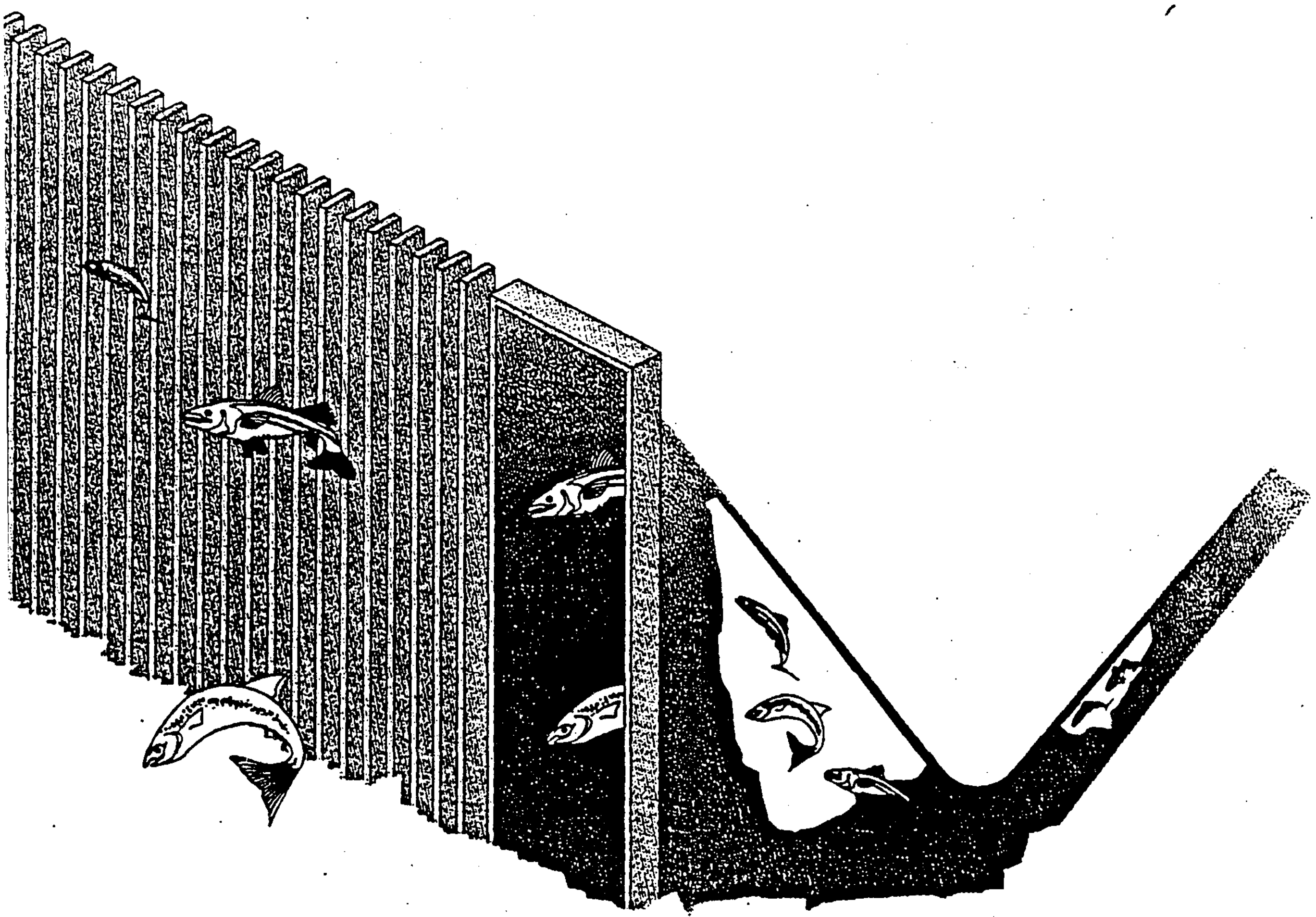

TRACY FISH COLLECTION FACILITY STUDIES
CALIFORNIA

Volume 4

Preliminary Examination of Factors That Influence Fish Salvage Estimates at the Tracy Fish Collection Facility, California, 1993 and 1994

United States Department of the Interior
Bureau of Reclamation
Mid-Pacific Region and the Technical Service Center

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Preliminary Examination of Factors That Influence Fish Salvage Estimates at the Tracy Fish Collection Facility, California, 1993 and 1994

BY

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TRACY FISH COLLECTION FACILITY STUDIES,

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UNITED STATES DEPARTMENT OF THE INTERIOR

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PREFACE

The following report is the fourth volume in the Tracy Fish Collection Facility Studies series. These studies are investigating a variety of issues that are concerned with improving overall fish salvage at the Tracy Fish Collection Facility. The first volume summarized the 1991-1992 predator removal program and intake channel studies (Liston et al., 1994). The second volume summarized the 1991-1992 fish egg and larvae continuous sampling program (Hiebert, 1995). The third volume summarized the louver efficiency experiments conducted at the fish facility in 1993 (Karp et al., 1995). This volume preliminarily examines factors affecting fish salvage estimates.

ABSTRACT

The U.S. Bureau of Reclamation's Tracy Fish Collection Facility was constructed in the mid-1950's as part of the Central Valley Project. Ongoing studies at the facility provided data that were used to investigate how season, species, time of day, tide, and pump rate may influence fish salvage. It was found that fish salvage is strongly related to season and also appears to be influenced by time of day and tide. For example, in 1993 and 1994, chinook salmon and splittail were abundant in the salvage during May, while Delta smelt and striped bass were more abundant during June. Chinook salmon, splittail, and Delta smelt were more abundant in the salvage at 2200 hours than at other times of day. It is also suggested that salvage peaks for these species may occur during incoming tides. The relationship between pump rate and fish salvage was shown to be complex and multifaceted.

INTRODUCTION AND BACKGROUND

The Central Valley of California includes the Sacramento River drainage from the north, the San Joaquin drainage from the south, and outflows from several east-side tributaries. These systems converge in the central portion of the state, forming a huge natural estuary (western portion known as the Delta) whose hydraulics are influenced by many factors including tides, precipitation, freshwater outflows, export pumping, irrigation practices, and other factors (Figure 1).

The Central Valley Project (CVP) was authorized by Congress in 1934 to regulate flows in the Central Valley to provide water for irrigation. The CVP has been operated by the U.S. Bureau of Reclamation (Reclamation) since its inception.

The Tracy Pumping Plant, Tracy Fish Collection Facility (TFCF), and Delta Mendota Canal facilities in the Delta Division of the CVP operate to export water for irrigation, municipal, and industrial needs in the south-central valley while reducing associated fish losses. The Tracy Pumping Plant is one of two large pumping plants in the south Delta (the other is the State-operated Harvey O. Banks Delta Pumping Plant). The Tracy Pumping Plant draws water off the Old River channel of the lower San Joaquin River into the inlet to the Delta Mendota Canal (known as the intake channel) where it passes through the TFCF (Figure 2). The TFCF is a large fish diversion and salvage facility that diverts fish from the flow before water is lifted into the Delta Mendota Canal by the Tracy Pumping Plant. These facilities are located in the south Delta about 14.4 km northwest of Tracy, California.

The Tracy CVP facilities were constructed in the mid-1950's to export water. The fish diversion system at the TFCF uses a louver-bypass-collection system to divert fish from export flow (Figure 2). The louver section is a system of evenly spaced vertical slats that traverse the channel and allow water to pass to the pumps while creating some turbulence that the fish can detect. The fish guide along the louver face and are carried into a bypass opening and eventually into the holding tanks. The fish (and debris) are regularly removed from these tanks and transported to release sites in the western Delta. Those fish that are collected from the holding tanks and released, as described above, are referred to as "fish salvage" (fish saved from the pumps). Thus salvage represents those fish intercepted by the facility (entrained) and also guided into the fish bypass system.

An agreement between Reclamation and the California Department of Fish and Game (DFG) concerning the modification and improvement of TFCF to reduce and offset direct fish losses was executed July 17, 1992, following negotiations that had begun in the late 1980's. In association with these negotiations, an aggressive program was initiated to assist present fish salvage efforts and to provide long-term solutions to existing problems. This study represents one aspect of the overall effort. This study builds upon extensive work completed previously on various aspects of salvage [Interagency Ecological Study Program of the Sacramento-San Joaquin Estuary (IEP), 1978a and b, 1980, 1987, 1996 (winter); DFG, 1992] but focuses exclusively on the TFCF. For example, those factors discussed below and investigated here were those shown to influence fish salvage previously.

Potential Factors Affecting Fish Salvage

Many factors may influence fish salvage. Those factors that influence louver efficiency (see Karp et al., 1995; Mecum, 1977; DFG, 1973; Bates et al., 1960) will also affect fish salvage. For example, fish salvage could be affected by type of water year, time of year, species, tide, time of day, pump rate, water temperature, debris load at the louvers,

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The type of water year (wet, normal, or dry) is likely to influence both the biology of many fishes and export rates. Thus, yearly differences in salvage estimates are anticipated as a result of complex biological and physical factors related to the hydrology of the year and other factors.

Many fish move seasonally and therefore become vulnerable to the pumps only during parts of the year [e.g., see California Department of Water Resources (DWR) and U.S. Bureau of Reclamation, 1994]. This is important because the Delta is a migratory route for many fishes; each species' life history partly defines their vulnerability to entrainment at the pumps. Many fishes are known to migrate or move from place to place depending upon several life history factors, one of which is time of day. Some salmon, for example, initially move toward the sea more at night than during the day (Mason, 1975; Reimers, 1973; Hoar, 1956, 1958). Some data showing day/night differences for salmon in the Delta also exist (IEP, 1991).

Flow hydraulics and presumably salvage at the TFCF are influenced by tides, although the action is somewhat modified due to distance from the Pacific Ocean and effects of the many water diversions. Tidal fluctuations are thought to influence louver efficiency and therefore would influence salvage estimates. It is also thought that some fish in the Delta move more during ebb tides than during flood tides (IEP, 1991).

Fish are presumably most vulnerable to entrainment at maximum pumping rates. For example, IEP studies showed that the young striped bass Delta abundance index decreased as the percentage of Delta inflows diverted increased (IEP, 1978a). However, water exports do not explain all the variability in the young striped bass index (IEP, 1990 and 1991).

