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DEMONSTRATION PROJECT TO EVALUATE THE EFFECTIVENESS OF AN ACOUSTIC (UNDERWATER SOUND) BEHAVIORAL BARRIER IN GUIDING JUVENILE CHINOOK SALMON AT GEORGIANA SLOUGH: RESULTS OF 1993 PHASE I FIELD TESTS

A Cooperative Program by

San Luis & Delta-Mendota Water Authority
Delta Issues Participation Team

State Water Contractors

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U.S. Bureau of Reclamation

Prepared by:

Hanson Environmental, Inc.
500 Ygnacio Valley Road, Suite 250
Walnut Creek, California 94596
(510) 942-3133

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SUMMARY AND CONCLUSIONS

The potential effectiveness of an acoustic (underwater sound) behavioral barrier in guiding juvenile chinook salmon smolts from entering Georgiana Slough was examined during May and June, 1993. Objectives of the preliminary (Phase I) field investigation were (1) to install and operate an acoustic array upstream of Georgiana Slough with field measurements to document acoustic signal strength, frequency, and distribution; and (2) document the effectiveness of the acoustic barrier in reducing the numbers of juvenile fall-run chinook salmon smolts entering Georgiana Slough. Evaluation of the effectiveness of the acoustic behavioral barrier in reducing juvenile chinook salmon migration into Georgiana Slough involved a series of replicated fisheries collections within the Sacramento River and Georgiana Slough during periods when the barrier was in service (**on**) and periods when the barrier was not operating (**off**). The ratio of catch-per-unit-of-effort (CPUE) of juvenile chinook salmon collected within Georgiana Slough and downstream in the Sacramento River when the barrier was **on** and when the barrier was **off** was used to determine an index of guidance efficiency of the acoustic signal. The Phase I studies have been coordinated through the Interagency Ecological Study Program (IESP) Fish Facilities Committee.

This technical report documents methods and results of the Phase I field studies. Results of the Phase I Georgiana Slough acoustic barrier research program have shown the following:

- A floating fyke net was ineffective in collecting chinook salmon smolts, as a result of net avoidance, within the Sacramento River and Georgiana Slough;

- Chinook salmon smolts were effectively collected in Kodiak trawls. Data collected from Kodiak trawls within both Georgiana Slough and the Sacramento River, adjusted for variation in effort (CPUE), were used in the Phase I evaluation of acoustic barrier guidance;

- Juvenile chinook salmon comprised 95% (5,163 salmon) of the total number of fish collected (5,460 fish) in sampling conducted between May 6 and June 10. Other fish species collected included juvenile and sub-adult delta smelt, tule perch, steelhead, Sacramento sucker, threadfin shad, Sacramento splittail, and Sacramento squawfish;

- The majority of juvenile salmon ranged in length from 70-100 mm (fork length) with no apparent difference in length frequency distributions for fish collected within the Sacramento River and Georgiana Slough;

- Fisheries collections were characterized by relatively high variability with no clearly distinguishable diel (diurnal) pattern;

- Comparative collections using Kodiak trawls (surface collections) and otter trawls (bottom collections) indicate that although the majority of juvenile chinook salmon were collected in the upper portion of the water column, juvenile salmon were present in both surface and bottom samples;

- The frequency of injury and mortality for juvenile chinook salmon ranged from 0.8-1.1% and provided no evidence that acoustic barrier operations contributed to an immediate increase in either mortality or injury of juvenile chinook salmon. These data also demonstrate that a Kodiak trawl, equipped with a livecar, can be used as an effective sampling technique with minimal (approximately 1%) damage and mortality. No delayed mortality studies were conducted to assess long-term effects of either capture or exposure to the acoustic barrier on salmon survival;

- During the field studies only four striped bass were observed to be caught by anglers in the area adjacent to the acoustic barrier providing an insufficient database for evaluating potential effects of barrier operations on recreational angling success;

- No complaints were received from either recreational boaters or local residents regarding the acoustic barrier or its operations;

- Estimated effectiveness of the acoustic barrier showed a pattern of successive improvement in guidance efficiency as the barrier location and configuration was modified based on results of previous weeks' fisheries investigations;

- Estimated indices of guidance efficiency for the final two weeks of sampling (June 1-4 and June 7-10) showed a promising trend suggesting that the acoustic barrier was effective in reducing the numbers of juvenile chinook salmon entering Georgiana Slough.

Based on encouraging results from the Phase I field investigations a more thorough evaluation of the effectiveness of the acoustic array has been proposed for the period from April-June and September-November, 1994 (Phase II). The Phase II investigations are proposed as a cooperative effort with participation by the San Luis & Delta-Mendota Water Authority, State Water Contractors, Department of Water Resources, U.S. Bureau of Reclamation, California Department of Fish and Game, National Marine Fisheries Service, U.S. Fish and Wildlife Service, and other interested agencies and parties.

SECTION 1

INTRODUCTION

Juvenile chinook salmon emigrating from spawning and rearing areas within the upper Sacramento River and its tributaries are susceptible to diversion into the central Delta from the Sacramento River at the Delta Cross-channel, Georgiana Slough, and Three Mile Slough. Studies conducted using fall-run salmon smolts have demonstrated substantially higher mortality rates for those fish passing into the interior Delta (Kjelson *et al.* 1990; USFWS 1992). The increased mortality rates reflect, in part, increased susceptibility to predation, delays in migration, exposure to increased water temperatures, and increased susceptibility to entrainment losses at the State and Federal Water Projects (SWP and CVP) and a large number of other water diversion locations within the Delta. Juvenile winter-run chinook salmon losses as a result of entrainment at the SWP and CVP diversions are regulated by incidental take provisions of the Endangered Species Act. The allowable level of incidental take has been established as one percent of the estimated number of winter-run salmon smolts entering the Delta. If effective in successfully guiding a portion of juvenile chinook salmon from entering the interior Delta through Georgiana Slough, use of an acoustic behavioral barrier would contribute to an increase in survival of all races of salmon during emigration. The successful guidance of winter-run chinook salmon from entering Georgiana Slough would also contribute to a reduction in the susceptibility to entrainment losses at the SWP and CVP diversions and therefore a reduction in incidental take as a result of water diversion operations.

Juvenile chinook salmon migrating downstream within the Sacramento River may be diverted out of the main river channel at a variety of locations including Sutter Slough, Steamboat Slough, the Delta Cross-channel, and Georgiana Slough. The diversion of winter-run and other races of chinook salmon smolts from the Sacramento River into the interior Delta can be reduced through closure of the Delta Cross-channel gates coincident with the period of emigration. However, winter-run and other races of chinook salmon continue to be susceptible to movement from the Sacramento River into the central Delta through Georgiana Slough (Figure 1) where no facilities exist for fish protection.

It has been estimated (DWR, unpublished data) that the flow of Sacramento River entering the Delta through the Delta Cross-channel (open) and Georgiana Slough ranges from approximately 35-50% when Sacramento River flows range from approximately 10,000-30,000 cfs. During periods when the Delta Cross-channel is closed, Sacramento River flow entering Georgiana Slough is estimated to range from approximately 16-22% when Sacramento River flows range from 10,000-30,000 cfs. Although the Delta Cross-channel may be closed, and thereby reduce the flow and presumably numbers of juvenile chinook salmon entering the interior Delta, no similar provisions for reducing either the flow or numbers of salmon entering Georgiana Slough currently exist. Proposals have been considered to physically block the passage of juvenile salmon into Georgiana Slough through installation of a rock barrier or other structures. Concern has been expressed, however, that the use of a physical barrier in Georgiana Slough may adversely affect water quality within the slough and Delta, alter the natural flow of water from the Sacramento River through interior Delta channels, impede upstream migration of adult fish, and create an obstruction to recreational boating.

An alternative approach would be a carefully designed behavioral barrier designed to utilize the avoidance response of juvenile salmon to reduce diversion into Georgiana Slough without adversely affecting hydrology, flood protection, water quality, or navigation. A variety of behavioral barriers have been tested for use in controlling fish passage at diversion points. These behavioral barriers include lights, both constant (mercury vapor) and strobe illumination, air bubbles, velocity gradients, louvers, angled bar racks, electric barriers, and underwater sound. The use of behavioral barriers has, in previous laboratory and field tests, produced variable success in reducing losses of fish at water diversions (Burner and Moore 1962; Loeffelman *et al.* 1991a,b,c; Matousek *et al.* 1988; McKinley and Patrick 1988; McKinley *et al.* 1989; Moore and Newman 1956; Moulton and Backus 1955; Patrick *et al.* 1985, 1988; Schwartz 1985). Factors contributing to the variable results in these tests include differential response to a stimuli between species and life stages of fish, environmental conditions such as streamflow and turbidity, diversion hydraulics, etc. In several recent applications where a behavioral barrier was targeted on the avoidance response of a specific species, a substantial increase in effectiveness was demonstrated (Loeffelman *et al.* 1991a,b,c; Nestler *et al.* 1992; Patrick *et al.* 1988; Matousek *et al.* 1988; Taft 1990; McKinley and Patrick 1988).

The American Electric Power Company (AEP) has completed a four-year laboratory and field investigation of the use of sound, developed using a new signal development process, for diverting migratory and resident fish species from water diversions associated with hydroelectric facilities and power plant cooling water intake structures (Loeffelman *et al.* 1991a, b, c). The research program was initiated based on the observation that generator-induced sound associated with AEP's Racine hydroelectric project on the Ohio River served as a behavioral barrier deflecting fish away from the intake structure. The acoustic signature associated with the hydroelectric generator was evaluated through field measurements which were then compared with information available from the literature on sound frequencies audible to various fish species (Figure 2). Recognizing that various fish species are able to detect sound within various frequency ranges resulted in the development of a sound signal evaluation procedure designed to establish species-specific sound frequencies for use in the behavioral guidance and barrier systems.

Species-specific frequencies have been established for various anadromous and resident freshwater fish, including smolt and adult chinook salmon and steelhead trout, striped bass, freshwater drum, largemouth bass, and catfish (Loeffelman *et al.* 1991a,b, and c). The species-specific frequencies were established based on laboratory recordings of the sound generated by each fish species based on the assumption that a species would produce sounds which were audible and most easily detected by the same lifestage and species. Using the species-specific audiograms (Figure 2) a computerized synthesizer was then used by AEP to produce a new signal to stimulate the target fish species in the most sensitive portion of its hearing range. The computer controlled synthesized sound frequencies were tuned to accommodate species-specific differences in acoustic detection and incorporate site-specific factors known to affect underwater sound such as ambient background sound levels, bottom shape and composition, water currents, and water temperature.

As part of their research and development program Loeffelman *et al.* (1991a, b, c) conducted a series of field trials to evaluate the effectiveness of the species-specific synthesized sound in diverting fish from water intake structures. The tests were performed as paired, replicate trials, with and without the underwater sound signal, which were designed to also test potential diel differences in diversion efficiency of the sound barrier. Preliminary tests performed at the Racine Hydroelectric Generating

Facility demonstrated that 66% of all fish (and 70% of fish other than gizzard shad) were diverted away from the intake area by the sound system. Differences in fish collections made using electrofishing and gillnetting showed a statistically significant reduction in the relative abundance of fish in the vicinity of the intake with the underwater acoustic signal.

Field tests of the effectiveness of the underwater sound system reported by Loeffelman *et al.* (1991a, b, c) in guiding downstream migrant chinook salmon smolts (3.5 inch in length) and steelhead (7 inch length) was tested at the Buhaman Hydroelectric Project on the Saint Joseph River, Indiana. These fish had been stocked approximately 30 miles upstream from the hydroelectric project. An angled sound field was shown to be 94% effective in diverting steelhead smolts and 81% effective in diverting chinook salmon smolts from the hydroelectric intake structure. It was estimated that the effective acoustical field from each underwater sound projector (acoustic speaker) was a sphere approximately 70 feet in diameter.

It has been generally concluded that the effectiveness of a behavioral barrier in successfully guiding fish from a water diversion will be less than that for physical barriers (e.g., intake screens). Behavioral barriers, however, represent a non-destructive method for reducing fish entrainment (there is no handling or known physical injury associated with certain types of behavioral barriers such as those using light or sound). In light of provisions of the Endangered Species Act which limit the incidental take of protected species the application of behavioral barriers in reducing losses at water diversions represents a potentially significant benefit contributing to an overall reduction in incidental take resulting from water diversion operations. The application of behavioral barrier technology, if proven successful, may be most appropriate for reducing fish losses at locations where physical barrier intakes are not feasible or for use in combination with physical barrier intakes to improve overall fish protection. However, additional consideration, and scientific evaluation, needs to be given to evaluating both the guidance efficiency of behavioral barriers and also the potential for increased susceptibility to predation losses, sublethal physiological effects, potential delays or blockage in adult upstream migration, and other factors which influence the overall biological benefit (e.g., increased survival rate) associated with behavioral barrier operations.

Based on a review of scientific data available from laboratory and field investigations (Patrick *et al.* 1987; Smith and Anderson 1984; Nestler *et al.* 1992; Dunning *et al.* 1992; Taft 1990; Haymes and Patrick 1986; Loeffelman *et al.* 1991a,b,c) of the effectiveness of various behavioral barriers in reducing fish losses at water intakes, a phased research and demonstration project has been developed for evaluating the potential application of behavioral barriers at selected locations in the Sacramento-San Joaquin Delta. Recent advances in research and military technology transfer have led to improvements in the effectiveness of underwater sound generated at specific frequencies to elicit a species- and lifestage-specific behavioral avoidance response.

The first phase of this research program involved a field test of an underwater acoustic repulsion system (barrier) in deflecting fall-run chinook salmon smolts from entering Georgiana Slough at its confluence with the Sacramento River (Figure 3). The acoustic array used species-specific sound frequencies targeted to chinook salmon smolts.

Experimental Design

Objectives of the Phase I field investigation were:

- o Install and operate an acoustic array upstream of Georgiana Slough on the Sacramento River with field measurements to document acoustic signal strength and barrier operations; and

- o Document the effectiveness of the acoustic barrier in reducing the numbers of juvenile fall-run chinook salmon smolts entering Georgiana Slough.

The Phase I biological evaluation of the effectiveness of the acoustic barrier was experimentally designed to determine changes in the ratio of juvenile fall-run chinook salmon captured within Georgiana Slough and the Sacramento River (expressed as catch-per-unit-effort to adjust for variation in sampling effort) during periods when the acoustic barrier is **on** and during periods when the barrier is **off**. Evaluation of the effectiveness of the acoustic behavioral barrier in reducing juvenile chinook salmon migration into Georgiana Slough involved a series of fisheries collections within the Sacramento River and Georgiana Slough during a series of two-day periods when the barrier is in service (**on**) and periods when the barrier is not operating (**off**). During each four-day test sequence random numbers were used to determine whether the acoustic array was in service (**on**) during the first two days of each test. Testing was conducted Monday through Thursday each week during May and early June to avoid, to the extent possible, interference between sampling activities and recreational boating. A clearance interval of four hours was used at the beginning of each barrier-on period to allow fish between the barrier and sampling nets time for passage before sampling began. The 4-hour clearance period was also intended to minimize the potential effect of acoustic barrier operations on the distributional characteristics of juvenile chinook salmon within the Sacramento River and Georgiana Slough which may effect results of Kodiak trawl collections during the barrier off portion of the evaluation cycle.

During each weekly four-day test sequence fisheries sampling was performed 20-24 hours per day. Collections were therefore made over all tidal stages and during both day and nighttime periods. Results of fisheries collections, performed using a Kodiak trawl, were each normalized to account for variation in sampling effort and reported as a catch-per-unit-of-effort (CPUE) based on both the number of salmon collected per minute of trawling and the number of salmon per 1000 m^3 of water sampled. Sampling was standardized, to the extent possible, based on both the geographic location sampled and the duration of each trawl (see Section 3 for a description of collection methods). During each weekly test sequence an average CPUE was calculated based on results of all valid collections during each two-day test period when the acoustic barrier was on and when the barrier was off. In addition to calculations of the average CPUE for each two-day test condition, results of CPUE from individual collections were also examined to characterize variability among collections, the horizontal distribution in juvenile chinook salmon collections within the Sacramento River, diurnal patterns, etc.

The ratio of catch-per-unit-of-effort (CPUE) of juvenile chinook salmon collected within Georgiana Slough and downstream in the Sacramento River when the barrier was on and when the barrier was off was used to determine an index of guidance efficiency for the acoustic barrier. The index of guidance efficiency of the acoustic barrier was calculated as:

$$\text{index of guidance efficiency} = (1-(a/b))100$$

where

> a = mean CPUE within Georgiana Slough when the barrier was on divided by the mean CPUE within the Sacramento River when the barrier was on;
>
> b = mean CPUE within Georgiana Slough when the barrier was off divided by the mean CPUE within the Sacramento River when the barrier was off.

A hypothetical example is presented below to illustrate the calculation for the index of guidance efficiency of the acoustic barrier.

	CPUE		
Sound Barrier	**River**	**Slough**	**Ratio**
On	120	80	0.67 (a)
Off	100	100	1.00 (b)

$$\text{index of guidance efficiency} = (1-(0.67/1.00))100 = 33$$

Note from this hypothetical example that the index of guidance efficiency, although providing a measure of the biological performance of the acoustic barrier (reduced numbers of juvenile chinook salmon entering Georgiana Slough when the barrier is on) does not reflect an absolute measure of the percentage reduction in juvenile salmon entering the slough. In the hypothetical example shown above the numbers of salmon collected within Georgiana Slough was reduced from 100 to 80 fish (a 20% reduction) in response to acoustic barrier operations while the calculated index of guidance efficiency is 33. The use of the ratio estimate in calculating the index of guidance efficiency was required during the Phase I field investigations, however, since field sampling did not allow for precise estimates of the numbers of salmon approaching the acoustic barrier and subsequently passing downstream within the Sacramento River and Georgiana Slough (mass balance). The use of the ratio estimate in calculating an index diversion efficiency also accounted for absolute variations in the numbers of juvenile chinook salmon collected between test periods when the barrier was on and when the barrier was off. Furthermore, although not tested, it is expected that the Kodiak trawl might have a differential collection efficiency within Georgiana Slough and the Sacramento River as a consequence of differences in channel width, depth, and velocity. However, the use of the ratio estimate based on collections with the same sampling gear at the same locations with the barrier on and off served to minimize potential bias resulting from variation in sampling efficiency.

The primary objective of the 1993 Phase I evaluation was to evaluate trends in CPUE between Georgiana Slough and the Sacramento River as a function of acoustic barrier operations (e.g., ratio approach for calculating the index of guidance efficiency) for use in a preliminary determination of the potential effectiveness of the acoustic technology in reducing juvenile chinook salmon passage into Georgiana Slough. The 1993 studies were not designed to provide a rigorous statistical analysis nor definitive calculation of absolute guidance efficiency of the acoustic barrier, but rather to determine if the technology is promising and warrants more detailed field investigations in the future.

The Phase I behavioral barrier test at Georgiana Slough was designed and conducted as a cooperative research and development project among a variety of State and Federal resource agencies and water districts. The primary coordination for the demonstration project was through the Interagency Ecological Study Program (IESP) fish facilities committee which includes participation by the California Department of Fish and Game (CDFandG), U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Reclamation (USBR), and California Department of Water Resources (DWR). Although the design of the demonstration project and field sampling activities was coordinated with several resource agencies, principal funding and labor required to perform the investigation were the responsibility of the San Luis & Delta-Mendota Water Authority, State Water Contractors, and contributing water resources agencies including DWR and USBR.

Phase I of the investigation was designed to use temporary facilities which were removed from the Sacramento River at the completion of the Phase I field investigation (June 1993). Operation of the acoustic barrier was not expected to result in significant mortality or injury to fish within the Sacramento River, although juvenile chinook salmon and other fish species were collected as part of the sampling program. Sampling as part of the evaluation program was conducted using techniques designed to reduce stress and potential mortality. All fish were released after enumeration and measurement. Scheduling of the test (May-June) was selected to avoid the period of juvenile winter-run chinook salmon emigration from the Sacramento River and the potential for incidental capture as part of the sampling program. The timing of the Phase I evaluation coincided with the emigration of large numbers of natural and hatchery-produced fall-run chinook salmon smolts from the upper Sacramento River.

SECTION 2

TEST FACILITIES/TEST CONDITIONS

Acoustic Signal Development

Using sound to guide or divert fish requires a signal development process customized to the species and lifestage of interest and site-specific environmental conditions. Because fish are vocal and have hearing receptors to receive these vocalizations, analysis of fish sounds can be used to determine characteristics of their hearing, such as frequency range, call duration and amplitude. Schwartz and Greer (1984) experimented with a variety of sounds on Pacific herring and concluded that the fish were capable of detecting directional sounds and characteristics of amplitude and frequency ranges of sound. McKinley *et al.* (1989) reviewed earlier fish guidance experiments using sound and concluded that the general ineffectiveness of acoustic barriers, was due to the sound source being incapable of producing the appropriate frequency, amplitude, etc. and/or the species-specific response to sound. McKinley *et al.* (1989) reported that sounds which one species avoided had inconsistent effects on others. These results were not surprising considering the extensive anatomical differences in auditory system structure among species. This is also beneficial in developing species-specific behavioral guidance systems intended to minimize potential adverse effects on non-target species and lifestages.

Details of the patented signal development process used in the Phase I tests are included in Loeffelman *et al.* 1991a, b, and c. To develop the appropriate sound signal for fall-run chinook salmon smolts, sounds from these fish were obtained by placing a group of salmon smolts in a portable acoustic recording studio (polyethylene tanks) set up along the river. Fall-run chinook salmon smolts from the Mokelumne River Hatchery were used in developing the acoustic signature for juvenile salmon. These fish were expected to produce audible sounds based upon previous recording sessions with chinook salmon smolts elsewhere in California and Michigan (Loeffelman, unpublished data; Figure 2). Loeffelman (unpublished data) held individual and groups of juvenile chinook salmon smolts in polyethylene enclosures while recording the amplitude and frequency of audible sounds produced by the juvenile salmon. The resulting sound spectra was used as a basis for characterizing the acoustic signal which juvenile chinook salmon should be able to detect (hear).

After technical analysis of the sound spectra, an artificial low-frequency acoustic signal was synthesized on a waveform generator. The signal was designed to be heard by salmon smolts to stimulate a behavioral response to the acoustic repulsion system created by the speaker array in the river. Two frequencies were used in a pulsed, crescendo pattern verified by field acoustic mapping. No masking effects from background sounds were identified which would limit the ability of the fish to hear the guiding signal. The same acoustic signal (frequency and amplitude) was used throughout the 1993 field studies.

Configuration and Placement of Sound Barrier

The effectiveness of the sound barrier was found to be dependent on an appropriate signal produced by speakers in an array which was optimized for channel bathymetry, water velocity, channel hydraulics, and salmon smolt swimming performance. The initial location and configuration of the acoustic array was established by EESCO based on consideration of the channel configuration, river velocities, and swimming performance capability of juvenile chinook salmon from the literature, and experience from the installation of acoustic barriers at other locations. After initial installation of the acoustic array, results of weekly Kodiak trawl collections within the Sacramento River and Georgiana Slough were used to provide additional information regarding preliminary estimates of guidance efficiency. The configuration and placement of the acoustic array was then modified from one week to the next based on results of the ongoing biological monitoring program.

The tests were carried out with acoustic equipment (speakers, amplifiers, computerized signal generator, etc.) being monitored from a fully instrumented electronics trailer, manned by qualified electronics technicians. Power to the trailer and underwater sound projectors was supplied by an enclosed diesel generator resulting in a recorded generator sound level of 62 dbA at 23 feet. For reference, a normal human conversation at a distance of 5 feet is about 68 dbA.

Underwater sound transducers (projectors or speakers) included Argotec Models 215 and 220. The acoustic array included 10 to 12 projectors. The speakers were suspended from floating orange marker buoys at a depth of 6 feet from the surface (Figure 4). Each projector was individually wired and anchored. The sound projectors and wiring withstood collisions with large tree trunks and other debris with no interruption in service. Occasionally large debris would move the projectors and anchors, but they were easily repositioned. Performance of all sound projectors was continuously monitored.

Underwater mapping was performed to document the acoustic signal associated with the final barrier configuration established on June 6 (Figure 3). Sound levels were measured using an underwater hydrophone at depths of 3, 6, and 12 feet below the surface at distances of 24 and 36 feet from the acoustic array (Figure 5). Results of the acoustic mapping are shown in Figure 6. Results of the acoustic mapping demonstrated that underwater sound levels were within the range of detection for chinook salmon smolts (salmon smolts in the acoustic tests were able to produce sound levels about 100 db; juvenile salmon have been reported to be able to detect sound levels of approximately 100 db and above [Loeffelman, unpublished data; Loeffelman *et al.* 1991a]). Characteristics of the acoustic spectra (sound frequency profile) associated with the acoustic barrier was not measured or recorded as part of the 1993 field studies. Sound levels were barely audible immediately adjacent to the array above the water surface. Sound associated with the acoustic barrier was not audible onshore.

Environmental Conditions During Testing

The Phase I acoustic barrier tests were performed between May 6 and June 10, 1993. During the period of each weekly test sequence the USBR/CVP Delta Cross-channel remained closed. Flow within the Sacramento River, as measured at Freeport (DWR, unpublished data), about 15 miles upstream, averaged 31,013 (SD 10,998, n = 36) cfs with a range from 19,358 to 55,514 cfs (daily average flow). Sacramento River flow measured at Freeport during each acoustic barrier test period are summarized below:

Sacramento River Flow at Freeport (cfs)

Acoustic Barrier Test Period	Mean flow (cfs)	Standard Deviation	Min	Max	Number
May 6-7	25,226	117	25,143	25,309	2
May 10-14	24,720	1132	23,015	25,785	5
May 17-21	20,414	1089	19,358	21,891	5
May 24-26	24,306	2664	21,631	26,958	3
June 1-4	48,730	7733	41,222	55,514	4
June 7-10	47,469	1284	45,715	48,739	4

(Source: DWR unpublished data)

Flow measured within the Sacramento River at Freeport as shown above is greater than the flow approaching the acoustic barrier since a portion of the Sacramento River flow is diverted upstream into Steamboat and Sutter Sloughs. The Delta Cross-channel, another location where Sacramento River flow may be diverted upstream of the acoustic barrier, was closed throughout the period of the 1993 studies. Although the USGS maintains acoustic velocity meters within the Sacramento River upstream of the Delta Cross-channel and downstream of the Georgiana Slough confluence, these data were not available for use in calculating the actual flow rate and flow split between the Sacramento River and Georgiana Slough during the period of these tests.

Water temperature, monitored hourly at the DWR water quality monitoring station at Rio Vista, about 15 miles downstream, averaged 17.4 C (SD 0.6; n 181) with a range from 15.9 to 19.0 (average 63 F with a range from 61 to 66). Dissolved oxygen concentrations averaged 8.6 mg/L (SD 0.2; n 163) with a range from 8.2 to 8.9.

During the period of the investigation the Department of Water Resources and U.S. Geological Survey periodically monitored flow rates at various locations within the Sacramento River and Georgiana Slough. Based on results of these velocity measurements, the hydraulic flow split occurring between the Sacramento River and Georgiana Slough was estimated. At a flow of 14,000 cubic feet per second (cfs) in the Sacramento River it was estimated on an ebb tide that the flow entering Georgiana Slough would be approximately 2,800 cfs and the flow passing downstream in the Sacramento River would be approximately 11,200 cfs. This represents approximately 20% of the Sacramento River flow entering Georgiana Slough on the ebb tide. Results of field measurements, based on USGS velocity measurements, are consistent with results of analyses developed by DWR (DWR, unpublished data) indicating that flow entering Georgiana Slough during periods when the Delta Cross-channel is closed (such as was the case during the period of the May-June acoustic barrier tests) range from approximately 16-22% over a range of Sacramento River flows from 10,000-30,000 cfs. It is currently unknown, however, whether the number of juvenile chinook salmon entering Georgiana Slough occurs in direct proportion to the flow split.

The flow within Georgiana Slough has been shown to vary throughout the day as a consequence of tidal conditions within the Delta. Flow within Georgiana Slough was estimated at 15 minute intervals from May 1 through May 24, 1993 with a DWR recording velocity meter (S4) located within the slough approximately one mile downstream of the confluence with the Sacramento River. The resulting estimates of flow within Georgiana Slough (Figure 7) illustrate the cyclic pattern and magnitude of flows occurring during the acoustic barrier testing program. Results of detailed velocity and flow measurements from the Sacramento River in the vicinity of the confluence with Georgiana Slough during the period of this test are not available for use in estimating changes in the flow split between the Sacramento River and Georgiana Slough which may occur on an hourly basis in response to variation in flow rates within the Sacramento River and the influence of tidal stage on current velocity, flow, and flow splits at the confluence between the Sacramento River and Georgiana Slough.

The U.S. Geological Survey measured water velocities at various depths within Georgiana Slough and the Sacramento River (Figures 8a-e) after the research project was completed. The velocity measurements were measured on July 23, 1993 (flow in the Sacramento River at Freeport was 20,170 cfs on July 23, 1993; the Delta Cross-channel gates were open). Results of velocity magnitudes and directions (flow lines) at water depths of 3.5 and 5 feet are shown in Figure 9 within Georgiana Slough and the Sacramento River. Results of these measurements, although collected after completion of the 1993 acoustic barrier tests, provide useful information on velocities within the Sacramento River and Georgiana Slough. Results of the velocity measurements conducted on July 23, 1993, do not, however, necessarily characterize the magnitude or direction of flows occurring during the period of the acoustic barrier tests.

SECTION 3

FISHERY COLLECTION METHODS

Fisheries collections were made using two sampling techniques including fixed location fyke nets and Kodiak trawls. Fyke nets were located on floating platforms (docks) anchored within Georgiana Slough and the Sacramento River (Figure 10). Fyke nets were four feet deep (mouth 4 feet by 4 feet) with 50 foot wings. Fyke nets were constructed of 1/4 inch mesh wings and 1/8 inch mesh body per USFWS specifications for concurrent sampling elsewhere in the Delta. Fyke nets were positioned offshore with one wing extending at approximately a 30° angle onshore and the second wing extending offshore at approximately the same angle. The fyke nets were located in areas having a water depth of 15-20 feet in the Sacramento River and 10-14 feet in Georgiana Slough. Velocities approaching the fyke nets were approximately 1.5 ft/sec at both locations. Both fyke nets were equipped with a live car for sample collection. Live cars were checked approximately hourly throughout each test. A General Oceanics flow meter was suspended adjacent to the mouth of each fyke net for use in estimating water volumes sampled during each collection interval for calculation of CPUE.

A Kodiak trawl was also used to collect juvenile chinook salmon within Georgiana Slough and the Sacramento River. The Kodiak trawl had a graded stretch mesh from 2 inch at the net mouth to 1/4 inch mesh at the cod end. The trawl has an overall length of 65 feet with a mouth opening 6 feet deep and 25 feet wide. The Kodiak trawl was towed between two skiffs operating at a constant engine speed of approximately 2000 RPM. The trawl was equipped with an aluminum framed cod end which served as a live car in reducing stress and injury to fish during collection and processing. Trawl duration was approximately 10-minutes, sampling in an upstream direction. Kodiak trawling was performed over a period of approximately 20 hours per day. All samples were collected within a consistent reach of Georgiana Slough and the Sacramento River (Figure 11). A General Oceanics flow meter was used to estimate the volume of water sampled during each collection for use in calculating CPUE. Triplicate trawl samples were collected within both Georgiana Slough and the Sacramento River throughout each testing series. As a consequence of the relatively narrow channel width, all trawls within Georgiana Slough were performed at mid-channel. Trawls within the Sacramento River were performed parallel to the left bank, mid-channel, and right bank (looking downstream; Figure 11) to provide information on the horizontal distribution of juvenile chinook salmon within the Sacramento River downstream of the acoustic barrier. Trawls were made within 50-75 feet of the shoreline along both the left and right banks of the river. In addition, a limited series of Kodiak trawl collections were periodically performed within the Sacramento River upstream of the acoustic barrier location as well as immediately behind the acoustic barrier. Results of these collections, although not presented in this report, were used to provide qualitative information on the general distributional pattern of chinook salmon approaching the acoustic barrier and to provide information on salmon passage through the barrier ("leakage") which was used in realigning the barrier array and modifying the spacing between underwater transducers to improve barrier performance.

