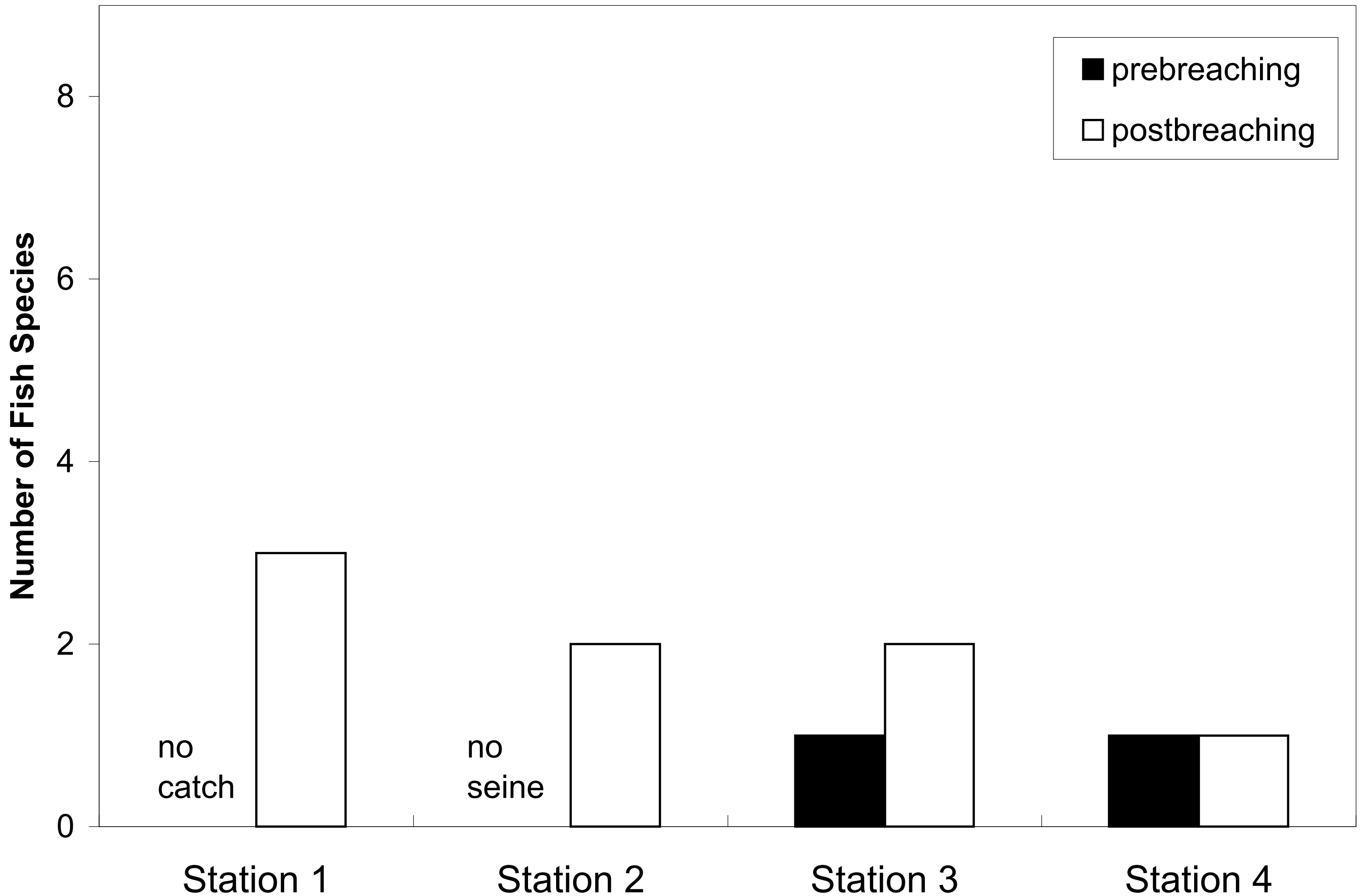


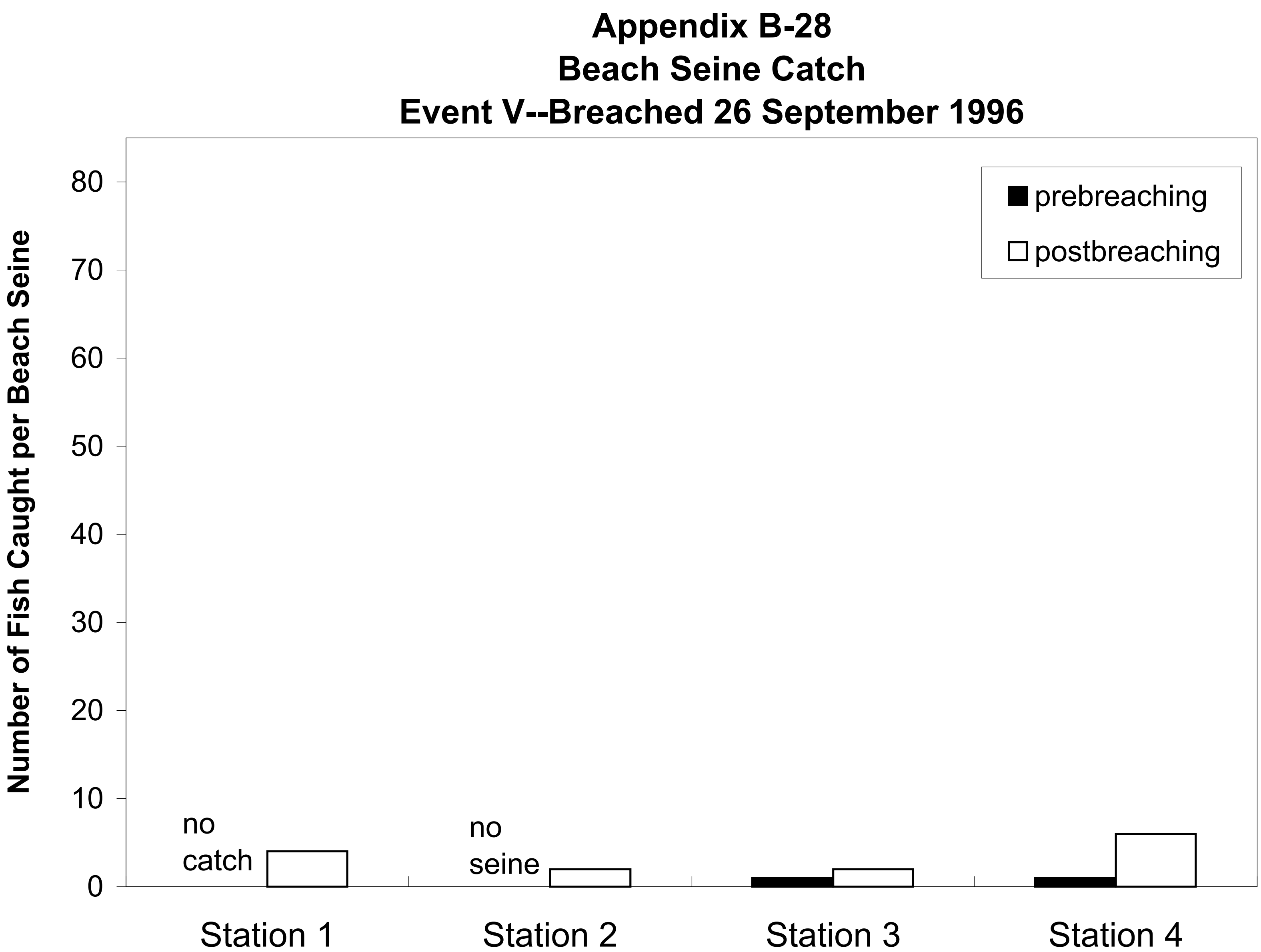
Appendix B-25
Number of Fish Species in Beach Seines
Event II--Breached 3 August 1996
prebreaching
postbreaching
Number of Fish Species
0
2
4
6
8
Station 1
Station 2
Station 3
Station 4