Similarly, a clear relationship between pump rate and fish salvage has not been determined because other factors simultaneously influence fish salvage. An understanding of louver system efficiency is critical for correct interpretation of salvage, especially with respect to pump rate. That is, salvage estimates also depend upon whether system efficiency is high or low. This is variable due to the amount of debris in the system and other factors (Karp et al., 1995). Operation of the pumps has changed over the years (Arthur, 1987) and the changes have likely had a strong influence on fish salvage.

During the first few years of operation, pumping was mostly restricted to the summer months—a time when some species were less vulnerable to entrainment by the pumps. This period of peak pumping coincided with the presence of large numbers of young striped bass, however, it was believed that the louver-bypass system diverted most of these fish. The current practice of year-round pumping at high rates (and consequently higher velocities) was instituted in the late 1960's with construction of San Luis Reservoir. One consequence of year-round pumping at relatively high rates is that the louver system may operate less efficiently than originally intended and could result in lower salvage rates than if the system were operating at maximum efficiency (see Karp et al., 1995).

Other factors thought to influence salvage estimates include operation of the State Water Project radial gates at the entrance to Clifton Court Forebay. It is believed that these gates alter the hydraulic conditions at the TFCF and therefore could influence fish salvage.

This study preliminarily evaluates the influence of species, season, tide, time of day, and pump rate on salvage.

METHODS

The data presented here were collected by State and Reclamation personnel at the TFCF under established guidelines. Fish salvage estimates are obtained from 10-minute samples (or 5-minute samples if fish abundance is very high) taken every 2 hours throughout the 24-hour day at the TFCF. Thus, sampling typically represents one-twelfth of the total salvage (10-minute sample for every 2-hour period). These data were collected by Reclamation personnel and stored in a database at the DFG Stockton Office, and the data presented herein were obtained from DFG.

The salvage data set includes information on the following variables: number and types of fishes, time of day, date, primary depth (water depth measured at the primary louvers which was used to indicate tide), pump rate, and various other information not used here.

Data were converted from database format to spreadsheet format for ease of handling; data were then organized as necessary to display the desired factors. Many of the figures in the results section present raw data as a function of time, often within selected periods and for selected species. Other figures display the 10-minute salvage estimates added together; for example all the 10-minute salvage estimates for chinook salmon between May 1 and May 17 at 2200 hours might be added together and presented with the same data gathered at 0800 hours (see Figure 7b).

RESULTS AND DISCUSSION

Fish Salvage by Season and Year

Fish salvage shows a clear seasonal periodicity. Total salvage, representing all species, is highest in June and July for both 1994 (Figure 3a) and 1993 (Figure 3b). Striped bass, the most abundant species, drives the shape of this curve. Overall salvage estimates were higher in 1993, a wet year, than in 1994, a critical dry year.

Fish Salvage by Species and Season

Individual species were most abundant in the salvage during specific months (Figures 4, 5, and 6). Chinook salmon were most abundant in the spring during both 1993 (Figure 4a) and 1994 (Figure 5a). Young salmon are migrating to the ocean during these months and thus are vulnerable to entrainment. During 1994, a critical dry year, young chinook salmon were abundant in the salvage earlier in the year than during 1993, a wet year. Steelhead were abundant in the salvage slightly earlier than chinook salmon, and steelhead were more abundant in 1993 (Figures 4b and 6b) than in 1994 (Figure 5b).

Striped bass spawn in April, May, and June, and young fish were salvaged in high numbers in June and July (Figures 4f and 5f). Spawning is dependent upon temperature and, therefore, also related to flow in the Sacramento River (Moyle, 1976). Thus the type of water year could alter when the young appear in the salvage. Also, it is possible that wetter years provide more favorable habitat for both spawning and rearing in the Delta. Nutrient enrichment in wetter years may provide larger plankton populations, supporting better food chains. There did not appear to be any seasonal shift in salvage between these 2 years, however many more young striped bass were salvaged in 1993 than in 1994 (Figure 6f), a critical dry year.

Splittail potentially spawn from late January through July, probably often where streambank vegetation is flooded (Moyle et al., 1989). The adults comprise much of the January through April salvage, and young fish may be abundant in May through July depending on water-year type. Many more splittail were salvaged in 1993 (Figures 4e and 6e) than in 1994 (Figure 5e), possibly because the high flows of 1993 may have increased the availability of spawning habitat and the subsequent number of the young.

Delta and longfin smelt spawn between February and June (Moyle et al., 1989). Both species are relatively uncommon in the salvage, but some adults are captured in February through April and young fish are entrained in May and June (Figures 4c and d and 5c and d). Type of water year alters the location of the entrapment zone which may affect young smelt distribution and susceptibility to entrainment by South Delta export pumps.

American shad were abundant in the salvage during November, December, and January in 1993 (Figure 4g) and in July and November 1994 (Figure 5g).

Seasonal salvage could be directly affected by pumping rates. In an attempt to see seasonal trends without the influence of pumping rate, expanded salvage is also presented as salvage per unit of water pumped (Figures 4 and 5, right-side scale). In most cases, adjusting for pump rate does not alter the seasonal patterns shown in Figures 4 and 5.

Fish Salvage by Species, Time of Day, and Tide

Chinook Salmon, 1993

Time of day and tidal influences were evaluated during periods of species abundance and when pump rates were relatively uniform. The period from May 1 through May 17, 1993, was selected to evaluate the influence of time of day and tide on chinook salmon salvage because pumping rates were uniform and chinook salmon were abundant during this period. Each 2-hour salvage estimate is displayed by time of day for the period May 1 through May 17, 1993. Several instances of daily peak salvage counts occurred at 2200 (Figure 7a). The total number of chinook salmon salvaged from May 1 through May 17 is shown by hour in Figure 7b, again showing that total salvage at 2200 hours is more than double that of other hours.

Daily tidal fluctuations are plotted with expanded salvage of chinook salmon from May 1 through May 17, 1993 (Figure 8). Several peaks appear to coincide with an incoming tide; this could be investigated further to discern whether any true tidal influence occurs. The single biggest peak occurred on an incoming tide at 2200 hours. Chinook salmon have been known to hold in the secondary louver system and it may be that, with loss of visual orientation at night, these fish are more easily moved into the holding tanks. The counts at 2200 hours represent the first count after dark and may indicate that more chinook salmon are drawn into the facility at this time. Furthermore, incoming high tide brings in Sacramento River water, which carries the bulk of the chinook salmon.

These data, used here to represent tidal fluctuation, also reflect the altered hydraulics of the facility as the tide changes. For example, during an incoming tide, more water comes through the louvers to fill the intake channel; the opposite is true during an outgoing tide. These hydraulic changes, associated with tide, may alter system efficiency and thus fish salvage. Simultaneously, tides may influence fish distributions which could also change fish salvage estimates.

Splittail, 1993

The period from June 5 through June 15 was selected to investigate the influence of time of day and tide on young-of-year (30 mm) splittail because pump rates were relatively uniform and splittail were abundant in the salvage. Each 2-hour expanded salvage estimate for splittail are plotted for the dates June 5 through June 15 (Figure 9a). Splittail showed slightly increased salvage at 0800 hours and 2200 hours (Figure 9b).

Daily tidal fluctuations during the same period are plotted with the 2-hour expanded salvage estimates (Figure 10). Several peaks appear to occur during the incoming tide.

Delta Smelt, 1994

The period of May 3 through May 26 was selected to look at Delta smelt. Two-hour salvage estimates are plotted by time of day for each day of this period (Figure 11a). The total number of Delta smelt salvaged during this period are shown by time of day in Figure 11b; more fish move into the TFCF at 2200 hours than at other times during the day. Expanded salvage is also plotted with tidal fluctuations, and several peaks appear to coincide with the incoming tide (Figure 12). These Delta smelt are post larval size and only about 1 inch (25 mm) long. They are not good swimmers at this point so it seems unlikely that these fish would be exhibiting attraction to light or loss of visual orientation. It is possible that high incoming tides could move larval smelt toward the fish facility.

Fish Salvage and Pump Rate

Pump rate likely has an influence on salvage estimates. However, pump rate will only influence fish already in the vicinity of the facility, thus there is an interaction between the influence of pumping rate and season on fish salvage (see Figure 3 and compare to Figure 14). Pumping rates have changed dramatically over the years. Figure 13 shows average monthly pumping rates by year. During 1954 to the late 1960's, pumping rates were high from about April through September but then fell off dramatically during the rest of the year. Starting in the late 1960's or early 1970's, pumping came closer to maximum rates year-around. These changes were associated with the construction of additional features of the CVP, including the San Luis Reservoir and the San Felipe Unit of the CVP.

Previous studies (see DFG, 1992) showed that the young striped bass abundance index was related to the mean June and July Delta outflow and the effective percent inflow diverted. These studies generally combined State and Federal export rates. The purpose of this study was to focus on pump rate at the Tracy Fish Salvage Facility (exclusively) and fish salvage.

To get a clear picture of overall pump rate influences on salvage, it would be necessary to look at historical data; data from 1993 and 1994 can be used to investigate pump rate effects only in a restricted manner, not representing the broad influences of the pumps. Furthermore, salvage estimates will be influenced by system efficiency (Karp et al., 1995) and system efficiency likely changes with pumping rate and species.

In the early 1990's, pumping rates began decreasing during the summer months. In 1993, a wet year, pumping was nearly maximum from January through April and July through December, but reduced pumping occurred in May and June (Figure 14) because of endangered species issues. In 1994, a critical dry year, pumping rates were highly variable and generally lower than during 1993. To look at potential pump rate influences on fish salvage within 1993 and 1994, we plotted daily salvage by species and pump rate during the month of May 1993 (Figure 15). The presentation of data in this format partly masks any true relationship between pump rate and salvage because salvage estimates are summed for the day and pump rates are expressed as a daily average. To clearly see the impact of the pumping rate, it would be necessary to plot 2-hour salvage counts and hourly pump rates because the response of the fish will likely be more immediate than delayed.

CONCLUSIONS AND RECOMMENDATIONS

The TFCF was designed in the mid-1950's to salvage young striped bass and young migrating chinook salmon from flows being exported to the Delta Mendota Canal. It is now recognized that over 40 species of fish may pass through the facility, and some of these are endangered species. Increased analyses of recent fish salvage data are directed at gaining a clearer understanding of factors that may be affecting salvage.

