Status report on Sacramento splittail and longfin smelt

DRAFT

submitted to Fish and Wildlife Service

August 25, 1993

Lesa Meng

Wildlife and Fisheries Biology

University of California

Davis, CA 95616

SUMMARY

Analyses of Sacramento splittail *Pogonichthys macrolepidotus* and longfin smelt *Spirinchus thaleichthys* survey data indicate that these species have declined by 62% and 90%, respectively, in the Sacramento-San Joaquin River Estuary over the last 15 years. During this time, both species have undergone dramatic range constrictions. Concentration of longfin smelt in lower river channels in dry years results in increased entrainment in state and federal water project pumps. Highest declines of Sacramento splittail are in the Suisun Bay area and may reflect loss of shallow, low-salinity habitat. Strong outflow-abundance relationships for Sacramento splittail young and longfin smelt appear to be breaking down, suggesting that these species are losing their ability to recover when higher outflows return. Shallow brackish-water habitat in Suisun Bay, important to both species as nursery grounds, is being lost in many years due to decreases in outflow which move the mixing zone upstream into deep river channels.

List of Figures

Figure 1. Splittail declines since 1984. Percent declines were calculated by comparing abundance averages of years prior to and following 1984. FMWT = fall midwater trawl, SUIS = Suisun Marsh study, BAY = Bay Study, SACTR = Sacramento trawl, CHIPPS = Chipps Island trawl.

Figure 2. Yearly abundances of splittail adults and young from the Bay Study and Chipps Island trawls.

Figure 3. Yearly abundances of splittail from the Suisun Marsh study and Sacramento trawl.

Figure 4. Yearly abundances of splittail from the fall midwater trawl.

Figure 5. Splittail young salvage per acre foot of water pumped during May and June at the state (SWP) and federal (CVP) pumping facilities.

Figure 6. Splittail abundances in wet and dry years from the Bay Study.

Figure 7. Splittail abundances in wet and dry years from Chipps Island trawl.

Figure 8. Relationship between splittail young and February-May outflow (Bay Study). Equation for regression is Y = 1.5X - 5.9. Numbers in graph denote years.

Figure 9. Relationship between splittail young and February-May outflow (Chipps Island trawl). Equation for regression is Y = 1.2X - 5.8. Numbers in graph denote years.

Figure 10. Relationships between splittail (all size classes) and splittail adults and February-May outflow (Chipps Island trawl). Equation for splittail is Y = 0.88X - 1.83. Equation for splittail adults is Y = 0.15X + 1.0. Numbers in graph denote years.

Figure 11. Splittail young abundance and proportion inflow diverted. Note increases in proportion of inflow diverted since 1984.

Figure 12. Splittail young numbers predicted for outflow (minus exports) and unimpaired outflow (Chipps Island trawl equation).

Figure 13. Splittail distribution and numbers of splittail caught by each study. Abbreviations for locations are: BAY = San Francisco Bay; SPBAY = San Pablo Bay; SUIS = Suisun Bay; DELTA = central Delta; SACR = Sacramento River; NSAC = north of Sacramento on the Sacramento River; CARQ = Carquinez Straits area; GRIZZLY = Grizzly Bay.

Figure 14. Splittail captured by different gear types.

Figure 15. Yearly abundances of longfin smelt from the fall midwater trawl.

Figure 16. Relationship between longfin smelt abundance and outflow. $R^2 = 0.70$.

Figure 17. Plot of residuals of longfin smelt abundance-outflow relationship against time.

Figure 18. Longfin smelt abundance-outflow relationship with confidence intervals for the estimate of Y.

Figure 19. Longfin smelt salvaged at state (SWP) and federal (CVP) water pumps.

Status report on Sacramento splittail and longfin smelt

Introduction

On November 5, 1992, the Fish and Wildlife Service (Service) received a petition from Mr. Gregory A. Thomas of the Natural Heritage Institute to add Sacramento splittail (*Pogonichthys macrolepidotus*) and longfin smelt (*Spirinchus thaleichthys*) to the List of Endangered and Threatened Wildlife and to designate critical habitat for each species in the Sacramento and San Joaquin Rivers and the Sacramento-San Joaquin River Estuary, California. In his letter, Mr. Thomas identified the following eight organizations as co-petitioners: American Fisheries Society, Bay Institute of San Francisco, Natural Heritage Institute, Planning and Conservation League, Save San Francisco Bay Association, Friends of the River, San Francisco Baykeeper, and Sierra Club. On June 24, 1993, the Service issued a 90-day finding that the petition presented substantial information indicating that the requested action may be warranted. This report summarizes additional information on Sacramento splittail and longfin smelt.

Although primarily a freshwater species, Sacramento splittail can tolerate salinities as high as 10-18 parts per thousand (ppt). Spawning occurs over flooded vegetation in tidal freshwater and euryhaline habitats of estuary marshes and sloughs from late January to early July. Shallow-water habitat is important for rearing of young and freshwater outflows may be important for the dispersion of young to appropriate nursery areas in Suisun Bay.

Longfin smelt are an anadromous euryhaline species, with a two-year life cycle, that can tolerate salinities ranging from freshwater to pure sea water. Spawning occurs in fresh to brackish water over sandy-gravel substrates, rocks, or aquatic plants. Spawning may take place as early as November and extend into June, although the peak spawning period is from February to April. Principal nursery habitat for larvae are the productive waters of Suisun and San Pablo bays. Adults are found mainly in Suisun, San Pablo and San Francisco bays, although their distribution is shifted upstream in years of low river outflows.