Appendix B-26
Beach Seine Catch
Event II--Breached 3 August 1996

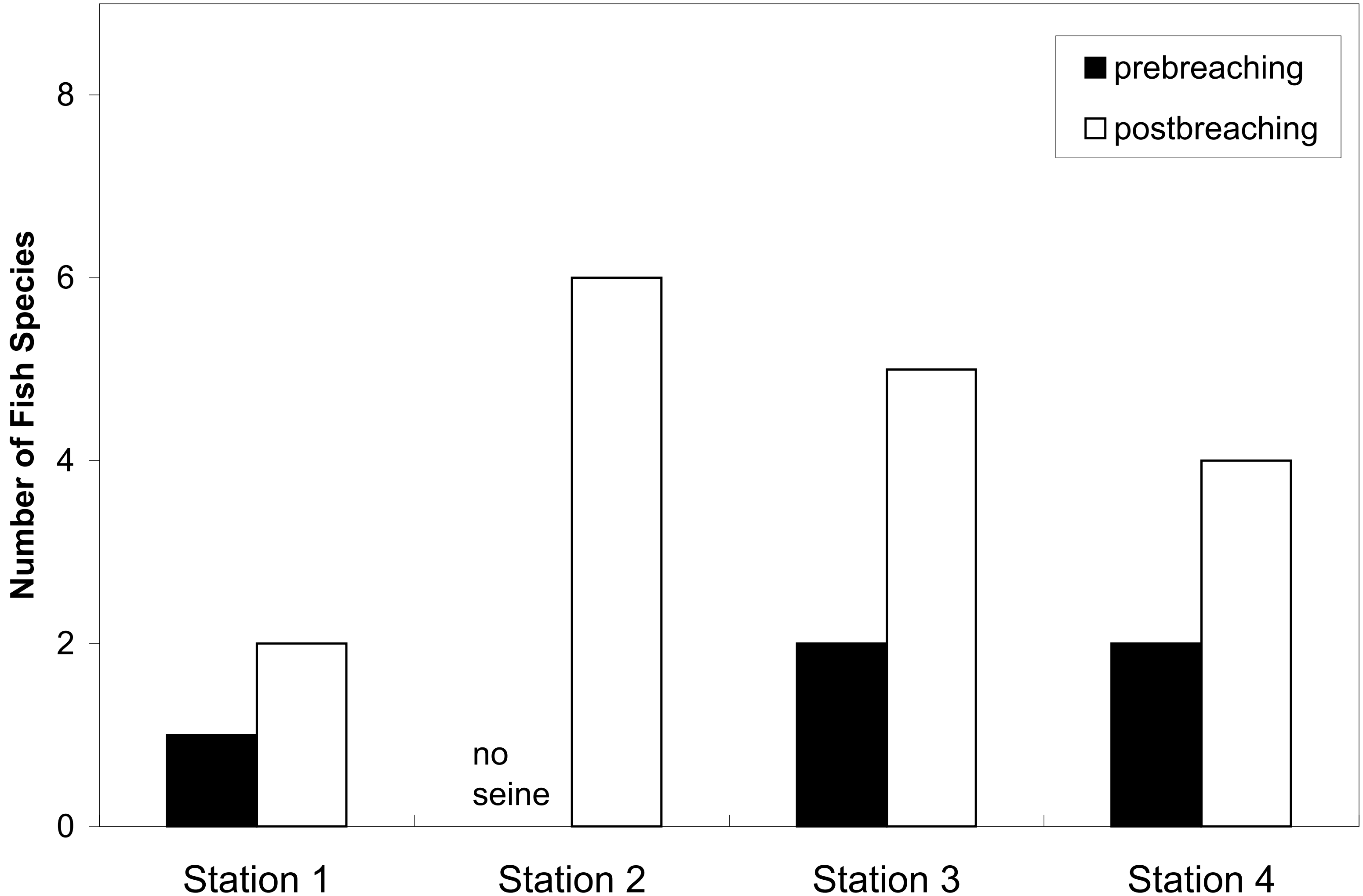


Appendix B-27
Number of Fish Species in Beach Seines
Event V--Breached 26 September 1996