Fish salvage at TFCF is influenced by many factors, only some of which are examined in this report. The data presented demonstrate that the basic biology and life history of each species partly determine when the fish are near the pumps and whether the fish are salvaged. For example, each species shows characteristic seasonal patterns in the salvage data. Time of day and tidal fluctuations appear to influence salvage for some species such as chinook salmon and Delta smelt.

Pump rates are assumed to influence salvage and some variations are shown in these data.

Care must be taken in the interpretation of salvage estimates because salvage efficiency is not uniform (Karp et al., 1995). System efficiency varies by species and due to factors like bypass velocity, which can be altered by tide and debris loading. The State and Federal salvage facilities are probably the largest fish sampling gear in the world. In spite of biases inherent in the salvage samples, this database represents an important source of information. The following recommendations are offered:

✔ We recommend that more effort be directed at analyzing the fish salvage data sets because these data represent an important source of information routinely collected. The 1993 and 1994 databases could be used to develop hypotheses that could then be tested in other years. A time line could be created showing the important changes and events that likely influence fish salvage at TFCF (e.g., changes in sampling routines). This chart would improve interpretation of these data.

✔ Plot Old River, Middle River, and San Joaquin River flows and fish salvage estimates. These results, at least for salmon, could then be compared with coded wire tag information [IEP, 1990, 1991, 1992 (winter)].

✔ The influence of the State Water Project radial gate operation on salvage could be investigated. It is believed that the operation of State Water Project radial gates may impact the TFCF salvage, possibly by affecting bypass velocities and debris loads.

✔ The database could be evaluated by species for the months March through July to look for impacts associated with pump rates. This will help assure that altering pump rates will reduce entrainment, especially of sensitive species. There are existing estimates of system efficiency as a function of pump rate and these could be used to help interpret the salvage data. The immediate response of the fish to the pumps should be evaluated by using the 10-minute counts measured every 2 hours and hourly pump rate data (not average daily data).

✔ A fourier transform analysis (or alternative statistical analysis) could be conducted on the tidal data to test whether more fish are salvaged on incoming tides.

✔ Use the database to look for changes in fish salvage as a function of the Delta barrier operations.

✔ Evaluate salvage data as a function of the percent of Delta inflows that are diverted by the State and Federal facilities.

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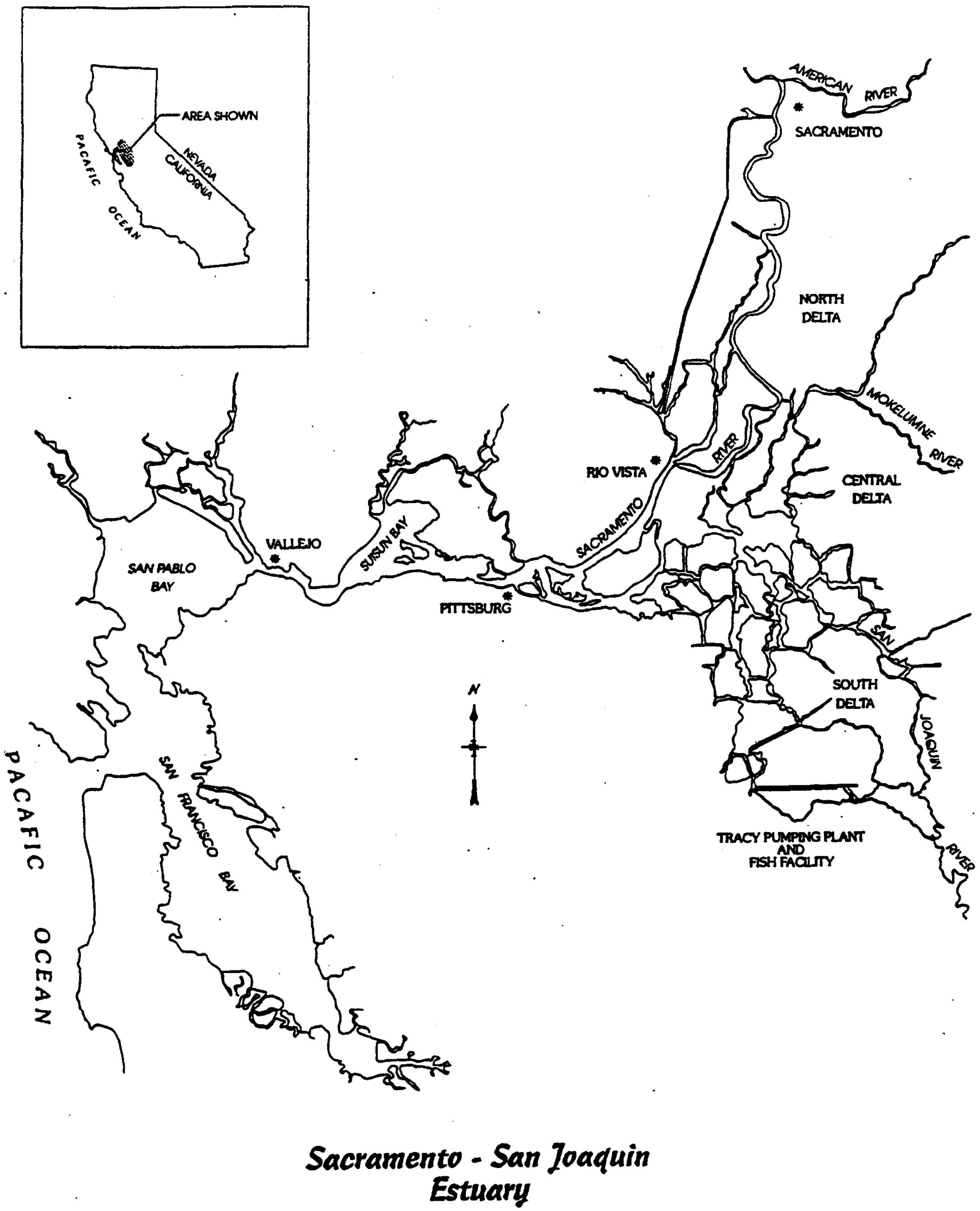


Figure 1. - Map of the Sacramento - San Joaquin Delta showing the location of the Tracy Fish Collection Facility

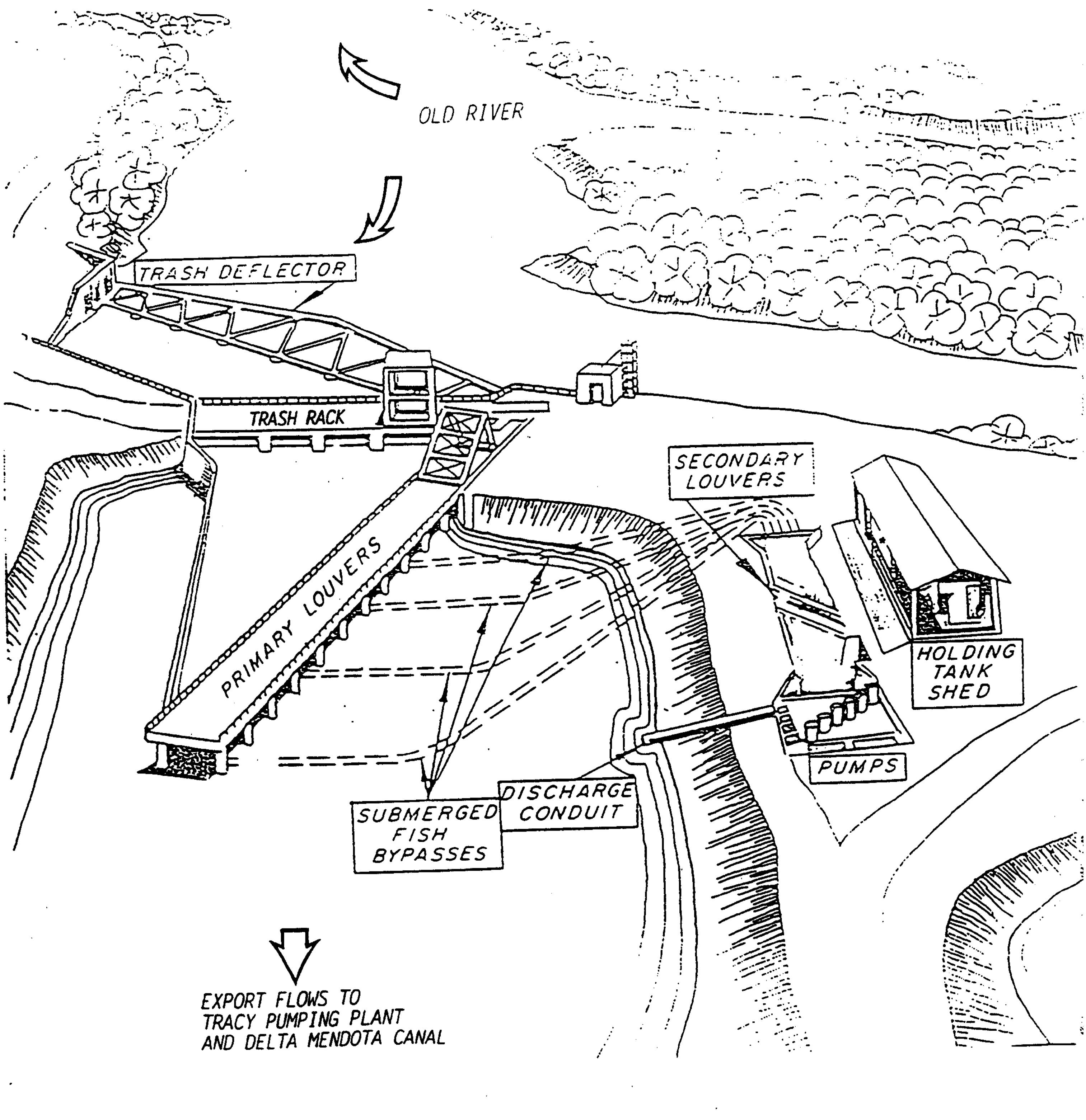


Figure 2. - Schematic of the Bureau of Reclamation's Tracy Fish Collection Facility, Tracy, California