A limited series of otter trawl collections was performed to provide information on the vertical distribution of chinook salmon within Georgiana Slough and the Sacramento River. The Kodiak trawl provides data from collections in the upper portion of the water column (from the surface to a depth of approximately 6 feet). Otter trawls were used to provide comparative catches of juvenile chinook salmon in the lower portion of the water column. The otter trawl was constructed of one-inch stretch mesh body and 1/2 inch stretch mesh cod end. The trawl has a mouth opening approximately 16 feet wide. For purposes of calculating volume sampled, it was assumed that the effective trawl width was 60% (CDFandG unpublished data). A General Oceanics model 2030R flow meter was suspended from the side of the towing vessel during each trawl to estimate water volume sampled as part of the calculation of CPUE. Otter trawl samples were approximately 10 minutes in duration. The comparison in juvenile chinook salmon catches between the otter trawl (bottom samples) and Kodiak trawl (surface samples) was based on a series of paired collections performed on June 3-4, 1993. Sampling using both trawls was coordinated to maintain starting times and the location sampled as closely as possible.

All fish collected were immediately transferred from the live car to buckets filled with river water where the fish were held during processing. Fish were released downstream of the survey area after sample processing. Data collected during each trawl or fyke net sample included enumeration of juvenile chinook salmon and other fish species collected, fork length, and water volume sampled. Mortality and damage to fish collected was also documented. Catch-per-unit-of-effort was calculated as the number of chinook salmon per minute and the number of chinook salmon per 1000 cubic meters of water sampled during each collection.

Data were excluded from the analysis (sample voids; 12 out of 622 kodiak trawl samples [2%] were voided) for collections in which gear failure or net snagging resulted in unreliable collections. Individual samples were voided if the estimated volume sampled was unusually low suggesting that the flow meter and net may have become tangled during deployment. Collections were also voided in the event of failure to record specific information on the datasheets such as the start or end flow meter readings. The resulting database for Kodiak and otter trawl collections is included in Appendices B and C.

During the period of the acoustic barrier evaluation a recreational angler creel survey program was conducted within the Sacramento River and Georgiana Slough, including the area adjacent to the acoustic array, to provide information regarding potential changes in fishing success corresponding with periods when the acoustic barrier was in service. The creel survey included both direct observations and interviews with anglers. The creel survey, conducted by members of the fishery sampling crew, encompassed the area upstream to the Highway 160 bridge and downstream within the Sacramento River and Georgiana Slough where Kodiak trawling was routinely performed (Figure 11). The location of recreational anglers was mapped and point of contact interviews were performed to assess the species composition and relative success (CPUE) measured as catch-per-angler-hour in the vicinity of the acoustic barrier.

SECTION 4

RESULTS OF PHASE I FISHERIES MONITORING

Recreational Creel Survey

Prior to initiating field testing it was hypothesized that operation of the acoustic barrier might affect the behavior of adult resident or migratory fish and consequently recreational angling. During the survey period a number of anglers were observed in the area with striped bass being the predominant target species. Anglers were observed fishing with both natural (e.g., shad, anchovy) bait and trolling. During the field studies, only four striped bass were observed to be caught in the area providing an insufficient database for evaluating potential effects of barrier operation on either adult striped bass or other fish or recreational angling success. Recreational angler creel surveys, although an important component in evaluating acoustic barrier operations, generally provide only qualitative information on changes in angler success (CPUE) which could then be related to acoustic barrier operations. It is unlikely that results of a recreational angler creel survey, even with a more intensive effort and larger database, would provide a sufficient dataset to quantify, with confidence, changes in CPUE which could be directly related to acoustic barrier operations.

Fyke Net Collections

Fyke netting began May 4 and proceeded through May 13 after which time collections were discontinued. Fish collected in the fyke nets included both juvenile chinook salmon and juvenile squawfish. Results of fyke net collections are summarized below:

	Georgiana Slough		Sacramento River	
Acoustic Barrier	Off	On	Off	On
May 4-7				
Hours of Collection	47	18	41.2	17.9
Number Salmon	3	0	0	0
May 10-13				
Hours of Collection	24.5	48	24.5	48
Number Salmon	2	0	1	0

The use of floating under dock mounted fyke nets proved to be an ineffective method for collecting juvenile chinook salmon smolts within both the Sacramento River and Georgiana Slough. The low numbers of fish collected appeared to be a result of algal and debris loading on the fyke net wings despite cleaning and maintenance efforts, interference from the floating docks and anchor lines, and behavioral avoidance. Juvenile chinook salmon were observed to routinely move into, then actively swim out of the fyke net mouth thereby avoiding capture. As a consequence of the low numbers of fish sampled using fyke nets, results of these collections have not been included in the evaluation of the acoustic barrier. However, the floating fyke net concept in alternative locations or configurations may be evaluated further in later efforts.

Kodiak Trawl Collections

A total of 610 Kodiak trawls were completed within Georgiana Slough and the Sacramento River between May 6 and June 10 for use in evaluating the effectiveness of the acoustic barrier (Table 1). Juvenile chinook salmon comprised 95% (5,163 salmon) of the total number of fish collected (5,460 fish) during the sampling period. The length frequency for juvenile chinook salmon collected in both the Sacramento River and Georgiana Slough is presented in Figure 12.

In addition to juvenile chinook salmon other fish species collected included juvenile and sub-adult delta smelt, tule perch, steelhead, Sacramento sucker, threadfin shad, Sacramento splittail, and Sacramento squawfish. Tadpoles were also collected. No winter-run chinook salmon were collected based on analysis of daily length intervals established by CDFandG and NMFS (Fisher, unpublished data). During Kodiak trawl collections conducted on May 25 two delta smelt were captured during sampling. Taxonomic identification of the delta smelt was verified by Dr. Johnson Wang. The U.S. Fish and Wildlife Service (Bob Pine) was notified of the delta smelt collections in accordance with terms and conditions of project permits. At the request of USFWS all sampling associated with the acoustic barrier operation was stopped May 26 resulting in the collection of only nine Kodiak trawl samples within the Sacramento River and nine samples within Georgiana Slough when the acoustic barrier was on (Table 1). Subsequently, the acoustic barrier project, and associated scientific collection activity, was incorporated into the Interagency Ecological Study Program (IESP) which allowed for continuation of the project evaluation under terms and conditions of the IESP scientific research permit that allows for the incidental collection of delta smelt. The project evaluation, including Kodiak trawling, was resumed on June 1, 1993.

Data collected during fisheries surveys between May 17 and May 21 and June 1 and June 4 have been summarized to provide information on juvenile chinook salmon catches within the Sacramento River and Georgiana Slough. Data for these two series of collections were selected for temporal and spatial analysis since they reflect periods when juvenile salmon catches were relatively high and sampling was performed within Georgiana Slough and the Sacramento River during periods when the acoustic barrier was both in and out of service (on and off; Table 1). The temporal distribution of juvenile chinook salmon is shown in Figures 13 and 14. Kodiak trawl collections were characterized by relatively high variability in the numbers of juvenile chinook salmon collected in each sample within both Georgiana Slough and the Sacramento River. Catch-per-unit-of-effort (CPUE) for juvenile chinook salmon in Kodiak trawl collections during sampling periods other than those shown in Figures 13 and 14 also demonstrate high variability among collections (Appendix B). No diel pattern was apparent in the numbers of chinook salmon collected during these studies (Figures 13 and 14). Additional data collection and analyses of diel distribution patterns and the effect of environmental factors such as tidal stage will be included in the Phase II studies proposed for 1994.

Analysis of length frequency data collected for juvenile chinook salmon (Figures 15 and 16) showed similar distributions between Georgiana Slough and the Sacramento River during both periods when the acoustic barrier was on and off. Results of the length frequency analysis provide no indication of size-selective movement of juvenile chinook salmon into Georgiana Slough. The analysis of size-selective movement of juvenile chinook salmon into Georgiana Slough or behavioral response to the acoustic barrier, however, is limited due to the narrow size range of juvenile chinook salmon (Figures 15 and 16) and selectivity of the Kodiak trawl. No literature was found that provided information on the size-specific behavioral response of fish to underwater sound such as that tested at Georgiana Slough.

Kodiak trawl collections within the Sacramento River downstream of the acoustic barrier were analyzed for trends in the horizontal distribution of fish within the channel. It was hypothesized that greater numbers of juvenile chinook salmon may occur along the left bank (downstream orientation) representing the outside shoreline along a sweeping bend in the river (Figure 1). Kodiak trawls were performed parallel to the left river bank, mid-channel, and the right river bank (Figure 11) during the study. Results of these collections are summarized in Table 2 for periods when the acoustic barrier was on and for periods when the acoustic period was off. Mean CPUE for these collections are shown in Figure 17. Results of collections performed between May 17 and 21 showed higher numbers of juvenile chinook salmon collected in mid-channel and along the left bank (looking downstream) although the variability inherent in individual collections was high. However, no horizontal distribution pattern was apparent for collections performed between June 1 and 4. Examination of individual collections throughout the sampling period showed evidence of higher collections along the left bank (easterly) when compared with collections along the right bank, however variability among collections at all sampling locations was high.

Examination of data on the horizontal distribution of juvenile chinook salmon within the Sacramento River both upstream of the acoustic barrier (unpublished data) and downstream of the acoustic barrier (Table 2) did not show a consistent change in the horizontal distribution of chinook salmon in response to acoustic barrier operations. Results of several collections performed in the immediate vicinity of the acoustic barrier suggested an increase in fish density at the mid-channel location and a reduction in density along the left bank (looking downstream) when the acoustic barrier was on - these observations are consistent with the hypothesis that juvenile chinook salmon behaviorally responded to the acoustic barrier signal. The horizontal distribution of juvenile chinook salmon at downstream sampling locations within the Sacramento River (Table 2) did not, however, show a consistent pattern corresponding to acoustic barrier operations. It has been speculated, although not verified, that the sampling location for Kodiak trawls within the Sacramento River (Figure 11) was a sufficient distance downstream of the acoustic barrier for the fish to become redistributed within the river channel and therefore not reflect a consistent change in the distribution of fish in response to acoustic barrier operations. Additional sampling would need to be performed in the immediate area upstream and downstream of the acoustic barrier to provide information on a change in the horizontal distribution of juvenile chinook salmon in response to acoustic barrier operations.

Results of the otter trawl (bottom sample) and Kodiak trawl (surface sample) comparison performed on June 3 and 4 are summarized in Table 3 and Figure 18. Results of these paired tests showed a general pattern of higher juvenile chinook salmon collections (CPUE) in the upper six foot portion of the water column sampled using the Kodiak trawl. However, results of these collections also showed a substantial increase in the numbers of juvenile chinook salmon collected in the lower portion of the water column (otter trawl) on June 4 within the Sacramento River. These results demonstrate that juvenile chinook salmon may be located throughout the water column within the Sacramento River at certain times. Water depth within the Sacramento River in the area sampled averaged approximately 20 feet during sampling. Factors contributing to the higher numbers of juvenile chinook salmon collected in otter trawls on June 4 within the Sacramento River are unknown. Future studies should include a greater number of replicate samples for use in comparing catches between Kodiak and otter trawls and examining the influence of such factors as diurnal movement on the vertical distribution of juvenile chinook salmon.

Acoustic Barrier Evaluation

The ratio of juvenile chinook salmon catches in Kodiak trawls within the Sacramento River *versus* Georgiana Slough when the acoustic barrier was in (on) and out (off) of service (Table 1) was used to evaluate the effectiveness of the acoustic barrier. The relative number of salmon entering Georgiana Slough when the barrier was off was used as the base condition (control). A change in the relative number (ratio) of salmon entering Georgiana Slough when the barrier was in service (on) was used to calculate an index of guidance efficiency for the acoustic barrier (treatment). If the acoustic barrier is effective in repulsing juvenile chinook salmon from entering Georgiana Slough the ratio of CPUE between Georgiana Slough and the Sacramento River would decrease (e.g., fewer fish collected within Georgiana Slough when compared with the Sacramento River) when the barrier is in service compared with the corresponding ratio for periods when the barrier was out of service. The analysis was performed using catch data adjusted for variation in sampling effort (CPUE). Catch-per-unit-of-effort in these studies was calculated both as the number of juvenile chinook salmon caught per unit time sampled (number/minute) and catch-per-unit-volume-sampled (number/1000m^3).

Results of the acoustic barrier analyses are summarized in Figures 19 and 20. Ratio estimates for collections within the river and slough and the calculated index of guidance efficiency for the acoustic barrier was performed separately for each four-day test sequence. Results of these analyses showed a consistent pattern based on both methods of calculating CPUE. Results of the first complete weekly testing cycle performed from May 10-14 (Table 1) showed a greater relative number (ratio) of juvenile chinook salmon entering Georgiana Slough when the acoustic barrier was in service when compared to catches when the acoustic barrier was out of service resulting in a negative index of guidance efficiency. Based on results of the first week of testing it was hypothesized that the angle and location of the acoustic barrier was too close to the entrance to Georgiana Slough given the channel hydraulics, resulting in an insufficient reaction time and distance for juvenile chinook salmon to respond to the acoustic barrier and overcome velocities of water entering the slough. Based on this hypothesis, the configuration of the acoustic barrier was modified to extend the array and increase the angle in an attempt to guide juvenile chinook salmon towards the mid-channel area of the Sacramento River a sufficient distance upstream of the confluence with Georgiana Slough to allow guidance and passage downstream.

The location and configuration of the acoustic barrier were modified weekly based on preliminary results of Kodiak trawl collections. Modifications to the barrier primarily included changes in the angle of the barrier with respect to the Sacramento River channel, the spacing between speakers, and the number of speakers used. The frequency and amplitude of the acoustic signal remained constant throughout all tests. Results of the biological evaluation (Figures 19 and 20) show a general pattern of increasing guidance efficiency during each weekly testing sequence. The final two testing sequences, performed between June 1 and 4 and June 7 and 10, had an estimated index of guidance efficiency above 50%. As a consequence of weekly modifications to the acoustic barrier the 1993 studies do not, however, provide the necessary degree of replication of results for statistically evaluating the guidance effectiveness of the acoustic array. In addition, detailed documentation from aerial photographs on the acoustic barrier location was not available for each weekly test nor was information on river velocities which may have influenced acoustic barrier guidance efficiency.

Although there was a promising trend of increasing guidance efficiency for the acoustic barrier (Figures 19 and 20), specific factors contributing to the apparent trend (e.g., biological design criteria for the acoustic barrier) resulting in the increased efficiency could not be verified. Investigations proposed for 1994 will include additional measurements and documentation on the location of the barrier, velocities and flows, acoustic signal characteristics (signal mapping), and fisheries studies. Results of the proposed 1994 studies will provide a more comprehensive basis for statistically evaluating the performance of the acoustic barrier and establishing a basis for design criteria for the use of acoustic barriers within the Sacramento River at the confluence with Georgiana Slough and other potential locations within the Delta.

As part of the acoustic barrier evaluation, the condition of juvenile chinook salmon collected in Kodiak trawls downstream of the acoustic barrier in Georgiana Slough and the Sacramento River was documented. Observations were recorded during sample processing on fish mortality and injury. A comparison was then made of the percent frequency of injuries and mortality combined for juvenile chinook salmon collected within Georgiana Slough and the Sacramento River when the acoustic barrier was in service (on) and out of service (off). It was hypothesized that a higher frequency of injury or mortality observed in these collections when the acoustic barrier on would provide insight into potential adverse effects associated with barrier operation. Results of these comparisons are summarized below:

	Number Salmon Smolts		Percentage
	Injured & dead	Total	Injured & Dead
Sacramento River			
Barrier On	15	1330	1.1
Barrier Off	14	1469	1.0
Georgiana Slough			
Barrier On	7	850	0.8
Barrier Off	11	1332	0.8

The frequency of injury and mortality associated with Kodiak trawls ranged from 0.8-1.1% and provide no evidence that acoustic barrier operations contributed to an immediate increase in either mortality or injury to juvenile chinook salmon. Results of these initial observations do not, however, provide any information regarding potential delayed mortality, sublethal stress, or increased susceptibility to predation for juvenile chinook salmon exposed to the underwater acoustic signal. These issues will need to be addressed through additional field and laboratory investigations proposed as part of Phase II investigations to be conducted during 1994. These observations do, however, demonstrate that the Kodiak trawl, when combined with live cars, can be used as an effective sampling tool for juvenile chinook salmon with a relatively low rate (approximately 1%) of damage to those fish that are collected. These observations were made immediately after sample collection and do not provide any information regarding either sublethal physiological stress or delayed mortality associated with either exposure to the acoustic barrier or sample collection. These factors require further evaluation (assessment) which will be included as part of a field/laboratory investigation being planned for 1994.

SECTION 5

DISCUSSION

The Phase I evaluation of the potential effectiveness of an acoustic behavioral barrier for chinook salmon at Georgiana Slough has been developed, in part, as a feasibility and reconnaissance level study. Findings of the Phase I study are encouraging. Results of the barrier evaluation (Figures 19 and 20) indicate that application of an acoustic barrier may be a useful method (or tool) for protecting chinook salmon by reducing the passage of juveniles from the Sacramento River into Georgiana Slough which should reduce overall Delta-wide smolt mortality. Although not tested as part of the Phase I investigation, the indices of guidance efficiency of the barrier for fall-run salmon smolts suggests that an acoustic barrier may also be an effective alternative for reducing passage of winter-run and other races of salmon smolts from the Sacramento River into the interior Delta *via* Georgiana Slough.

Although results of the 1993 Phase I field investigations provided encouraging results these studies were not designed to provide rigorous statistical testing of the effectiveness of an acoustic barrier. The Phase I field tests were used to develop an index of guidance efficiency, based on ratio estimates of juvenile chinook salmon collections in Kodiak trawls within the Sacramento River and Georgiana Slough, but did not provide the necessary degree of replication to support rigorous statistical analysis, calculation of absolute guidance efficiency which can be used with confidence to represent a range of environmental conditions, or detailed analyses on changes in the distribution pattern of juvenile chinook salmon in response to acoustic barrier operations. Results of Phase I field collections did, however, provide extensive information on the use of Kodiak trawls for collecting juvenile chinook salmon within the Sacramento River and Georgiana Slough, estimates of variation in CPUE among trawls, and the necessary scientific foundation for the design of a more comprehensive and rigorous field and laboratory investigation to further evaluate the effectiveness and potential benefits associated with operation of an acoustic barrier within the Sacramento River at the confluence with Georgiana Slough.

Although a substantial amount of information was collected from Kodiak trawls during the 1993 studies results of these collections have not been subject to rigorous statistical analysis. The 1993 studies lacked replication in test conditions between weeks. Although results of the 1993 studies are promising, results of these preliminary investigations are not intended to be used to calculate either a absolute guidance efficiency for the acoustic barrier or to be used in statistical analysis of significant differences in the numbers of juvenile chinook salmon collected within the Sacramento River and Georgiana Slough in response to acoustic barrier operations. Based on the promising results of the 1993 investigations a more rigorous evaluation of the effectiveness of the acoustic barrier has been proposed for 1994 which will be based on an experimental design developed for hypothesis testing and statistical analysis. Statisticians from CDFandG and NMFS will be invited to participate in the design of the 1994 investigation and to participate and review results of statistical analyses performed using the 1994 data. Based upon results of field data collection and statistical analyses, a calculation of guidance efficiency and statistical confidence in the significance of changes in juvenile chinook salmon collections within the Sacramento River and Georgiana Slough during periods when the acoustic barrier is on and off will be performed.

The 1994 sampling program will also include a more rigorous analysis of Kodiak trawl CPUE within the Sacramento River and Georgiana Slough in response to both diel and tidal effects. Additional collections will also be made to provide information on changes in the horizontal distribution of juvenile chinook salmon within the Sacramento River upstream and downstream of the acoustic barrier for use as an additional indicator of a potential behavioral response of juvenile chinook salmon to the acoustic signal. As a consequence of the naturally-occurring high variability in juvenile chinook salmon CPUE the 1994 studies will be designed to utilize a variety of independent measures for evaluating the acoustic barrier.

Results of the Phase I field tests have also been useful in identifying specific issues to be addressed in further evaluations of acoustic barrier technology which form the foundation for the design of studies to be conducted as part of subsequent evaluation of acoustic barrier technologies. Additional studies (Phase II) and evaluations will be required to provide more thorough information on a range of potential environmental issues associated with long-term installation and operation of an acoustic array. Issues that require additional evaluation include, but are not limited to, the following:

1. Documentation of acoustic barrier location;

2. Velocity measurements in the areas adjacent to the acoustic barrier;

3. Flow measurements within the Sacramento River and Georgiana Slough;

4. Acoustic measurements to document characteristics of the underwater sound within both laboratory and field tests;

5. Determination of the guidance efficiency of the acoustic barrier for juvenile chinook salmon emigrating within the Sacramento River;

6. Evaluation of potential effects of acoustic barrier operations on recreational angler success;

7. Evaluation of the application of hydroacoustic monitoring technologies for both juvenile and adult chinook salmon;

8. Evaluation of potential adverse effects of acoustic signal exposure on delta smelt egg development and hatching success;

9. Evaluation of the potential for increased susceptibility of juvenile chinook salmon, striped bass, and other fish (prey) to predation;

10. Evaluation of potential blockage or delays in adult sturgeon migration (sensitivity and behavioral response to acoustic signals);

11. Evaluation of potential blockage and delays in migration of adult striped bass and adult fall-run chinook salmon (used as a surrogate for adult winter-run chinook salmon);

12. Evaluation of acute and delayed mortality effects on juvenile striped bass as a result of exposure to the acoustic signal;

13. Effects of acoustic barrier operations on resident fish populations; and

14. Evaluation of the vertical and horizontal distribution of juvenile chinook salmon within the Sacramento River and Georgiana Slough based on comparison of paired otter and Kodiak trawls.

These and other potential environmental issues have been identified as part of the Phase I research program. Activities during the Phase I investigation were designed to collect preliminary information on such factors as sound levels of the acoustic barrier above and below the water surface and at various distances, a recreational angler creel survey program to document potential changes in CPUE during periods when the barrier is in and out of service, recreational angler use in the area of the confluence between the Sacramento River and Georgiana Slough, etc. Preliminary study designs for evaluating the behavioral response of juvenile and adult fish encountering the barrier, the use of Georgiana Slough as a migratory pathway for adult chinook salmon and other fish species, the use of coded-wire tag mark-recapture studies to evaluate long-term survival of juvenile chinook salmon exposed to the acoustic barrier, and the evaluation of the effects of the acoustic barrier on resident and migratory fish species will be considered and evaluated, as appropriate, as part of the Phase II investigations.

The Phase II investigations have been designed to provide more comprehensive documentation on environmental conditions such as velocity, flow rates, acoustic signal mapping, etc. to document conditions occurring during the testing period. The Phase II research investigation will also involve more replication and allow statistical testing for differences in juvenile chinook salmon CPUE within Georgiana Slough and the Sacramento River as a function of acoustic barrier operations. The research program has been designed to include a number of independent measures of acoustic barrier efficiency to help in evaluating barrier performance given the relatively high degree of variability in Kodiak trawl CPUE observed during the 1993 studies. In addition to Kodiak trawling during 1994, emphasis will be given to documenting changes in the horizontal distribution of juvenile chinook salmon in response to acoustic barrier operations, the use of hydroacoustic monitoring to determine the distribution characteristics and response of juvenile fish to the barrier, use of coded-wire tag mark-recapture studies to estimate survival rates for juvenile chinook salmon migrating downstream during periods when the acoustic barrier is on and off, and an attempt to determine the mass balance of juvenile chinook salmon approaching the acoustic barrier and the subsequent numbers of chinook salmon smolts entering Georgiana Slough and migrating downstream within the Sacramento River during periods when the acoustic barrier is on and off. Although each of these alternative approaches has inherent strengths and weaknesses for use in evaluating acoustic barrier performance, collectively results of the 1994 tests should provide a sufficient basis for evaluating guidance efficiency of the acoustic barrier for juvenile chinook salmon smolts.

The 1994 studies will be performed during the period from April through June focusing on fall-run chinook salmon smolts. Results of acoustic barrier guidance tests, and other laboratory/field studies performed using fall-run salmon have been assumed to be an effective and acceptable surrogate for evaluating potential benefits associated with acoustic barrier operations on winter-run salmon smolts.

In addition to evaluating guidance efficiency, 1994 studies will also consider, through various field and laboratory experimental tests, effects of the acoustic signal on hatching success and survival of various larval and juvenile fish, increased susceptibility to predation, and potential changes in resident fish populations in response to acoustic barrier operations. Radio tagging and hydroacoustic surveys are also proposed to evaluate the behavioral response of adult striped bass and upstream migrating fall-run chinook salmon exposed to the acoustic barrier. Fall-run adult salmon radio tagging and hydroacoustic studies, designed to evaluate the potential for blockage or delays in adult upstream migration as a result of exposure to the acoustic barrier are scheduled to be performed during the period from mid-September through mid-November 1994.

The design and execution of the 1994 investigations will be performed under the auspices of the Interagency Ecological Study Program (IESP). CDFandG and NMFS biostatisticians and scientists from a variety of resource agencies will be provided an opportunity to review the experimental design and study plan for the 1994 investigations and participate in the review of statistical analyses of the 1994 guidance efficiency tests and draft documentation report. Phase II studies will be developed in coordination with representatives of the California Department of Fish and Game, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Department of Water Resources, U.S. Bureau of Reclamation, and other interested resource and regulatory agencies to help ensure that all future research needs are adequately addressed as part of the subsequent field and laboratory investigations.

SECTION 6

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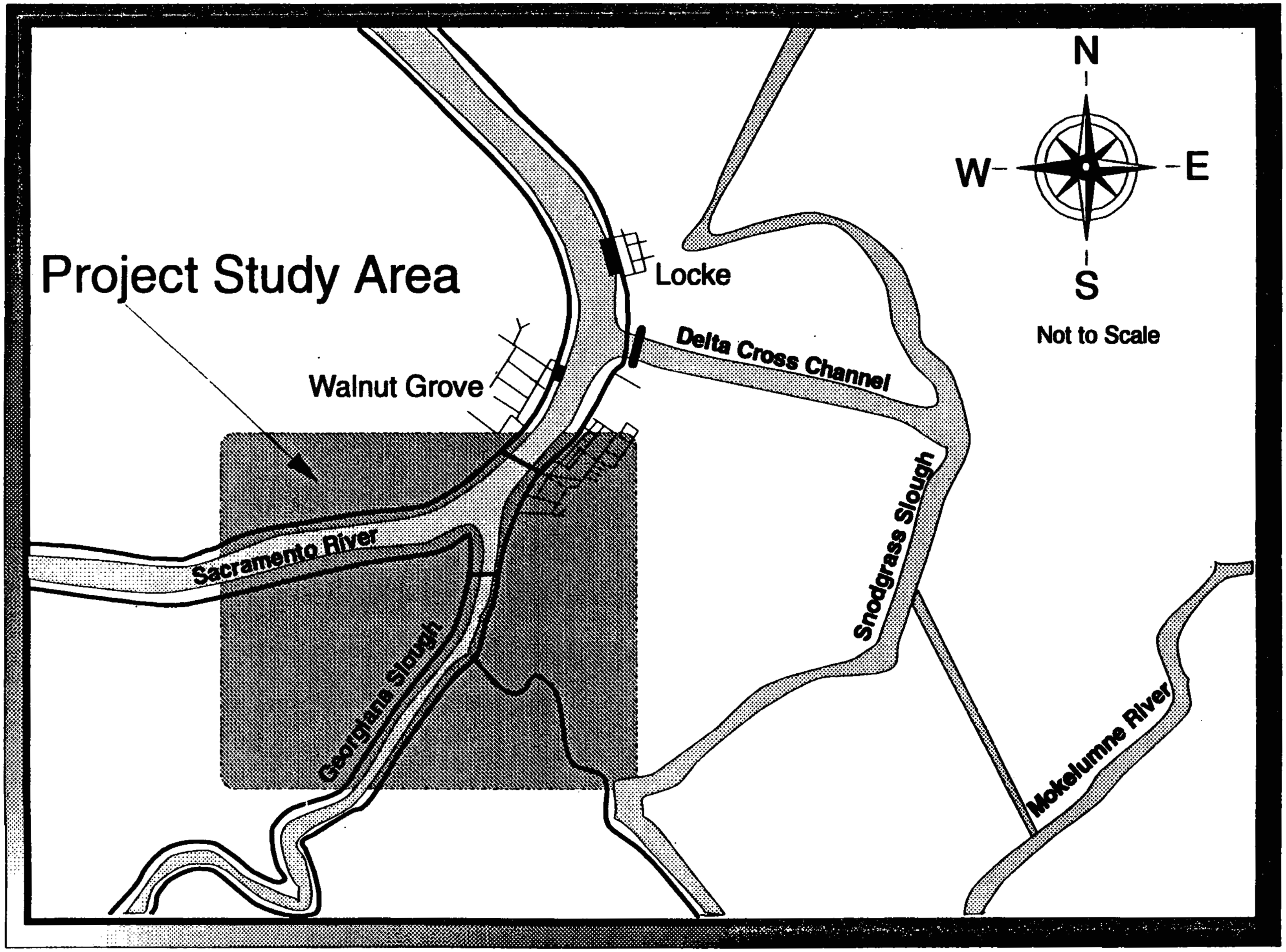


Figure 1. Project study area including the Sacramento River and Georgiana Slough for the biological evaluation of the effectiveness of an acoustic barrier.

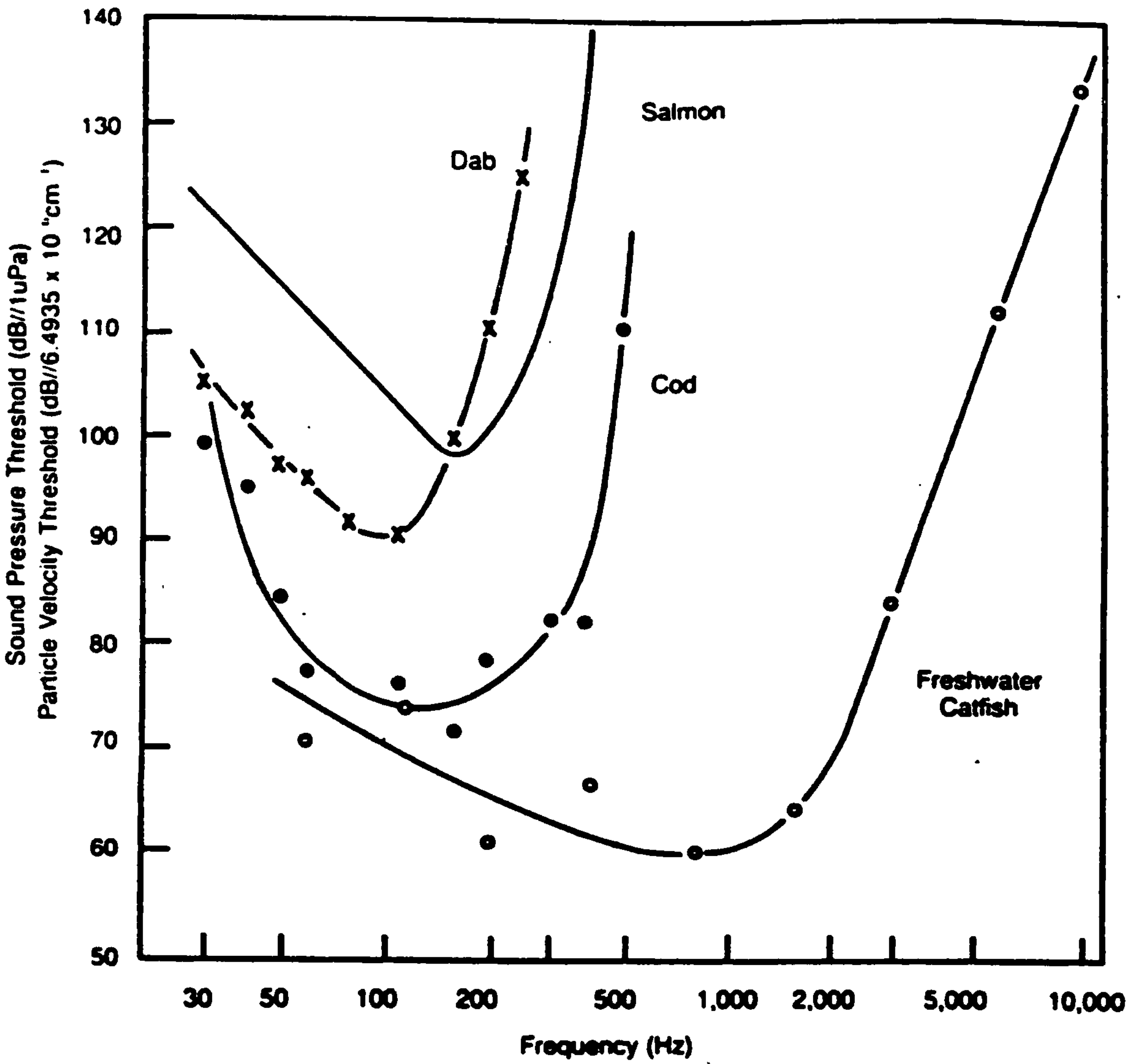


Figure 2. Audiogram for various fish species. (Source: Loeffelman *et al.* 1991a).