Methods

Data were obtained from the California Department of Fish and Game (CDFG), the University of California, Davis (UCD), the Service, and state and federal water project facilities. The data sets analyzed included different seasons, years, locations, and gear types. Fish were collected by seven independent means: (1) an autumn midwater trawl survey in the upper estuary by CDFG, (2) a monthly midwater and otter trawl survey in the lower estuary by CDFG (San Francisco Bay-Outflow Study, hereafter Bay Study), (3) a monthly otter trawl survey of Suisun Marsh, a tidal marsh next to Suisun Bay by UCD, (4) a midwater trawl survey at Chipps Island in Suisun Bay by the Service, (5) a midwater trawl survey in the Sacramento River by the Service, (6) a beach seine survey in the Delta and Sacramento River by the Service (Delta refers to the area upstream of the confluence of the Sacramento-San Joaquin rivers to Walnut Grove on the Sacramento and Mossdale on the San Joaquin) and (7) salvage at state and federal pumping facilities located in the south Delta by the California Department of Water Resources and U. S. Bureau of Reclamation. Fish were identified, measured (SL in UCD study, FL in all other studies) and returned to the water.

Data from two CDFG studies were used. Autumn midwater trawl collecting sites are established at standardized locations scattered from San Pablo Bay through Suisun Bay and the Delta upstream to Rio Vista on the Sacramento River and to Stockton on the San Joaquin River. Surveys have been conducted monthly at 87 sites from September to December in most years from 1967 to present. The Bay Study is a monthly, year-round, trawling program that began in 1980. Its 42 sites are distributed throughout the lower estuary from South San Francisco Bay upstream to the confluence of the Sacramento and San Joaquin rivers. The Bay Study uses otter and midwater trawls.

The Suisun Marsh fish survey has been conducted monthly by UCD since 1979 with an otter trawl. Two 5- or 10-min tows are made at 10 locations throughout the marsh. Because sloughs of the marsh are shallow (2-3 m), the otter trawl samples most of the water column.

Data from three Service studies were used. The Chipps Island survey is conducted with a midwater trawl deployed mostly at the surface. Each sampling effort consists of ten 20-min trawls made in Suisun Bay in the channel between Chipps Island

and Pittsburg. Sampling effort has varied in the Chipps Island survey, but a core data set for the months of April, May and June was used in this analysis. Sampling began in 1976 and is conducted two-three times per week. The Sacramento trawl uses similar methodology, but is conducted in the Sacramento River from Walnut Grove to Sacramento (the location has varied over the years). The Sacramento trawl began in 1976 and continues to present; no sampling was done from 1982-1987. A core data set for May, June and July was used. The beach seine survey samples about 23 sites in the Delta and on the Sacramento River upstream to Colusa. This survey began in 1976 and data from January to June were used.

State and federal water project pumps in the south Delta are fitted with fish protection facilities. The fish facilities are composed of a series of behavioral louvers which direct fish into salvage wells. Fish are sampled from salvage wells, then transported by truck upstream to sites in the Sacramento River near Rio Vista. Fish are sampled at the fish facilities year-round; records for splittail and longfin smelt date back to 1980. The amount effort depends upon the amount of water pumped and varies seasonally.

In summary, the Bay Study, Suisun Marsh fish sampling and fish salvage facilities provide year-round splittail and longfin smelt abundance data from 1980 (Suisun Marsh began in 1979) to present. The autumn midwater trawl, Chipps Island and Sacramento trawls surveys provide seasonal information. The Suisun Marsh study, Chipps Island and Sacramento trawls sample a limited geographical area. The autumn midwater trawl survey covers a wide area of splittail and longfin smelt range and dates back to 1967.

Data were summarized as catch per unit effort by month. Fall midwater trawl and Bay Study data represent fish densities, where catch per unit effort is multiplied by volume of water sampled.

Results

Sacramento splittail

Splittail abundance declined an average of 62% over seven surveys in the last 15 years (Figure 1). Percent declines were calculated by comparing abundance averages of years prior to and following 1984. Yearly abundances were averaged for the pre-decline period (start of survey to and including 1984) and for the post-decline period (1985-1992); these averages were then compared to calculate percent decline. The decline period was chosen by examining graphs of yearly abundances (Figures 2, 3, 4). Splittail numbers declined dramatically after 1984. The last good year of splittail reproduction was 1983 and the abundance of recruits into 1984 (1-yr olds) partially masks the beginning of a decline that coincides with other estuary fishes in 1984 (e.g., delta smelt and longfin smelt).

Percent decline varied among studies (Figure 1), with greatest declines occurring in studies that center around the shallow Suisun Bay area (i.e., Suisun Marsh and Chipps Island, with declines of 81% and 83%, respectively). The lowest decline was seen in the Bay Study (34%), which may be due to the later years encompassed by this study (1980-1992). The fall midwater trawl sampled about the same geographical area as the Bay Study, but began in 1976 and showed a greater decline (46%). The number of splittail young salvaged (per acre-foot of water pumped) has declined an average of 64%. A higher decline was calculated for federal pumps, 87% versus 41%, compared to state pumps (Figure 5). In 1993 splittail salvage was three times higher at the federal pumps. This may reflect changes in operation of Clifton Court forebay that may have led to increased predation, or spawning near the federal pumps. Before 1986, salvage was consistently higher at the federal pumps.

Wet years increase splittail reproductive success. Plots of young-of-year and adults in wet versus dry years (Figures 6, 7) indicate that large year-classes occur in wet years and that few young are sampled in dry years. Furthermore, wet-year related young-of-year spikes have declined. The plot of Chipps Island trawl (Figure 7) shows young-of-year abundances for 1978, 1982, 1983, 1986 and 1993 of 123, 80.5, 20, 13 and 3 respectively.

Regressions of splittail young versus outflow show strong relationships. Coefficients of determination (R^2) range among studies from 0.65 for the Bay Study (Figure 8) to 0.73 for Chipps Island (Figure 9). The relationship between all year classes and outflow (Figure 10) is slightly weaker (0.70 for Chipps Island). The corresponding relationship for adults is very weak (Figure 10, 0.09), indicating that the relationship between splittail and outflow is particularly important for reproduction.