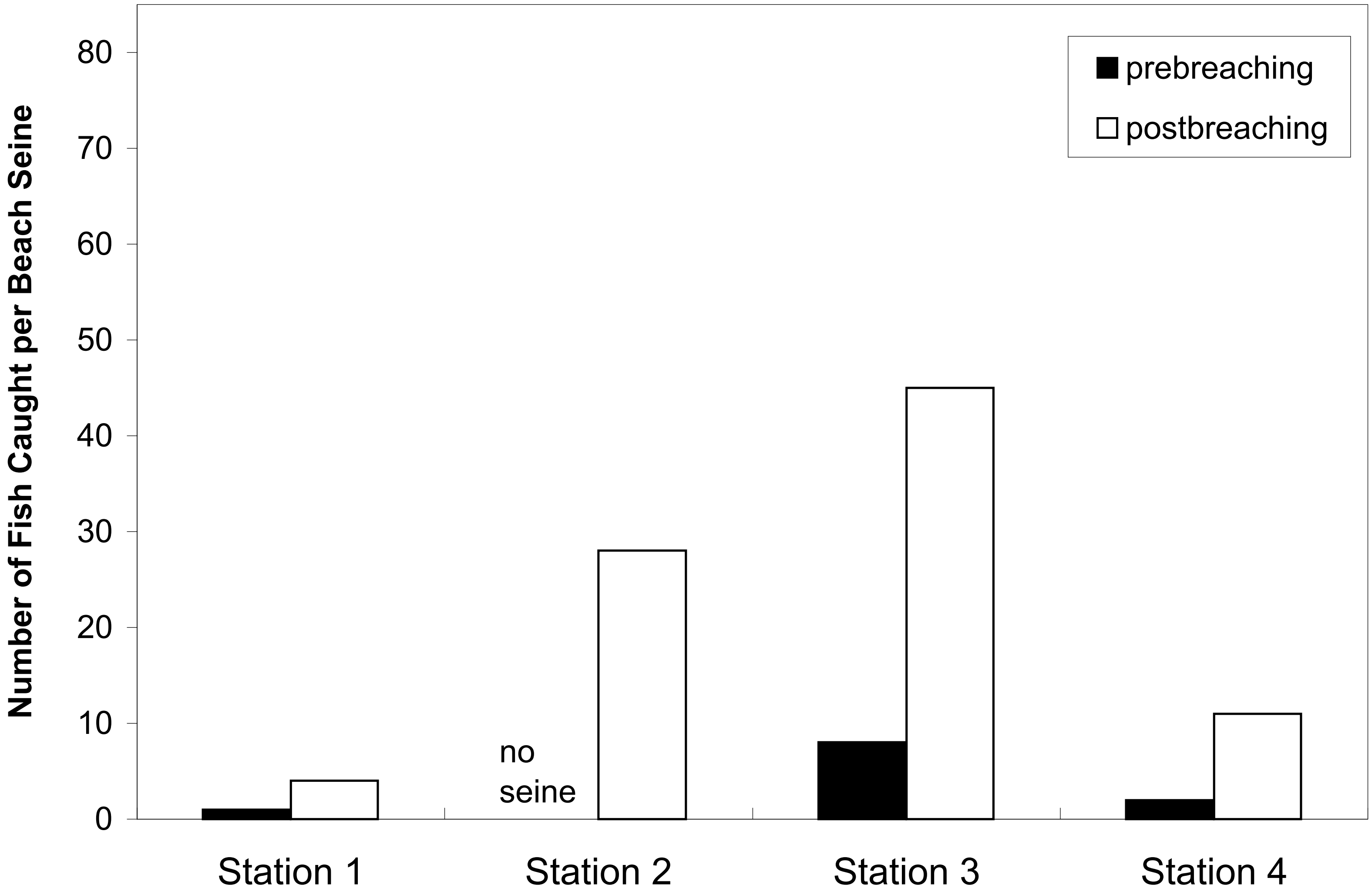



Appendix B-28
Beach Seine Catch
Event V--Breached 26 September 1996
Number of Fish Caught per Beach Seine
0
10
20
30
40
50
60
70
80
prebreaching
postbreaching