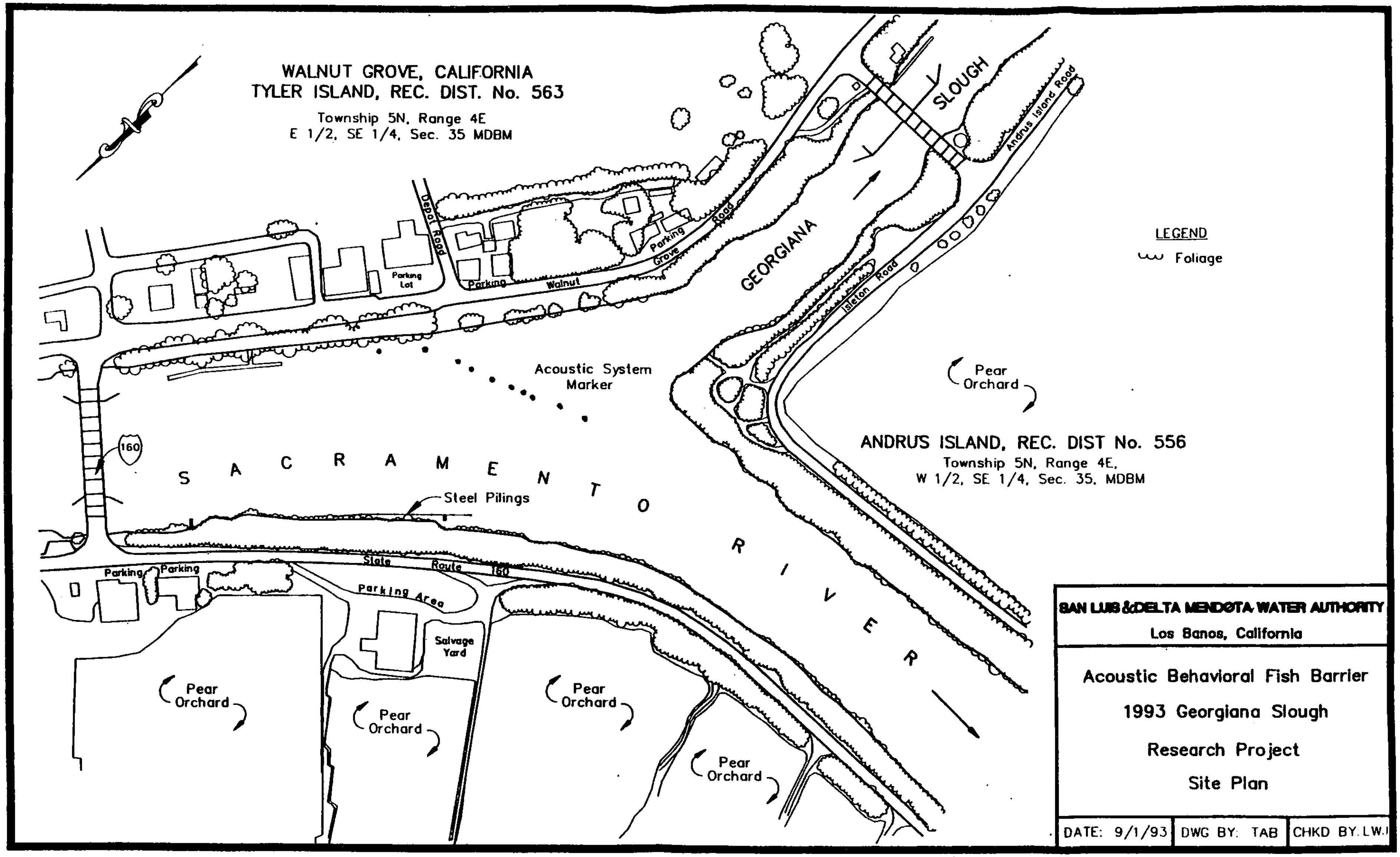


Figure 3. Location and configuration of the acoustic barrier within the Sacramento River upstream of the confluence with Georgiana Slough during the final week of the Phase I field test (based on aerial photographs taken June 11, 1993).

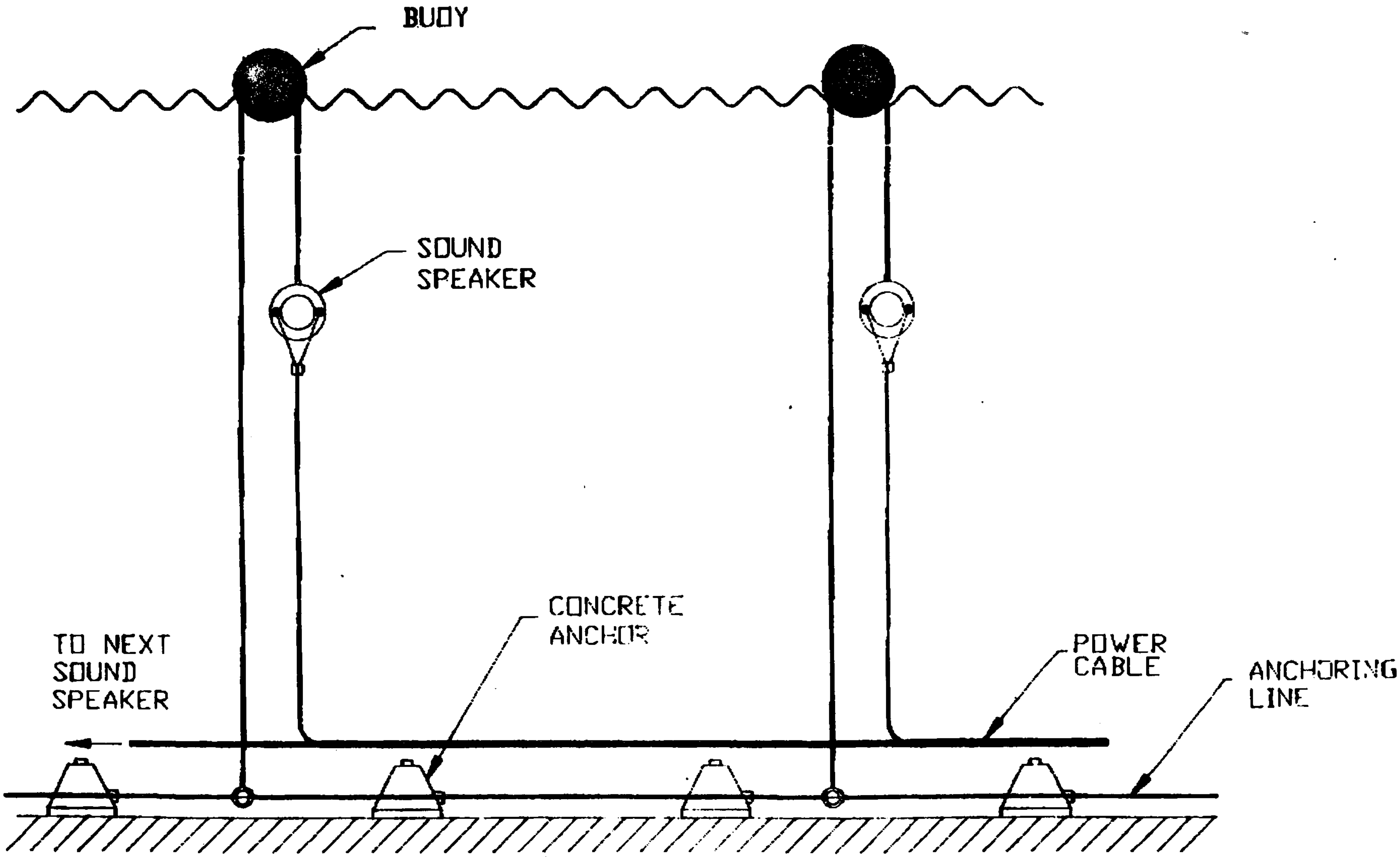


Figure 4. Anchoring system for the acoustic barrier.

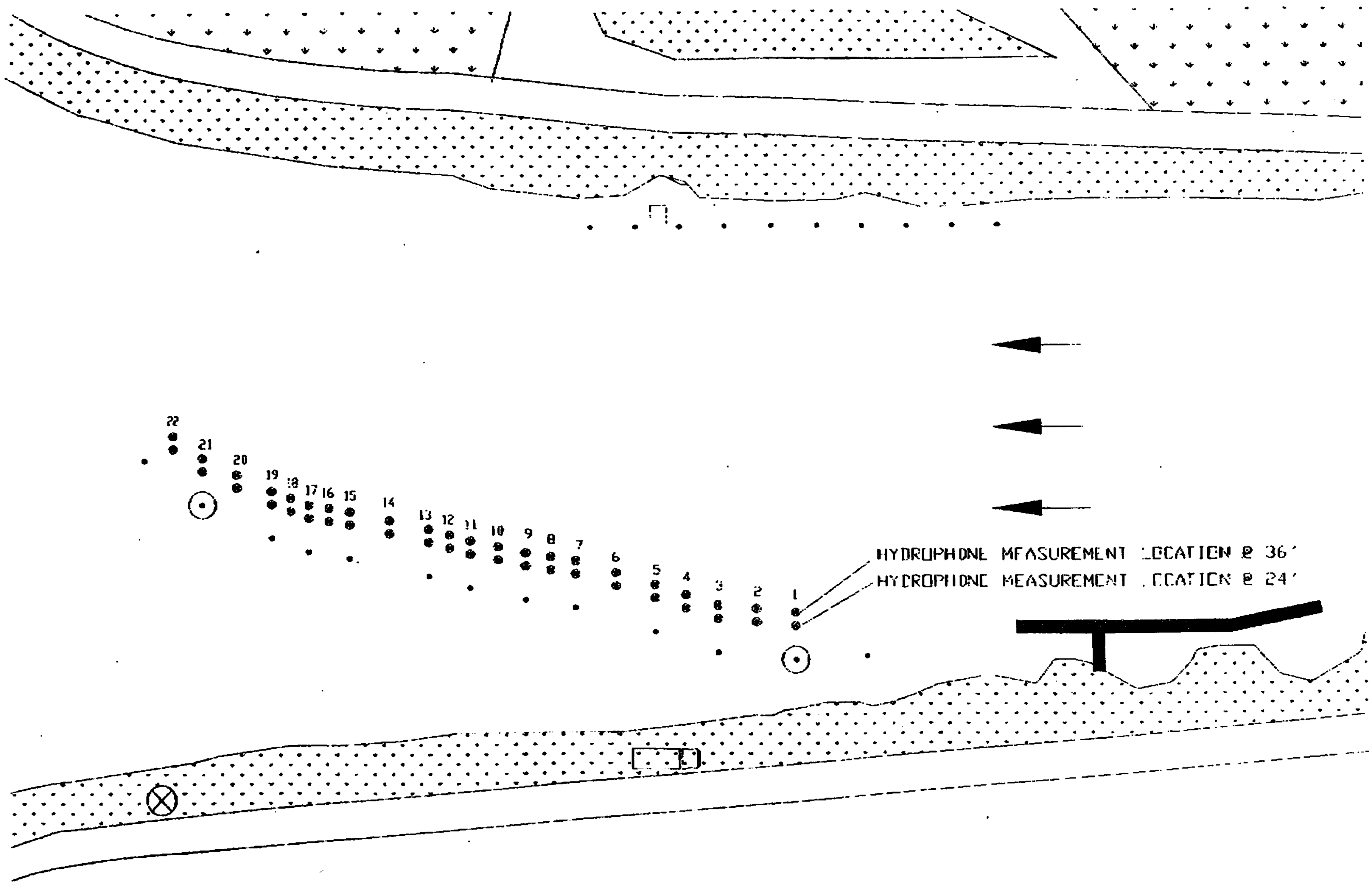
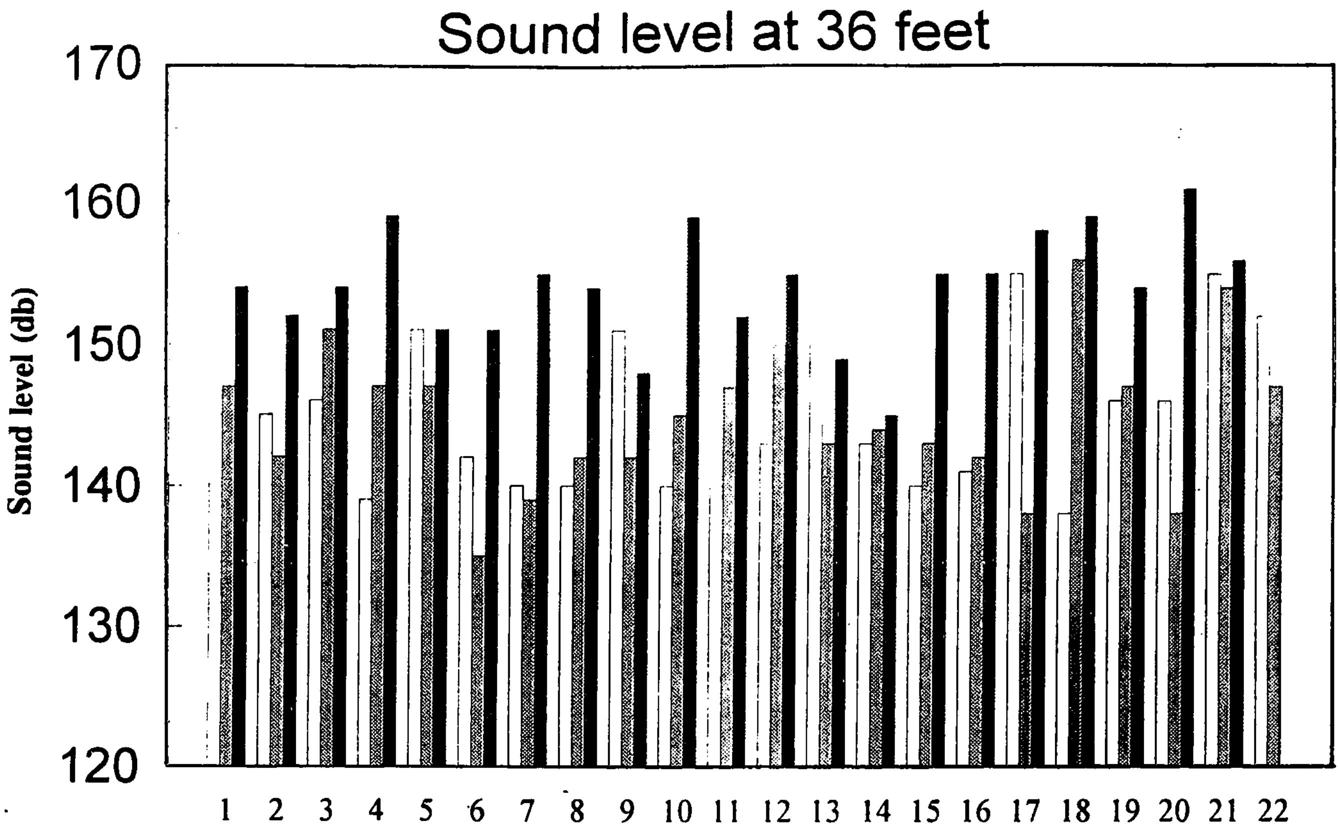


Figure 5. Hydrophone measurement locations used in mapping the sound signal associated with operation of the acoustic barrier (June 7-8, 1993).



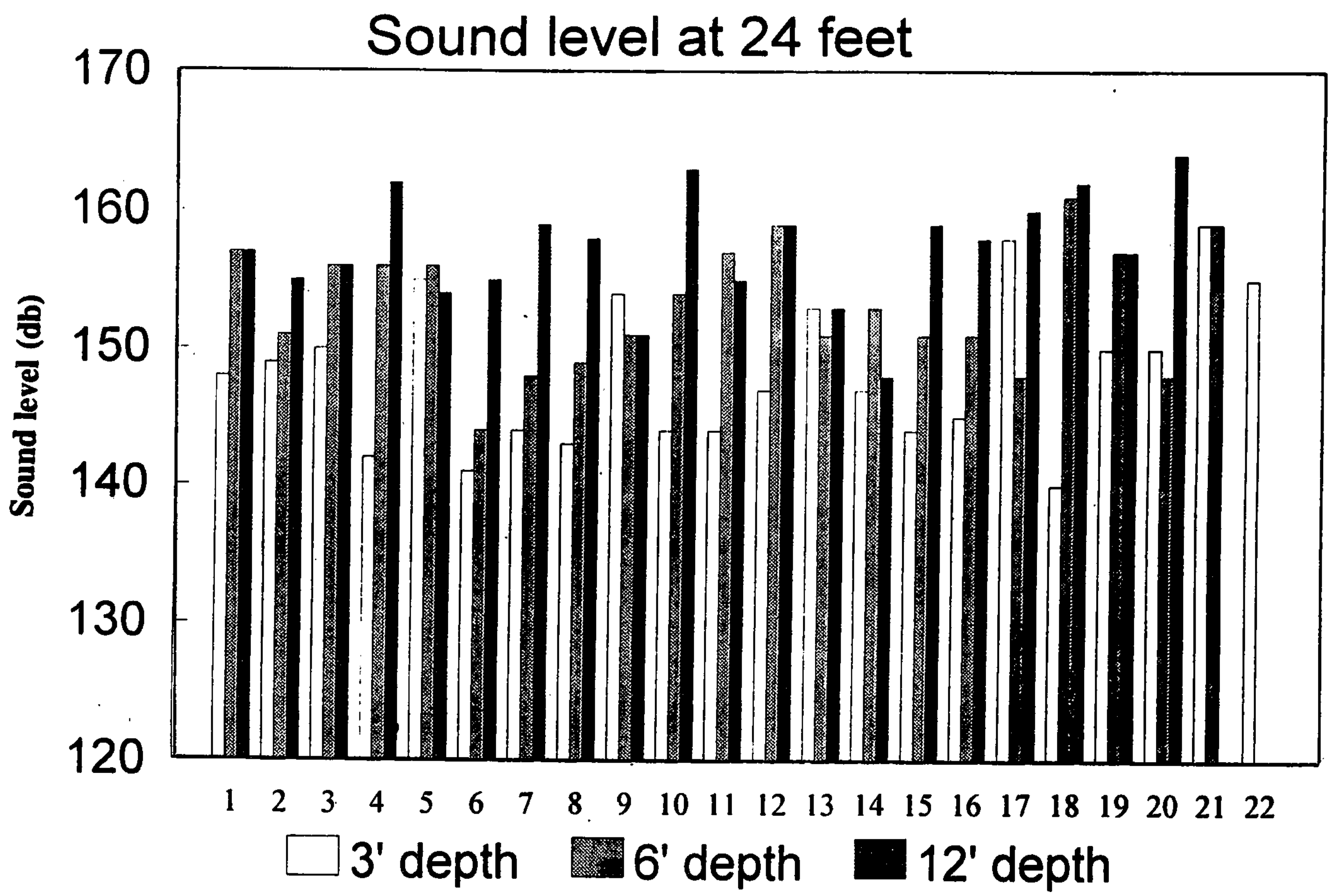


Figure 6. Sound levels (db) measured at 3, 6, and 12 foot depths at locations adjacent to the acoustic barrier. (Source: EESCO, unpublished data; see Figure 5 for sound monitoring stations).

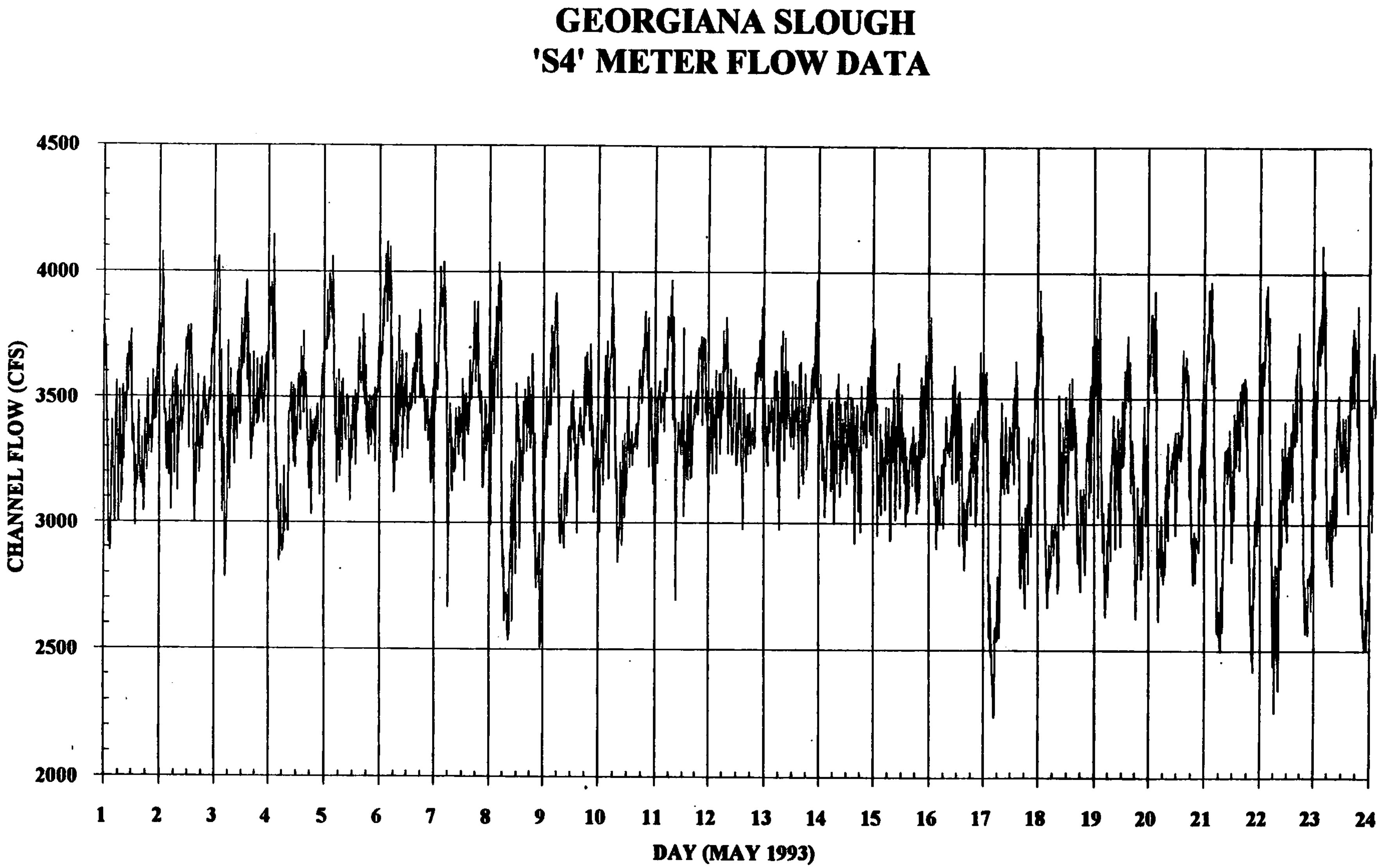


Figure 7. Estimated flow (cfs) within Georgiana Slough during the period from May 1 through 24, 1993. (Source: DWR, unpublished data).

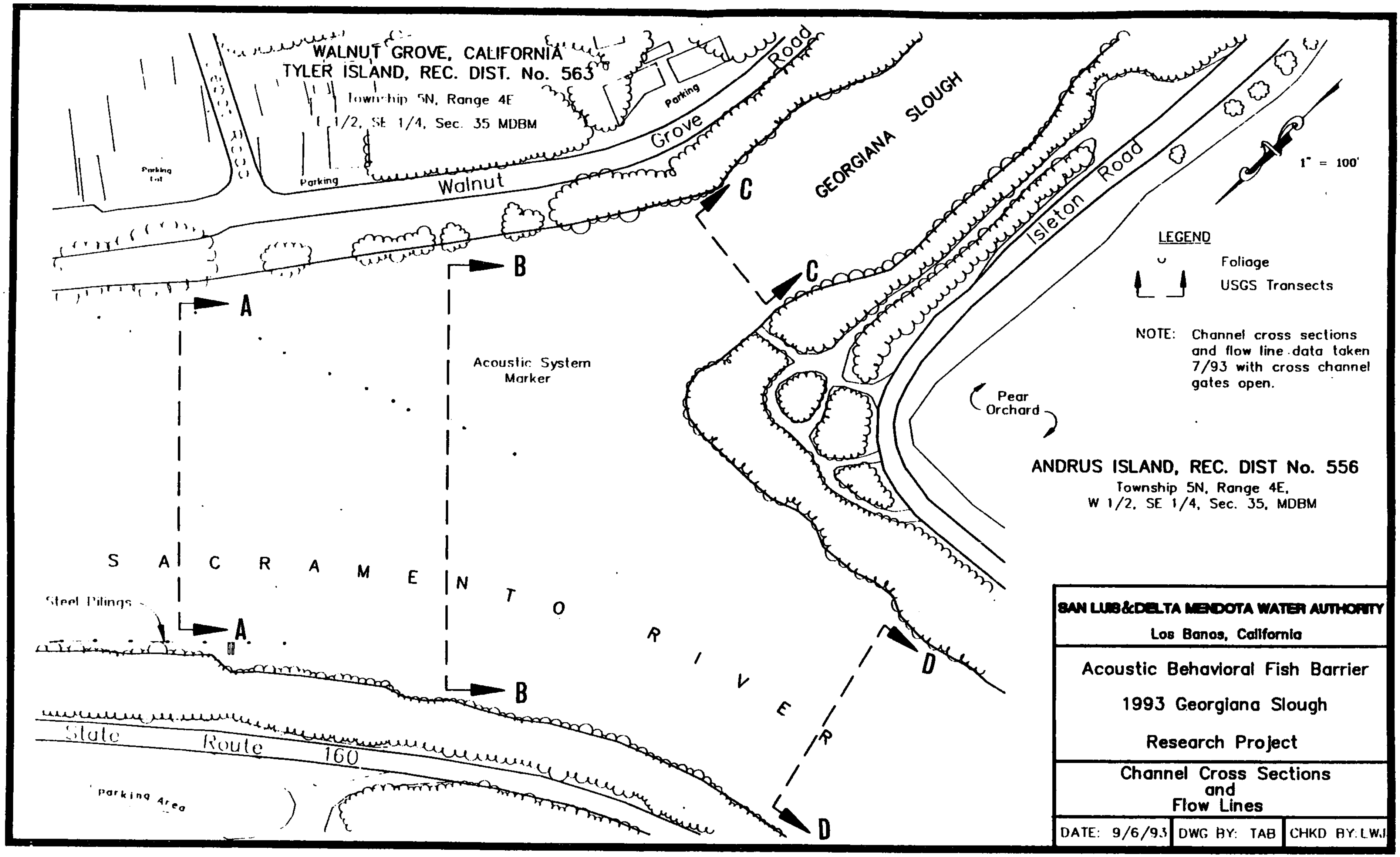


Figure 8a. Flow velocity measurement transect locations within Georgiana Slough. (Source: USGS, unpublished data).

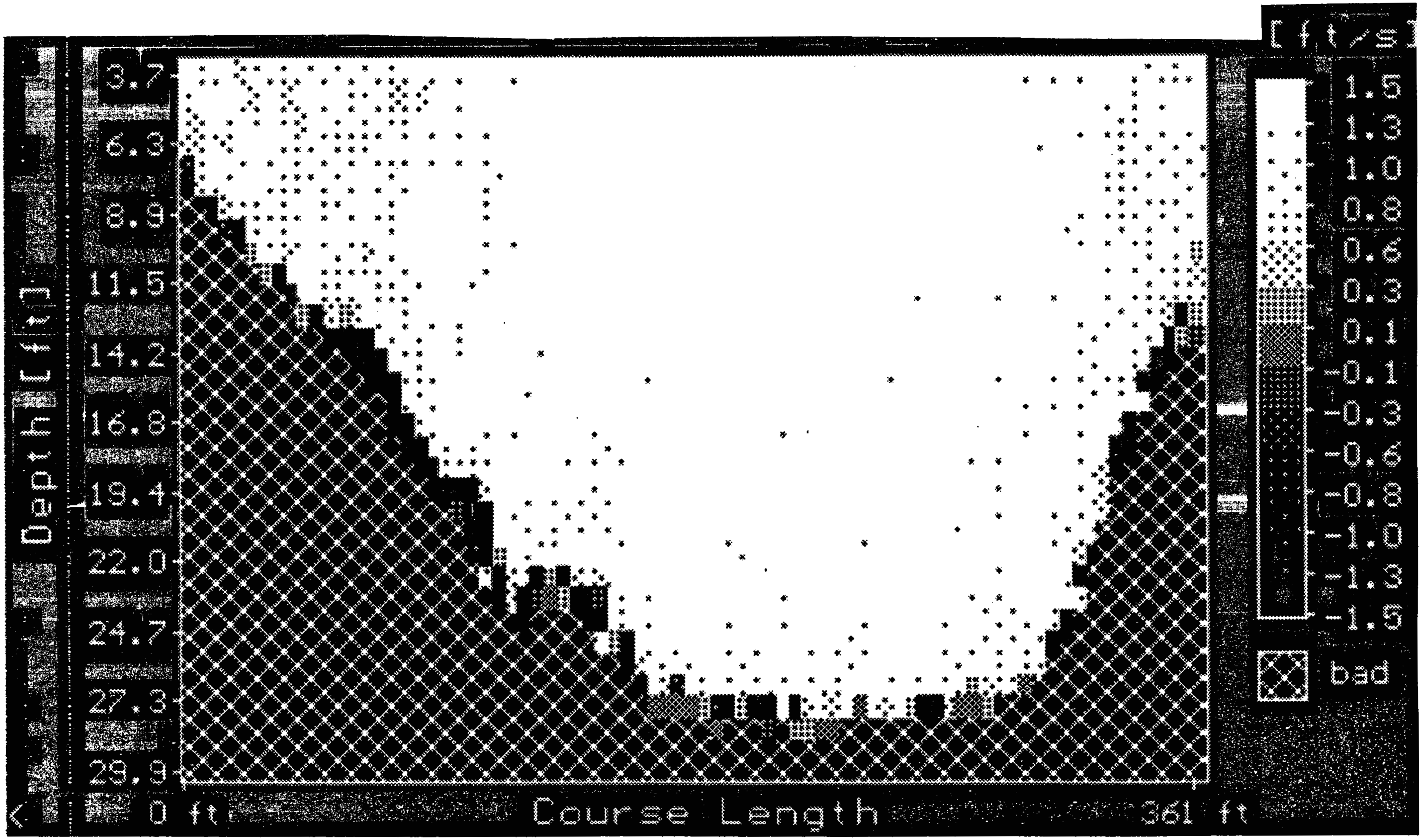


Figure 8b. Velocity (ft/sec) at channel cross-section A-A (see Figure 8a).

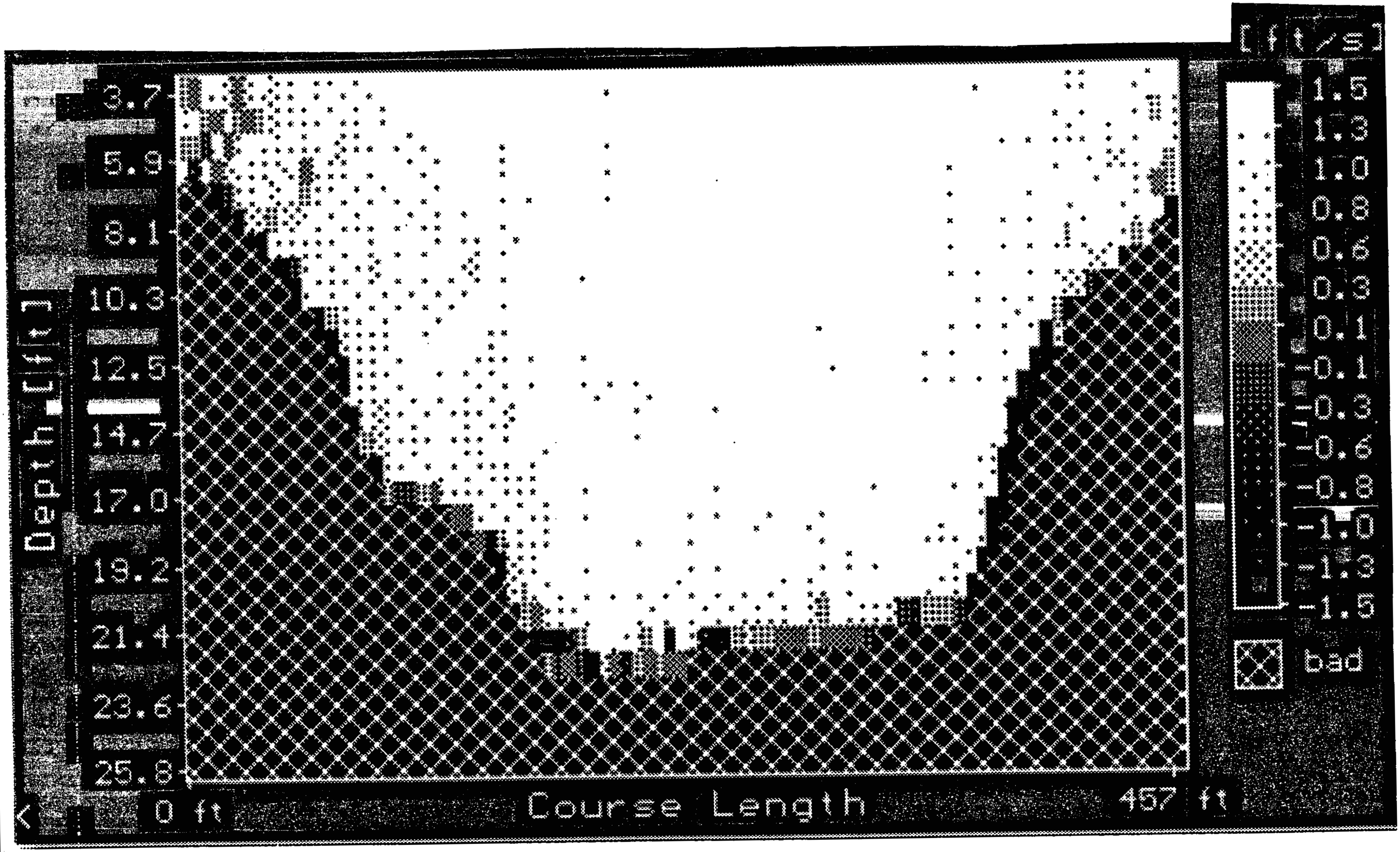


Figure 8c. Velocity (ft/sec) at channel cross-section B-B (see Figure 8a).