A graph of young-of-year abundances and proportion inflow diverted shows close correspondence between high proportions of inflow diverted and low splittail young numbers (Figure 11). Splittail young numbers at unimpaired outflows (outflow plus exports) can be predicted from the equation developed for splittail young and outflow. Plots of splittail young numbers predicted from outflow and unimpaired outflow (Figure 12) indicate that the water projects have significant effects in dry years. In dry years there is an uncoupling between young predicted with outflow versus unimpaired outflow. Abundances predicted when exports are removed are consistently lower in dry years. Moreover, there has been a consistent decoupling between the predicted abundances since 1987. A similar trend has been noted by Randy Baxter of CDFG, Stockton, for longfin smelt (see next section).

Although splittail are taken as far north as Colusa and as far downstream as San Francisco Bay in very wet years, the center of distribution is Suisun Bay (Figure 13). Overall, splittail catches have been the highest in the shallow-water areas of Grizzly and Suisun bays. Fall midwater trawl and Bay Study data indicate that 79% and 76% of the splittail catch has been in Suisun and Grizzly bays (Figure 13).

Suisun Marsh has many areas of shallow-water habitat and is adjacent to the center of splittail distribution. However, Suisun Marsh data show the most consistent downward trend in splittail numbers (Figure 3). Salinities in Suisun Marsh have increased steadily since 1979, effectively decreasing shallow-water habitat for splittail (primarily a freshwater fish). Shallow-water habitat is related to freshwater outflow in the estuary, because outflow pushes the mixing zone downstream and creates brackish water (around 2 ppt) habitat in the shallows of Suisun Bay. When the mixing zone moves upstream into Sacramento River channels, shallow brackish-water habitat is lost. The high percent declines seen in studies located in the Suisun Bay area (Suisun Marsh and Chipps Island, see Figure 1) may be related to the loss of shallow-water habitat in those areas.

The shift in splittail distribution upstream into the lower Sacramento River and south Delta also reflects loss of shallow-water habitat in the Suisun Bay area. Fall midwater trawl data indicate that 91% of the splittail captured in San Pablo and lower Suisun bays were taken before 1983, whereas 77% of the fish taken in the lower Sacramento River and south Delta were captured after 1983. Because state and federal pumps are located near the lower Sacramento River and south Delta, this upstream shift in distribution may increase splittail mortality at the pumps.

Gear used in the studies analyzed is effective for capturing splittail of all sizes. Plots of three age classes of splittail captured by otter and midwater trawls indicate that these methods capture all size classes effectively (Figure 14). Beach seining, on the other hand, captures mostly young-of-year.

Longfin smelt

Fall midwater trawl data on longfin smelt were analyzed by Randy Baxter of CDFG, Stockton.

Fall midwater trawl data indicate that longfin smelt numbers have declined by 50% annually since 1987 and that the decline since 1984 has been 90%. In 1991 and 1992, indices were lower than any previously calculated index (Figure 15). Although outflow increased in 1992, the strong outflow-abundance relationship (R^2 = 0.70, Figure 16), appears to be breaking down. Residuals (differences between the estimated index, based on the regression, and the actual index) have been consistently negative for the last four years (Figure 17) and abundance for 1992 occurred outside of the 95% confidence interval (Figure 18). A similar situation was noted for splittail and suggests that other factors are affecting abundance, such as a shortage of spawners. In other words, stocks are so depressed that there aren't enough fish to produce a good year class.

Salvage data indicate that longfin smelt are vulnerable to pumping. Although fall midwater trawl data show a 90% decline for longfin smelt since 1984, state pumping data show only a 24% decline. This discrepancy in decline rates is due to the increased entrainment of longfin smelt at the pumps (Figure 19). The federal facility "salvaged" four times as many longfin smelt per acre-foot of water pumped from 1985-91 compared to 1981-84. Numbers for state pumps are 12 times as many longfin smelt salvaged after 1984 for the same time periods. It is doubtful that longfin smelt survive salvage operations. The increase in salvage rate despite a well-documented decline suggests that longfin smelt have been more vulnerable to pumping operations in recent years (since 1984). The increase in vulnerability may be due to the concentration of longfin smelt populations in the upper estuary close to the pumps due to decreases in outflow. Moreover, decreases in outflow fail to disperse larvae downstream to Suisun Bay nursery areas where they removed from pumping effects.

Conclusions

Analyses of survey data for **splittail** indicate:

1) Splittail have declined an average of 62% over seven surveys since 1984.

2) Successful reproduction is highly correlated with wet years, but young-of-year abundance has declined steadily in wet years since 1976.

3) There is a strong relationship between young-of-year abundance and spring outflow (outflow into San Francisco Bay after water exports are removed).

4) Predicted young-of-year abundance using unimpaired outflow (outflow without exports removed) is higher than expected in dry years indicting that water exports affect young-of-year abundance in dry years.

5) The relationship between predicted abundances for outflow and unimpaired outflow weakened during the six-year drought and suggests stocks may be losing the ability to recover.

6) Splittail are most abundant in shallow areas of Suisun and Grizzly bays and are vulnerable to increasing salinities in these areas caused by upstream migration of the mixing zone due to water exports and drought. Concentration of splittail in shallow

areas suggests that they are particularly vulnerable to reclamation activities.

7) Midwater and otter trawls are efficient gear for catching all size classes of splittail.

Analyses of survey data for **longfin smelt** indicate:

1) Longfin smelt have declined 90% since 1984 and numbers have declined by 50% annually since 1987.

2) In 1991 and 1992, indices were lower than any previously calculated index.

3) The strong outflow-abundance relationship appears to be breaking down. Differences between estimated and actual indices have been consistently negative for the last four years and abundance for 1992 lies outside of the 95% confidence interval.

4) Although longfin smelt have declined by 90% in the estuary, numbers salvaged by state and federal pumping facilities have increased several-fold since 1984. This suggests that longfin smelt populations (particularly young-of-year) concentrated above Suisun Bay due to low outflows are increasingly vulnerable to entrainment.