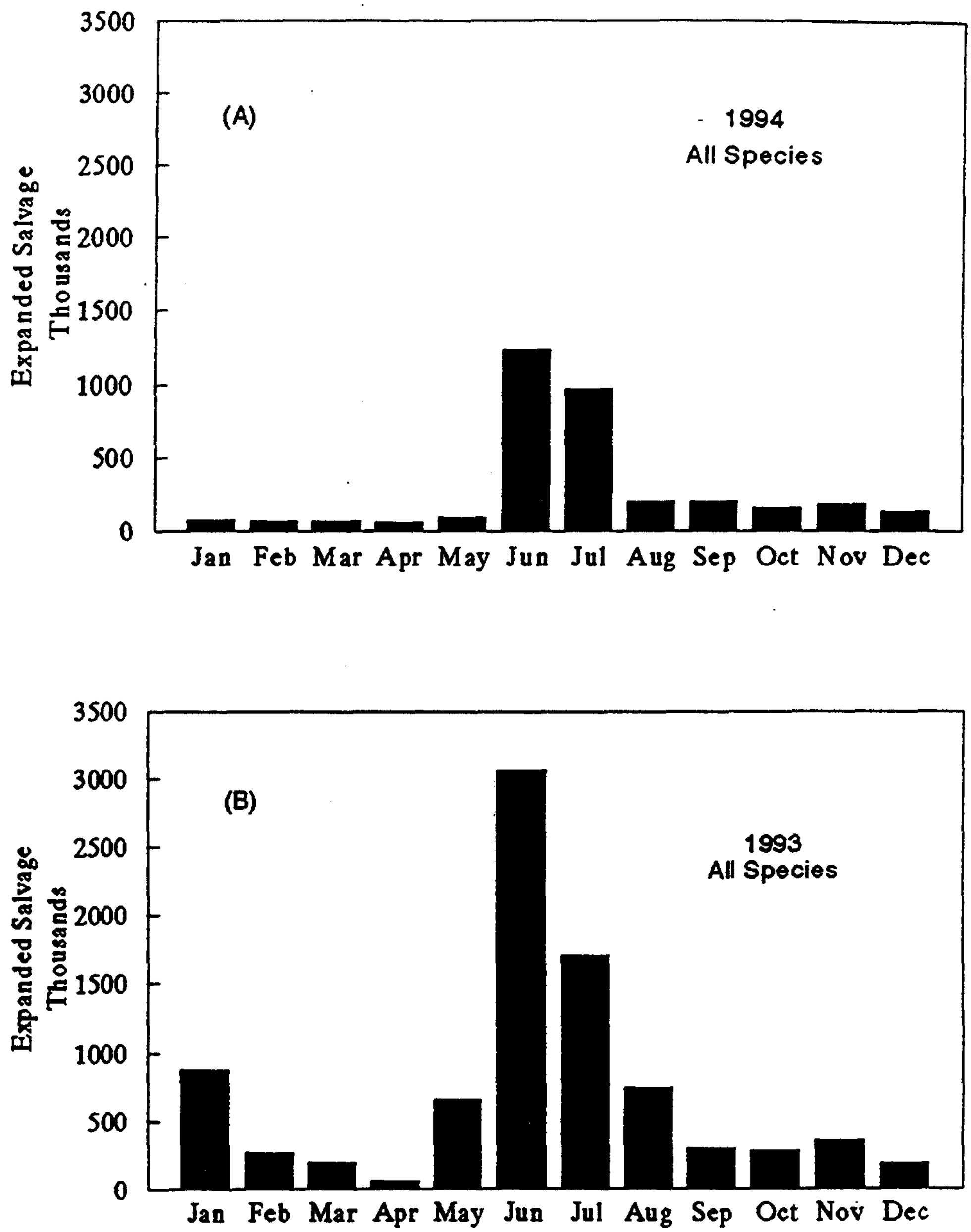


Figure 3. - Expanded salvage by month for 1993 and 1994. (A) Expanded salvage for all species combined in 1994 by month. (B) Expanded salvage for all species combined in 1993 by month.

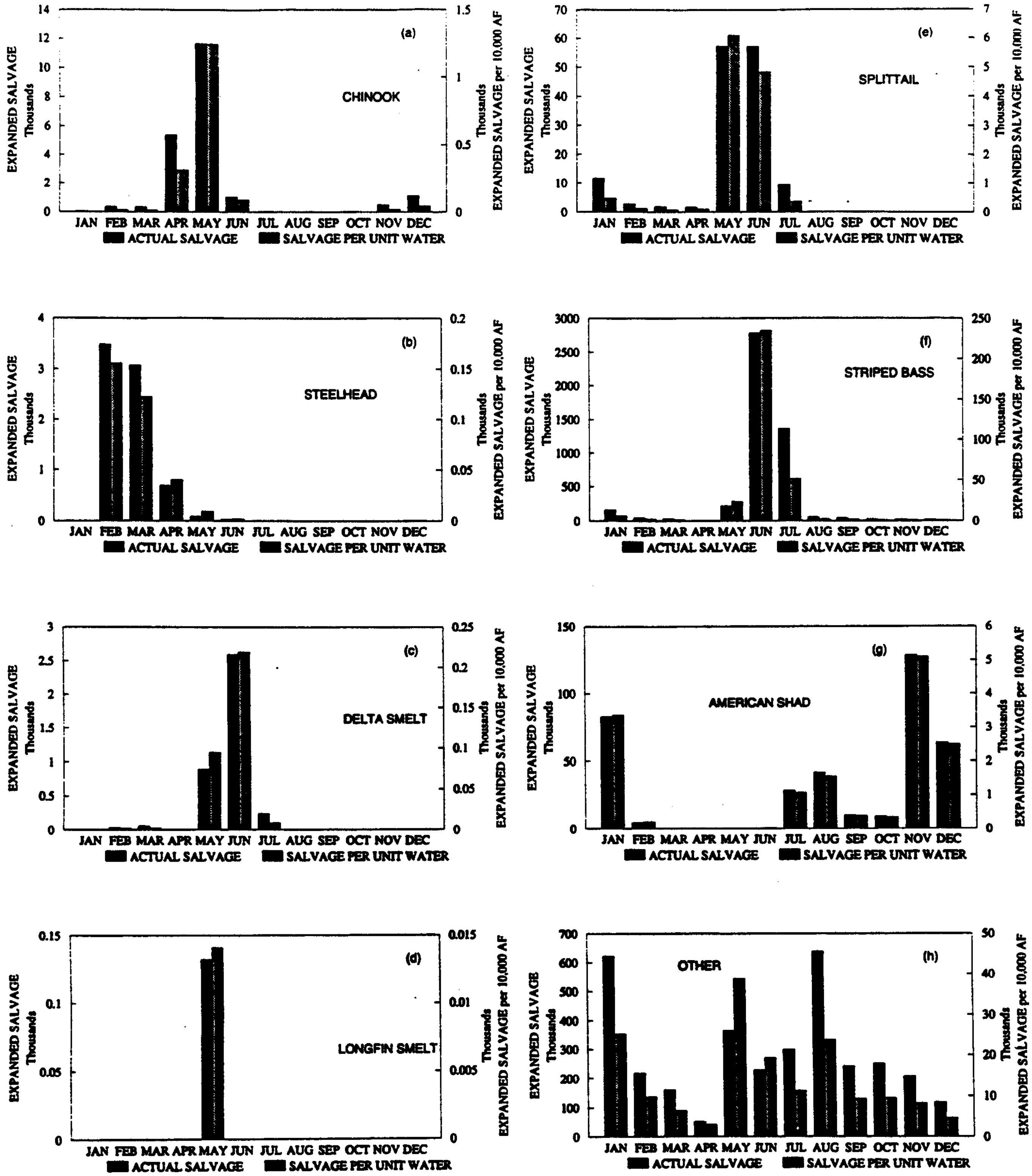


Figure 4. - Expanded salvage by species and month in 1993. Actual expanded salvage is shown in black and expanded salvage per unit of water pumped is shown in a lighter shade. Species shown are (A) chinook salmon, (B) steelhead trout, (C) Delta smelt, (D) longfin smelt, (E) splittail, (F) striped bass, (G) American shad, and (H) all other species combined.

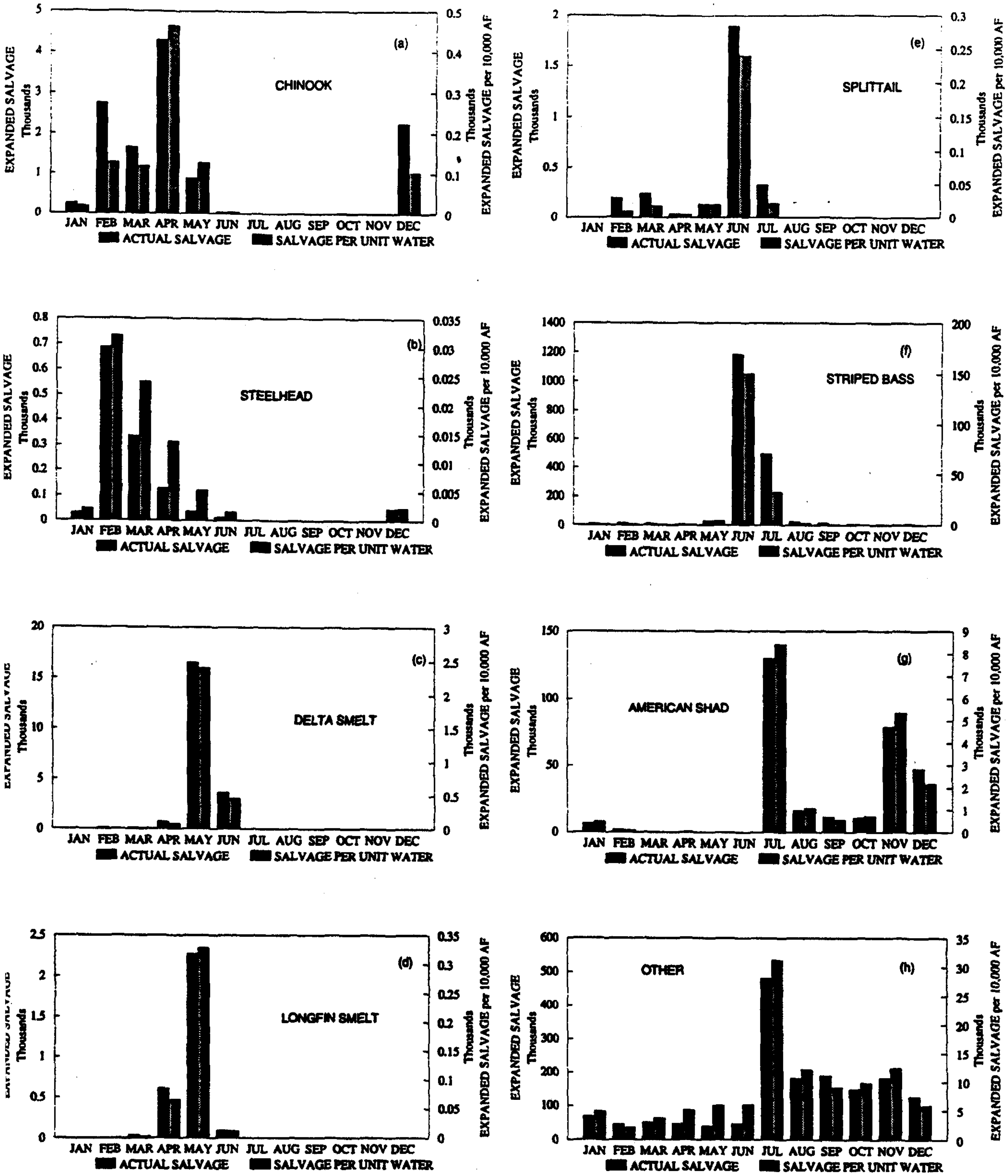


Figure 5. - Expanded salvage by species and month in 1994. Actual expanded salvage is shown in black and expanded salvage per unit of water pumped is shown in a lighter shade. Species shown are (A) chinook salmon, (B) steelhead trout, (C) Delta smelt, (D) longfin smelt, (E) splittail, (F) striped bass, (G) American shad, and (H) all other species combined.