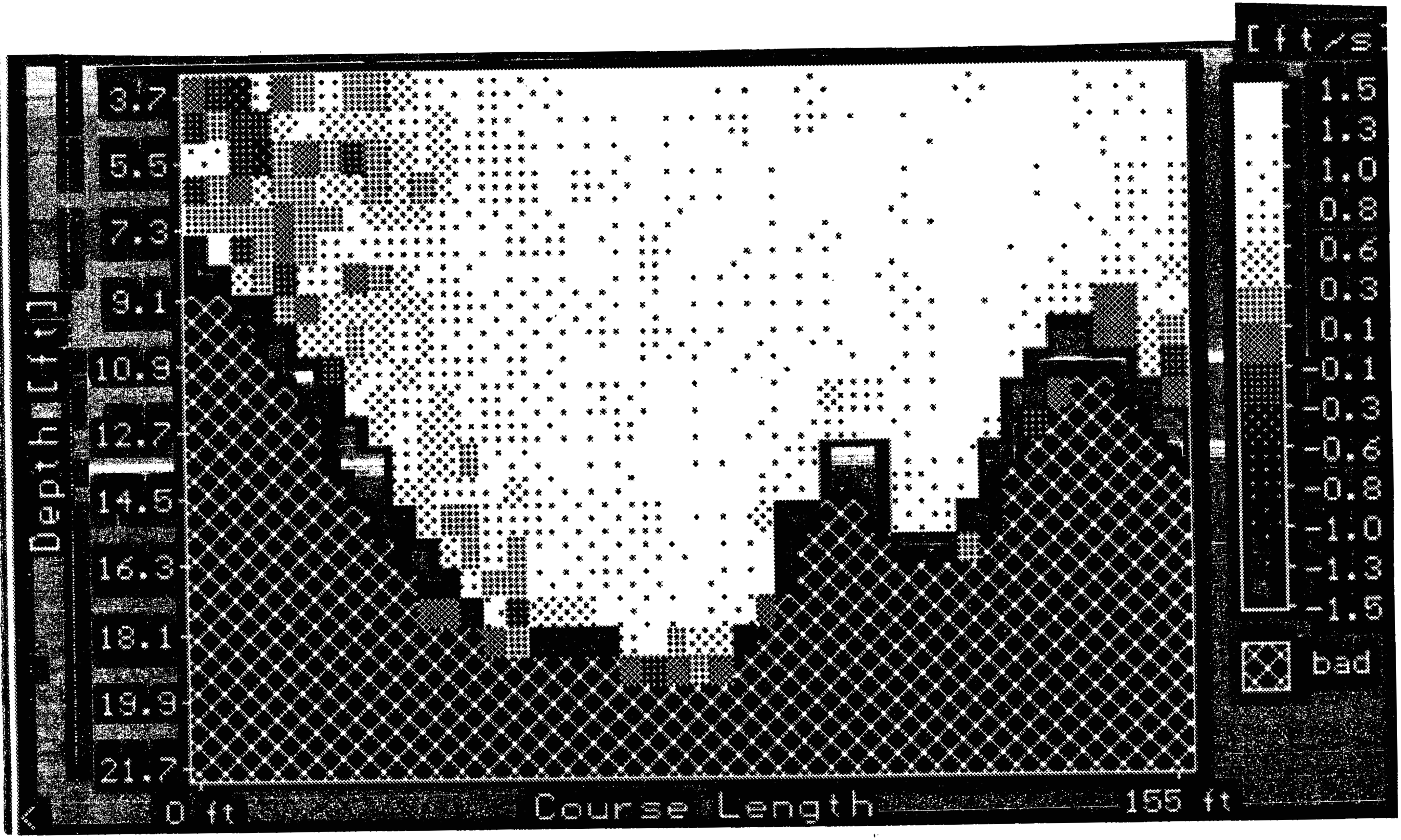


Figure 8d. Velocity (ft/sec) at channel cross-section C-C (see Figure 8a).

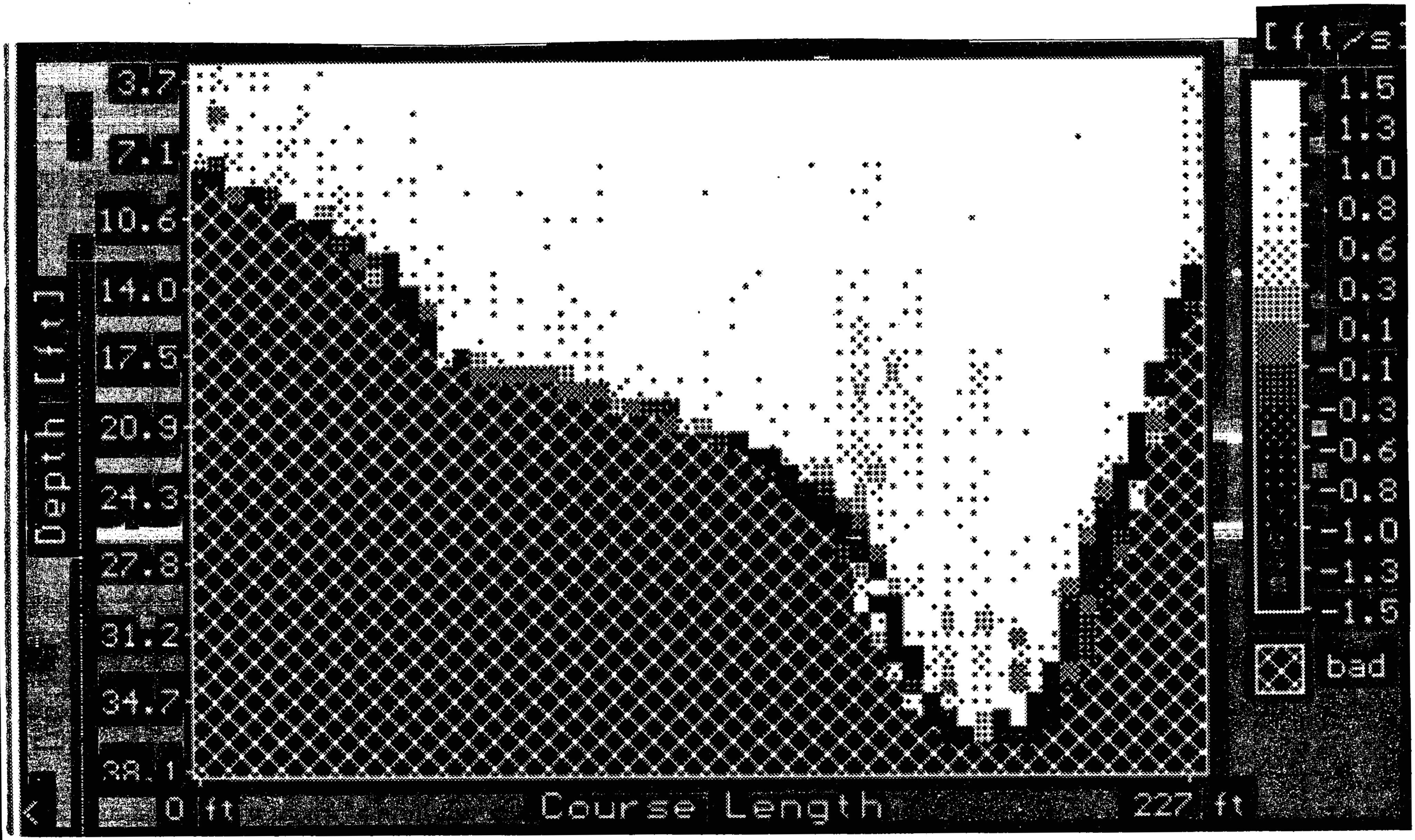


Figure 8e. Velocity (ft/sec) at channel cross-section D-D (see Figure 8a).

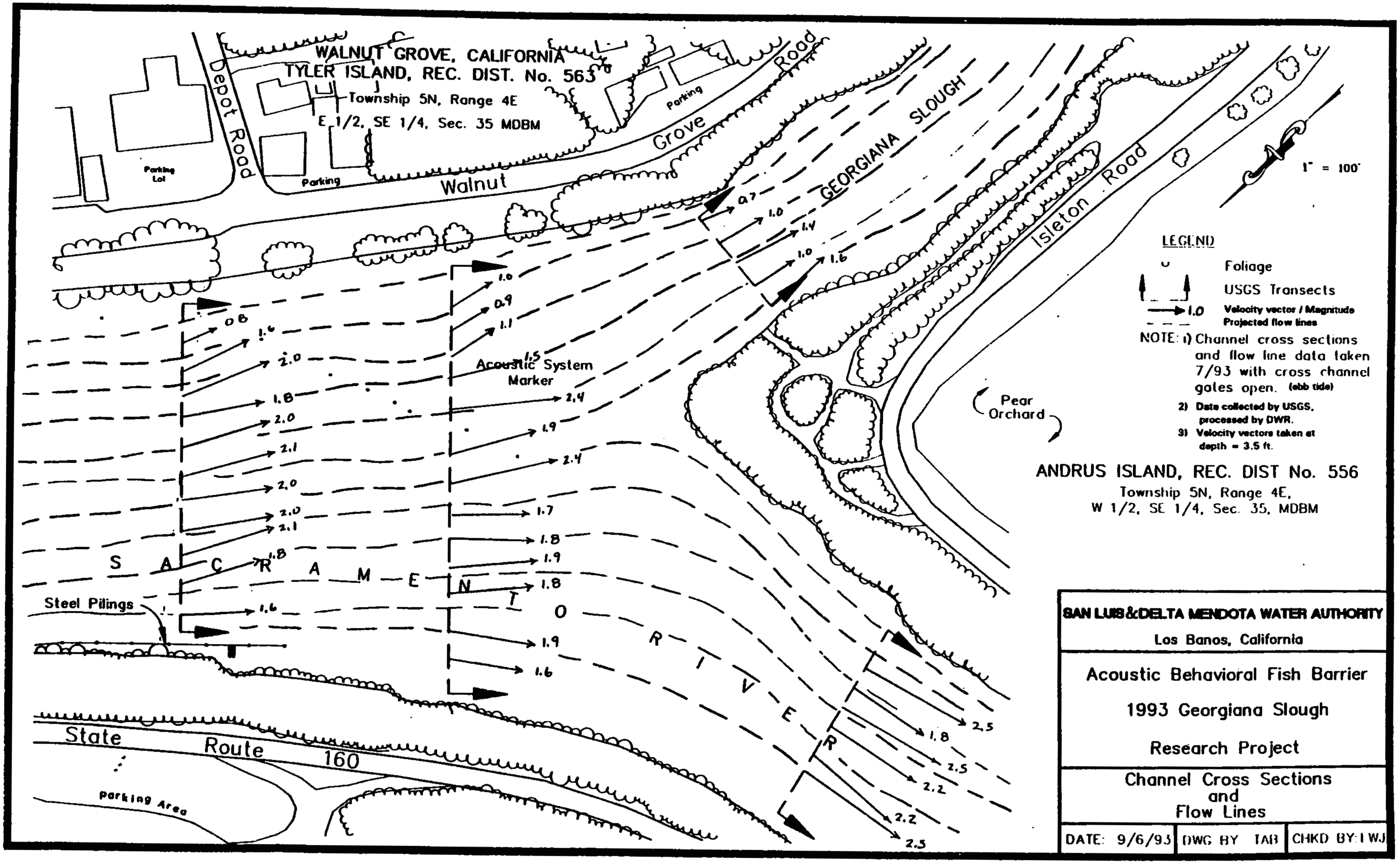


Figure 9a. Results of velocity measurements (flow vectors and velocities - ft/sec) within the Sacramento River and Georgiana Slough in the vicinity of the acoustic barrier at a depth of 3.5 feet. (Source: USGS, unpublished data; processed by DWR).

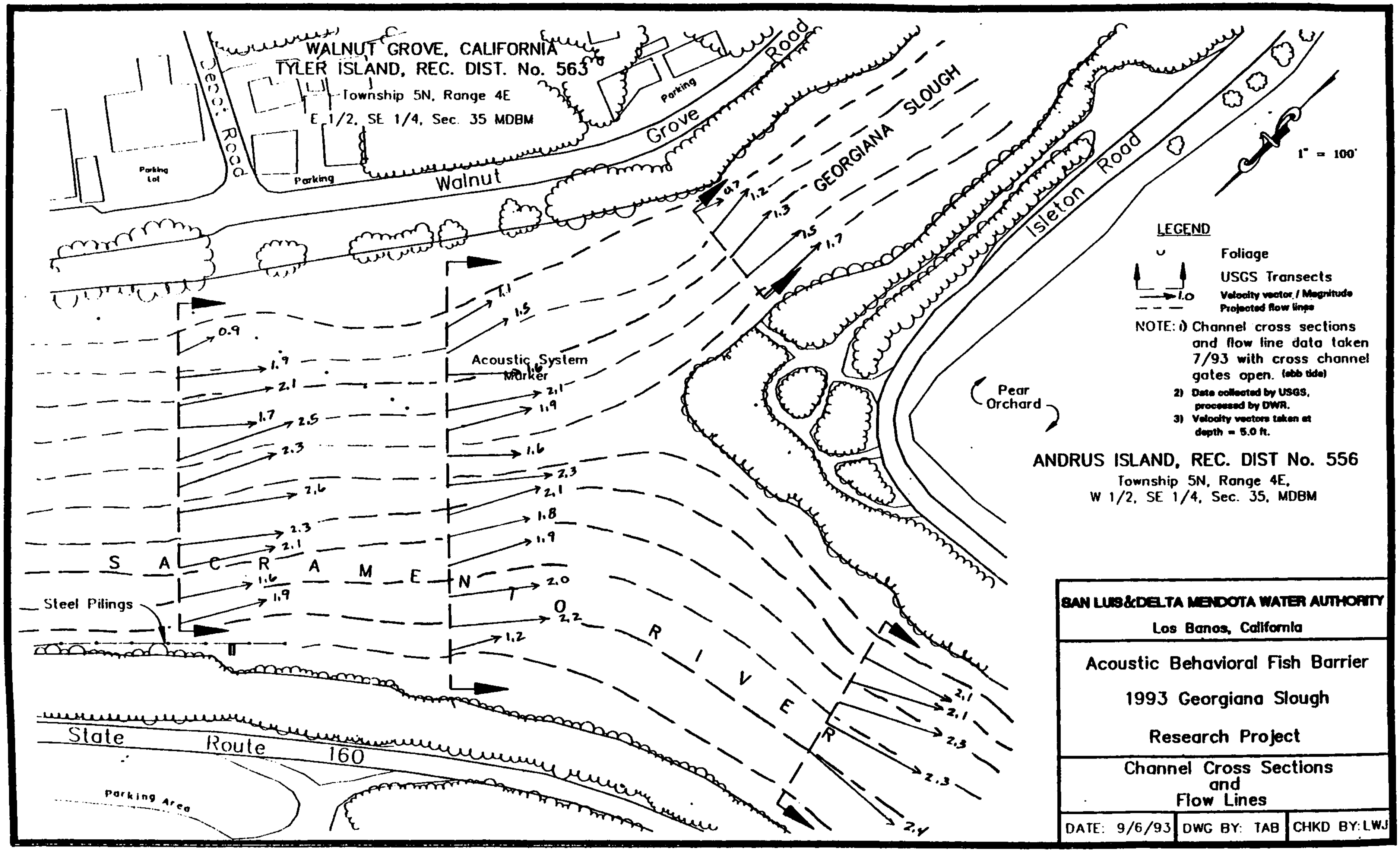


Figure 9b. Results of velocity measurements (flow vectors and velocities - ft/sec) within the Sacramento River and Georgiana Slough in the vicinity of the acoustic barrier at a depth of 5 feet. (Source: USGS, unpublished data; processed by DWR).

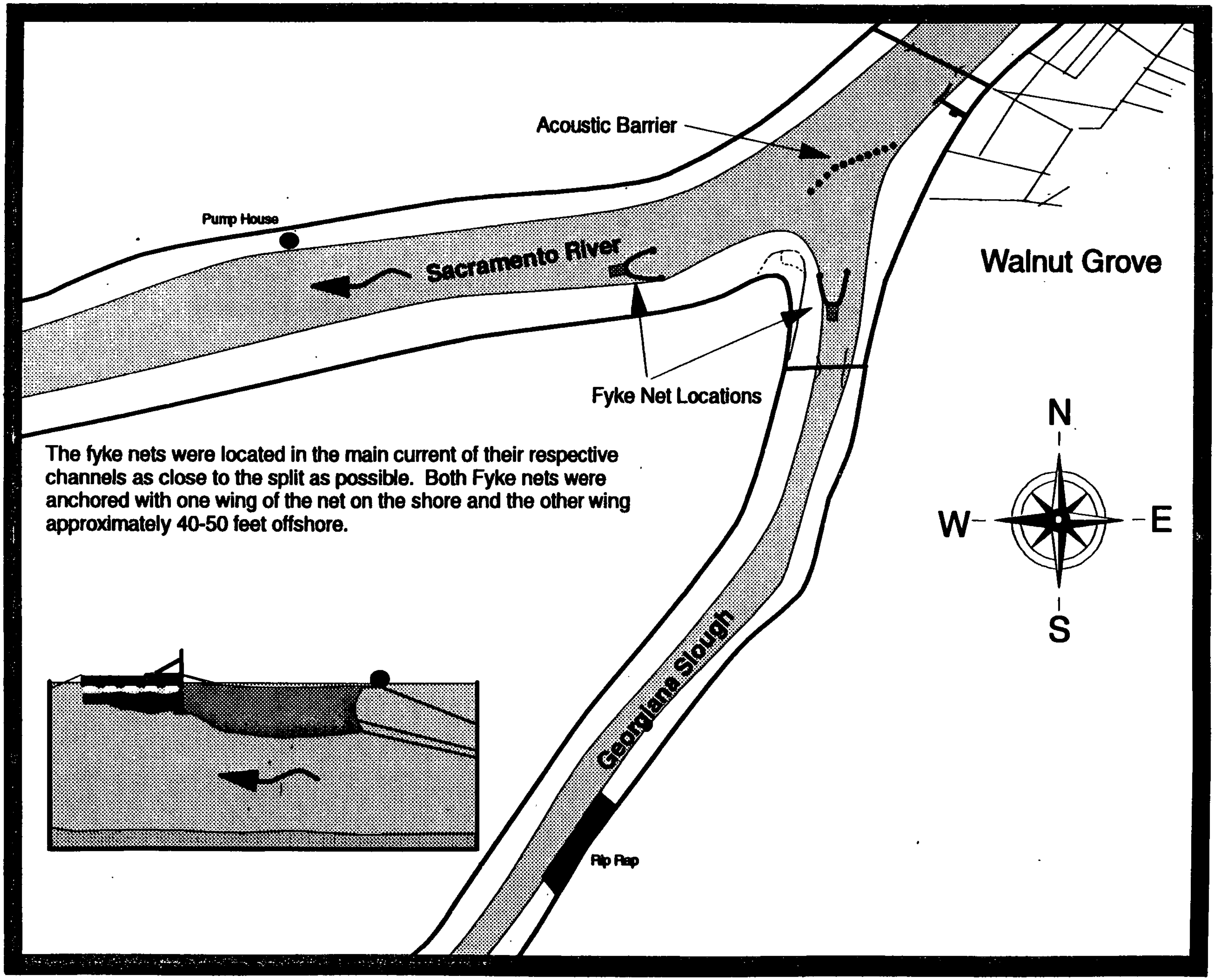


Figure 10. Location of fyke net collections within the Sacramento River and Georgiana Slough.

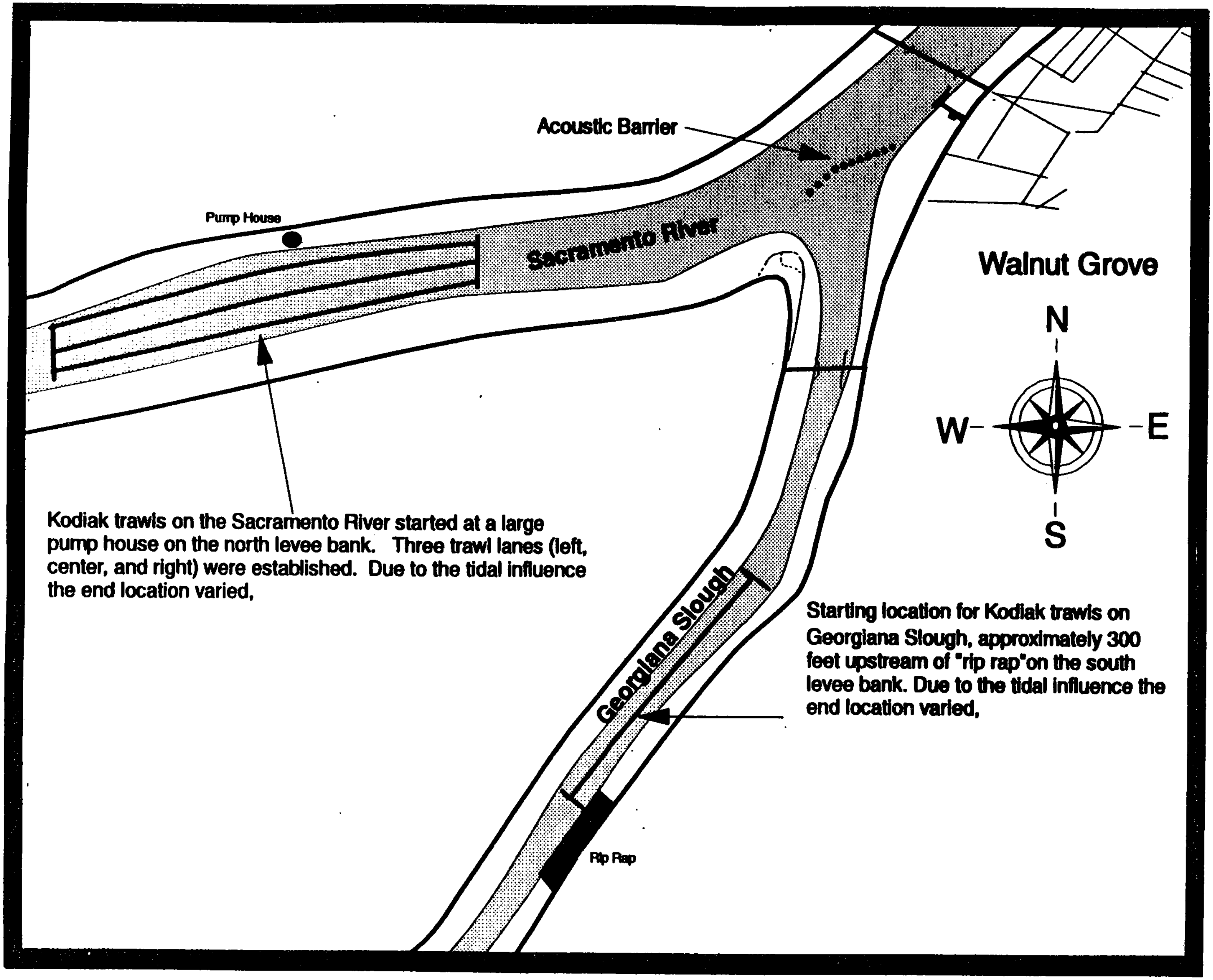
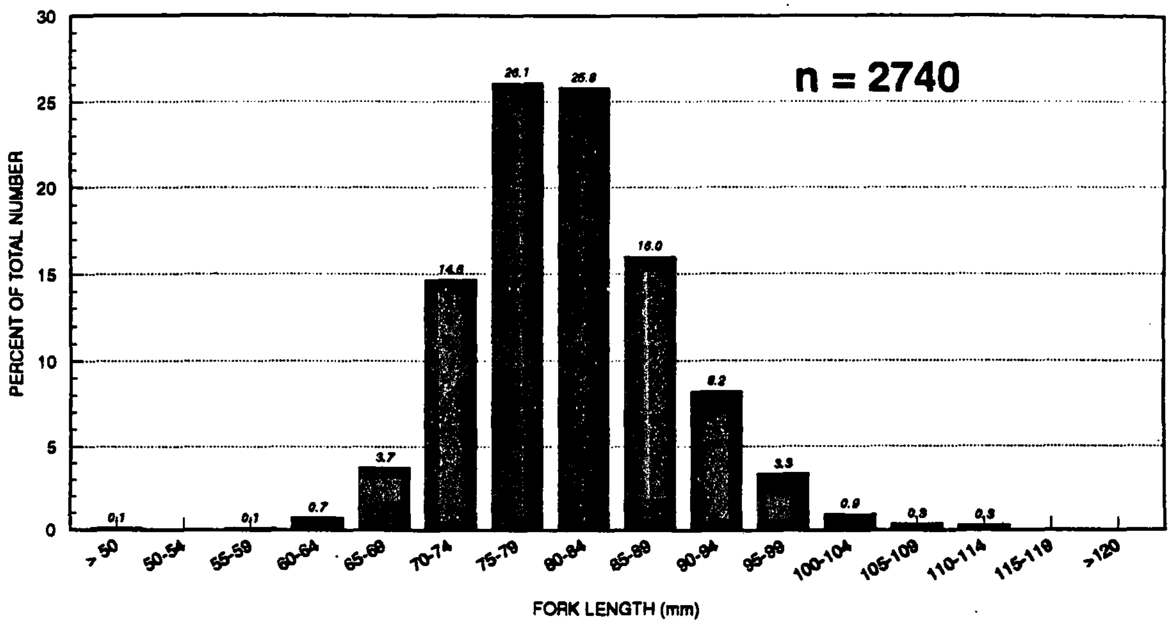


Figure 11. Sampling locations for Kodiak trawls within the Sacramento River and Georgiana Slough.

SACRAMENTO RIVER



GEORGIANA SLOUGH

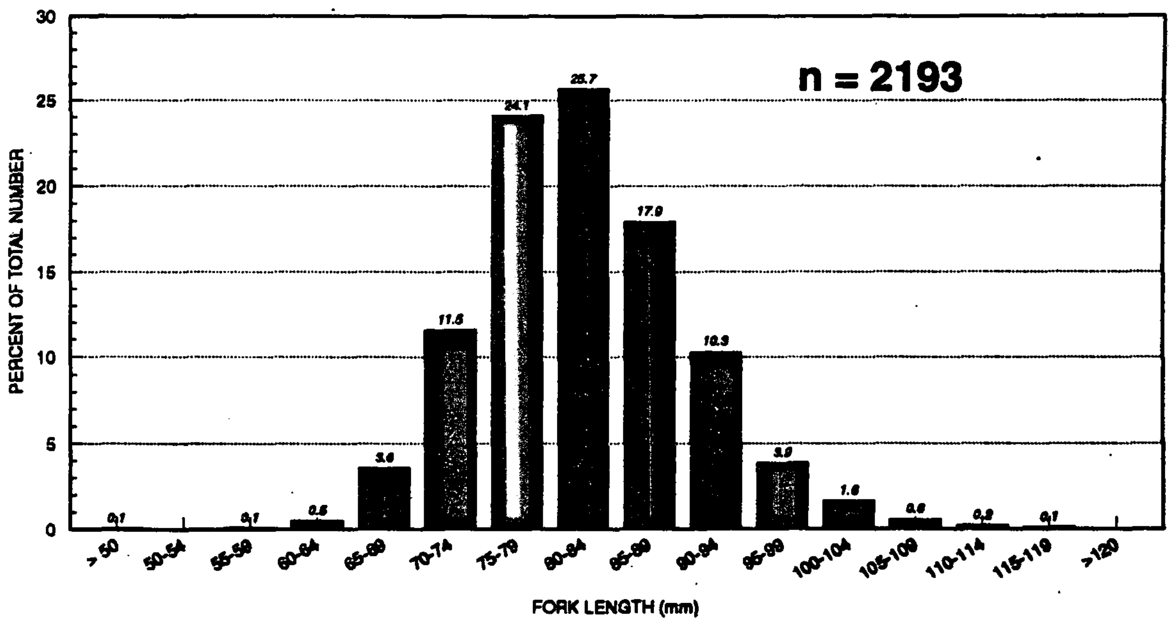


Figure 12. Length-frequency distributions as a percentage of total catch of juvenile chinook salmon in the Sacramento River and Georgiana Slough.

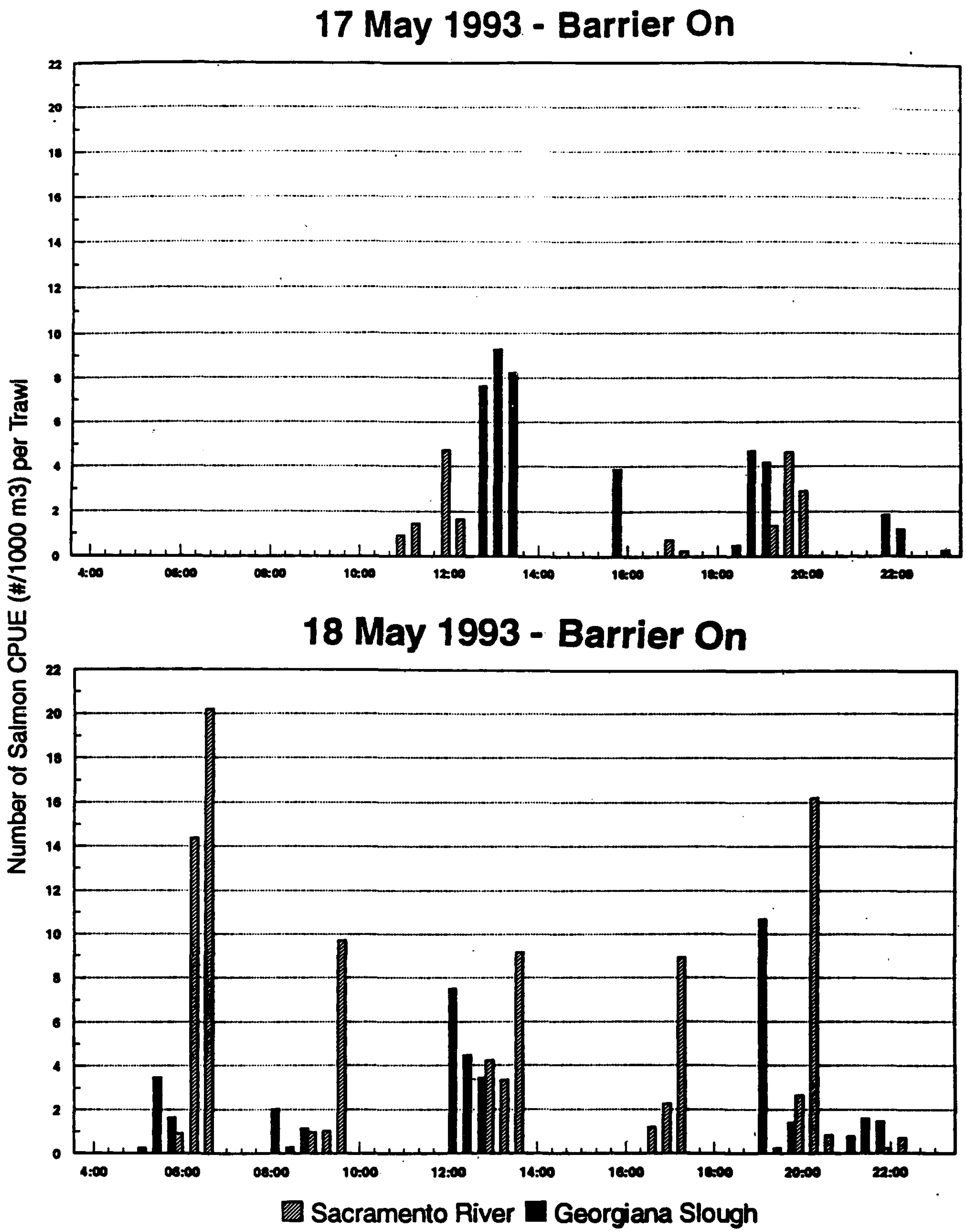


Figure 13. Temporal distribution in juvenile chinook salmon catches in Kodiak trawls conducted within the Sacramento River and Georgiana Slough, May 17-20, 1993.