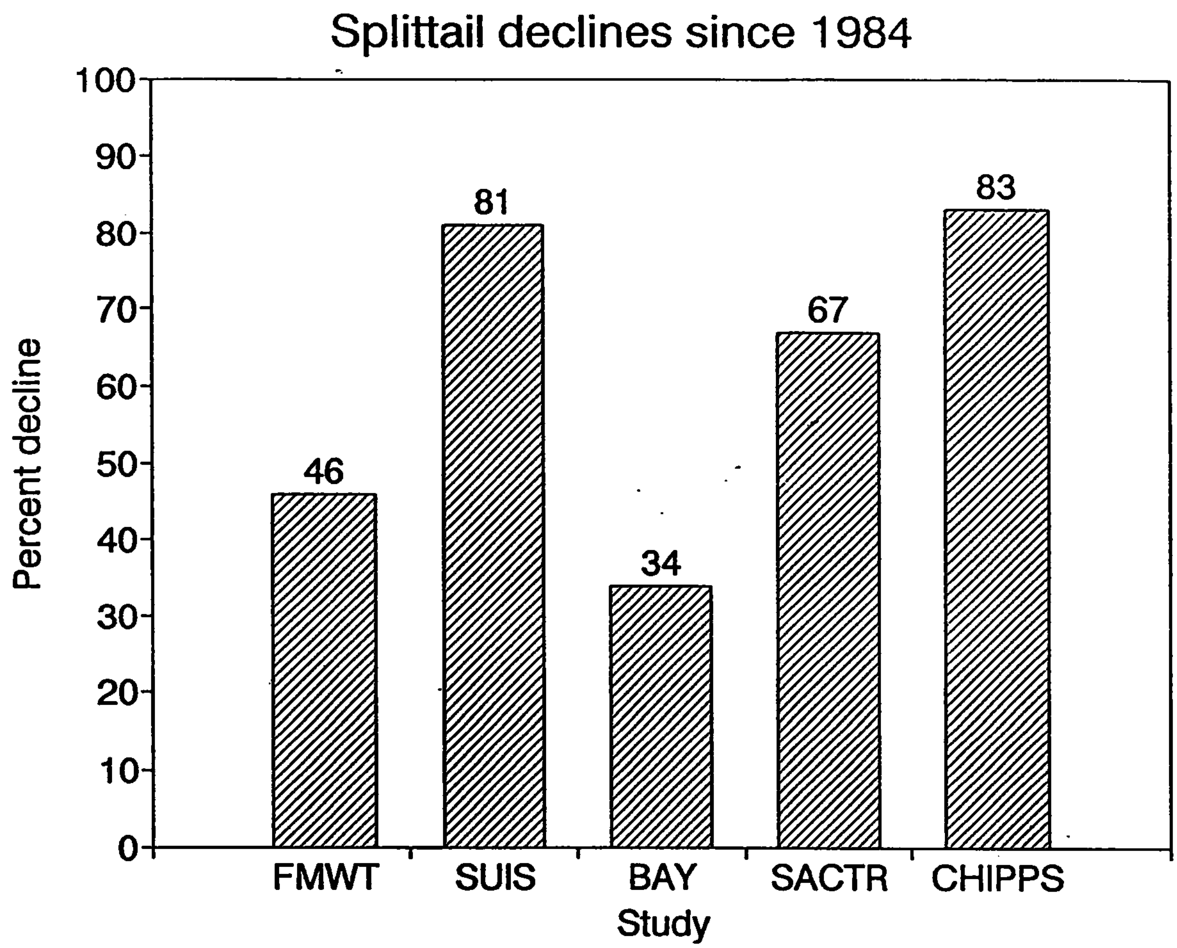
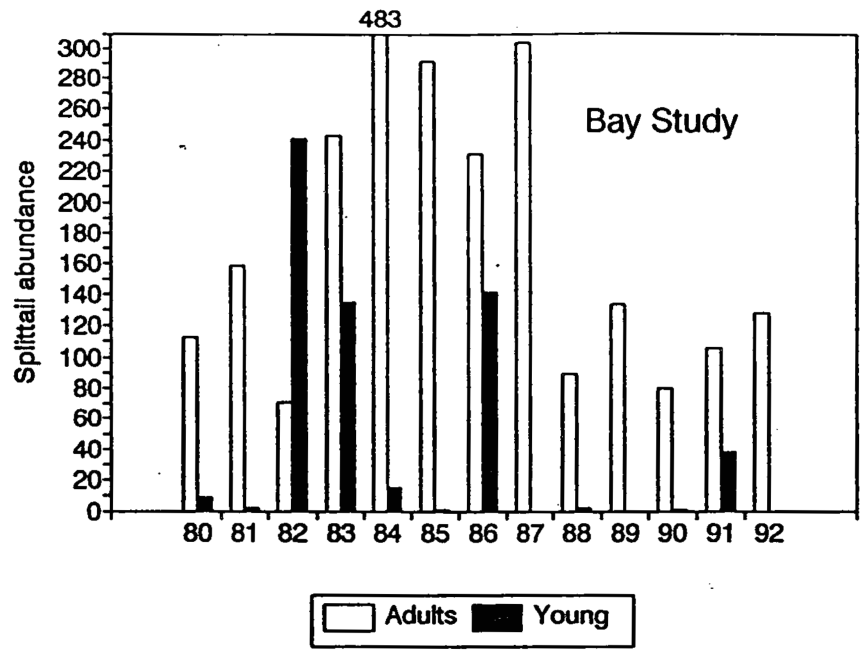


Figure 1. Splittail declines since 1984. Percent declines were calculated by comparing abundance averages of years prior to and following 1984. FMWT = fall midwater trawl, SUIS = Suisun Marsh study, BAY = Bay Study, SACTR = Sacramento trawl, CHIPPS = Chipps Island trawl.