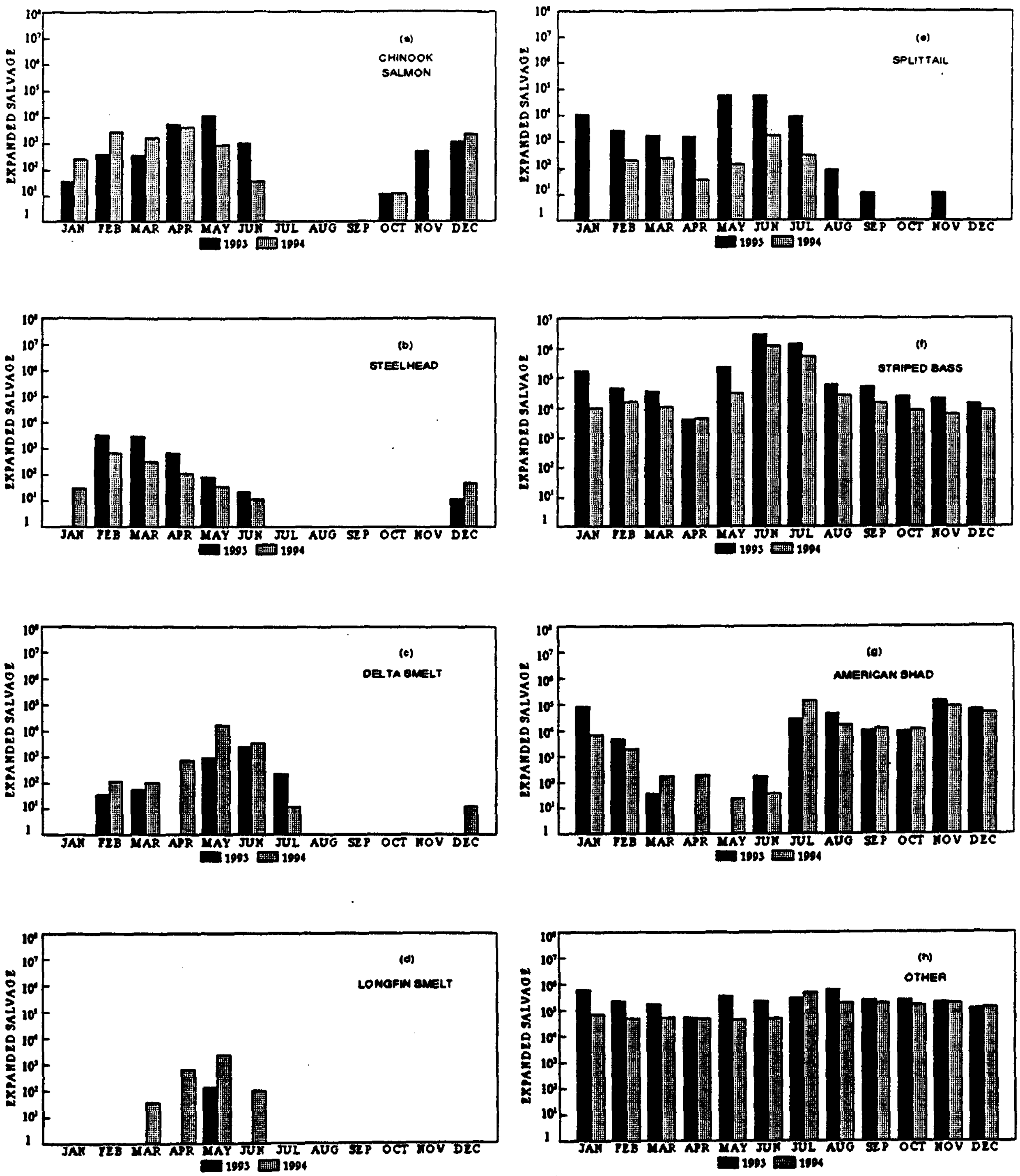
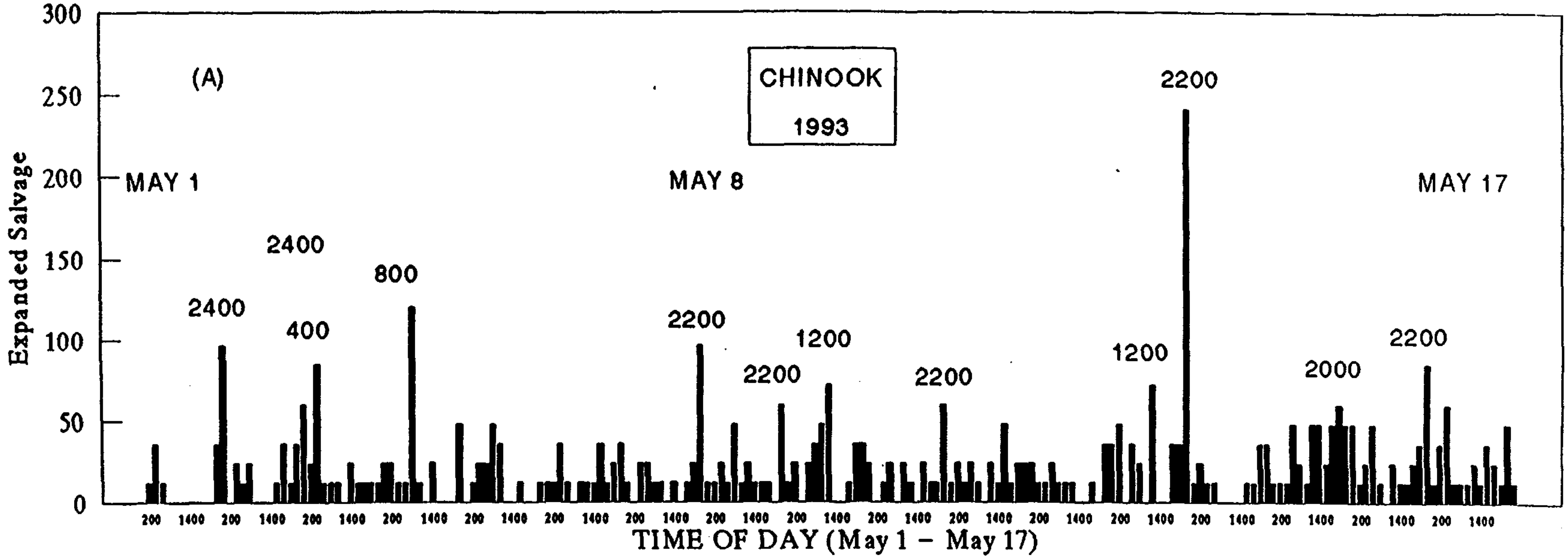


Figure 6. - Expanded salvage by species and month in 1993 and 1994. Actual expanded salvage in 1993 is shown in black and actual expanded salvage in 1994 is shown in a lighter shade. Note that the scale is logarithmic so that small differences in bar height represent large changes in salvage. Species shown are (A) chinook salmon, (B) steelhead trout, (C) Delta smelt, (D) longfin smelt, (E) splittail, (F) striped bass, (G) American shad, and (H) all other species combined.



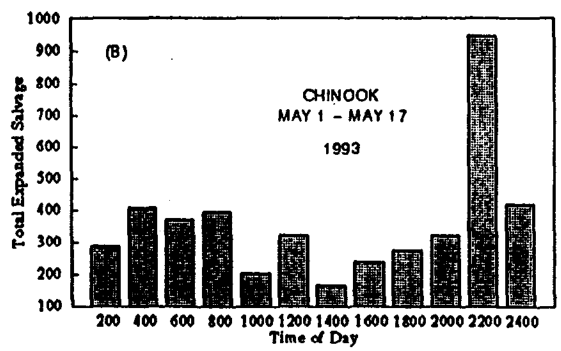


Figure 7. Chinook salmon expanded salvage and time of day. (A) Chinook salmon expanded salvage shown as a function of time of day from May 1 through May 17, 1993. Each bar represents a two-hour salvage count and is placed at the time of day that it was collected: 0200 hours, 0400 hours, etc. (B) Summed chinook salmon expanded salvage during the period May 1 through May 17, 1993, shown by time of day.