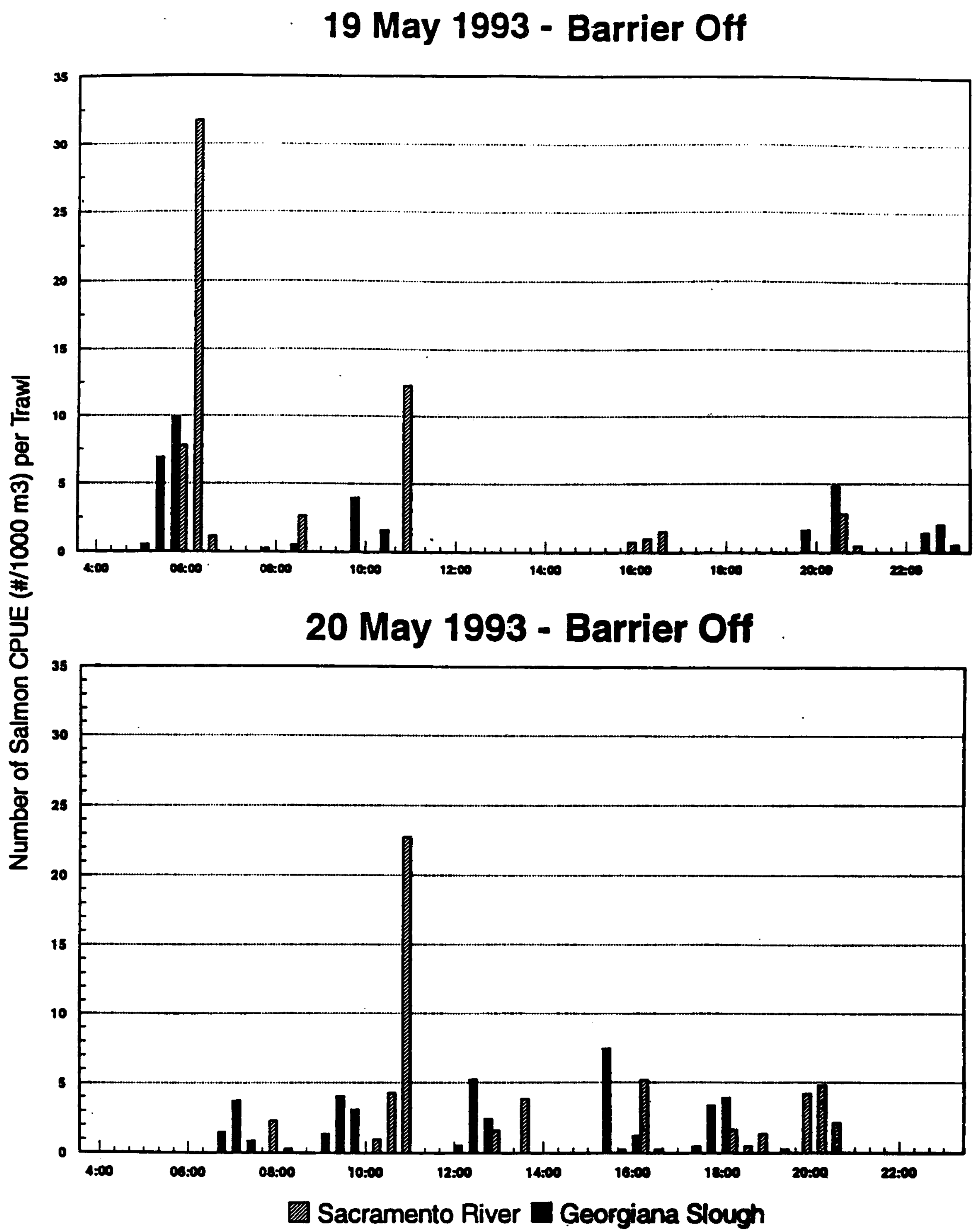


Figure 13. **Continued**

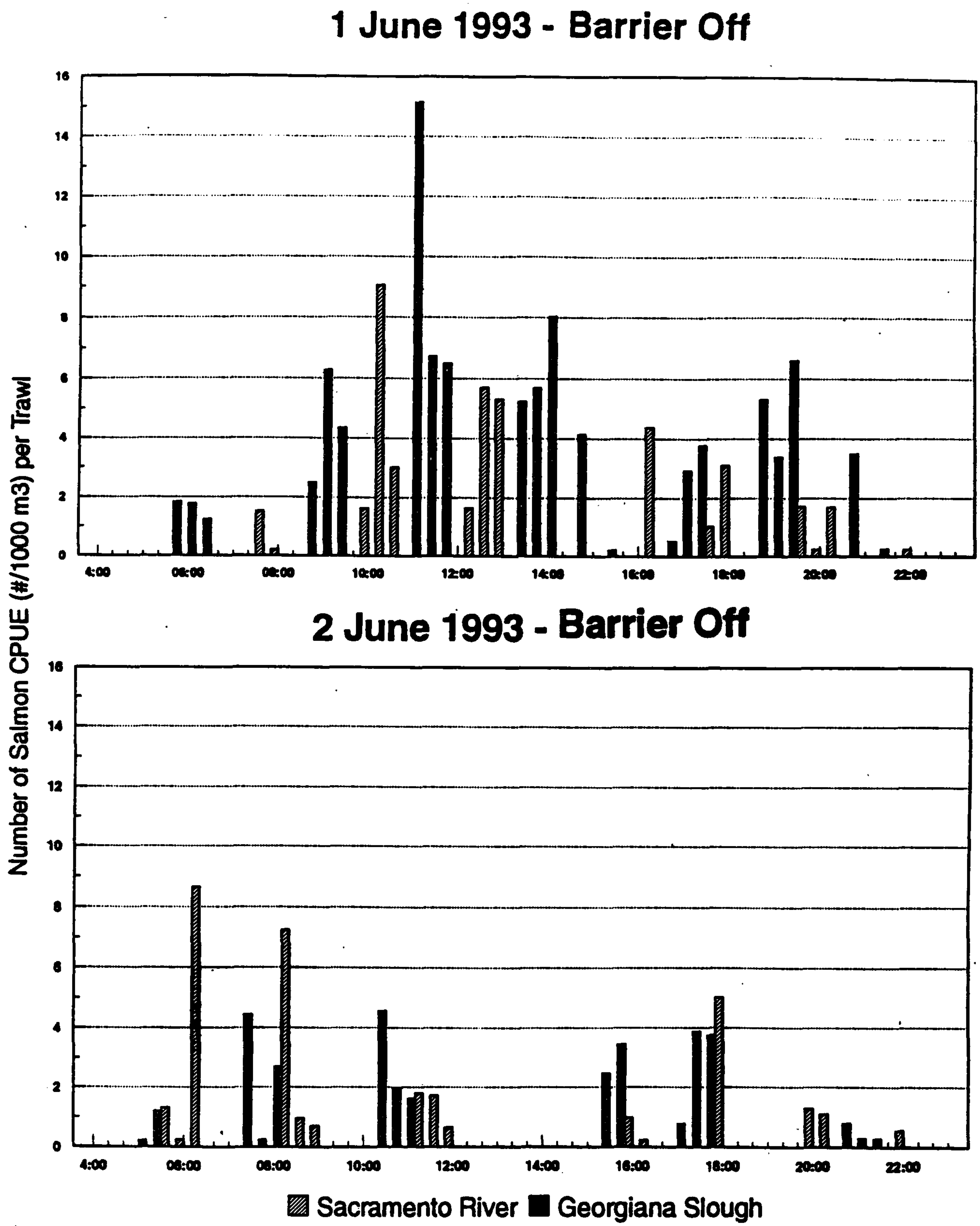


Figure 14. Temporal distribution in juvenile chinook salmon catches in Kodiak trawls conducted within the Sacramento River and Georgiana Slough, June 1-4, 1993.

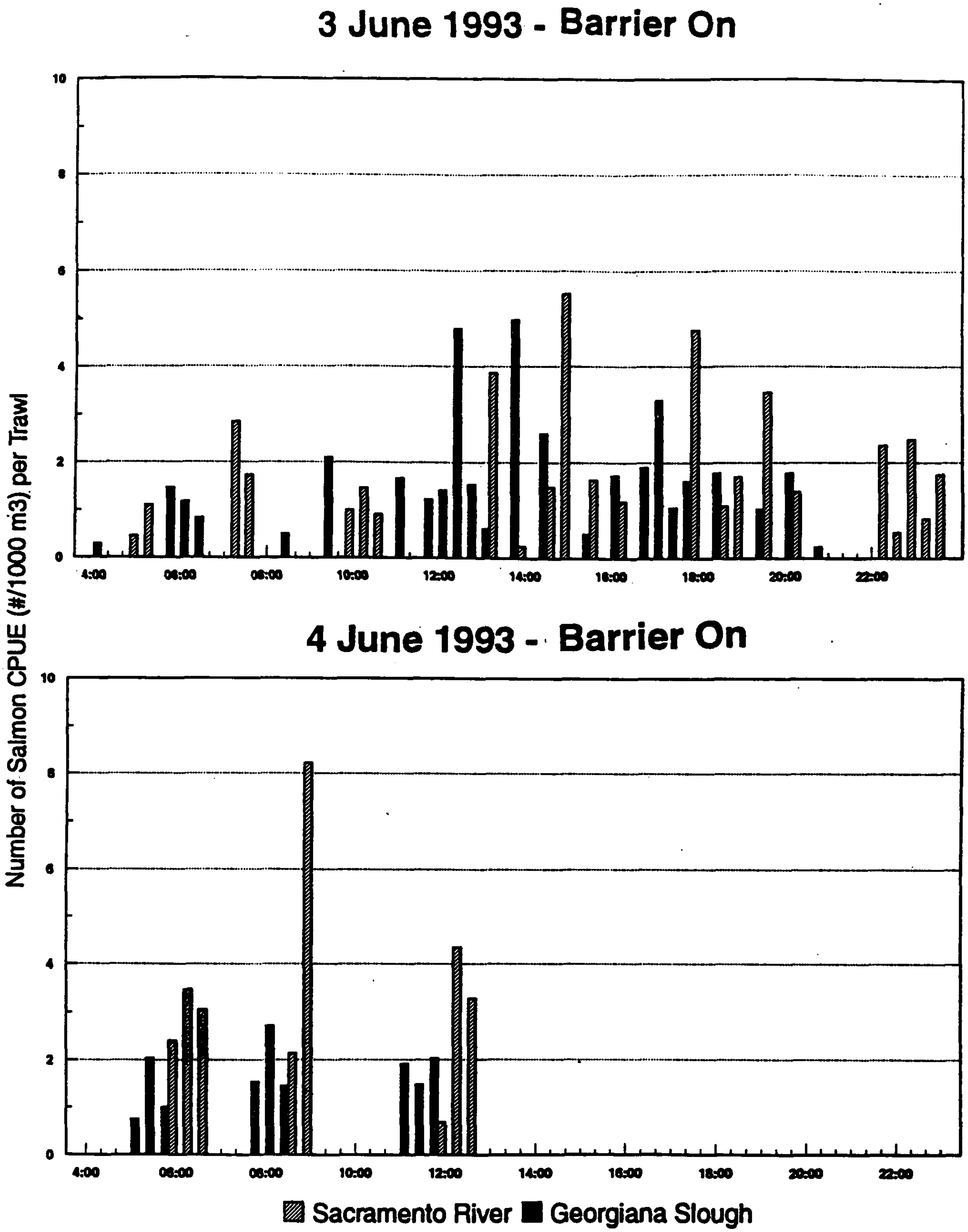


Figure 14. **Continued**

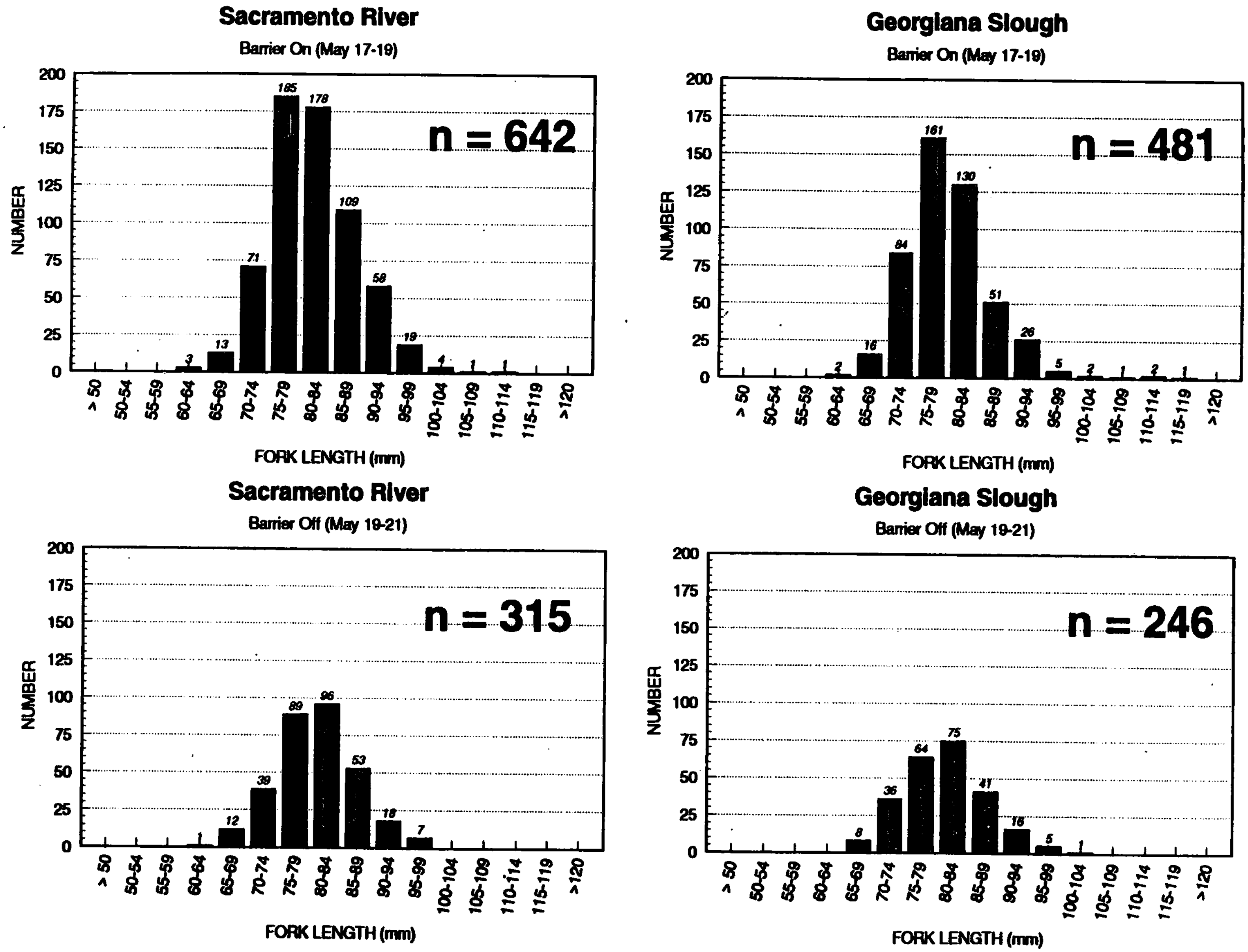


Figure 15. Length-frequency distributions for juvenile chinook salmon captured in the Sacramento River and Georgiana Slough, May 17-21, 1993.

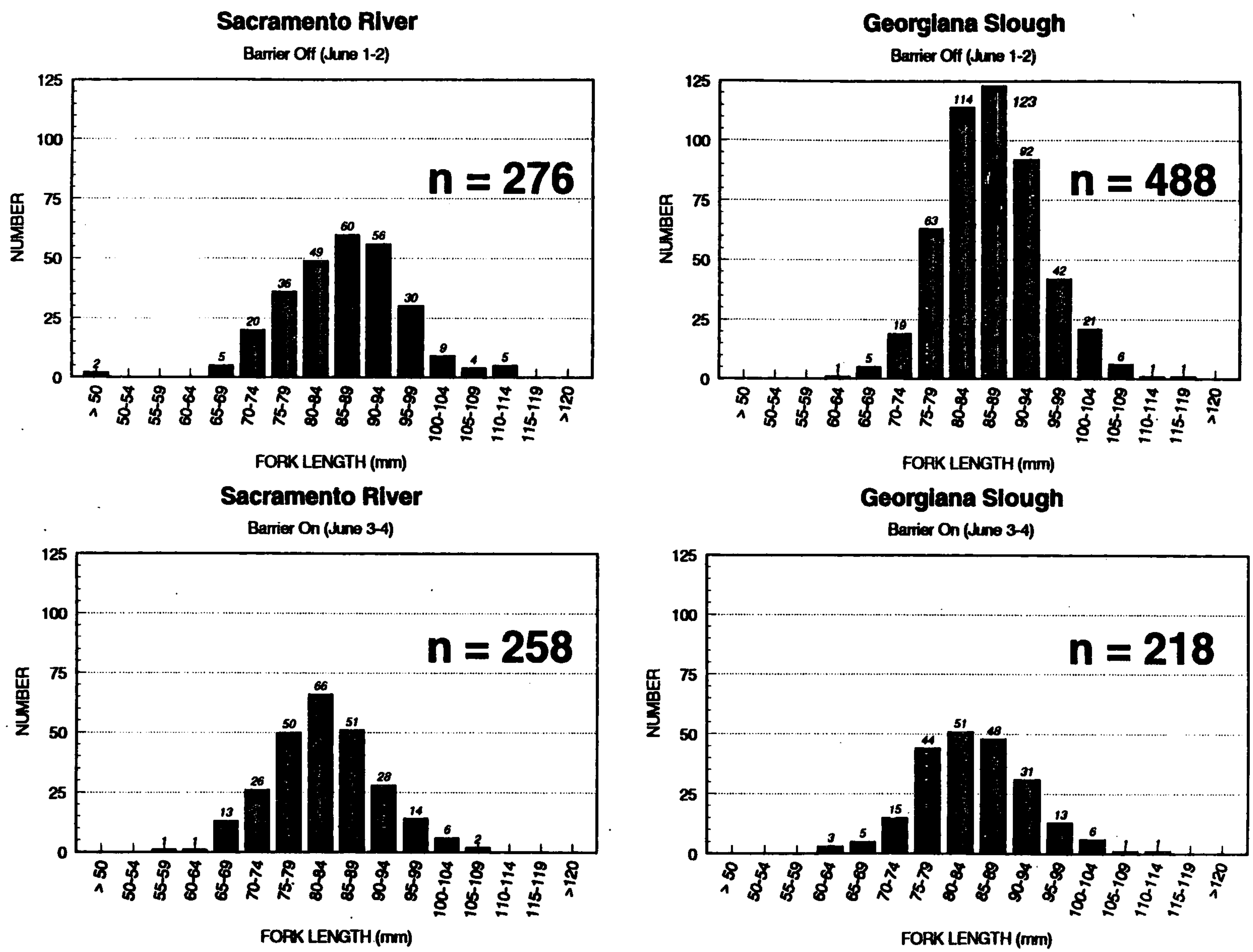


Figure 16. Length-frequency distributions for juvenile chinook salmon captured in the Sacramento River and Georgiana Slough, June 1-4, 1993.

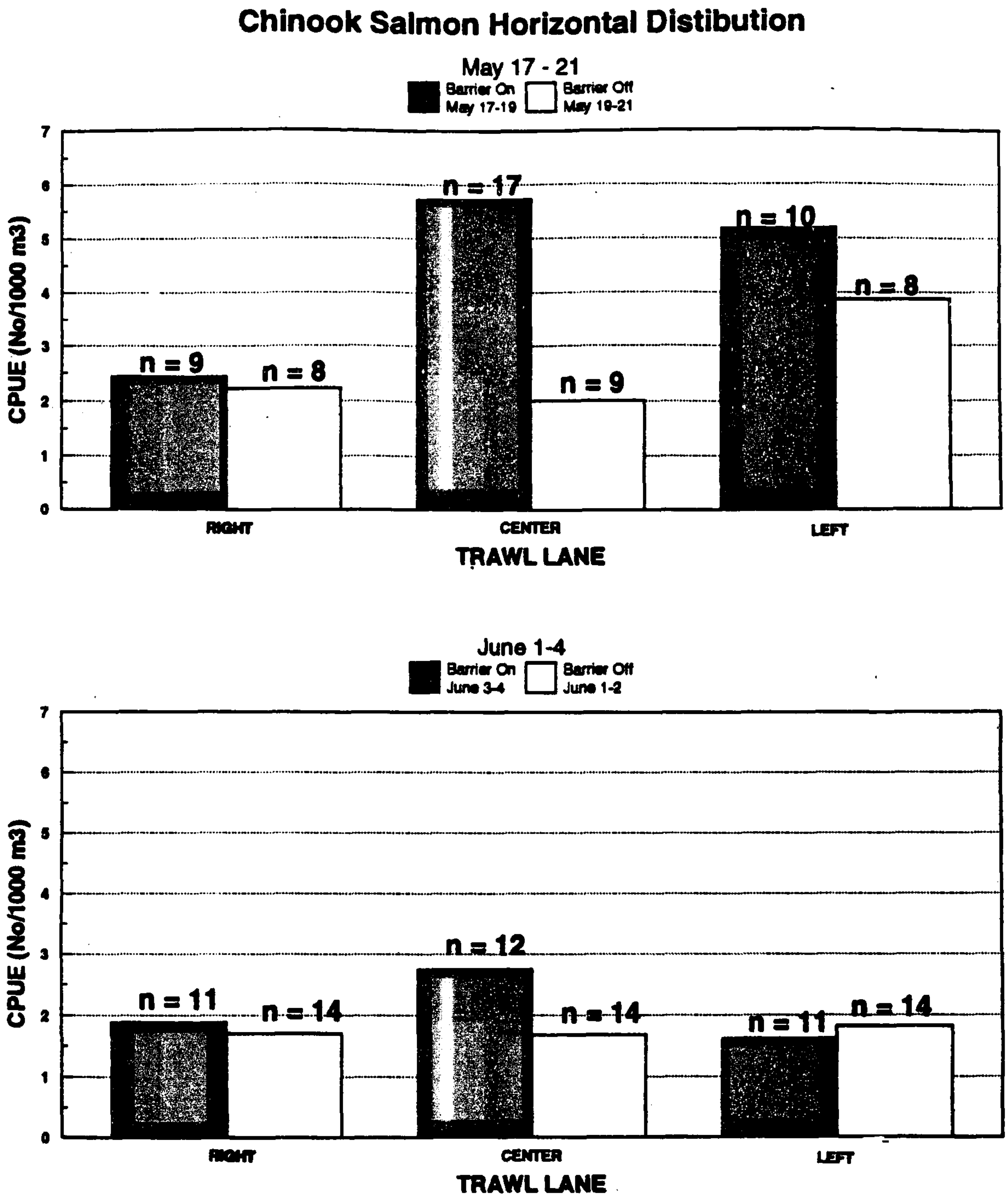
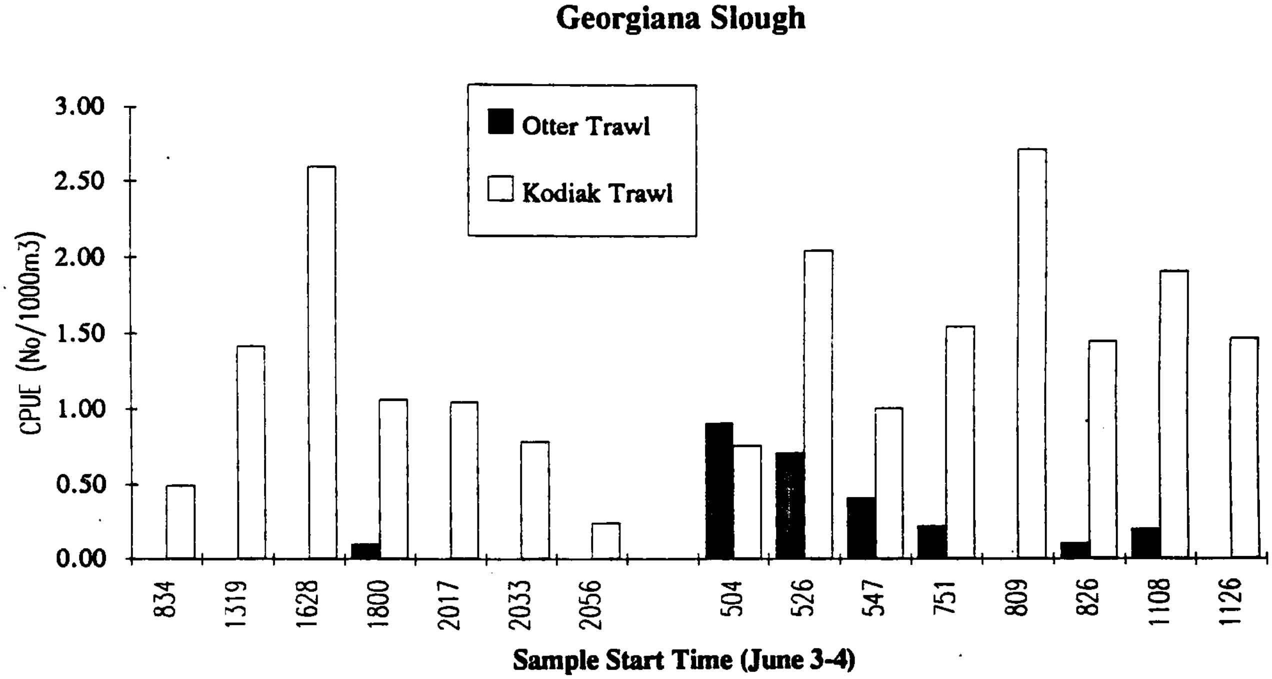


Figure 17. Horizontal distribution of juvenile chinook salmon catches within the Sacramento River downstream of the acoustic barrier.



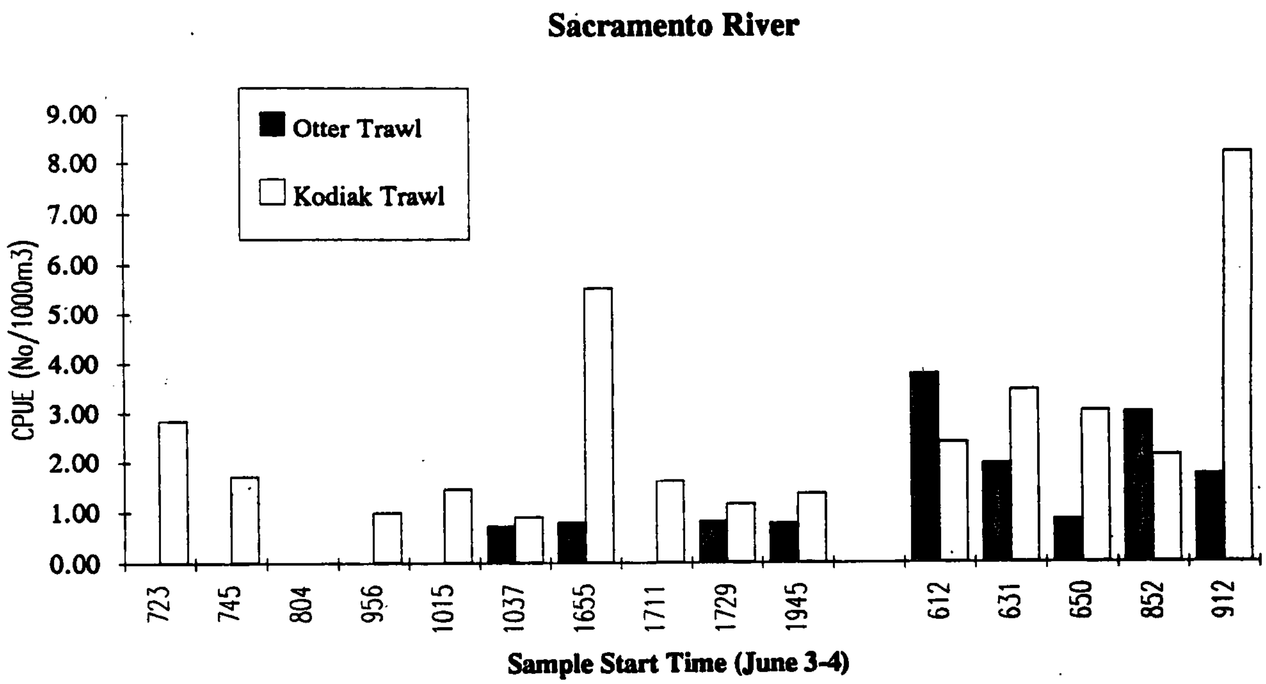
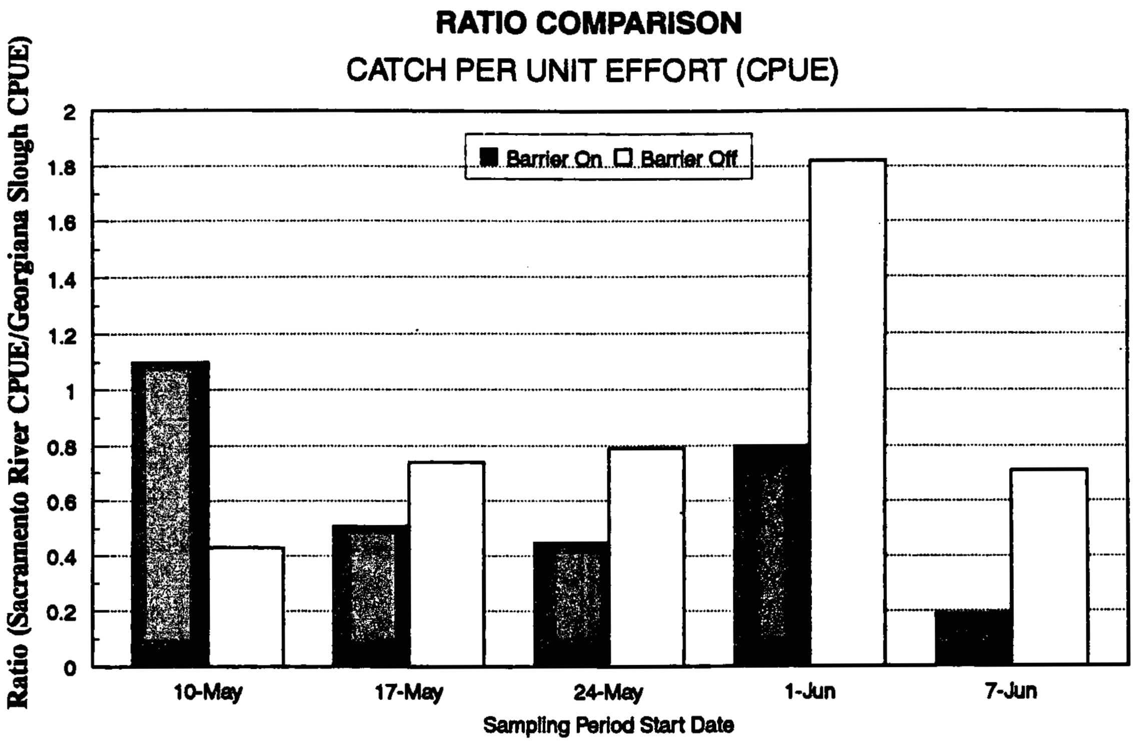


Figure 18. Vertical distribution of juvenile chinook salmon catches based on results of paired Kodiak trawl (surface collections) and otter trawl (bottom collections) within the Sacramento River and Georgiana Slough, June 3-4, 1993.