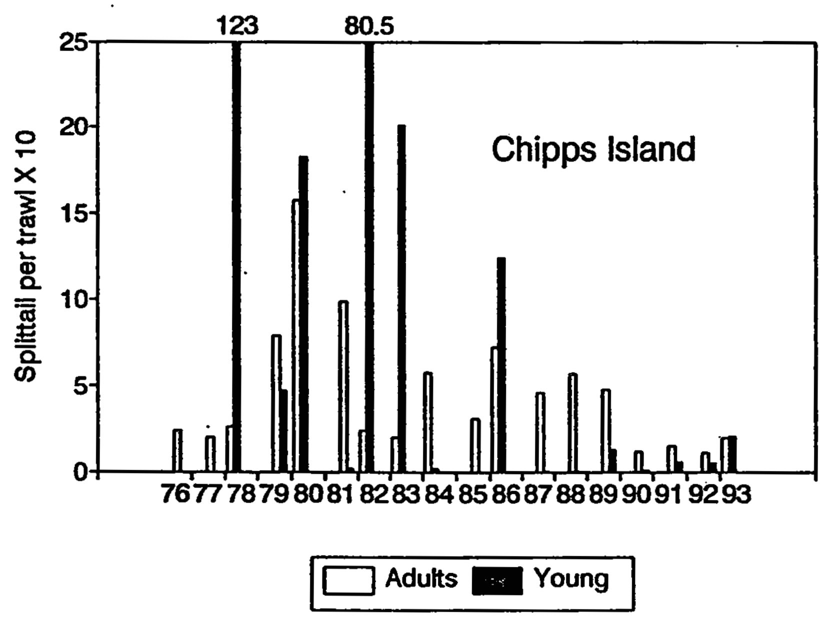


Figure 2. Yearly abundances of splittail adults and young from the Bay