no catch
no seine
Station 1
Station 2
Station 3
Station 4

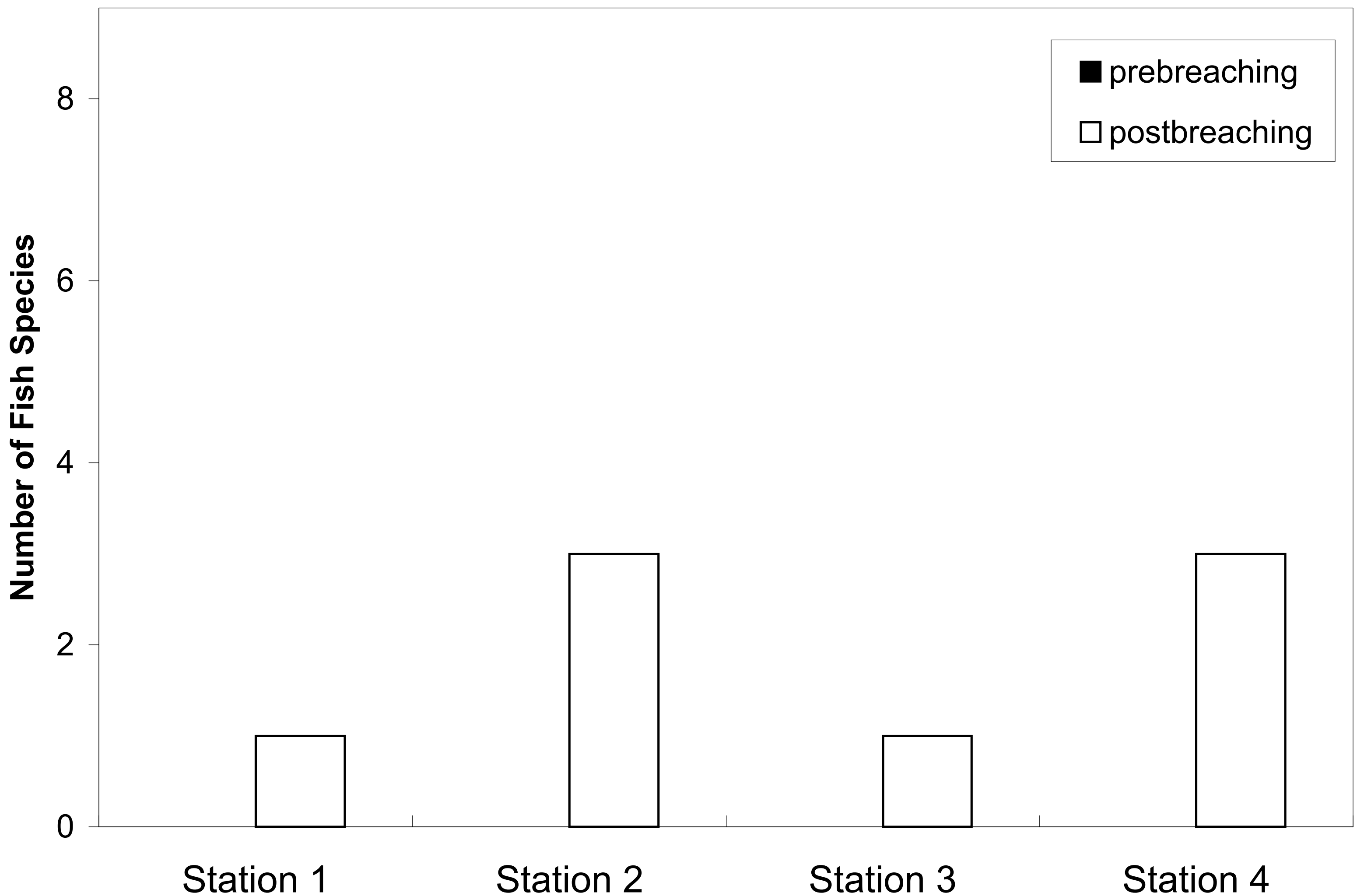
Appendix B-29
Number of Fish Species in Beach Seines
Event VI--Breached 15 October 1996