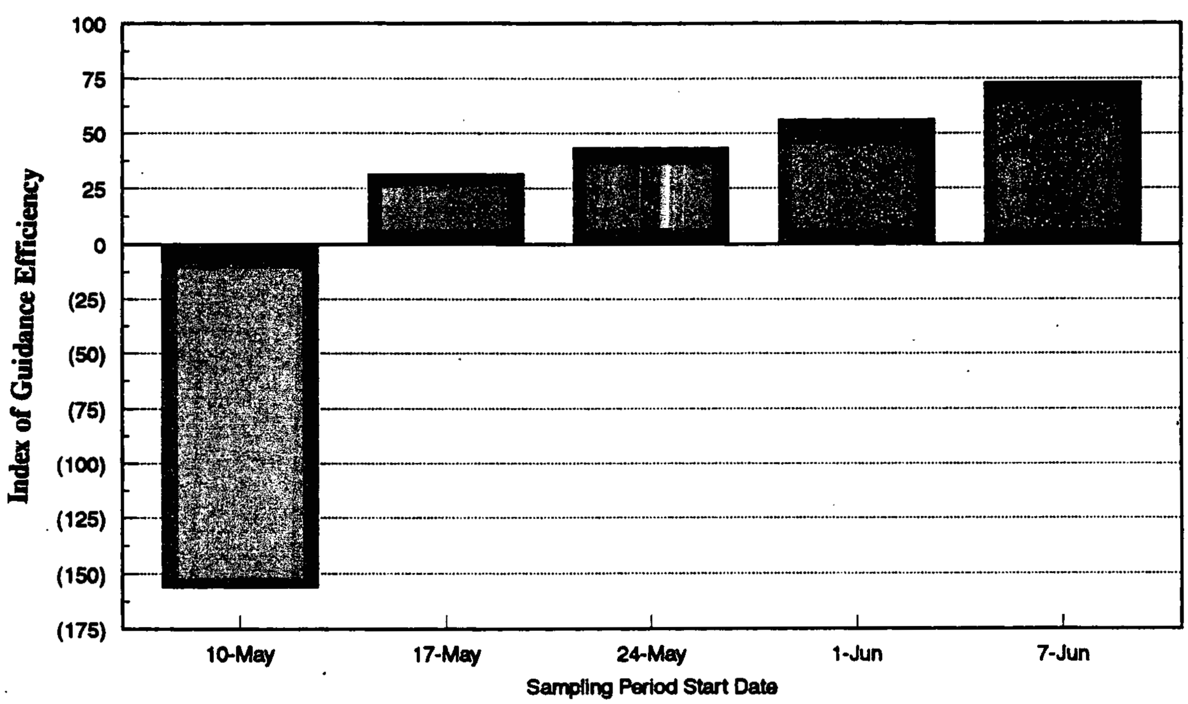
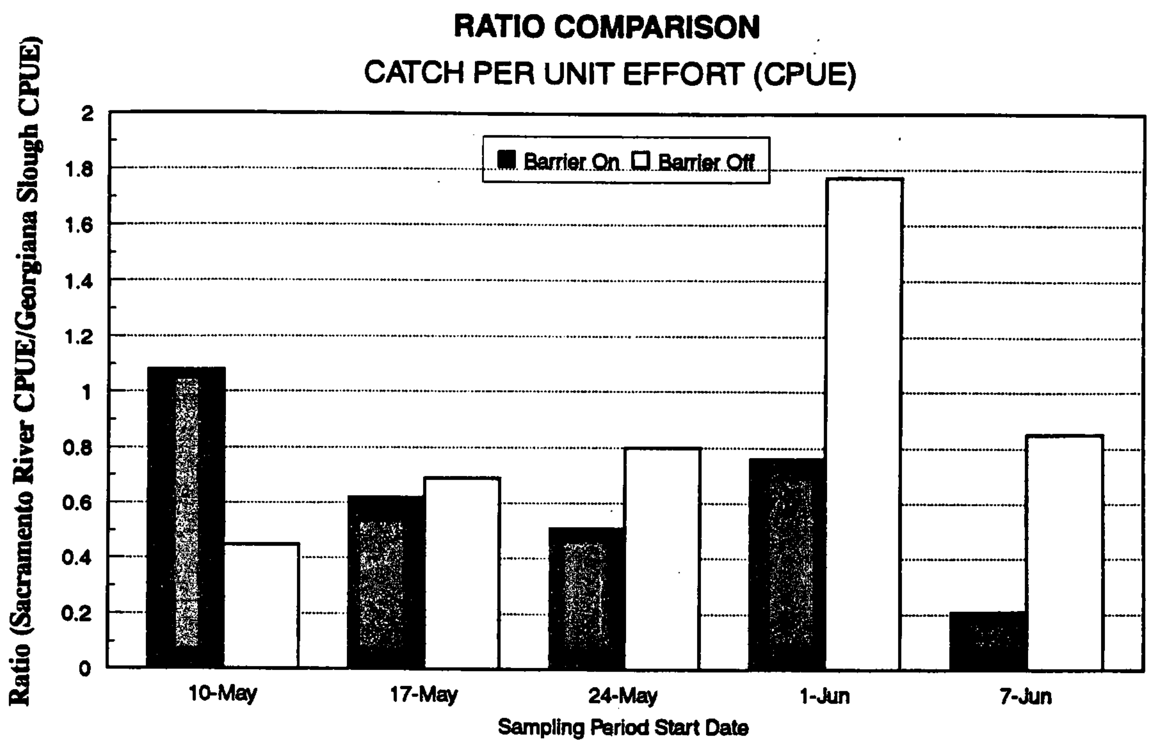


Figure 19. Ratio estimates and the index of guidance efficiency of the acoustic barrier based on mean chinook salmon catch per minute in Kodiak trawls within the Sacramento River and Georgiana Slough.



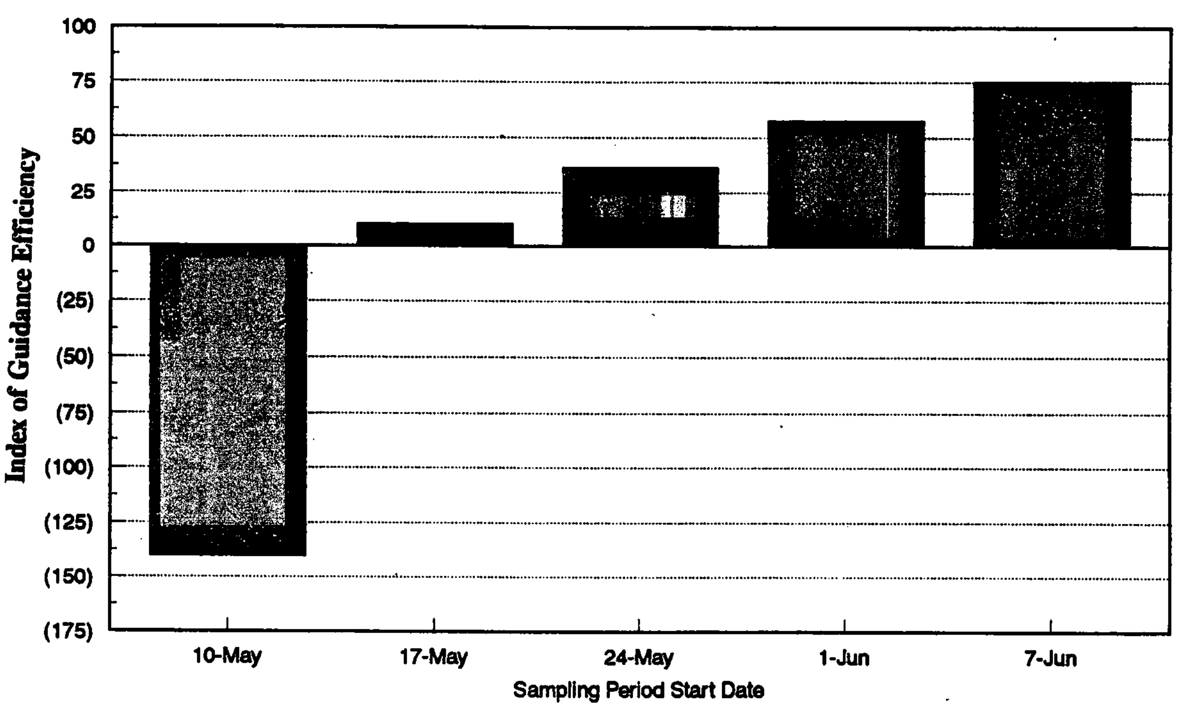


Figure 20. Ratio estimates and the index of guidance efficiency of the acoustic barrier based on chinook salmon catch per 1000m^3 sampled in Kodiak trawls within the Sacramento River and Georgiana Slough.

Table 1. Summary of Kodiak trawl collections within the Sacramento River and Georgiana Slough associated with the Phase I acoustic barrier test, May-June 1993.

Survey Period	Location	Barrier Operation	Number Samples	Number Salmon	Total Fish	Salmon CPUE No./min	Salmon CPUE No./1000m^3	Ratio (GS/SACT) No./min	Ratio (GS/SACT) No./1000m^3
6-7 May	Sac. River	on	8	42	54	0.49	1.65	0.69	0.87
6-7 May	Geo. Slough	on	9	35	49	0.34	1.44		
10-12 May	Sac. River	on	25	130	151	0.50	1.85	1.10	1.08
10-12 May	Geo. Slough	on	20	112	126	0.55	1.99		
13-14 May	Sac. River	off	19	228	237	1.15	3.03	0.43	0.45
13-14 May	Geo. Slough	off	23	116	132	0.50	1.37		
17-19 May	Sac. River	on	38	786	791	2.07	4.92	0.51	0.62
17-19 May	Geo. Slough	on	40	430	442	1.05	3.03		
19-21 May	Sac. River	off	29	341	353	1.17	2.80	0.74	0.69
19-21 May	Geo. Slough	off	30	260	271	0.86	1.94		
26 May	Sac. River	on	9	117	118	1.30	3.15	0.45	0.51
26 May	Geo. Slough	on	9	52	53	0.58	1.61		
24-25 May	Sac. River	off	33	625	637	1.90	5.03	0.79	0.80
24-25 May	Geo. Slough	off	30	457	458	1.51	4.02		
3-4 June	Sac. River	on	34	255	276	0.75	2.10	0.80	0.76
3-4 June	Geo. Slough	on	37	221	248	0.60	1.60		
1-2 June	Sac. River	off	42	275	288	0.65	1.73	1.82	1.77
1-2 June	Geo. Slough	off	42	499	505	1.18	3.06		
7-8 June	Sac. River	on	29	78	92	0.27	0.66	0.19	0.21
7-8 June	Geo. Slough	on	32	16	48	0.05	0.14		
9-10 June	Sac. River	off	36	51	66	0.14	0.34	0.71	0.85
9-10 June	Geo. Slough	off	36	37	65	0.10	0.29		
		TOTAL	**610**	**5163**	**5460**				

NOTE: See Figure 4 for information on the location and configuration of the acoustic array during each test sequence.

GSSUMRY/b:GS/9593/CHH/sgh

Table 2. **Horizontal distribution of juvenile chinook salmon smolts collected (CPUE) in Kodiak trawls within the Sacramento River downstream of the acoustic barrier, May-June 1993.**

Survey Period		Barrier Operation	Right Bank	Center Channel	Left Bank
17-May	19-May	on			
Mean (no/1000m^3)			2.44	5.72	5.18
Standard Deviation			2.34	8.46	6.68
Sample Size (N)			9	17	10
19-May	21-May	off			
Mean (No/1000m^3)			2.23	2.01	3.88
Standard Deviation			1.72	2.02	7.73
Sample Size (N)			8	9	8
3-June	4-June	on			
Mean (No/1000m^3)			1.88	2.75	1.61
Standard Deviation			1.72	2.28	0.97
Sample Size (N)			11	12	11
1-Jun	2-Jun	off			
Mean (No/1000m^3)			1.70	1.68	1.82
Standard Deviation			2.05	2.63	2.63
Sample Size (N)			14	14	14

NOTE: **Channel sampling locations (e.g., left bank, right bank) are identified looking downstream.**

Table 3. Comparison between Otter and Kodiak trawls within the Sacramento River and Georgiana Slough, June 1993.

Georgiana Slough(1)

	Otter Trawl		Kodiak Trawl	
Date	**Start Time**	**Salmon/ $1000m^3$**	**Salmon/ $1000m^3$**	**Start Time**
3-Jun	834	0.00	0.49	834
	1319	0.00	1.41	1305
	1628	0.00	2.59	1621
	1800	0.10	1.06	1808
	2017	0.00	1.04	2010
	2033	0.00	0.78	2027
	2056	0.00	0.24	2045
4-Jun	504	0.90	0.75	504
	526	0.70	2.04	526
	547	0.40	1.00	546
	751	0.22	1.54	750
	809	0.00	2.72	807
	826	0.10	1.45	825
	1108	0.20	1.91	1104
	1126	0.00	1.47	1123

Sacramento River(2)

3-Jun	723	0.00	2.84	723
	745	0.00	1.73	745
	804	0.00	0.00	804
	956	0.00	1.00	956
	1015	0.00	1.47	1015
	1037	0.73	0.91	1037
	1655	0.81	5.53	1652
	1711	0.00	1.64	1707
	1729	0.83	1.18	1724
	1945	0.80	1.39	1942
4-Jun	612	3.81	2.41	612
	631	1.99	3.48	631
	650	0.87	3.05	650
	852	3.02	2.14	851
	912	1.77	8.22	913

(1)Georgiana Slough water depth was approximately 15 feet.

(2)Sacramento River water depth was approximately 20 feet.

Appendix A

Comments Received on the

1993 Phase I Draft Documentation Report

Note: Additional comments written directly on the Phase I draft report were received from D. Hayes and T. Sommer (Department of Water Resources) but have not been included in this appendix.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento/San Joaquin Estuary Fisheries Resource Office
4001 N. Wilson Way, Stockton, CA 95205
209-946-6400 (Fax) 209-946-6355

October 18, 1993

MEMORANDUM

To: Chuck Hanson

From: Martin A. Kjelson

Subject: Review of Georgiana Slough Phase I Draft Report of September 21, 1993

Thanks for the opportunity to review the report. Overall, it is a comprehensive document that conveys what you did and found. I have several comments and suggestions to enhance the report and possibly improve future studies.

Page/Paragraph	Comment
Page 2, 1st par Summary/Conclusion	Odd sentence - "no immediate increase" - I think you mean to omit the second no.
Page 1	Kjelson, et. al., 1989 Reference - Our Exhibit 7 from Bay/Delta hearings (1992) may be a better reference.
	Add increased temperature as reason for higher mortality in interior delta.
Page 3, top par	Is there any indication of how predators respond to the behavior barriers?
Page 5, Diversion Efficiency Equation	I think I understand what you did with the equation but ratios are tricky to interpret. I feel more confident with your basic ratio of Sacramento/Georgiana CPUE. I tried some example values and found one could make wrong conclusions on efficiency even when more were seen in Georgiana. To make it work, "a" must be less than "b". Was that always the case? Can you get efficiencies > 1.0, etc?

Page 7, par 1	Is there any data to suggest adult Chinook respond to different sound frequencies than juvenile Chinook. This could help adult problem.
Page 8, par 3	I think you need to explain more specifically how you established the angle of the barrier to guide fish. It is a very complex issue I would think.
Page 9, par 1	How sensitive are salmon smolts to sound, i.e., in terms of distance?
Page 15, par 1	Creel Surveys - These are very messy and I would doubt you can really evaluate any effects of barrier even with a much larger data base. Suggest mentioning so.
Page 16-19	A few details missing. Such as, when did you trawl above Georgiana in the Sacramento River? Did you attempt to trawl 24 hours per day? There is great possibility to analyze the data further as with the diel pattern. Figure 13-14 do not allow for easy conclusions. Also, there is a major need to evaluate if fish really stayed on east bank. If so, this is evidence that the barrier did not work. Conversely, if they were on west bank it probably worked. Also, the issue of doing a mass balance of density above barrier equal to sum of densities in Georgiana and below barrier could allow for evidence of barrier success. My brief review of Appendix C for May 12 and 19 where you sampled at all three stations suggests mass balance is not there. Key point is we should use a lot of approaches to draw our conclusions. More analysis is needed on the horizontal distribution and time of day (diel issue). I see more fish in the otter trawl in early morning.
Page 20, par 1	While I live in a glass house too, I think you may have enough data to evaluate the statistical confidence of your conclusions regarding the effectiveness of barrier. Others will do this for you. At first glance one would conclude there is no effect based on significance. The ratio approach, while creative, can give you misleading conclusions. The change in the barrier array really does not look to be very great based on Figures 4a-d. If really a change, show it better.
Page 20, par 2	The increasing guidance effectiveness (Figure 20) seems too good to believe.
Page 24	A thought. Data should allow you/us to evaluate response of fish to tides. This is critical as the density differences in Sacramento versus Georgiana may only be reflecting tidal behavior, i.e., what if smolts stack up below Georgiana in the

Sacramento due to hydrology alone. I am not sure this is really a concern and your design seems pretty solid, but we need to check all possible issues that my cause us to interpret data wrong.

Figure 4	Model 215 transducer is not clearly identified.
Figure 9a-b	What are units feet/sec?
Figures/Tables	As written, it appears you selected data in general sets, i.e., Figure 17 uses only 5/17-21 and 6/1-4. The natural question is, what is the conclusion if you use all 5 or 6 survey periods?
Appendix A	Needs further description of what these profiles are.

Marty

Martin A. Kjelson

cc: Pat Coulston
Randy Brown
Dan Odenweller
Robert Pine
Gary Stern

930084.WPF

September 30, 1993

Dr. Charles Hanson
500 Ygnacio Valley Road, Suite 250
Walnut Creek, CA 94596

Dear Chuck:

I read your "GEORGIANA SLOUGH, PHASE I---Acoustic Barrier Tests Report" and found it very interesting. I thought you did a very good job in preparing the report and have few comments.

Comment #1. I thought a little more emphasis could be placed on the fact barrier operation would reduce the numbers of smolts reaching the State and Federal pumping plants and also reduce possible impacts from the 1000 plus central delta diversions. I know you mention this, but I think this is the **KEY POINT YOU ARE TRYING TO MAKE WITH THE REPORT.**

Comment #2. Page 13, line 19. I thought the DFG otter trawl was deeper than 1.7 feet. Please double check the measurements.

Comment #3. Page 25, line 3. If the 1994 Phase II study is considered part of the IESP Work it would be covered by the blanket protection for sampling programs and incidental take of Delta smelt provided for under the CVP/SWP Biological Opinion.

The IESP has also just completed its winter-run salmon scientific collection permit. It was discussed rather we should include the Georgiana Slough work. I can not remember the final decision---talk to Pat Coulston who prepared the document. If not covered I would think it easier to amend an existing permit rather than apply for a new one. THESE ARE THE REASONS WHY THE GEORGIANA SLOUGH WORK SHOULD PROCEED UNDER THE AUSPICES OF THE IESP!

Comment #4. Figure 4a and figure 4c are the same. I don't think this is right. If different, you need to point out the differences more clearly.

Again, I thought the report was top notch.

Lloyd Hess

Lloyd

State of California

Memorandum

To : Chuck Hanson
Hanson Environmental

Date : October 16, 1993

From : Department of Fish and Game

Subject: Georgiana Slough Acoustic Barrier Phase 1 Report Comments

I want to thank you for the opportunity to review your draft report on the evaluation of an acoustic barrier at Georgiana Slough. Moreover, I want to express my gratitude for the high level of coordination you have sought throughout this project with Interagency Ecological Study Program. I am pleased to hear that you will be attending the October 19, 1993 IESP Fish Facilities Technical Committee meeting to discuss the report and your future plans with the Committee. Please except my apologies for not getting these comments to you sooner.

In general, I thought your report was excellent. The following are my specific comments:

<u>Acknowledgements:</u>

I appreciate the fact that you acknowledged the work of my staff and the Fish Facilities Technical Committee.

<u>Summary and Conclusions:</u>

Throughout the report you use the term "guidance efficiency" which you define mathematically on Page 5. I do not have a problem with the index of the barrier effectiveness that you have chosen, but I think the meaning of it needs more discussion. Somewhere in the report I recommend that you provide a laymen's definition of the index of effectiveness you have chosen and discuss how it relates to the protection of emigrating smolts. Later on when you say that the diversion efficiency is 50%, some might interpret this to mean that 50% of the smolts making it past the Delta Cross-Channel will be prevented from entering Georgiana Slough. Perhaps the report could include a general description of the fate of smolts as they migrate through the lower Sacramento River below Sacramento and how the barrier, if 50% effective, would change their fate. Also, your report could include the application of the Kjelson, Brandes, and Greene survival model to estimate the effect of the barrier on overall smolt survival under various conditions.

The tenth conclusion needs to be reworded.

Page 1, Para. 1:

I think most biologists would agree that, all others things being equal, an effective barrier will reduce the indirect as well as entrainment related losses associated with SWP and CVP export pumping.

I have never been sure why export pumping was curtailed in spring of 1993, because the 2700 was never even approached. Was the curtailment the "consequence of winter-run entrainment losses" or caused by some other factor.

Page 2, Para. 1:

To give some perspective to the potential benefits of an effective barrier at Georgiana Slough consider describing (at least in general) here the channel hydrology of the lower Sacramento River beginning at Sacramento. In other words, describe where the fish and water are likely to go at high and low flows. This is important because I think some people do not understand that only the fish reaching the barrier potentially can benefit from it.

Page 6, Para. 1:

The National Marine Fisheries Service is not, unfortunately, a member agency of the IESP. Marcin Whitman does, when his schedule allows, participate in Fish Facilities Technical Committee meetings.

Page 7, Para. 1:

Is there literature that addresses what adult, as opposed to juvenile salmon, hear. If information of this kind is available it could help address people's concern about how the barrier might affect adult winter-run immigration in 1994.

Page 8, Para. 3:

The discussion of the factors considered in barrier placement seems a bit overstated to me. Are we not still pretty much in the arena of guesswork and intuition at this point as to how to configure the barrier?

Page 17, Para. 2:

"Delta" and "Tule" should not be capitalized.

Page 17, Para. 4:

I was intrigued by the fact that there appeared to be no relationship between size and diversion efficiency. I expected larger fish to be more easily excluded than smaller fish because I presumed they had a greater ability to swim away from the speakers. Does the literature have anything to say about this?

Page 18, Para. 1:

If the barrier is effective you would expect not only a decrease in the density of fish in Georgiana Slough, but also a corresponding increase in the density of fish in the Sacramento River downstream of Georgiana Slough, probably along the right bank and middle. I realize this change would be harder to detect, but I recommend analyzing for it anyway.

Page 18, Para. 2:

I would like to see more of the vertical distribution sampling next year to see if a diel or tide related pattern emerges.

Page 20, Para. 1:

I think "Figure 3" is supposed to be Figure 4. As I looked at Figures 4a-4d it struck me that the differences in barrier configuration were very subtle given the dramatic differences in resulting diversion efficiency. This reminds me that we need to be mindful of the possibility that the four weekly experimental efforts were really just four tests of the same thing that exhibited a lot of variation and an average efficiency of about 10%.

Page 20:

I recommend adding some additional diversion efficiency analysis to the report. Specifically, I would like to see an examination of the variation in diversion efficiency based on individual paired Sacramento River and Georgiana Slough trawling efforts. This type of analysis could identify diel and tide related variations in barrier effectiveness. It would also give us some idea about the sampling effort required for a conclusive test of the barrier.

Page 22, Para. 2:

Serious consideration should be given in the future to including experimental releases of hatchery reared smolts in the barrier evaluation. One possible experiment is to make simultaneous releases of smolts in Georgiana Slough and in the Sacramento River above and below the barrier. A series of these experiments conducted with the barrier "on" could examine whether the observed diversion efficiency results in the expected improvement in survival to Chipps Island.

Page 25, Para. 2:

I agree the 1993 results are encouraging and warrant additional experimentation in 1994.

Table 2:

The word "smolt" in the heading should be "smolts".

Again, I thank you for the opportunity to review your report. If my comments require clarification, please do not hesitate to contact me at (209) 948-7800.

Pat

Patrick Coulston
Senior Biologist
Bay-Delta and Special
Water Projects Division

cc: Perry Herrgesell
Lance Johnson
Dan Odenweller
Randy Brown
Jim White
Stein Buer
Ken Lentz
Debra McKee
Gary Stern
Darryl Hayes

State of California

Memorandum

To: Chuck Hanson

Date: October 18, 1993

From: Department of Fish and Game
Bay Delta and Special Water Projects Division

Subject: Comments on Draft of Georgiana Slough Demonstration Project

I want to thank you for the opportunity to review your draft report. Overall, I thought the study was handled properly and the report was well written. I had a few comments that I wanted to get to you before tomorrow's FFTC meeting.

1) Figures 13 and 14 headings don't agree with Tables 1 and 2. The on and off listings are transposed. Tables 1 and 2 agree with the raw data listings.

2) The distribution graphs for all samples (other than May 17-21 and June 1-4) would help to clarify the data. These are the Figures 13-18. If this is not possible maybe a comment would help to explain?

3) What happened on May 26th to shorten the number of samples from approximately 30 to 9?

4) Pat Coulston, Terry Tillman, and I visited the site on the morning of May 18th. The trawling was being done directing behind the acoustic barrier and not as indicated in Figure 11. Pat remembers some discussion of changing the area of trawling, but there is no mention of it in the report.

5) Should trawling be done before the barrier on/off cycle starts for control trawling instead of using the barrier off trawling? The times when the barrier was on first may influence the barrier off salmon distribution.

Please contact me at (209) 948-7097 if you have any questions.

Scott Barrow

Scott Barrow
Fisheries Biologist
Bay-Delta and Special Water
Projects Division

STATE OF CALIFORNIA—THE RESOURCES AGENCY

PETE WILSON, Governor

DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

FAX FAX FAX

Cover Sheet

10/6/93
Date

Send To: Lance Johnson
SL-DM Water Authority

FAX Number: (209) 826-9698

Telephone: (209) 826-9696

From: Steve Roberts
Delta Planning

2
Number of Pages
(Including Cover)

Telephone: (916) 653-2118

Comments/Instructions

Comments on Demo Project Draft. Overall, this is an excellent report. We have very few comments, but they are included on attached page. Review by S. Bruer, S. Roberts + M. Wong.

FAX
PUBLIC: (916) 653-6077
CALNET: 8-453-6077

Assistance: (916) 653-7129 Erma Calton
(916) 653-4391 Betty Reed

Division Date/mat
DWR Fax Cover Sheet
Revised 7/23/92

DWR Delta Planning Branch has reviewed the report and the following are our comments:

- Define diel pattern
- First page of Summary and Conclusions--the last line should move up
- Second page of Summary and Conclusions--Are you trying to say there is no evidence of injury caused by acoustic barrier operations?
- Page 2 paragraph 3 and top of page 3--Acoustic barriers also have the advantage of not impacting 1) flood protection, 2) water quality, 3) cultural resources on left bank of Georgiana Slough, 4) navigation, 5) reverse flow conditions in the Delta
- Page 9 paragraph1--What dbA do fish normally converse at?
- Page 12 of report--RD 108 used the screw trap, 8 ft diameter. Do you feel your collection methods are better, or could be improved in future sampling years?
- Section 4 of report, page 15--In order to draw a conclusion here, some baseline data needs to be developed as to success of fishing prior to barrier.
- Page 17 of report--Do you have number of each species listed in a table?
- Why show Figure 3? If you can't put in scales, what am I looking at?

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213
TEL (310) 980-4000; FAX (310) 980-4018

NOV 18 1993 F/SW03:GRS

Mr. Lance W. Johnson
Senior Resources Engineer
San Luis & Delta-Mendota Water Authority
842 Sixth Street, Suite 7
P.O. Box 2157
Los Banos, California 93635

Dear Mr. Johnson:

Thank you for you letter regarding formal section 7 consultation, pursuant to the Federal Endangered Species Act (ESA), on the San Luis & Delta-Mendota Water Authority's (Authority) proposed Phase II Applied Research Project at Georgiana Slough.

The formal consultation process called for in section 7 of the ESA applies only to Federal agencies so the National Marine Fisheries Service (NMFS) is unable to consult directly with non-Federal entities such as the Authority. However, since your project will require a permit from the U.S. Army Corp of Engineers (Corps), the NMFS will be consulting with the Corps to assess the potential impacts of the project on the threatened winter-run chinook salmon and its critical habitat. It is through this consultation process that the NMFS may provide the Authority with an authorization to take winter-run chinook salmon incidental to the proposed project.

Based on information provided to my staff, I understand that the Authority soon will be submitting a detailed study proposal for the installation, operation, and monitoring of the acoustic repulsion system at Georgiana Slough in 1994. In anticipation of receiving a more detailed study plan, I am not providing comments on the initial 1994 study plan at this time. However, I have enclosed my comments on the draft report that was prepared for the 1993 Phase I field tests. I hope these comments will assist you in developing the 1994 program.

If you have questions concerning these comments, please contact Mr. Greg Bryant or Mr. Gary Stern at (707) 578-7513.

Sincerely,

for J J Slawson

Gary Matlock, Ph.D.
Acting Regional Director

Enclosure

cc: Wayne White, FWS
Boyd Gibbons, DFG
Roger Patterson, BOR
Robert Potter, DWR
Art Champ, COE

Attachment

NMFS Comments on the Draft Report:
Demonstration Project to Evaluate the Effectiveness of an Acoustic (Underwater Sound) Barrier in Guiding Juvenile Chinook Salmon at Georgiana Slough: Results of 1993 Phase I Field Tests

General Comments:

Due to limited data, inherent variability, and sampling error it is very difficult to draw conclusions about the effectiveness of this technology from Phase I. NMFS would like to work with the Authority to improve the study design so that future sampling and analysis will be as effective as possible and unbiased.

Specific Comments:

Page 2, 2nd Paragraph: Further discussion of recent applications of behavioral barriers should be included here. I recommend briefly discussing information on the target species, lab or field application, analytical methodology, and results of previous tests in the literature.

Page 2, 3rd Paragraph: Discussion regarding the advantages of behavioral barriers versus physical barriers does not accurately portray the existing state-of-the-art technology available in this field. State-of-the-art positive barrier fish screens generally operate at an efficiency of 95 to 98 percent for salmonid juveniles and most applications do not require the collection and handling of fish.

Behavioral barrier devices are presently experimental in nature and several questions remain among the experts as to their potential effectiveness. Optimistic projections for behavior barriers estimate efficiency levels of 50 to 75 percent. Thus, the projected losses associated with an effective behavioral barrier are significantly larger than losses at state-of-the-art positive barrier screens. In light of NMFS's obligation under the Endangered Species Act (ESA) to specify reasonable and prudent measures necessary to minimize incidental takings, deference must be given to the proven effectiveness of positive barrier fish screens. I concur that behavioral devices may have potential benefit for reduction of fish losses at water diversions, but the information currently available suggests these devices are unlikely to serve as a sufficient conservation measure for ESA listed species.

Page 4, Experimental Design: There are several inconsistencies in the draft regarding the barrier "on" and "off" sequence in the experimental design. It does not appear from the results that the design was always a series of two-day periods with the barrier "on" followed by two days with the barrier "off". Experiments conducted between May 24 and 26 are reported as barrier "off" for two days and "on" for the next day. Experiments during June 1 and 4 also began with the barrier "off" followed by two days of the barrier "on". The titles of Figures 13 and 14 are also inconsistent with the barrier operation description in Table 1.

It is unclear as to how several environmental variables were treated in the experimental design and data analysis. How did the sequence of barrier operations account for the tidal conditions and diel patterns if random numbers were used to determine whether the sequence of the barrier's operation? Other environmental variables that could have influenced the investigation's results include total streamflow, flow split between the Sacramento River and Georgiana Slough, lunar phase, temperature, and daily variation in juvenile salmon behavior (outmigration pulses).

Page 5: Description of the analysis should be expanded and clarified including the catch-per-unit-of-effort (CPUE) model, percent efficiency, and the manner in which normal variability of fish movement was addressed. Specifically, was the objective of the experiment and analysis to examine trends between test conditions or quantify guidance efficiency? Given the variance in trawl samples and test conditions, it is inherently difficult to quantify guidance efficiencies and it appears that Phase I was not designed to quantify percent effectiveness.

Page 6, Last Paragraph: Is there any information regarding latent effects or delayed mortality on salmonids from this type of low-frequency acoustic system? Could repulsion from the barrier increase predation opportunities for predators?

Page 7, Last Paragraph: Are the sounds of chinook salmon held within the "portable acoustic recording studio" (tanks), the same as chinook salmon sounds in the wild?