Study and Chipps Island trawls.

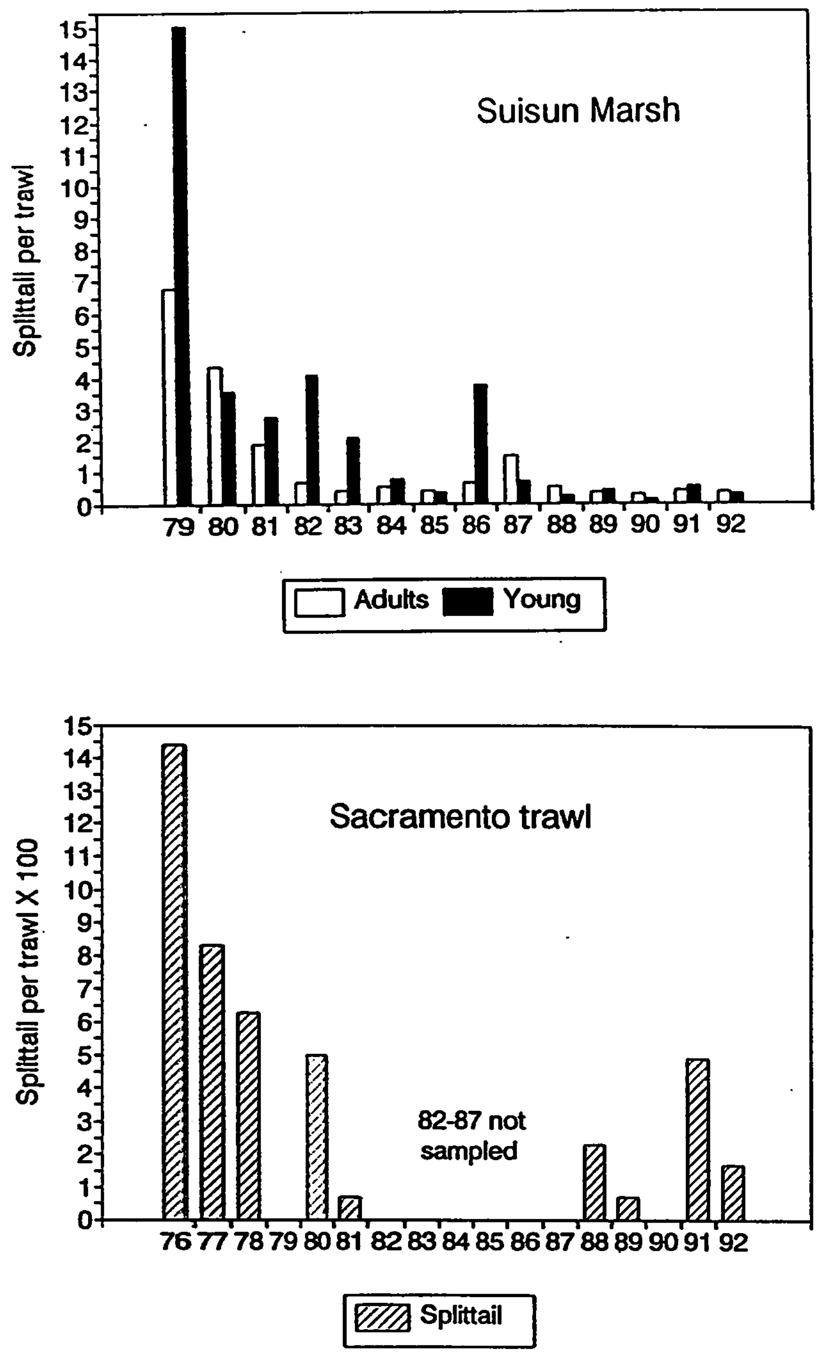
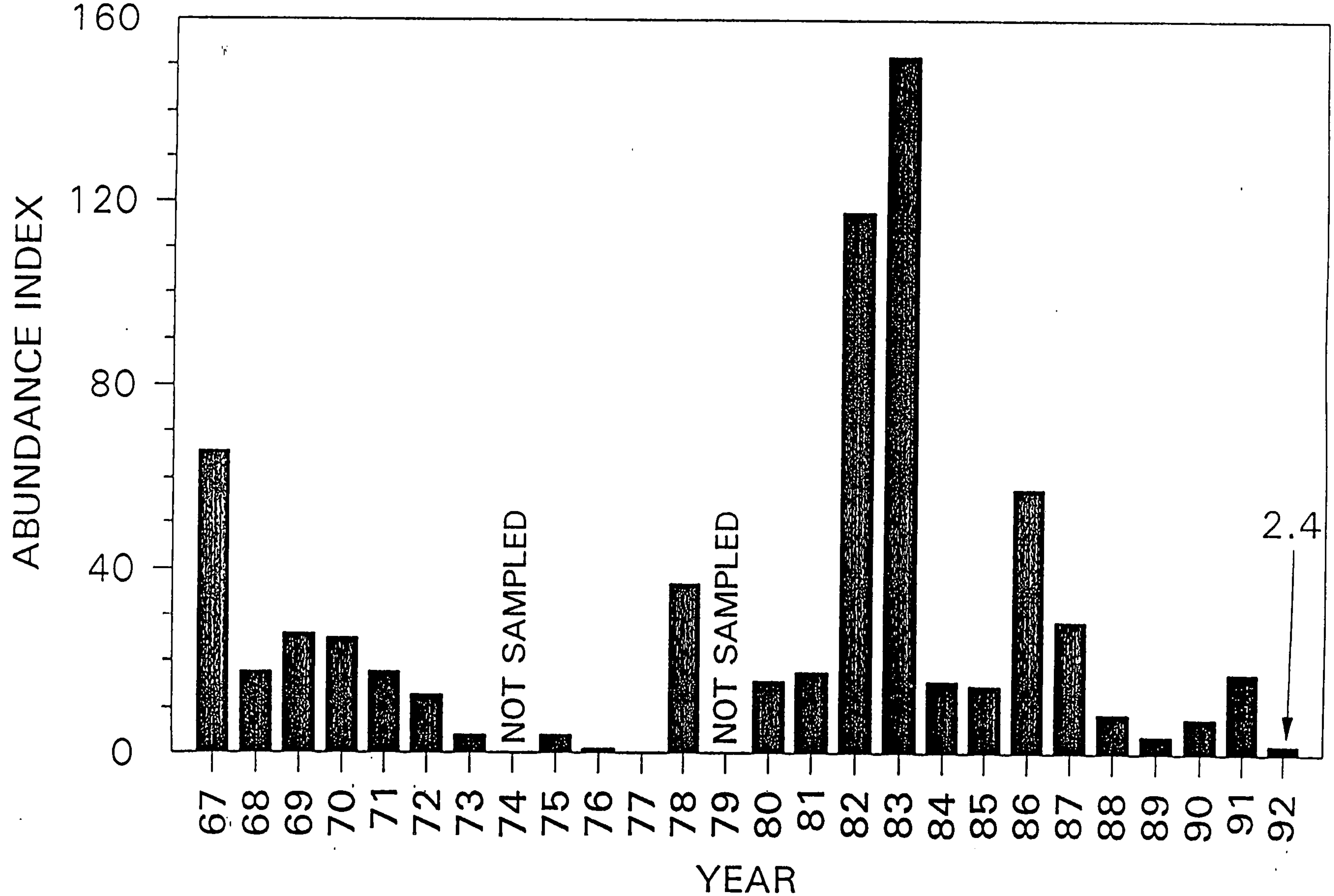