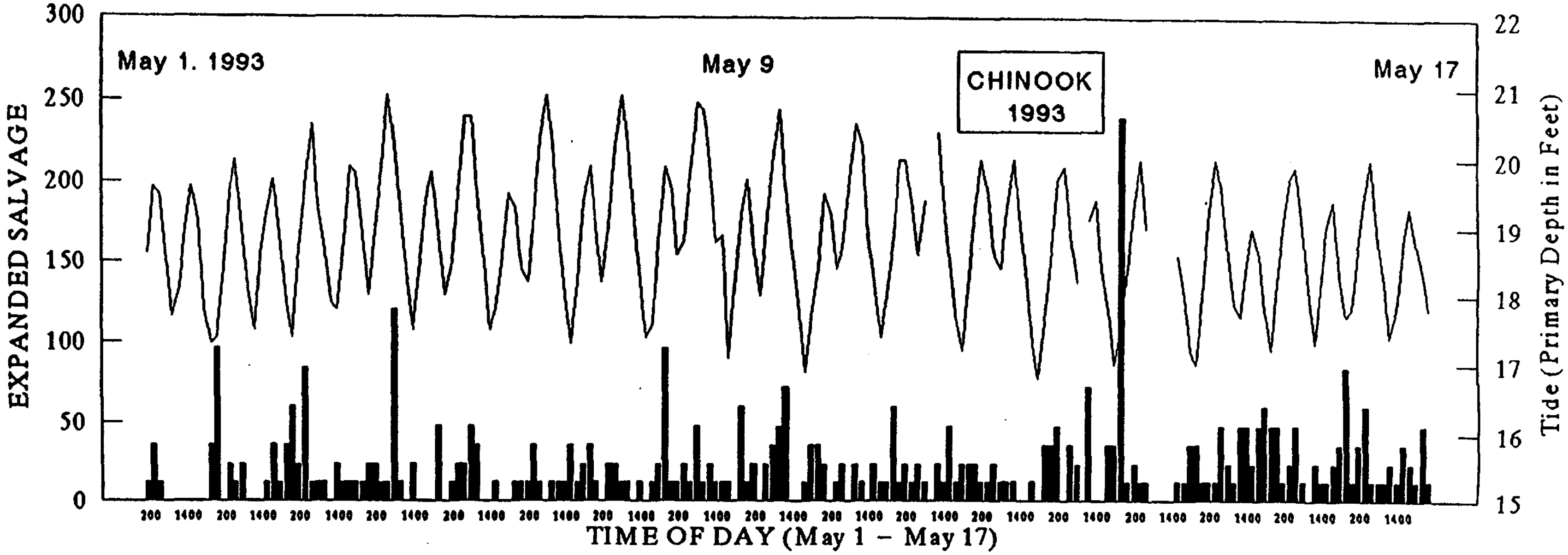
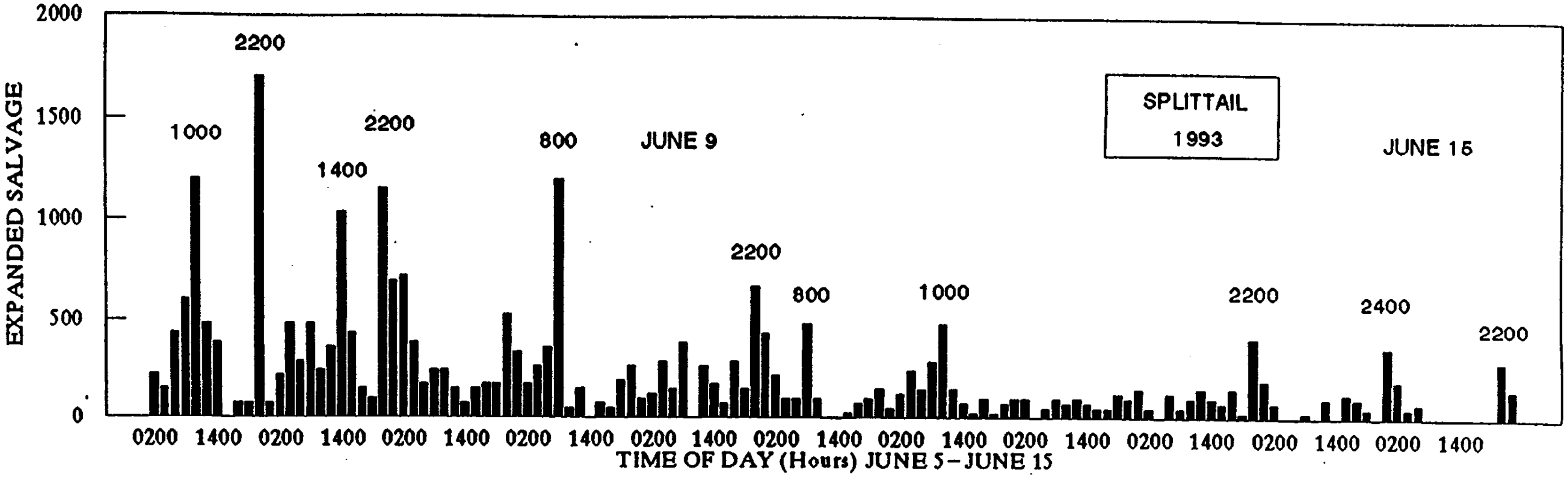


Figure 8. - Chinook salmon expanded salvage and tidal fluctuations. Chinook salmon expanded salvage shown as a function of time of day from May 1 through May 17, 1993. Each bar represents a two-hour salvage count and is placed at the time of day that it was collected: 0200 hours, 0400 hours, etc. Tidal fluctuations are plotted on the right side "y" axis.

(A)



(B)

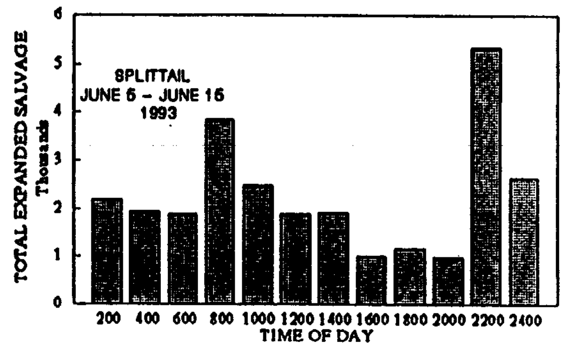


Figure 9. - Splittail expanded salvage and time of day. (A) Splittail expanded salvage shown as a function of time of day from June 5 through June 15, 1993. Each bar represents a 2-hour salvage count and is placed at the time of day that it was collected: 0200 hours, 0400 hours, etc. (B) Summed splittail expanded salvage during the period June 5 through June 15, 1993, shown by time of day.

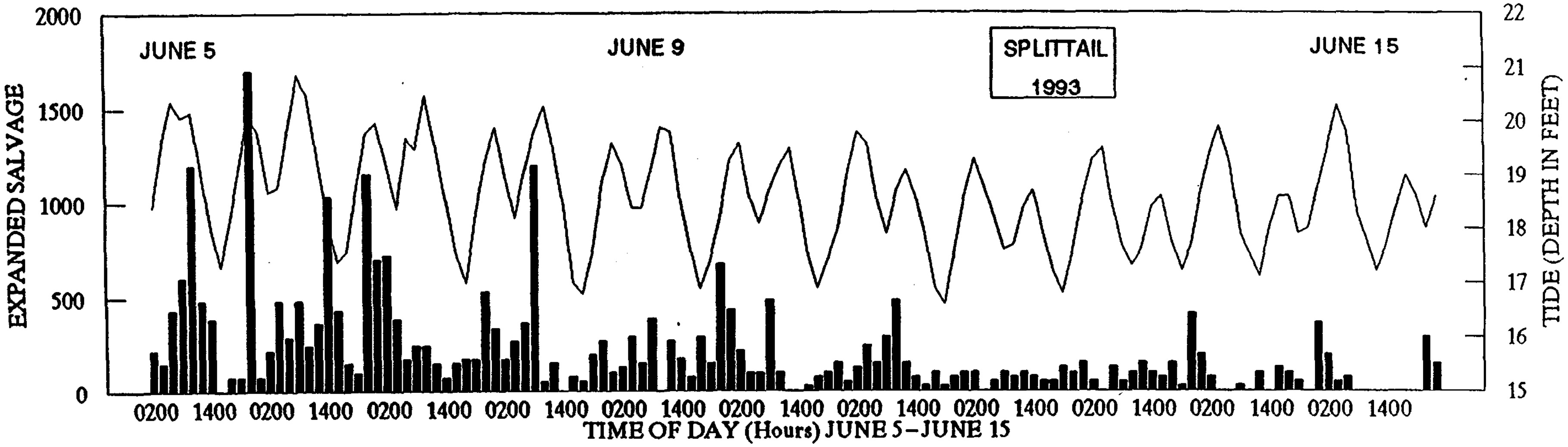
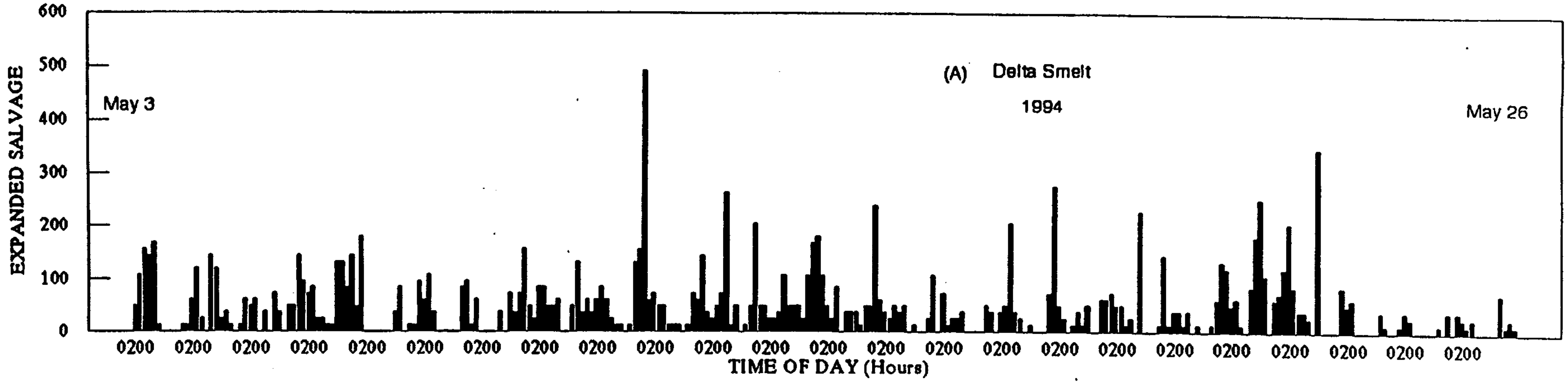


Figure 10. - Splittail expanded salvage and tidal fluctuations. Splittail expanded salvage shown as a function of time of day from June 5 through June 15, 1993. Each bar represents a two-hour salvage count and is placed at the time of day that it was collected: 0200 hours, 0400 hours, etc. Tidal fluctuations are plotted on the right side "y" axis.