Page 8, Last Paragraph: How did you determine that fish were not swept through the sound barrier? The experiment's results do not necessarily support this conclusion. I would expect the task of establishing the appropriate angle of the acoustic barrier to be difficult in a channel with highly variable flows such as the lower Sacramento River. Changing hydraulics and velocity distribution with streamflow are likely to significantly influence the performance of the barrier and the conditions that would allow fish to be swept through the barrier.

Page 9, 3rd Paragraph: The basis for these modifications to the barrier placement should be presented here or in the discussion section.

Page 9, 4th Paragraph: Were the hydrophones calibrated to measure the sound at various depths? Did you consider use of a copper sphere as a standard target?

Page 11, 1st Paragraph: Discussion regarding the flow split between the Sacramento River and Georgiana Slough pertains to flows in the range of 14,000 cfs in the Sacramento River. Data presented on page 10 indicate Sacramento River flows ranged from 20,000 cfs to 55,000 cfs during the study period. Flow splits during the study period should be presented and discussed in relation to the potential number of chinook salmon entering Georgiana Slough (availability).

Page 13, 1st Paragraph: It appears that the triplicate trawl sampling design within the narrow confines of Georgiana required all trawls be performed along the same transect and each trawl was repeated within minutes of the previous trawl. However, triplicate Sacramento River trawls were performed along three different transects with hours lapsing between trawls along the same transect. Closely repeated trawls within Georgiana Slough may have depleted the numbers of fish in the area and increased the variability between trawls in Georgiana Slough.

Page 13, 2nd Paragraph: How did you arrive at a 60 percent trawl efficiency?

Page 14, 2nd Paragraph: Where were the fish released after sample processing? If they were released on site during flood tide, could this affect replicate trawl samples (i.e. 2nd and 3rd trawls).

Page 17, 3rd Paragraph: It is important to keep in mind that CPUE estimates are of limited value for documenting changes (test conditions) unless the estimates are precise. The wide variability between trawl collections indicates that this sampling methodology may not have been a precise measure of fish density during the tests. This is an important aspect of the results and its significance should be discussed in further detail. If all the CPUE values are based on the Kodiak trawl data, the variability between samples may be greater than the variability between barrier test conditions and render the conclusions invalid. I also suggest the data for all surveys be summarized and presented as shown in Figures 13 and 14.

Page 17, Last Paragraph: Analysis of size-selective movement is limited due to the narrow size range of available fish and the selectivity of the gear used for sampling.

Page 18, 1st Paragraph: Did the results suggest that the horizontal distribution of fish in the Sacramento River was influenced by stream flow conditions (position of thalweg) or repellant from the right bank during the operation of the barrier? Again, the high variability among samples makes it difficult to distinguish trends.

Page 18, Last Paragraph: Discussion of the paired otter and Kodiak trawls to provide information on the vertical distribution of juvenile chinook is confusing. Why would there be a substantial increase in the utilization of the lower portion of the water column on June 4 in the Sacramento River? Review of the data presented in Table 3 and Figure 18 indicates relatively high variability in the numbers of juvenile chinook collected in each sample and a general pattern is difficult to distinguish. In addition, the barrier's operation during the paired tests or stratification of temperature and salinity may have influenced the position of fish within the water column.

Page 19, last paragraph: The analysis of CPUE ratios employed here calculated an <u>index</u> of diversion efficiency. Therefore, caption on the lower graphs in figures 19 and 20 should not read "percent effectiveness". The Y-axis legend on the upper graph of figures 19 and 20 should read "CPUE Ratio".

Page 20, 1st Paragraph: It appears unusual that during the May 10-14 test period the CPUE ratio during the barrier "on" was more than double the CPUE ratio during the barrier "off". If the barrier configuration was ineffective, the ratios for the barrier "off" and the barrier "on" should be similar. The high variability among samples has likely masked the results in this test and led to the false conclusion that the operation of the barrier attracted fish. High sampling variability could have also led to false conclusions in subsequent tests. I suggest the results of each test condition be pooled to examine the range of ratio values when the barrier was "off" compared to the range of ratio values then the barrier was "on." Large overlap between the ranges suggests there is no significant difference between the two test conditions.

Page 20, 3rd Paragraph: Immediate mortality or injury to chinook salmon captured in trawls does not necessarily imply cause and effect from the acoustical barrier. Adverse effects associated with exposure to the acoustical barrier may be expressed as latent effects or delay mortality.

Page 22, Discussion: This section should be expanded to include discussion of the investigation's results in support the report's conclusions. Sampling and environmental variables including streamflow, flow split (Sacramento River and Georgiana Slough), tidal influence, lunar cycles, sampling gear selectivity, temperature, and juvenile salmon behavior (outmigration pulses) are not discussed, but certainly exerted influence on the investigation's results.

Appendices: I recommend an appendix with additional information regarding the equipment requirements for an acoustic barrier (speakers, amplifiers, computerized signal generator, etc.). Considering the general interest in the application of behavioral technology for reducing fish entrainment losses, it would be useful to outline the cost of this equipment including its operation and maintenance requirements.

Appendix B

Kodiak Trawl Data Summary

May 6-June 10, 1993

Station 1	**Sacramento River downstream of the acoustic barrier**
Station 2	**Georgiana Slough**
Station 3	**Sacramento River upstream of the acoustic barrier**

Location 1	**Right Bank (looking downstream)**
Location 2	**Middle**
Location 3	**Left Bank (looking downstream)**

Barrier operation	**1**	**On**
	2	**Off**

1993 Acoustic Barrier Test

Gear: Kodiak Trawl

Station	Location	Barrier	Date	Start Time	Duratio (Min)	Number Salmon	Number Fish	Flow Meter End	Flow Meter Start	Volume (M3)	CPUE Salmon/min	CPUE Salmon/ 1000 m3
1	2	1	6-May	1605	10	1	1	629721	609817	4670	0.10	0.21
1	2	1	6-May	2111	11.2	2	6	658978	643156	3712	0.18	0.54
1	2	1	6-May	2300	10.3	0	4	684198	671710	2930	0.00	0.00
1	2	1	7-May	36	11.7	3	6	708494	694784	3217	0.26	0.93
1	2	1	7-May	281	10.5	5	6	731445	720333	2607	0.48	1.92
1	2	1	7-May	325	10.8	6	6	753476	740861	2960	0.56	2.03
1	2	1	7-May	739	10.5	12	12	779247	763261	3751	1.14	3.20
1	2	1	7-May	953	10.7	13	13	804696	791951	2990	1.21	4.35
1	2	1	10-May	1420	11	37	39	824703	813480	2633	3.36	14.05
1	2	1	10-May	1641	10	1	1	834610	825590	2116	0.10	0.47
1	2	1	10-May	1831	11	5	5	855535	843400	2847	0.45	1.76
1	1	1	10-May	2244	13.8	1	13	891963	870970	4926	0.07	0.20
1	2	1	10-May	2313	11	1	1	909937	891963	4217	0.09	0.24
1	3	1	10-May	2338	6.5	1	1	915833	909941	1382	0.15	0.72
1	3	1	11-May	601	10.5	28	28	19106	7616	2696	2.67	10.39
1	1	1	11-May	524	10.1	9	9	994384	979231	3555	0.89	2.53
1	2	1	11-May	404	11.5	0	1	954864	943819	2592	0.00	0.00
1	3	1	11-May	425	10.5	0	1	965873	954864	2583	0.00	0.00
1	2	1	11-May	544	10.1	31	31	1007616	994384	3105	3.07	9.98
1	1	1	11-May	344	10.8	0	3	943819	928340	3632	0.00	0.00
1	3	1	11-May	1705	11	2	2	138956	123506	3625	0.18	0.55
1	1	1	11-May	1616	10	7	7	107790	92440	3602	0.70	1.94
1	2	1	11-May	1644	11	0	0	123506	107792	3687	0.00	0.00
1	3	1	12-May	51	10.7	2	2	270664	258018	2967	0.19	0.67

1	2	1	12-May	29	11.5	1	1	258018	242445	3654	0.09	0.27
1		1	12-May	651	10.3	0	0	427502	416103	2675	0.00	0.00
1	2	1	12-May	632	10.5	0	0	416103	400945	3557	0.00	0.00
1	1	1	12-May	613	10.6	0	0	400945	368607	7588	0.00	0.00
1	1	1	12-May	311	10.6	1	1	324157	312132	2822	0.09	0.35
1	2	1	12-May	432	10.2	1	1	350005	334388	3664	0.10	0.27
1	3	1	12-May	250	10.4	0	0	312138	300818	2656	0.00	0.00
1	2	1	12-May	333	10	2	4	VOID			0.20	
1		1	12-May	201	10.8	0	0	290819	271045	4640	0.00	0.00
1	1	1	17-May	1110	10	4	4	618979	600320	4378	0.40	0.91
1	2	1	17-May	2233	10	0	0	584602	567022	4125	0.00	0.00
1	2	1	17-May	2006	10.1	12	12	521621	503997	4135	1.19	2.90
1	2	1	17-May	1946	10	18	18	503997	487433	3887	1.80	4.63
1	2	1	17-May	1923	10.2	6	8	487433	468770	4379	0.59	1.37
1	2	1	17-May	1746	10.2	0	0	419722	401022	4388	0.00	0.00
1	2	1	17-May	1705	10	3	3	383417	365837	4125	0.30	0.73
1	3	1	17-May	1212	10.3	6	6	255583	239868	3687	0.58	1.63
1	1	1	17-May	1128	10	7	7	220060	199382	4852	0.70	1.44
1	2	1	17-May	1153	10.3	22	22	239868	220062	4647	2.14	4.73
1	3	1	17-May	1727	10.2	1	1	401022	383417	4131	0.10	0.24
1	3	1	18-May	1335	10	29	29	908903	895394	3170	2.90	9.15
1	1	1	18-May	1301	10.7	18	18	877533	859334	4270	1.68	4.22
1	2	1	18-May	1319	10.8	14	14	895394	877533	4191	1.30	3.34
1	3	1	18-May	936	10	40	40	816729	799179	4118	4.00	9.71
1	2	1	18-May	919	10.2	4	4	799179	782539	3904	0.39	1.02
1	2	1	18-May	900	10.3	4	4	782539	764704	4185	0.39	0.96
1	3	1	18-May	2238	10.3	0	0	752074	735270	3943	0.00	0.00
1	1	1	18-May	2205	10.1	1	1	717015	697748	4521	0.10	0.22
1	2	1	18-May	2220	10.1	3	3	735270	717015	4283	0.30	0.70
1	3	1	18-May	2040	10.1	3	4	648136	632449	3681	0.30	0.82
1	2	1	18-May	2022	10.2	69	71	632499	614330	4263	6.76	16.19
1	1	1	18-May	2005	10	11	11	614330	596602	4160	1.10	2.64
1	3	1	18-May	1721	10	32	32	545655	530363	3588	3.20	8.92

1	2	1	18-May	1702	10.1	10	10	523063	504260	4412	0.99	2.27
1	1	1	18-May	1642	10.1	5	5	504259	486442	4181	0.50	1.20
1	3	1	18-May	641	10.2	66	66	722944	709020	3267	6.47	20.20
1	1	1	18-May	607	10.2	4	4	690353	671661	4386	0.39	0.91
1	2	1	18-May	624	10	63	63	709020	690353	4380	6.30	14.38
1	2	1	19-May	1109	10.1	57	57	55077	35298	4641	5.64	12.28
1		1	19-May	1138	9	59	59	78097	55077	5401	6.56	10.92
1	1	1	19-May	1051	10	8	8	VOID			0.80	
1	3	1	19-May	922	10.4	0	0	977080	962998	3304	0.00	0.00
1	1	1	19-May	842	10.2	12	12	928994	909486	4577	1.18	2.62
1	2	1	19-May	904	10.2	0	0	962498	928994	7861	0.00	0.00
1	1	1	19-May	558	10	43	43	825948	802388	5528	4.30	7.78
1	2	1	19-May	618	10	148	148	845801	825948	4658	14.80	31.77
1	3	1	19-May	636	10	4	4	861141	845801	3599	0.40	1.11
1	3	1	26-May	1114	10	6	6	552785	542365	2445	0.60	2.45
1	1	1	26-May	1039	10	1	2	526113	509075	3998	0.10	0.25
1	2	1	26-May	1057	10	0	0	542365	526113	3813	0.00	0.00
1	1	1	26-May	758	10	2	2	431403	410218	4971	0.20	0.40
1	2	1	26-May	814	10	3	3	450818	431403	4556	0.30	0.66
1	3	1	26-May	831	10	5	5	464848	450838	3287	0.50	1.52
1	3	1	26-May	600	10	19	19	362506	348592	3265	1.90	5.82
1	2	1	26-May	545	10	72	72	348592	328463	4723	7.20	15.24
1	1	1	26-May	528	10	9	9	328463	309568	4434	0.90	2.03
1	3	1	3-Jun	804	10	0	0	169717	157376	2896	0.00	0.00
1	2	1	3-Jun	745	10	7	7	157376	140113	4051	0.70	1.73
1	1	1	3-Jun	723	10	12	13	140113	122128	4220	1.20	2.84
1	1	1	3-Jun	445	10	0	1	47000	30083	3969	0.00	0.00
1	2	1	3-Jun	503	10	2	3	66157	47000	4495	0.20	0.44
1	3	1	3-Jun	523	10	3	3	77804	66157	2733	0.30	1.10
1	3	1	3-Jun	1037	10	3	3	265107	250991	3312	0.30	0.91
1	1	1	3-Jun	956	10	4	6	233591	216474	4016	0.40	1.00
1	2	1	3-Jun	1015	10	6	7	250991	233591	4083	0.60	1.47

1	1	1	3-Jun	1652	10	24	24	390856	372370	4338	2.40	5.53
1	2	1	3-Jun	1707	10	7	9	409007	390856	4259	0.70	1.64
1	3	1	3-Jun	1724	10	4	6	423443	409007	3387	0.40	1.18
1	2	1	3-Jun	1924	10	13	13	506450	490449	3754	1.30	3.46
1	1	1	3-Jun	1908	10.1	7	7	490449	472883	4122	0.69	1.70
1	3	1	3-Jun	1942	10	4	4	518754	506450	2887	0.40	1.39
1	2	1	3-Jun	2233	10	8	8	599355	584916	3388	0.80	2.36
1	3	1	3-Jun	2253	10.1	7	7	611393	599355	2825	0.69	2.48
1	1	1	3-Jun	2205	10	0	0	584916	568946	3747	0.00	0.00
1	3	1	3-Jun	1633	10	4	6	978850	967407	2685	0.40	1.49
1	2	1	3-Jun	1615	9.9	1	1	967393	950629	3934	0.10	0.25
1	1	1	3-Jun	1600	10	15	16	950629	934085	3882	1.50	3.86
1	3	1	3-Jun	1845	10	3	3	69571	57851	2750	0.30	1.09
1	2	1	3-Jun	1825	9.8	17	18	57843	42695	3554	1.73	4.78
1	3	1	3-Jun	2320	10	5	5	160806	148595	2865	0.50	1.75
1	2	1	3-Jun	2300	10.1	3	4	148590	133091	3637	0.30	0.82
1	1	1	3-Jun	2240	9.8	2	5	133090	117058	3762	0.20	0.53
1	1	1	4-Jun	612	10	9	9	678125	662240	3727	0.90	2.41
1	2	1	4-Jun	631	10	14	15	695278	678125	4025	1.40	3.48
1	3	1	4-Jun	650	10	6	6	703675	695278	1970	0.60	3.05
1	1	1	4-Jun	851	10	9	9	771517	753566	4212	0.90	2.14
1	2	1	4-Jun	913	10	27	28	785509	771517	3283	2.70	8.22
1	1	1	4-Jun	1230	10	3	3	863241	844282	4449	0.30	0.67
1	2	1	4-Jun	1247	10	16	16	878933	863241	3682	1.60	4.35
1	3	1	4-Jun	1306	10.2	10	11	891917	878933	3047	0.98	3.28
1	1	1	7-Jun	554	10	3	4	227388	208506	4430	0.30	0.68
1	2	1	7-Jun	611	10	4	4	246591	227388	4506	0.40	0.89
1	3	1	7-Jun	629	10	1	1	260819	246591	3338	0.10	0.30
1	1	1	7-Jun	835	10	4	5	332320	313342	4453	0.40	0.90
1	2	1	7-Jun	854	10	9	9	351008	332320	4385	0.90	2.05
1	3	1	7-Jun	911	10	2	3	363403	351008	2908	0.20	0.69
1		1	7-Jun	1142	10	1	3	429661	413421	3811	0.10	0.26
1		1	7-Jun	1201	10	2	2	446532	429661	3959	0.20	0.51

1		1	7-Jun	1218	10	2	4	463887	446532	4072	0.20	0,49
1		1	7-Jun	1554	10	1	2	534911	517355	4119	0.10	0.24
1		1	7-Jun	1610	10.2	0	0	552452	534911	4116	0.00	0.00
1	1	1	8-Jun	613	10	2	4	932174	912336	4655	0.20	0.43
1	2	1	8-Jun	641	10	3	4	949293	932174	4017	0.30	0.75
1	3	1	8-Jun	658	10	0	0	960687	949293	2673	0.00	0.00
1	2	1	8-Jun	2130	10.1	2	2	449323	433333	3752	0.20	0.53
1	1	1	8-Jun	855	10	7	7	VOID			0.70	
1	2	1	8-Jun	914	10	1	1	40199	22388	4179	0.10	0.24
1	3	1	8-Jun	933	10	1	1	51294	40199	2603	0.10	0.38
1	1	1	8-Jun	1212	10	1	1	134375	116425	4212	0.10	0.24
1	2	1	8-Jun	1229	10	7	7	150043	134375	3676	0.70	1.90
1	3	1	8-Jun	1253	10	1	2	163648	150043	3192	0.10	0.31
1	3	1	8-Jun	1702	10	0	0	262915	247925	3517	0.00	0.00
1	2	1	8-Jun	1645	10	6	6	244925	232667	2876	0.60	2.09
1	1	1	8-Jun	1625	10	1	1	232667	215542	4018	0.10	0.25
1	3	1	8-Jun	1935	10.2	1	2	367229	349950	4054	0.10	0.25
1	3	1	8-Jun	2151	10.3	3	3	465954	449323	3902	0.29	0.77
1	2	1	8-Jun	1905	10.1	5	6	349950	333609	3834	0.50	1.30
1	1	1	8-Jun	1845	9.8	4	4	333609	317851	3697	0.41	1.08
1	1	1	8-Jun	2107	10	4	4	433333	416212	4017	0.40	1.00
2	2	1	6-May	1347	30	3	3	VOID			0.10	
2	2	1	6-May	1507	8	6	6	VOID			0.75	
2	2	1	6-May	2007	11	9	9	643151	629723	3151	0.82	2.86
2	2	1	6-May	2217	16.4	3	6	671685	639023	7664	0.18	0.39
2	2	1	7-May	4	10.9	1	5	VOID			0.09	
2	2	1	7-May	113	10.9	0	4	720333	708506	2775	0.00	0.00
2	2	1	7-May	249	11.9	8	10	740869	731451	2210	0.67	3.62
2	2	1	7-May	425	10.5	1	2	763245	753478	2292	0.10	0.44
2	2	1	7-May	918	10.5	4	4	791948	779245	2981	0.38	1.34
2	2	1	10-May	1347	11	0	0	813450	802140	2654	0.00	0.00
2	2	1	10-May	1608	10	23	23	VOID			2.30	

2	2	1	10-May	1753	10	38	39	843393	834610	2061	3.80	18.44
2	2	1	10-May	2201	11.1	0	5	870790	858538	2875	0.00	0.00
2	2	1	11-May	455	10	5	6	979231	965870	3135	0.50	1.59
2	2	1	11-May	248	10.5	1	7	928337	915850	2930	0.10	0.34
2	2	1	11-May	1510	10	4	4	92444	80808	2730	0.40	1.47
2	2	1	11-May	1446	11	2	2	80808	65930	3491	0.18	0.57
2	2	1	11-May	1417	10	4	4	65927	48053	4194	0.40	0.95
2	2	1	11-May	1733	10	0	0	156340	138960	4078	0.00	0.00
2	2	1	11-May	1750	10	19	19	171990	156340	3672	1.90	5.17
2	2	1	11-May	2229	10.5	1	1	193387	171911	5039	0.10	0.20
2	2	1	11-May	2249	10.3	0	0	209834	193387	3859	0.00	0.00
2	2	1	11-May	2310	10.6	0	1	225278	209234	3765	0.00	0.00
2	2	1	12-May	502	10.5	1	1	361921	350016	2793	0.10	0.36
2	2	1	12-May	548	10.4	4	4	386397	374751	2733	0.38	1.46
2	2	1	12-May	523	10.6	10	10	374751	361921	3010	0.94	3.32
2	2	1	12-May	221	11	0	0	VOID			0.00	
2	2	1	12-May	201	10.8	0	0	VOID			0.00	
2	2	1	12-May	142	10.4	0	0	281041	270680	2431	0.00	0.00
2	2	1	17-May	2250	10	1	1	600320	584602	3688	0.10	0.27
2	2	1	17-May	2210	10.2	0	0	567022	551702	3595	0.00	0.00
2	2	1	17-May	2135	10.2	7	8	537755	521625	3785	0.69	1.85
2	2	1	17-May	2153	10.2	4	4	551702	537755	3273	0.39	1.22
2	2	1	17-May	1852	10	16	16	468770	452415	3838	1.60	4.17
2	2	1	17-May	1835	10	17	17	452415	436935	3632	1.70	4.68
2	2	1	17-May	1815	10.2	2	3	436935	419716	4040	0.20	0.50
2	2	1	17-May	1637	10	14	14	VOID			1.40	
2	2	1	17-May	1617	10.8	3	3	VOID			0.28	
2	2	1	17-May	1545	10	16	16	319328	301756	4123	1.60	3.88
2	2	1	17-May	1247	10.4	29	30	271765	255580	3798	2.79	7.64
2	2	1	17-May	1310	10.4	35	35	287795	271762	3762	3.37	9.30
2	2	1	17-May	1325	10.2	27	27	301742	287795	3273	2.65	8.25
2	2	1	18-May	1231	10.1	10	10	859334	847003	2893	0.99	3.46
2	2	1	18-May	1215	10.1	15	15	847003	832655	3367	1.49	4.46

2	2	1	18-May	1157	10.6	28	28	832655	816729	3737	2.64	7.49
2	2	1	18-May	836	10	4	4	764704	749777	3502	0.40	1.14
2	2	1	18-May	820	10.1	1	1	749777	735596	3327	0.10	0.30
2	2	1	18-May	2139	10	6	6	697748	680360	4080	0.60	1.47
2	2	1	18-May	2122	10	6	6	680360	664275	3774	0.60	1.59
2	2	1	18-May	2106	10.2	3	3	664275	648136	3787	0.29	0.79
2	2	1	18-May	1942	10.1	6	6	596602	578521	4243	0.59	1.41
2	2	1	18-May	1924	10	1	1	578521	561591	3972	0.10	0.25
2	2	1	18-May	1905	10.1	40	41	561591	545655	3739	3.96	10.70
2	2	1	18-May	1550	10.2	12	12	VOID			1.18	
2	2	1	18-May	1532	10.1	0	0	VOID			0.00	
2	2	1	18-May	1512	10	5	5	VOID			0.50	
2	2	1	18-May	803	9.5	6	6	735596	722942	2969	0.63	2.02
2	2	1	18-May	540	10.8	7	7	671662	653364	4293	0.65	1.63
2	2	1	18-May	501	12	1	5	634964	618983	3750	0.08	0.27
2	2	1	18-May	521	10	15	17	653362	634964	4317	1.50	3.47
2	2	1	19-May	1024	10.6	6	6	25217	9222	3753	0.57	1.60
2	2	1	19-May	1008	10.7	0	0	1009222	993121	3778	0.00	0.00
2	2	1	19-May	950	10.8	15	15	993121	977078	3764	1.39	3.98
2	2	1	19-May	819	10	2	2	909486	893473	3757	0.20	0.53
2	2	1	19-May	803	10.1	0	0	893473	878174	3590	0.00	0.00
2	2	1	19-May	744	10	1	1	878174	861169	3990	0.10	0.25
2	2	1	19-May	458	10.4	2	3	768456	752064	3846	0.19	0.52
2	2	1	19-May	514	10.5	27	28	785167	768456	3921	2.57	6.89
2	2	1	19-May	532	10.3	40	40	802388	785167	4041	3.88	9.90
2	2	1	26-May	703	10	5	6	410216	394604	3663	0.50	1.36
2	2	1	26-May	629	10	11	11	378849	362508	3834	1.10	2.87
2	2	1	26-May	646	10	10	10	394604	378849	3697	1.00	2.71
2	2	1	26-May	1013	10	17	17	509075	494203	3490	1.70	4.87
2	2	1	26-May	940	10	0	0	479097	464847	3344	0.00	0.00
2	2	1	26-May	955	10	3	3	494203	479097	3544	0.30	0.85
2	2	1	26-May	1206	10	2	2	595674	581573	3309	0.20	0.60
2	2	1	26-May	1137	10	4	4	566666	552777	3259	0.40	1.23

2	2	1	26-May	1152	10	0	0	581573	566666	3498	0.00	0.00
2	2	1	3-Jun	547	10	5	6	92336	77804	3410	0.50	1.47
2	2	1	3-Jun	603	10	4	4	106794	92336	3392	0.40	1.18
2	2	1	3-Jun	619	10	3	4	122126	106794	3598	0.30	0.83
2	2	1	3-Jun	834	10	2	2	185175	167723	4095	0.20	0.49
2	2	1	3-Jun	356	10	1	1	200277	185161	3547	0.10	0.28
2	2	1	3-Jun	923	10	8	9	216476	200277	3801	0.80	2.10
2	2	1	3-Jun	1305	10	5	5	315466	300369	3542	0.50	1.41
2	2	1	3-Jun	1148	9	7	8	282985	265110	4194	0.78	1.67
2	2	1	3-Jun	1247	10	5	5	300369	282983	4079	0.50	1.23
2	2	1	3-Jun	1621	10	11	11	372375	354247	4254	1.10	2.59
2	2	1	3-Jun	1600	10.2	21	21	354247	336268	4219	2.06	4.98
2	2	1	3-Jun	1504	10	3	4	336268	315471	4880	0.30	0.61
2	2	1	3-Jun	1752	10.1	13	14	440240	423450	3940	1.29	3.30
2	2	1	3-Jun	1840	10	7	7	472883	456146	3927	0.70	1.78
2	2	1	3-Jun	1818	10	6	6	456146	440240	3732	0.60	1.61
2	2	1	3-Jun	2010	10.1	4	5	535159	518754	3849	0.40	1.04
2	2	1	3-Jun	2045	10	1	2	568946	551516	4090	0.10	0.24
2	2	1	3-Jun	2027	10	3	4	551516	535159	3838	0.30	0.78
2	2	1	3-Jun	1520	10	3	3	934084	915545	4350	0.30	0.69
2	2	1	3-Jun	1504	9.9	5	5	915552	901707	3249	0.51	1.54
2	2	1	3-Jun	1450	9.8	11	14	901700	891935	2291	1.12	4.80
2	2	1	3-Jun	1808	9.9	4	4	42695	26613	3773	0.40	1.06
2	2	1	3-Jun	1737	10	7	7	26611	10906	3685	0.70	1.90
2	2	1	3-Jun	1720	10	6	6	1010863	996047	3476	0.60	1.73
2	2	1	3-Jun	1703	10	2	2	996047	978851	4035	0.20	0.50
2	2	1	3-Jun	1947	10	6	6	117059	100496	3886	0.60	1.54
2	2	1	3-Jun	1930	9.8	6	8	100493	86140	3368	0.61	1.78
2	2	1	3-Jun	1913	10	4	5	86144	69547	3894	0.40	1.03
2	2	1	4-Jun	546	10	4	5	662240	645125	4016	0.40	1.00
2	2	1	4-Jun	504	10	3	5	628393	611397	3988	0.30	0.75
2	2	1	4-Jun	526	10	8	8	645125	628393	3926	0.80	2.04
2	2	1	4-Jun	825	10	6	8	753566	735903	4144	0.60	1.45

2	2	1	4-Jun	750	10	6	8	720246	703675	3888	0.60	1.54
2	2	1	4-Jun	807	10	10	12	735903	720246	3674	1.00	2.72
2	2	1	4-Jun	1123	10	6	8	827504	810131	4076	0.60	1.47
2	2	1	4-Jun	1141	10	8	8	844282	827504	3937	0.80	2.03
2	2	1	4-Jun	1104	10	7	8	810131	794505	3666	0.70	1.91
2	2	1	7-Jun	452	10	0	10	176463	160825	3669	0.00	0.00
2	2	1	7-Jun	512	10	0	0	193117	176463	3908	0.00	0.00
2	2	1	7-Jun	530	10	2	4	208506	193117	3611	0.20	0.55
2	2	1	7-Jun	738	10	0	1	281581	260824	4870	0.00	0.00
2	2	1	7-Jun	756	10	0	0	297350	281581	3700	0.00	0.00
2	2	1	7-Jun	812	10	2	2	313342	297350	3752	0.20	0.53
2	2	1	7-Jun	1047	10	0	1	380788	363403	4079	0.00	0.00
2	2	1	7-Jun	1105	10	0	0	397494	380788	3920	0.00	0.00
2	2	1	7-Jun	1121	10	0	0	483485	466337	4024	0.00	0.00
2	2	1	7-Jun	1515	10	2	4	500402	483485	3969	0.20	0.50
2	2	1	7-Jun	1531	10	0	0	517353	500402	3977	0.00	0.00
2	2	1	7-Jun	1650	10	0	0	587461	570836	3901	0.00	0.00
2	2	1	7-Jun	1707	10	0	0	604348	587461	3962	0.00	0.00
2	2	1	7-Jun	1732	10.1	0	1	620647	604348	3824	0.00	0.00
2	2	1	8-Jun	542	10	0	0	912336	896065	3818	0.00	0.00
2	2	1	8-Jun	507	10	0	4	894562	883827	2519	0.00	0.00
2	2	1	8-Jun	525	10	0	3	VOID			0.00	
2	2	1	8-Jun	833	10	2	2	1002490	985234	4049	0.20	0.49
2	2	1	8-Jun	800	10	1	3	971149	960687	2455	0.10	0.41
2	2	1	8-Jun	817	10	1	3	985234	971149	3305	0.10	0.30
2	2	1	8-Jun	2035	10	1	1	416212	399380	3949	0.10	0.25
2	2	1	8-Jun	2011	10	1	1	399380	384392	3517	0.10	0.28
2	2	1	8-Jun	1950	10.3	1	2	384392	367229	4027	0.10	0.25
2	2	1	8-Jun	1816	10.3	0	0	317851	299767	4243	0.00	0.00
2	2	1	8-Jun	1755	10	0	0	299767	278129	5077	0.00	0.00
2	2	1	8-Jun	1735	10	0	0	278129	262915	3570	0.00	0.00
2	2	1	8-Jun	1605	9.8	0	1	215542	200253	3587	0.00	0.00
2	2	1	8-Jun	1549	10.1	1	2	200253	183811	3858	0.10	0.26

2	2	1	8-Jun	1534	10	1	1	183811	163660	4728	0.10	0.21
2	2	1	8-Jun	1147	11	1	1	116425	101675	3461	0.09	0.29
2	2	1	8-Jun	1117	12	0	1	76982	51289	6029	0.00	0.00
2	2	1	8-Jun	1131	12	0	0	101675	76982	5794	0.00	0.00
3	2	1	11-May	1121	10	69	69	48053	35635	2914	6.90	23.68
3	2	1	11-May	1054	8	11	11	35635	19104	3879	1.38	2.84
3	3	1	26-May	1401	10	0	0	645901	633281	2961	0.00	0.00
3	3	1	26-May	1326	10	24	25	615111	595660	4564	2.40	5.26
3	2	1	26-May	1341	10	6	7	633281	615111	4263	0.60	1.41
1	2	2	13-May	1134	10	22	22	836081	816828	4518	2.20	4.87
1	1	2	13-May	1203	10	9	9	857132	836081	4939	0.90	1.82
1	3	2	13-May	1225	10	5	5	872456	857132	3596	0.50	1.39
1	3	2	13-May	1521	10	6	6	934351	920153	3331	0.60	1.80
1	3	2	13-May	411	10.5	0	0	729983	714126	3721	0.00	0.00
1	2	2	13-May	350	10.2	7	9	714126	696702	4088	0.69	1.71
1	1	2	13-May	326	10.2	3	8	696702	678563	4256	0.29	0.70
1	2	2	13-May	57	10.7	1	1	633161	618790	3372	0.09	0.30
1	3	2	13-May	38	10.7	0	1	618790	602100	3916	0.00	0.00
1	1	2	13-May	18	10.5	6	6	602100	584714	4079	0.57	1.47
1	1	2	13-May	2338	10.1	3	3	1013198	995746	4095	0.30	0.73
1	3	2	13-May	2259	10.4	3	3	978775	961365	4085	0.29	0.73
1	2	2	13-May	2319	10.4	2	2	995746	978775	3982	0.19	0.50
1	1	2	14-May	619	10	72	72	182722	165906	3946	7.20	18.25
1		2	14-May	638	12	56	56	199388	182722	3911	4.67	14.32
1	1	2	14-May	559	10	27	27	165906	149562	3835	2.70	7.04
1	3	2	14-May	343	10.3	2	2	103101	87028	3771	0.19	0.53
1	1	2	14-May	306	10.2	3	3	71473	60314	2618	0.29	1.15
1	2	2	14-May	324	10.2	1	2	87028	71473	3650	0.10	0.27