Figure 3. Yearly abundances of splittail from the Suisun Marsh study and Sacramento trawl.

Figure 4.

SACRAMENTO SPLITTAIL ABUNDANCE

Striped Bass Fall MWT Index



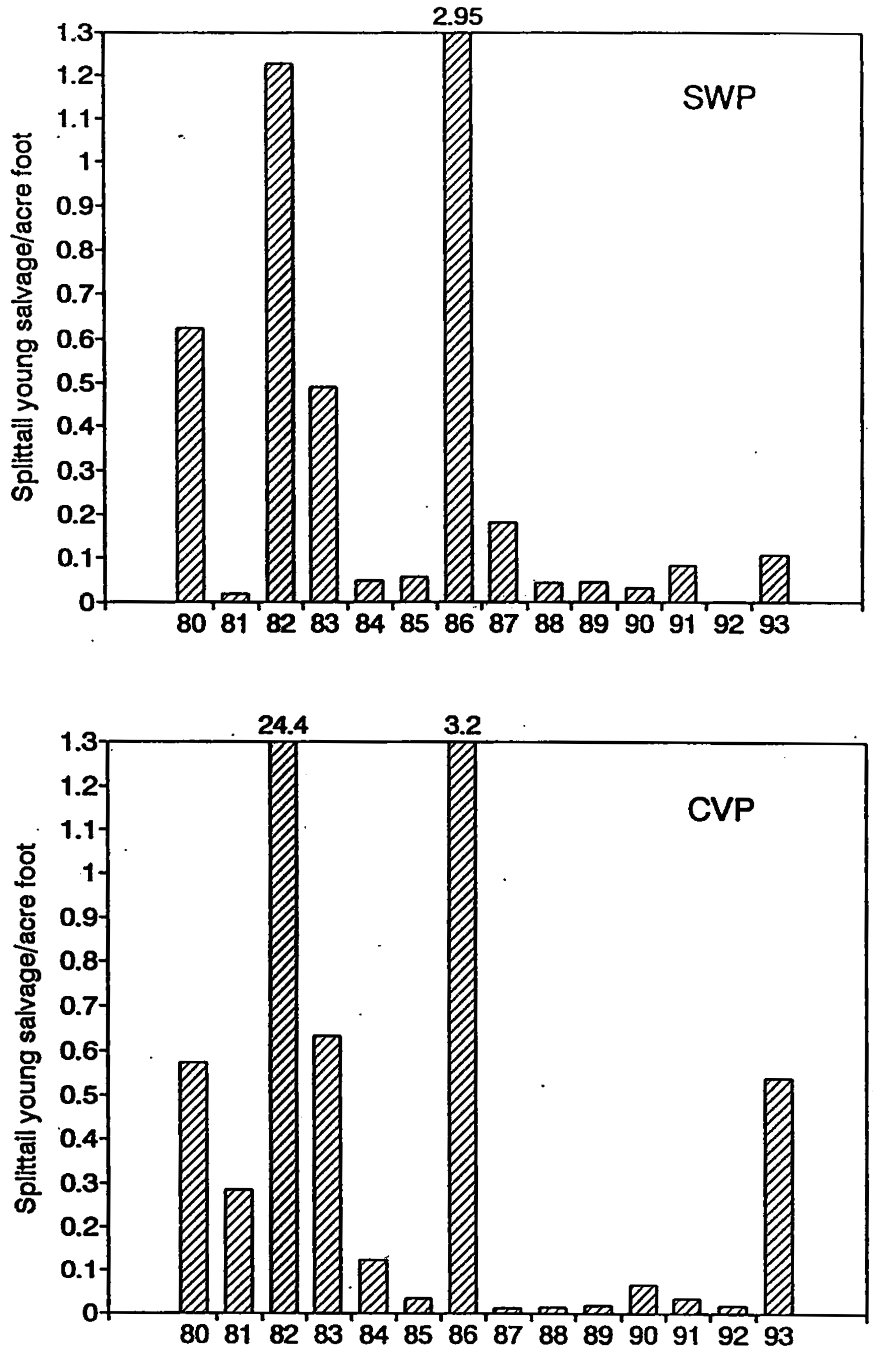
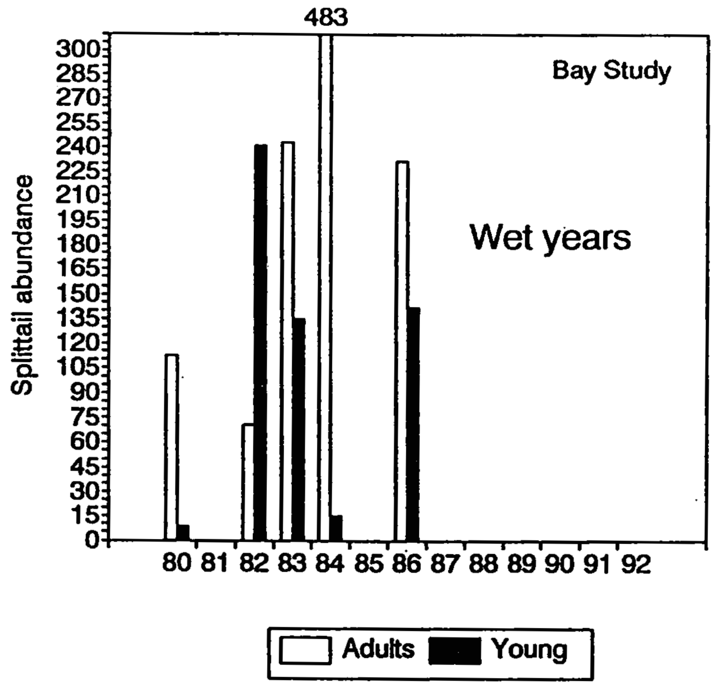


Figure 5. Splittail young salvage per acre foot of water pumped during May and June at the state (SWP) and federal (CVP) pumping facilities.



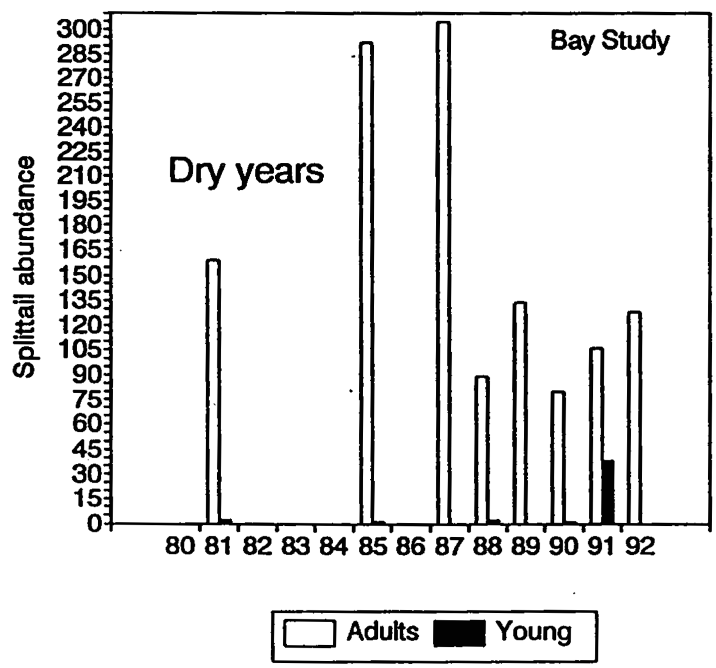


Figure 6. Splittail abundances in wet and dry years from the Bay Study.