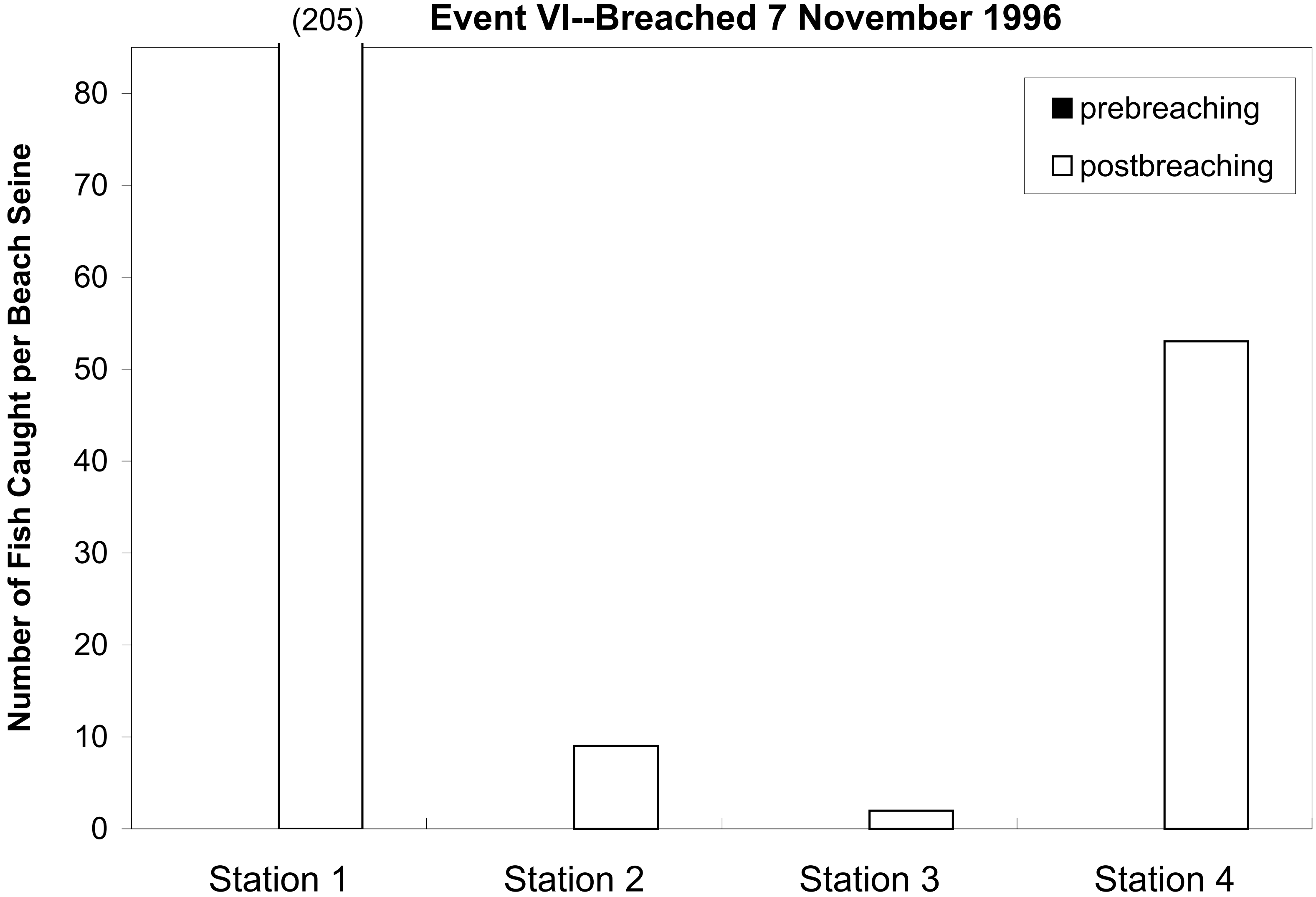
Appendix B-30
Beach Seine Catch
Event VI--Breached 15 October 1996