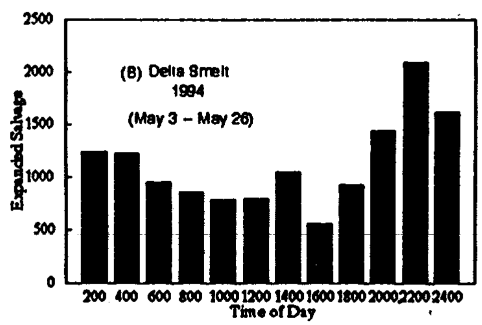


Figure 11. - Delta smelt expanded salvage and time of day. (A) Delta smelt expanded salvage shown as a function of time of day from May 3 through May 26, 1994. Each bar represents a two-hour salvage count and is placed at the time of day that it was collected: 0200 hours, 0400 hours, etc. (B) Summed Delta smelt expanded salvage during the period May 3 through May 26, 1994, shown by time of day.

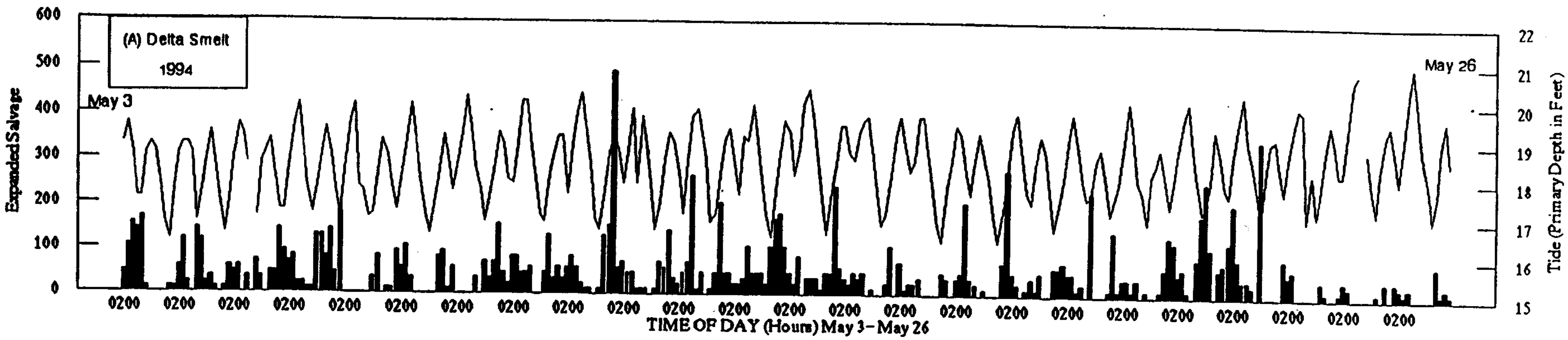


Figure 12. - Delta smelt expanded salvage and tidal fluctuations. Delta smelt expanded salvage shown as a function of time of day from May 3 through May 26, 1994. Each bar represents a two-hour salvage count and is placed at the time of day that it was collected: 0200 hours, 0400 hours, etc. Tidal fluctuations are plotted on the right side "y" axis.

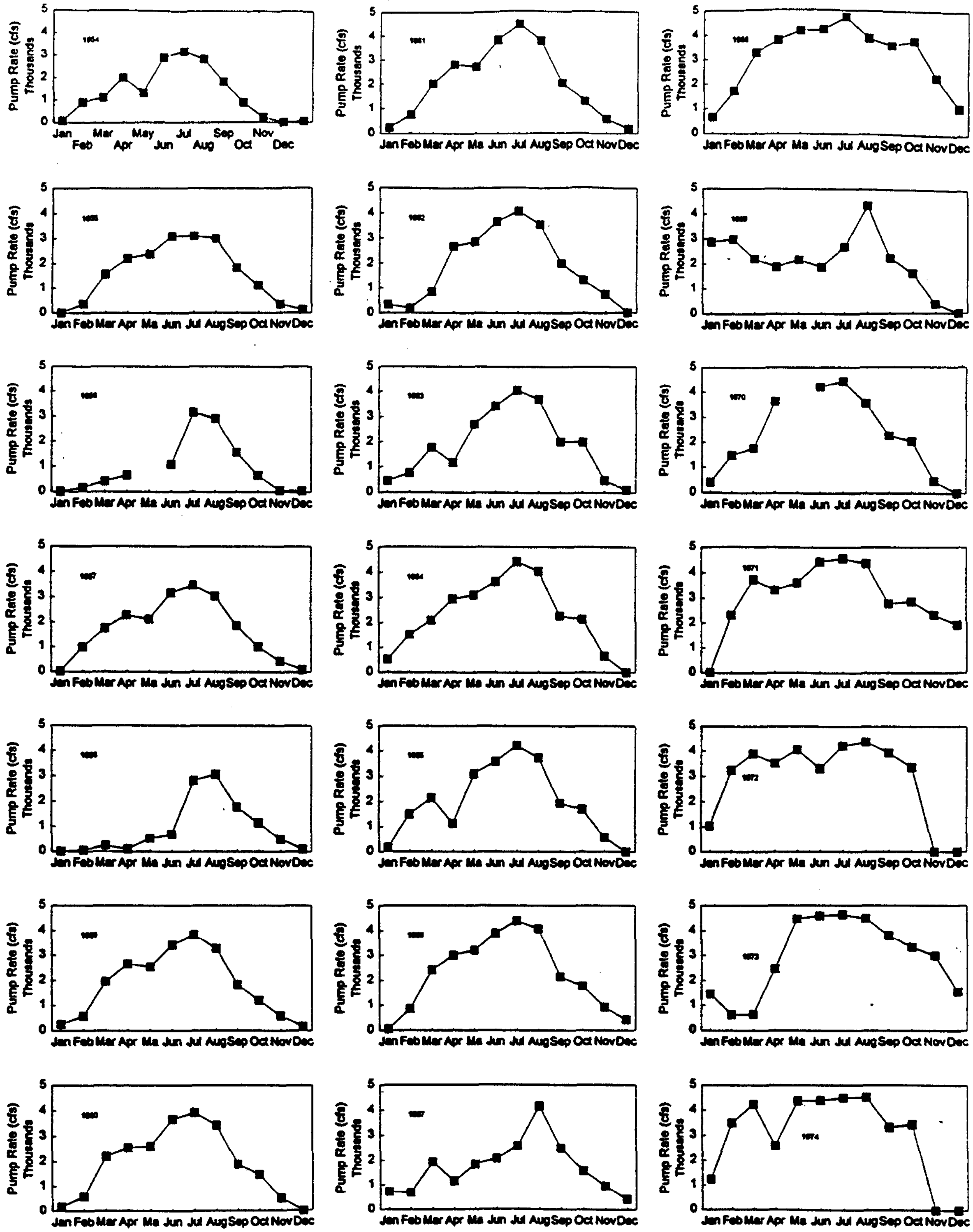


Figure 13. - Pump rates by month at the Tracy Pumping Facility from 1954 through 1994.

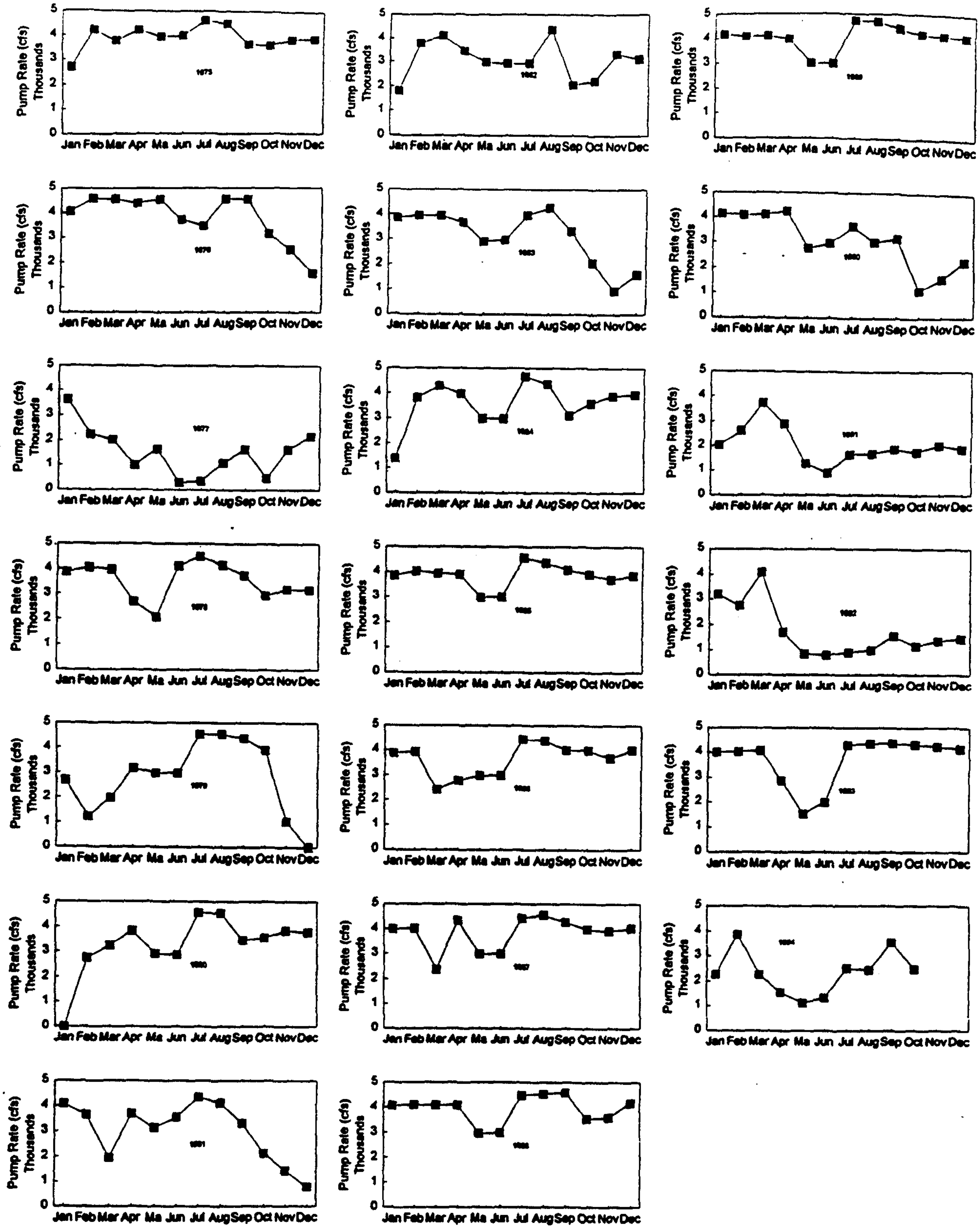
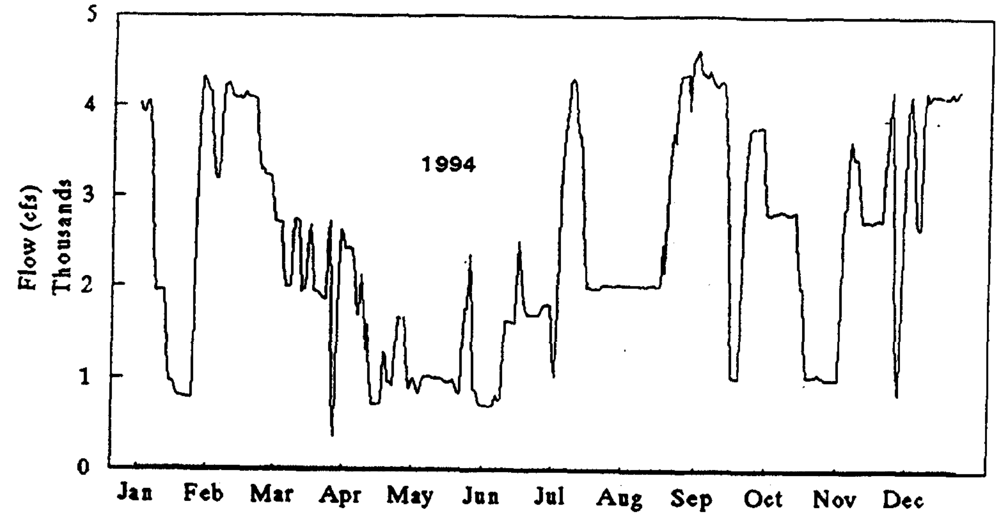