1		2	19-May	1850	10.1	51	51	326886	307883	4459	5.05	11.44
1		2	19-May	1908	10.1	0	0	343668	326886	3938	0.00	0.00
1		2	19-May	1832	10.5	0	0	307864	287446	4791	0.00	0.00
1	1	2	19-May	1633	10.2	7	7	234085	214432	4611	0.69	1.52
1	2	2	19-May	1612	10	4	4	214452	197282	4029	0.40	0.99
1	3	2	19-May	1549	10	3	3	197282	179690	4128	0.30	0.73
1	2	2	19-May	2105	10	2	3	434314	415679	4373	0.20	0.46
1	1	2	19-May	2040	10	12	14	415679	397433	4281	1.20	2.80
1	3	2	19-May	2223	10	0	3	449459	434314	3554	0.00	0.00
1	2	2	20-May	1640	10	1	1	917480	900278	4036	0.10	0.25
1	1	2	20-May	1623	10	21	21	900278	883013	4051	2.10	5.18
1	3	2	20-May	1659	10.8	0	0	934801	917501	4059	0.00	0.00
1	2	2	20-May	1834	10.1	2	3	21083	3677	4084	0.20	0.49
1	1	2	20-May	1816	10.3	7	7	1003677	985254	4323	0.68	1.62
1	3	2	20-May	1852	10	5	5	36782	21083	3684	0.50	1.36
1	3	2	20-May	1344	10.3	14	14	831394	815955	3623	1.36	3.86
1	2	2	20-May	2027	10.3	21	22	123308	104697	4367	2.04	4.81
1	3	2	20-May	2044	10.2	8	8	139560	123308	3813	0.78	2.10
1	1	2	20-May	2008	10	16	17	104697	88406	3823	1.60	4.19
1	2	2	20-May	1327	10.5	0	0	815955	794961	4926	0.00	0.00
1	1	2	20-May	1312	10.2	7	8	794961	775992	4451	0.69	1.57
1	2	2	20-May	803	9.9	10	10	597988	579080	4437	1.01	2.25
1	3	2	20-May	822	10.7	1	1	613490	597988	3637	0.09	0.27
1	2	2	20-May	1032	10	18	18	696160	678230	4207	1.80	4.28
1	3	2	20-May	1049	10	62	62	707781	696160	2727	6.20	22.74
1	1	2	20-May	1010	10	4	5	678230	660421	4179	0.40	0.96
1	2	2	21-May	1028	10	37	37	255545	221274	8041	3.70	4.60
1	3	2	21-May	1045	10	28	28	VOID			2.80	
1	1	2	21-May	1012	10	0	1	221274	202552	4393	0.00	0.00
1	2	2	24-May	1846	10	0	1	765644	748671	3983	0.00	0.00
1	3	2	24-May	1903	9.9	31	31	781647	765657	3752	3.13	8.26
1	2	2	24-May	2029	10	5	9	844165	828067	3777	0.50	1.32
1	1	2	24-May	2047	10	3	3	861863	844162	4153	0.30	0.72

1	3	2	24-May	2107	10	2	5	877272	861858	3617	0.20	0.55
1	1	2	24-May	1633	10.2	13	14	650315	633439	3960	1.27	3.28
1	2	2	24-May	1651	10	1	1	668120	650321	4176	0.10	0.24
1	3	2	24-May	1708	10	0	0	682581	668122	3393	0.00	0.00
1	1	2	24-May	1828	10	2	2	748659	731644	3992	0.20	0.50
1	2	2	24-May	1318	10	9	10	571438	552530	4437	0.90	2.03
1	3	2	24-May	1343	10	54	54	585286	571438	3249	5.40	16.62
1	1	2	24-May	1257	8	23	23	552570	535471	4012	2.88	5.73
1	3	2	24-May	714	10.7	26	26	381397	365325	3771	2.43	6.89
1	2	2	24-May	657	10	4	4	365325	347263	4238	0.40	0.94
1	1	2	24-May	628	10.5	22	22	347263	329500	4168	2.10	5.28
1	3	2	24-May	1043	10	9	9	484183	470495	3212	0.90	2.80
1	2	2	24-May	1019	10	81	81	470495	452496	4223	8.10	19.18
1	1	2	24-May	1006	10.6	2	2	452496	432556	4679	0.19	0.43
1	2	2	25-May	546	10.1	66	66	911516	896463	3532	6.53	18.69
1	3	2	25-May	604	10	36	36	926763	911516	3578	3.60	10.06
1	1	2	25-May	938	10	39	39	996720	978522	4270	3.90	9.13
1	2	2	25-May	954	10	33	33	1013587	996720	3958	3.30	8.34
1	3	2	25-May	1018	10	21	21	28835	14695	3318	2.10	6.33
1	1	2	25-May	525	10	19	19	896463	877278	4502	1.90	4.22
1	1	2	25-May	2107	10	0	0	309555	291102	4330	0.00	0.00
1	2	2	25-May	2031	10	31	32	291102	273144	4214	3.10	7.36
1	3	2	25-May	2248	10	7	7	VOID			0.70	
1	2	2	25-May	1615	10	33	33	112175	95061	4016	3.30	8.22
1	3	2	25-May	1633	10.1	27	27	127896	112175	3689	2.67	7.32
1	1	2	25-May	1556	10	2	3	95061	78761	3825	0.20	0.52
1	3	2	25-May	1812	10.1	1	1	193419	174451	4451	0.10	0.22
1	2	2	25-May	1831	10	1	1	210575	193419	4025	0.10	0.25
1	1	2	25-May	1847	10	22	22	227492	210575	3969	2.20	5.54
1	3	2	1-Jun	1246	10	19	19	1002498	987247	3578	1.90	5.31
1	1	2	1-Jun	1216	10	8	8	969304	948614	4855	0.80	1.65
1	2	2	1-Jun	1231	10	24	25	987247	969304	4210	2.40	5.70
1	3	2	1-Jun	516	10	0	0	698623	684751	3255	0.00	0.00

1	1	2	1-Jun	441	10	0	0	664169	645870	4294	0.00	0.00
1	2	2	1-Jun	458	10	0	0	684751	664169	4829	0.00	0.00
1	3	2	1-Jun	818	10	0	0	800272	787670	2957	0.00	0.00
1	1	2	1-Jun	745	10	7	8	768393	748813	4594	0.70	1.52
1	2	2	1-Jun	801	10.1	1	1	787670	768393	4523	0.10	0.22
1	3	2	1-Jun	1048	10	9	9	899984	887254	2987	0.90	3.01
1	1	2	1-Jun	1012	10	7	7	869329	851054	4288	0.70	1.63
1	2	2	1-Jun	1030	10	38	40	887254	869329	4206	3.80	9.03
1	1	2	1-Jun	1552	10	0	0	119778	103056	3924	0.00	0.00
1	2	2	1-Jun	1610	10.1	0	0	137706	119774	4208	0.00	0.00
1	3	2	1-Jun	1623	10	16	16	153300	137704	3659	1.60	4.37
1	1	2	1-Jun	2140	10.1	0	0	418274	400567	4155	0.00	0.00
1	2	2	1-Jun	2157	10	1	1	435191	418274	3969	0.10	0.25
1	3	2	1-Jun	2218	9.9	0	1	449149	435191	3275	0.00	0.00
1	1	2	1-Jun	1946	10	7	7	322142	304589	4119	0.70	1.70
1	2	2	1-Jun	2002	10	1	1	339292	322144	4024	0.10	0.25
1	3	2	1-Jun	2019	10	5	5	351934	339288	2967	0.50	1.69
1	1	2	1-Jun	1750	10	4	4	220551	203769	3938	0.40	1.02
1	2	2	1-Jun	1804	10	13	14	238530	220550	4219	1.30	3.08
1	3	2	1-Jun	1821	10.5	0	0	251954	238523	3151	0.00	0.00
1	1	2	2-Jun	551	10	5	6	516753	500566	3798	0.50	1.32
1	2	2	2-Jun	608	10	1	2	533477	516753	3924	0.10	0.25
1	3	2	2-Jun	625	10	20	20	543335	533477	2313	2.00	8.65
1	1	2	2-Jun	814	10	32	33	610166	591329	4420	3.20	7.24
1	2	2	2-Jun	846	10	4	4	628131	610166	4215	0.40	0.95
1	3	2	2-Jun	914	10	2	2	640496	628131	2901	0.20	0.69
1	1	2	2-Jun	1124	10.1	6	6	703716	689483	3340	0.59	1.80
1	2	2	2-Jun	1141	10.1	7	7	721080	703716	4074	0.69	1.72
1	3	2	2-Jun	1151	10	2	2	734295	721080	3101	0.20	0.65
1	2	2	2-Jun	1627	10	1	1	824519	806108	4320	0.10	0.23
1	3	2	2-Jun	1645	10	0	0	840439	824519	3735	0.00	0.00
1	1	2	2-Jun	1612	10	4	4	806108	788300	4178	0.40	0.96
1	3	2	2-Jun	2020	10	4	6	938346	922700	3671	0.40	1.09
1	2	2	2-Jun	2000	10	5	5	922700	906216	3868	0.50	1.29

1	1	2	2-Jun	1808	10	20	22	906216	889234	3985	2.00	5.02
1	3	2	2-Jun	2220	10	0	0	30900	17394	3169	0.00	0.00
1	1	2	2-Jun	2145	10	0	0	1001896	984612	4056	0.00	0.00
1	2	2	2-Jun	2202	10	2	2	17394	1896	3636	0.20	0.55
1	2	2	9-Jun	1657	10	0	0	825860	811031	3479	0.00	0.00
1	2	2	9-Jun	1623	10	3	3	VOID			0.30	
1	1	2	9-Jun	1557	10	0	1	811031	794399	3903	0.00	0.00
1	1	2	9-Jun	1911	10	1	1	892623	878843	3233	0.10	0.31
1	3	2	9-Jun	2002	10	0	0	925442	908919	3877	0.00	0.00
1	2	2	9-Jun	1933	10	2	2	908919	892623	3824	0.20	0.52
1	1	2	9-Jun	1213	10	1	4	717820	698582	4514	0.10	0.22
1	1	2	9-Jun	848	10	1	1	625080	605124	4682	0.10	0.21
1	2	2	9-Jun	908	11	2	3	644300	625080	4510	0.18	0.44
1	3	2	9-Jun	925	10	1	1	654186	644300	2320	0.10	0.43
1	3	2	9-Jun	638	10	1	1	561638	549885	2758	0.10	0.36
1	2	2	9-Jun	620	10	2	2	549885	531373	4344	0.20	0.46
1	1	2	9-Jun	559	10	1	4	531373	511258	4720	0.10	0.21
1	2	2	9-Jun	1231	10	2	4	734291	717820	3865	0.20	0.52
1	3	2	9-Jun	1254	10	2	2	750810	734291	3876	0.20	0.52
1	2	2	9-Jun	2137	10	1	1	1009930	993245	3915	0.10	0.26
1	3	2	9-Jun	2155	10.1	2	2	24270	9930	3365	0.20	0.59
1	1	2	9-Jun	2109	10	1	1	993245	975635	4132	0.10	0.24
1	1	2	10-Jun	2019	10	1	2	587762	569054	4390	0.10	0.23
1	2	2	10-Jun	2037	10	1	1	605040	587762	4054	0.10	0.25
1	3	2	10-Jun	2055	10	0	0	620021	605040	3515	0.00	0.00
1	1	2	10-Jun	1819	10	1	2	492955	474789	4262	0.10	0.23
1	2	2	10-Jun	1837	10	1	1	508652	492955	3683	0.10	0.27
1	3	2	10-Jun	1854	10	1	2	524887	508652	3809	0.10	0.26
1	1	2	10-Jun	1622	10	0	0	395002	376315	4385	0.00	0.00
1	2	2	10-Jun	1636	10	2	2	412692	395002	4151	0.20	0.48
1	3	2	10-Jun	1654	10	1	1	427644	412692	3508	0.10	0.29
1	1	2	10-Jun	1130	10	2	3	282116	262642	4569	0.20	0.44
1	2	2	10-Jun	1147	10	2	2	297988	282116	3724	0.20	0.54

1	3	2	10-Jun	1205	10	0	0	309068	297988	2600	0.00	0.00
1	1	2	10-Jun	834	10	5	6	184171	165340	4419	0.50	1.13
1	2	2	10-Jun	851	11	2	2	204280	184171	4718	0.18	0.42
1	3	2	10-Jun	909	10	0	0	214500	204280	2398	0.00	0.00
1	1	2	10-Jun	635	10	6	6	87392	67938	4565	0.60	1.31
1	2	2	10-Jun	656	10	2	2	104507	87392	4016	0.20	0.50
1	3	2	10-Jun	715	10	1	1	117643	104507	3082	0.10	0.32
2	2	2	12-May	2346	9.8	2	2	584689	570075	3429	0.20	0.58
2	2	2	12-May	2324	10.5	5	5	570075	554410	3676	0.48	1.36
2	2	2	12-May	2300	10.4	0	1	554410	537007	4083	0.00	0.00
2	2	2	13-May	215	10.1	7	8	60311	44738	3654	0.69	1.92
2	2	2	13-May	2332	10	1	1	983721	961365	5246	0.10	0.19
2	2	2	13-May	2151	10.2	3	6	947326	934359	3043	0.29	0.99
2	2	2	13-May	2212	10.2	0	5	961365	947326	3294	0.00	0.00
2	2	2	13-May	1018	10	14	14	783420	766752	3911	1.40	3.58
2	2	2	13-May	1041	11	3	3	801202	783420	4172	0.27	0.72
2	2	2	13-May	1103	10	6	6	816825	801202	3666	0.60	1.64
2	2	2	13-May	1412	10	0	0	889751	872462	4057	0.00	0.00
2	2	2	13-May	1430	10	8	8	904801	889751	3531	0.80	2.27
2	2	2	13-May	1449	10	15	15	920153	904801	3602	1.50	4.16
2	2	2	13-May	456	10.1	1	1	761931	746648	3586	0.10	0.28
2	2	2	13-May	433	10.5	1	1	746648	729997	3907	0.10	0.26
2	2	2	13-May	232	10.2	4	5	678567	664364	3333	0.39	1.20
2	2	2	13-May	145	7.3	1	1	643357	633161	2392	0.14	0.42
2	2	2	13-May	204	8.5	2	2	664364	643357	4929	0.24	0.41
2	2	2	13-May	150	10	5	6	44736	29651	3540	0.50	1.41
2	2	2	14-May	455	10.1	4	6	117757	103116	3435	0.40	1.16
2	2	2	14-May	514	10.2	5	5	133463	117757	3685	0.49	1.36
2	2	2	14-May	532	10	23	24	149562	133463	3777	2.30	6.09
2	2	2	14-May	131	10.3	6	7	29651	13184	3864	0.58	1.55
2	2	2	19-May	2234	10	6	6	467757	449476	4289	0.60	1.40
2	2	2	19-May	2251	10.3	8	9	484784	467757	3995	0.78	2.00

2	2	2	19-May	2308	10	2	2	500504	484784	3689	0.20	0.54
2	2	2	19-May	1934	10.3	7	7	362245	343688	4354	0.68	1.61
2	2	2	19-May	1951	10	0	0	379823	362245	4125	0.00	0.00
2	2	2	19-May	2008	10	20	20	397421	379838	4126	2.00	4.85
2	2	2	19-May	2105	10	2	3	434314	415679	4373	0.20	0.46
2	2	2	19-May	2040	10	12	13	415679	397433	4281	1.20	2.80
2	2	2	19-May	2223	10	0	3	449459	434314	3554	0.00	0.00
2	2	2	20-May	1231	10	18	18	761874	747163	3452	1.80	5.21
2	2	2	20-May	1247	10	8	8	775992	761874	3313	0.80	2.41
2	2	2	20-May	1529	10	30	30	848664	831383	4055	3.00	7.40
2	2	2	20-May	1547	10.1	1	1	865273	848664	3897	0.10	0.26
2	2	2	20-May	1603	10	5	5	882993	865273	4158	0.50	1.20
2	2	2	20-May	1719	9.9	2	2	951898	934815	4008	0.20	0.50
2	2	2	20-May	1751	9.5	14	14	985254	969951	3591	1.47	3.90
2	2	2	20-May	1735	10	14	14	969591	951898	4151	1.40	3.37
2	2	2	20-May	1930	10.2	0	0	71662	54306	4072	0.00	0.00
2	2	2	20-May	1914	10	1	1	54306	36782	4112	0.10	0.24
2	2	2	20-May	1946	10	0	0	88406	71662	3929	0.00	0.00
2	2	2	20-May	1155	10	5	5	747163	707781	9241	0.50	0.54
2	2	2	20-May	653	10.7	16	16	536094	517698	4316	1.50	3.71
2	2	2	20-May	636	10.2	6	7	517698	500529	4029	0.59	1.49
2	2	2	20-May	927	10	15	15	645038	629235	3708	1.50	4.05
2	2	2	20-May	943	10	11	11	660421	645038	3609	1.10	3.05
2	2	2	20-May	711	10.6	5	5	560932	536044	5840	0.47	0.86
2	2	2	20-May	909	10	5	5	629235	613490	3694	0.50	1.35
2	2	2	21-May	920	10	30	32	VOID			3.00	
2	2	2	21-May	935	10	12	14	184335	155053	6871	1.20	1.75
2	2	2	21-May	953	10	5	5	202552	184335	4274	0.50	1.17
2	2	2	24-May	609	10	68	68	329500	312104	4082	6.80	16.66
2	2	2	24-May	532	10.5	65	65	296502	279912	3893	6.19	16.70
2	2	2	24-May	551	10	26	26	312104	295602	3872	2.60	6.71
2	2	2	24-May	847	10	1	1	414047	397051	3988	0.10	0.25
2	2	2	24-May	831	10	7	7	397051	381395	3674	0.70	1.91

2	2	2	24-May	906	10	2	2	432562	414047	4344	0.20	0.46
2	2	2	24-May	1220	10	2	2	518540	500934	4131	0.20	0.48
2	2	2	24-May	1236	10	2	2	535471	518540	3973	0.20	0.50
2	2	2	24-May	1153	10	2	2	500934	484195	3928	0.20	0.51
2	2	2	24-May	1731	10	18	18	699395	682593	3942	1.80	4.57
2	2	2	24-May	1747	10	12	12	715852	699397	3861	1.20	3.11
2	2	2	24-May	1805	10	10	10	731631	715863	3700	1.00	2.70
2	2	2	24-May	1517	9.8	8	8	601842	585312	3879	0.82	2.06
2	2	2	24-May	1535	10	2	2	617456	601840	3664	0.20	0.55
2	2	2	24-May	1929	9.9	26	26	797258	781642	3664	2.63	7.10
2	2	2	24-May	1945	9.8	5	5	812458	797260	3566	0.51	1.40
2	2	2	24-May	2001	10.3	18	18	828033	812462	3654	1.75	4.93
2	2	2	25-May	649	10.1	17	17	962062	945105	3979	1.68	4.27
2	2	2	25-May	706	10.1	19	19	978528	962062	3864	1.88	4.92
2	2	2	25-May	632	10.4	14	14	945105	926758	4305	1.35	3.25
2	2	2	25-May	1512	10	0	0	62084	45785	3824	0.00	0.00
2	2	2	25-May	1455	10	2	2	45785	28826	3979	0.20	0.50
2	2	2	25-May	1529	10	10	10	78761	62084	3913	1.00	2.56
2	2	2	25-May	1912	10	30	30	243999	227922	3772	3.00	7.95
2	2	2	25-May	1724	10	55	55	158393	143948	3389	5.50	16.23
2	2	2	25-May	1707	10.2	1	1	143948	127896	3766	0.10	0.27
2	2	2	25-May	1929	10	23	23	258834	243999	3481	2.30	6.61
2	2	2	25-May	1945	10	6	6	273142	258834	3357	0.60	1.79
2	2	2	25-May	1551	9.8	6	6	633439	617456	3750	0.61	1.60
2	2	2	25-May	1744	10	0	1	174453	158393	3768	0.00	0.00
2	2	2	1-Jun	550	10	7	7	714888	698623	3816	0.70	1.83
2	2	2	1-Jun	601	10	7	7	731786	714888	3965	0.70	1.77
2	2	2	1-Jun	622	20	5	5	748819	731786	3997	0.25	1.25
2	2	2	1-Jun	915	10	17	17	851054	834367	3915	1.70	4.34
2	2	2	1-Jun	1327	10	20	20	36309	19996	3828	2.00	5.23
2	2	2	1-Jun	1341	10	22	20	52779	36309	3865	2.20	5.69
2	2	2	1-Jun	843	10	10	10	817356	800272	4009	1.00	2.49
2	2	2	1-Jun	858	10.1	25	25	834367	817356	3991	2.48	6.26

2	2	2	1-Jun	1147	10	25	25	947394	930976	3852	2.50	6.49
2	2	2	1-Jun	1113	10	56	56	915751	899992	3698	5.60	15.14
2	2	2	1-Jun	1129	10	24	25	930976	915751	3572	2.40	6.72
2	2	2	1-Jun	1510	10	17	17	19996	2498	4106	1.70	4.14
2	2	2	1-Jun	1456	9.9	31	31	69220	52785	3856	3.13	8.04
2	2	2	1-Jun	1512	9.8	0	0	85331	69214	3782	0.00	0.00
2	2	2	1-Jun	1527	10	1	1	103047	85337	4155	0.10	0.24
2	2	2	1-Jun	2040	9.9	13	13	367831	351934	3730	1.31	3.49
2	2	2	1-Jun	2055	10.3	0	1	384453	367832	3900	0.00	0.00
2	2	2	1-Jun	2111	9.9	1	1	400567	384457	3780	0.10	0.26
2	2	2	1-Jun	1848	10	21	21	268783	251956	3948	2.10	5.32
2	2	2	1-Jun	1904	10	14	14	286512	268784	4160	1.40	3.37
2	2	2	1-Jun	1921	10.4	28	28	304592	286517	4241	2.69	6.60
2	2	2	1-Jun	1724	10	15	15	203765	186786	3984	1.50	3.77
2	2	2	1-Jun	1709	10	12	12	186784	169255	4113	1.20	2.92
2	2	2	1-Jun	1653	10.1	2	2	169256	153302	3743	0.20	0.53
2	2	2	2-Jun	446	10	0	0	466303	449149	4025	0.00	0.00
2	2	2	2-Jun	503	10	2	2	482852	446303	8576	0.20	0.23
2	2	2	2-Jun	519	10	5	7	500566	482852	4156	0.50	1.20
2	2	2	2-Jun	752	10	10	10	591325	575565	3698	1.00	2.70
2	2	2	2-Jun	718	10	16	16	558745	543335	3616	1.60	4.43
2	2	2	2-Jun	734	10	1	2	575565	558745	3947	0.10	0.25
2	2	2	2-Jun	1058	10.5	6	6	689473	673709	3699	0.57	1.62
2	2	2	2-Jun	1026	10.2	17	17	656335	640491	3718	1.67	4.57
2	2	2	2-Jun	1042	10.1	8	8	673709	656335	4077	0.79	1.96
2	2	2	2-Jun	1545	10	13	13	788300	772192	3780	1.30	3.44
2	2	2	2-Jun	1508	10.1	0	0	753392	734294	4481	0.00	0.00
2	2	2	2-Jun	1527	10.2	11	11	772192	753392	4411	1.08	2.49
2	2	2	2-Jun	1718	10.3	15	15	873311	856815	3871	1.46	3.88
2	2	2	2-Jun	1737	10	14	14	889234	873311	3736	1.40	3.75
2	2	2	2-Jun	1705	10.1	3	3	856815	840430	3845	0.30	0.78
2	2	2	2-Jun	2100	10.1	1	3	969369	954466	3497	0.10	0.29
2	2	2	2-Jun	2115	10	1	2	984612	969369	3577	0.10	0.28
2	2	2	2-Jun	2043	10	3	3	954466	938346	3782	0.30	0.79

2	2	2	9-Jun	1118	10	2	2	668245	654186	3299	0.20	0.61
2	2	2	9-Jun	1136	10	0	1	682621	668245	3373	0.00	0.00
2	2	2	9-Jun	1152	10	1	0	698582	682621	3745	0.10	0.27
2	2	2	9-Jun	533	10	0	0	511258	496167	3541	0.00	0.00
2	2	2	9-Jun	455	11	0	7	480600	465965	3434	0.00	0.00
2	2	2	9-Jun	515	10	0	2	496167	480600	3653	0.00	0.00
2	2	2	9-Jun	809	10	1	1	586702	575916	2531	0.10	0.40
2	2	2	9-Jun	826	10	0	0	605124	586701	4323	0.00	0.00
2	2	2	9-Jun	749	10	0	3	575916	561638	3350	0.00	0.00
2	2	2	9-Jun	1520	10	4	4	794398	778625	3701	0.40	1.08
2	2	2	9-Jun	1437	10	0	0	763812	750800	3053	0.00	0.00
2	2	2	9-Jun	1500	10	2	2	778265	763812	3391	0.20	0.59
2	2	2	9-Jun	1723	10	0	0	841309	825860	3625	0.00	0.00
2	2	2	9-Jun	1752	10	1	2	857289	841309	3750	0.10	0.27
2	2	2	9-Jun	1836	10	0	2	874883	857289	4128	0.00	0.00
2	2	2	9-Jun	2027	10	1	1	942901	92544	199528	0.10	0.01
2	2	2	9-Jun	2127	10.1	1	1	975634	959249	3845	0.10	0.26
2	2	2	9-Jun	2104	10	0	0	959249	942899	3836	0.00	0.00
2	2	2	10-Jun	1917	10	0	1	539920	524887	3527	0.00	0.00
2	2	2	10-Jun	1935	10	1	1	554446	539920	3408	0.10	0.29
2	2	2	10-Jun	1953	10	1	2	569054	554446	3428	0.10	0.29
2	2	2	10-Jun	1715	10	1	1	443504	427644	3721	0.10	0.27
2	2	2	10-Jun	1740	10	1	1	458502	443504	3519	0.10	0.28
2	2	2	10-Jun	1806	10	0	0	474789	458502	3822	0.00	0.00
2	2	2	10-Jun	1546	10.1	0	0	376311	364372	2801	0.00	0.00
2	2	2	10-Jun	1516	10	1	1	VOID			0.10	
2	2	2	10-Jun	1537	10	0	0	364372	350335	3294	0.00	0.00
2	2	2	10-Jun	1032	11	1	1	229738	214499	3576	0.09	0.28
2	2	2	10-Jun	1047	10	0	2	243371	229738	3199	0.00	0.00
2	2	2	10-Jun	1104	10	0	2	262642	245771	3959	0.00	0.00
2	2	2	10-Jun	737	10	3	3	132770	117643	3549	0.30	0.85
2	2	2	10-Jun	755	10	2	2	149049	132770	3820	0.20	0.52
2	2	2	10-Jun	812	10	1	1	165340	149052	3822	0.10	0.26

2	2	2	10-Jun	554	10	4	6	53726	39953	3232	0.40	1.24
2	2	2	10-Jun	536	10	2	4	39953	27231	2985	0.20	0.67
2	2	2	10-Jun	611	10	6	9	67938	53726	3335	0.60	1.80
3	2	2	12-May	1325	10	19	19	462505	445057	4094	1.90	4.64
3	3	2	12-May	1353	8	37	37	477456	462505	3508	4.63	10.55
3	1	2	12-May	1635	10	8	8	493515	477435	3773	0.80	2.12
3	2	2	12-May	1659	10	25	25	519076	493515	5998	2.50	4.17
3	3	2	12-May	1724	10	33	33	537095	519076	4228	3.30	7.81
3	2	2	19-May	1449	10	5	5	144736	126661	4241	0.50	1.18
3		2	19-May	1506	10	5	5	161001	144736	3816	0.50	1.31
3		2	19-May	2315	10	18	18	179684	161001	4384	1.80	4.11
3	3	2	19-May	1720	10	0	0	250779	234092	3915	0.00	0.00
3		2	19-May	1808	10.2	0	0	287437	268214	4510	0.00	0.00
3		2	19-May	1738	10.3	3	3	268214	250779	4091	0.29	0.73
3	3	2	19-May	1328	10	0	1	126654	114305	2898	0.00	0.00
3	2	2	19-May	1312	10.2	55	55	114305	97360	3976	5.39	13.83
3	1	2	19-May	1248	10.4	3	3	97360	78104	4518	0.29	0.66

Appendix C

Otter Trawl Data Summary

June 3-4, 1993

Source: DWR, unpublished data

Station 1	**Sacramento River downstream of the acoustic barrier**
Station 2	**Georgiana Slough**
Station 3	**Sacramento River upstream of the acoustic barrier**

Location 1	**Right Bank (looking downstream)**
Location 2	**Middle**
Location 3	**Left Bank (looking downstream)**

Barrier operation	**1**	**On**
	2	**Off**

CATCHDTA.XLS

Gear: Otter Trawl - G.S.

Station	Location	Barrier	Date	Start Time	Tide Stage	Duration (Minutes)	Number Salmon	Number Fish	Flow Meter End	Flow Meter Start	Volume	CPUE Salmon/min	CPUE Salmon/m3
2	2		3-Jun	834		10	0	0	936903	913538	976	0.00	0.00
				856		10	0	1	957285	936903	851	0.00	0.00
				1319		10	0	1	151162	122851	1182	0.00	0.00
				1628		10	0	0	201201	166502	1449	0.00	0.00
				1800		10	1	1	321512	261174	2520	0.10	0.40
				2017		10	0	0	478689	450754	1167	0.00	0.00
				2033		10	0	0	507303	478689	1195	0.00	0.00
				2056		8	0	0	532937	507303	1071	0.00	0.00
			4-Jun	504		10	9	9	654526	628538	1085	0.90	8.29
				526		10	7	7	676962	654526	937	0.70	7.47
				547		10	4	5	701841	676962	1039	0.40	3.85
				751		9	2	2	800305	778635	905	0.22	2.21
				809		10	0	0	824335	800305	1004	0.00	0.00
				826		10	1	2	845860	824335	899	0.10	1.11
				1108		10	2	2	950255	925412	1038	0.20	1.93
				1126		10	0	0	976210	950255	1084	0.00	0.00
				1159		10	2	2	1013950	983796	1259	0.20	1.59
				1509		10	0	0	73410	41750	1322	0.00	0.00
				1707		10	0	0	-	-		0.00	
				1724		10	2	3	-	-		0.20	
				1740		10	0	0	-	-		0.00	

Gear: Otter Trawl - Sacramento

Station	Location	Barrier	Date	Start Time	Tide Stage	Duration (Minutes)	Number Salmon	Number Fish	Flow Meter End	Flow Meter Start	Volume	Salmon/min	CPUE
1	2		3-Jun	723		10	0	0	865072	842503	943	0.00	0.00
				745		10	0	0	893728	865072	1197	0.00	0.00
				804		10	0	0	913538	893728	827	0.00	0.00
				956		10	0	0	1002099	973687	1187	0.00	0.00
				1015		10	0	1	34696	2099	1361	0.00	0.00
				1037		10	1	1	67686	34696	1378	0.10	0.73
				1655		10	1	9	230794	201201	1236	0.10	0.81
				1711		10	0	1	261174	230794	1269	0.00	0.00
				1729		10	1	2	290046	261174	1206	0.10	0.83
				1945		10	1	1	450754	420709	1255	0.10	0.80
				2122		12	0	0	568020	532937	1465	0.00	0.00
				2140		11	1	1	602103	568026	1423	0.09	0.70
			4-Jun	612		10	4	4	726947	701841	1049	0.40	3.81
				631		9	2	2	750970	726947	1003	0.22	1.99
				650		10	1	1	778635	750970	1155	0.10	0.87
				852		10	3	3	869616	845860	992	0.30	3.02
				912		8	2	2	896666	869616	1130	0.25	1.77
				933		12	2	3	925412	896666	1201	0.17	1.67
				1558		10	0	0 -	-			0.00	
				1620		10	1	1 -	-			0.10	
				1637		10	0	0 -	-			0.00	
				1811		10	1	1 -	-			0.10	
				1831		10	0	0 -	-			0.00	