Appendix B-31
Number of Fish Species in Beach Seines
Event VII--Breached 7 November 1996



Appendix B-32
Beach Seine Catch
Event VI--Breached 7 November 1996



Appendix B-33. Fork Lengths (millimeters) of Steelhead Smolts Captured by Beach Seine, 1996.

Date	Station Number			
	1	2	3	4
7-Jul-96			90	85
			120	90
			120	120
			120	135
			120	
			120	
			125	
			125	
			130	
5-Aug-96		95	95	
		95	125	
		140		
		140		
27-Sep-96	185			
9-Oct-96	170		130	250
			150	
			155	
			155	
			160	
			165	
			205	
16-Oct-96	180	165		
9-Nov-96			130	
			200	

Appendix C-1. Summary of Organisms Caught in Plankton Tows in the Russian River Near Willow Creek, 1996.
up = upstream of creek mouth
down = downstream of creek mouth

	Post-breaching		Pre-breaching		Day-of-breaching		Pre-breaching		Day-of-breaching	
	Event II		Event V				Event VI			
	5-Aug-96		18-Sep-96		26-Sep-96		10-Oct-96		15-Oct-96	
	up	down	up	down	up	down	up	down	up	down
Oligochaeta (earthworms)										
naidid sp.										1
Crustacea (crustaceans)										
Cladocera (water fleas)										
Eurycercus sp.						2				
Simocephalus serrulatus						20				
Mysidacea (mysids)										
Neomysis mercedis		8	3	75	4	11			8	
Isopoda (sowbugs)										
sphaeromatid sp.			147	1					40	1
Amphipoda (scuds)										
Anisogammarus confervicoluous			1	1	2	5				
Corophium sp.		1	9			3				
Hydracharina (water mites)						2				1
Insecta (insects)										
Ephemeroptera (mayflies)										
Callibaetis sp.				187		35				
Odonata (dragonflies)										
aeschnid sp.						1				
Ischnura sp. nymphs				3		4				
Hemiptera (true bugs)										
corixid sp.				11		145				
Trichoptera (caddisflies)										
Oxyetheria sp. larvae						1				
Coleoptera (beetles)										
gyrinid sp.				1						
Diptera (flies)										
chironomid sp.				6		3				3
Mollusca (molluscs)										
Gastropoda (snails)										
Physella sp.				110	6	95				
Helosoma sp.				55	10	611				
Stagnicola sp.				16	2	39			2	5
Fish										
3-spine stickleback larvae & juv.				28		27				
number of taxa	0	2	4	11	5	15	0	0	3	4
number of individuals	0	9	160	466	24	977	0	0	50	10
volume filtered, cubic meters	18.3	18.3	18.3	18.3	9.2	9.2	18.3	9.2	18.3	16.8
total individuals per cubic meter	0	0.49	8.73	25.4	2.62	107	0	0	2.73	0.6