Figure 13. - Pump rates by month at the Tracy Pumping Facility from 1954 through 1994 (continued).



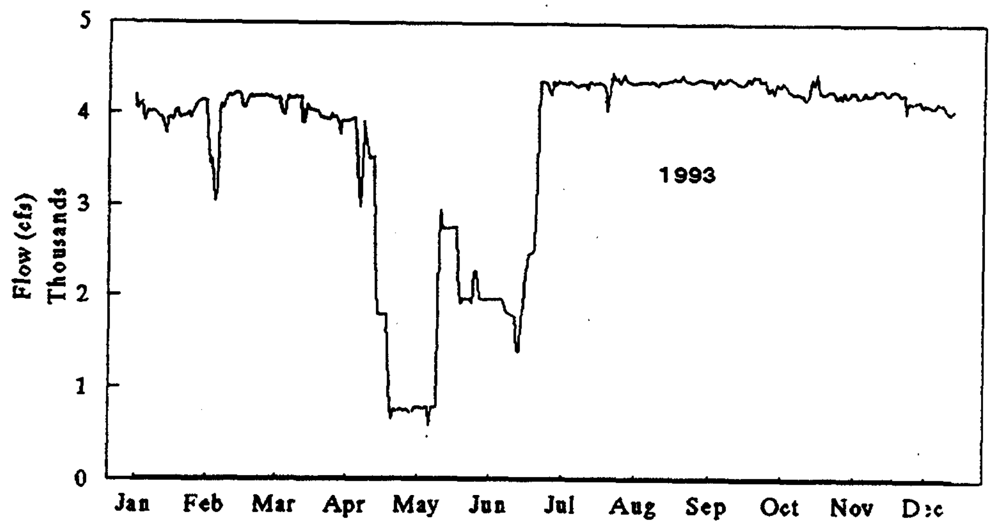


Figure 14. - Daily pump rates during 1993 and 1994.

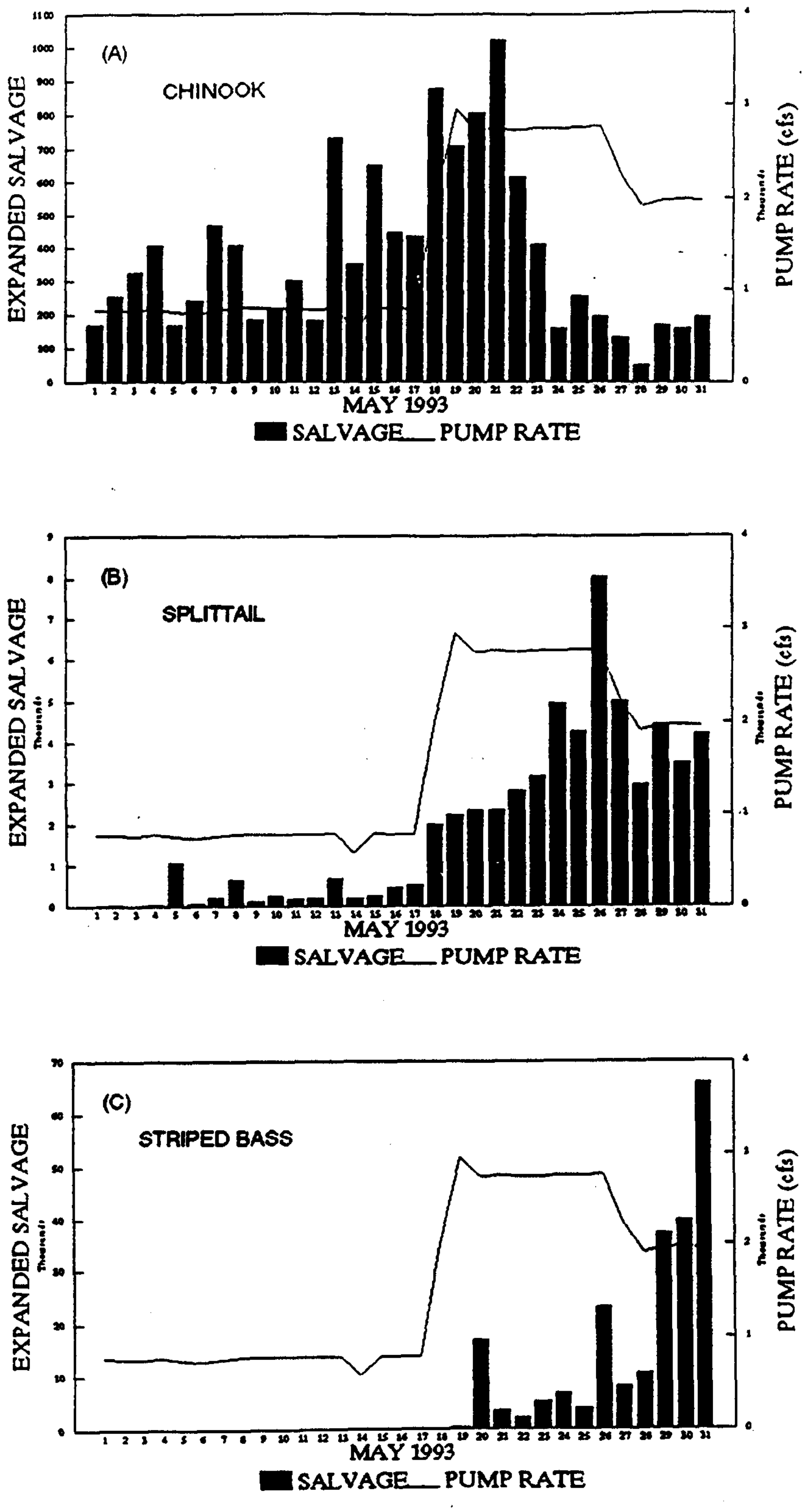


Figure 15. - Expanded salvage and daily pump rates shown for May 1993. (A) Chinook salmon salmon, (B) splittail, and (C) striped bass.

PEER REVIEW DOCUMENTATION

PROJECT AND DOCUMENT INFORMATION

Project Name Tracy Fish Collection Facility Studies WOID TFFSA

Document Preliminary Examination of Factors That Influence Fish Salvage Estimates at the Tracy Fish Collection Facility, California, 1993 and 1994

Document Date August 1996 Date Transmitted to Client August 1996

Team Leader Charles Liston

Leadership Team Member John Lease

(Peer Reviewer of Peer Review/QA Plan)

Peer Reviewer Michael J. Armbruster

Document Author(s)/Preparer(s) Kate Puckett, Charles Liston, Catherine Karp, Lloyd Hess

Peer Reviewer Personnel at Reclamation's Mid-Pacific Region and various outside agencies

REVIEW REQUIREMENT

Part A: Document Does Not Require Peer Review

Explain ____________________

Part B: Document Requires Peer Review: SCOPE OF PEER REVIEW

Peer Review restricted to the following Items/Section(s): Reviewer:

REVIEW CERTIFICATION

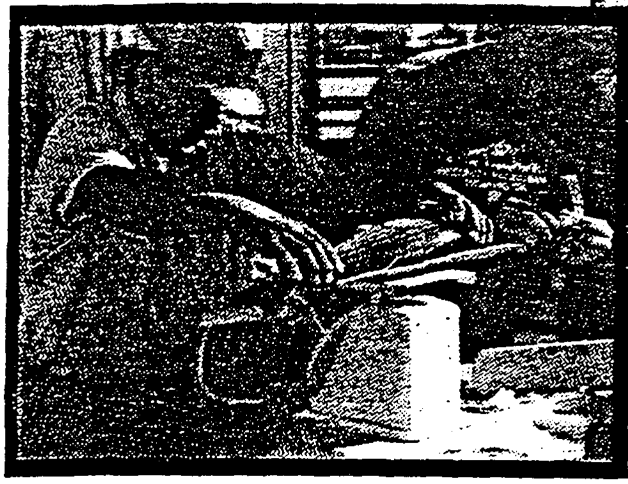
Peer Reviewer - I have reviewed the assigned Items/Section(s) noted for the above document and believe them to be in accordance with the project requirements, standards of the profession, and Reclamation policy.

Reviewer: Michael J Armbruster Review Date: 8-12-96
Signature

Reviewer: ____________________ Review Date: __________
Signature

Preparer - I have discussed the above document and review requirements with the Peer Reviewer and believe that this review is completed, and that the document will meet the requirements of the project.

Team Member: Kathryn J Puckett Date: 8-12-96
Signature



Tracy Fish Collection Facilities