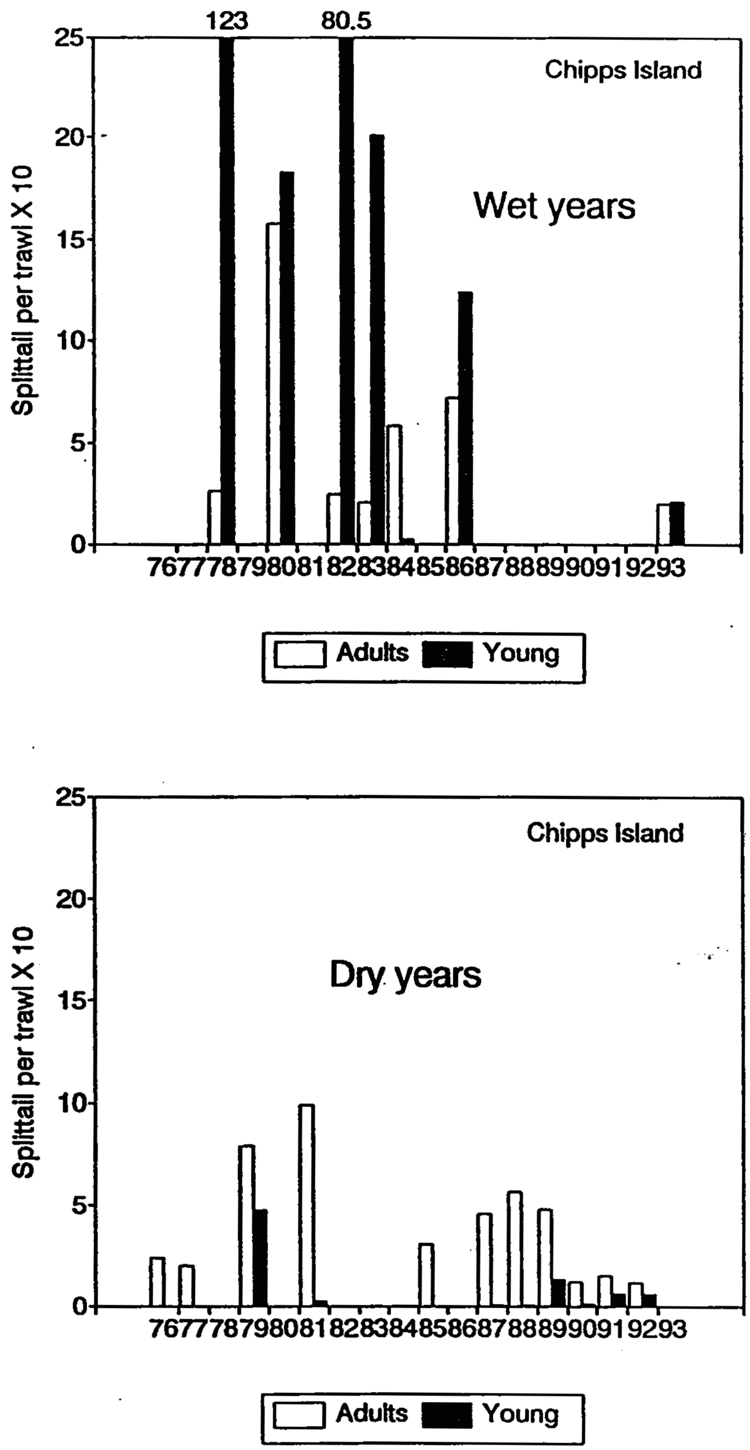


Figure 7. Splittail abundances in wet and dry years from Chipps Island trawl.

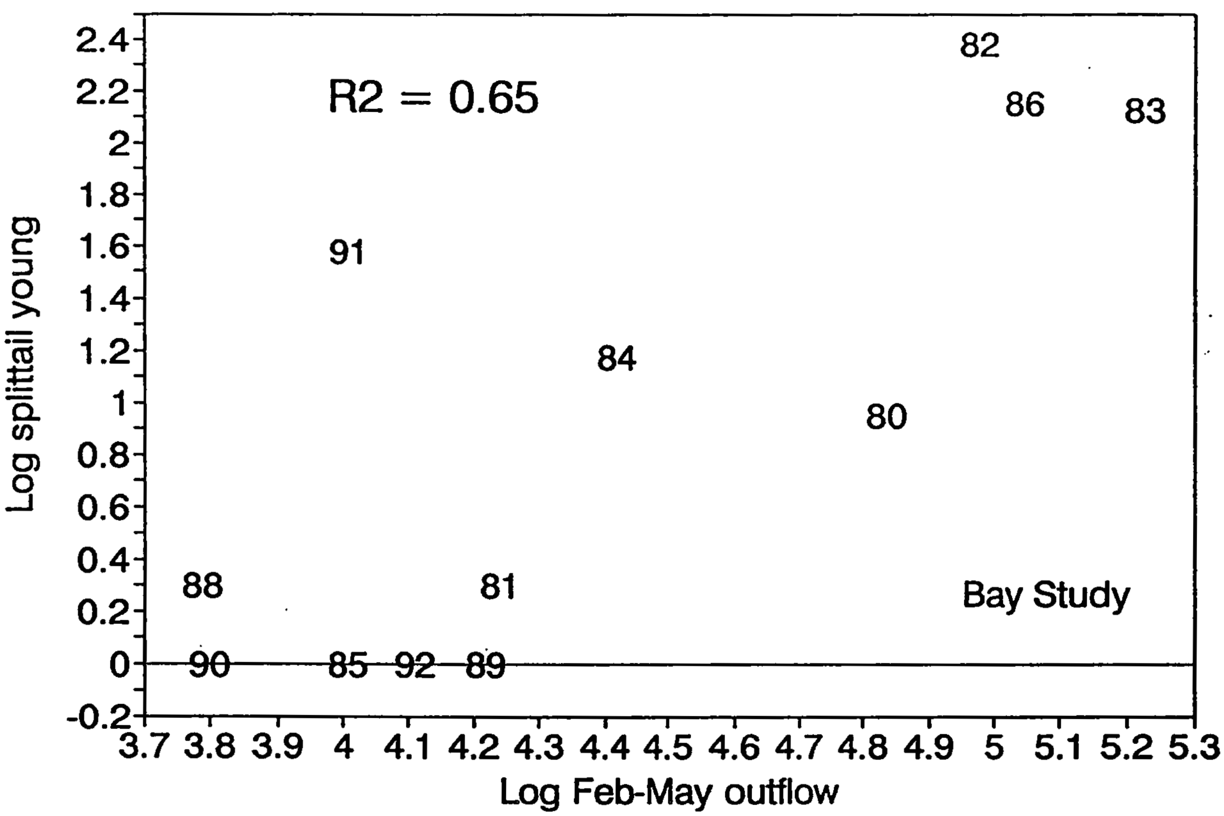


Figure 8. Relationship between splittail young and February-May outflow (Bay Study). Equation for regression is Y = 1.5X - 5.9. Numbers in graph denote years.

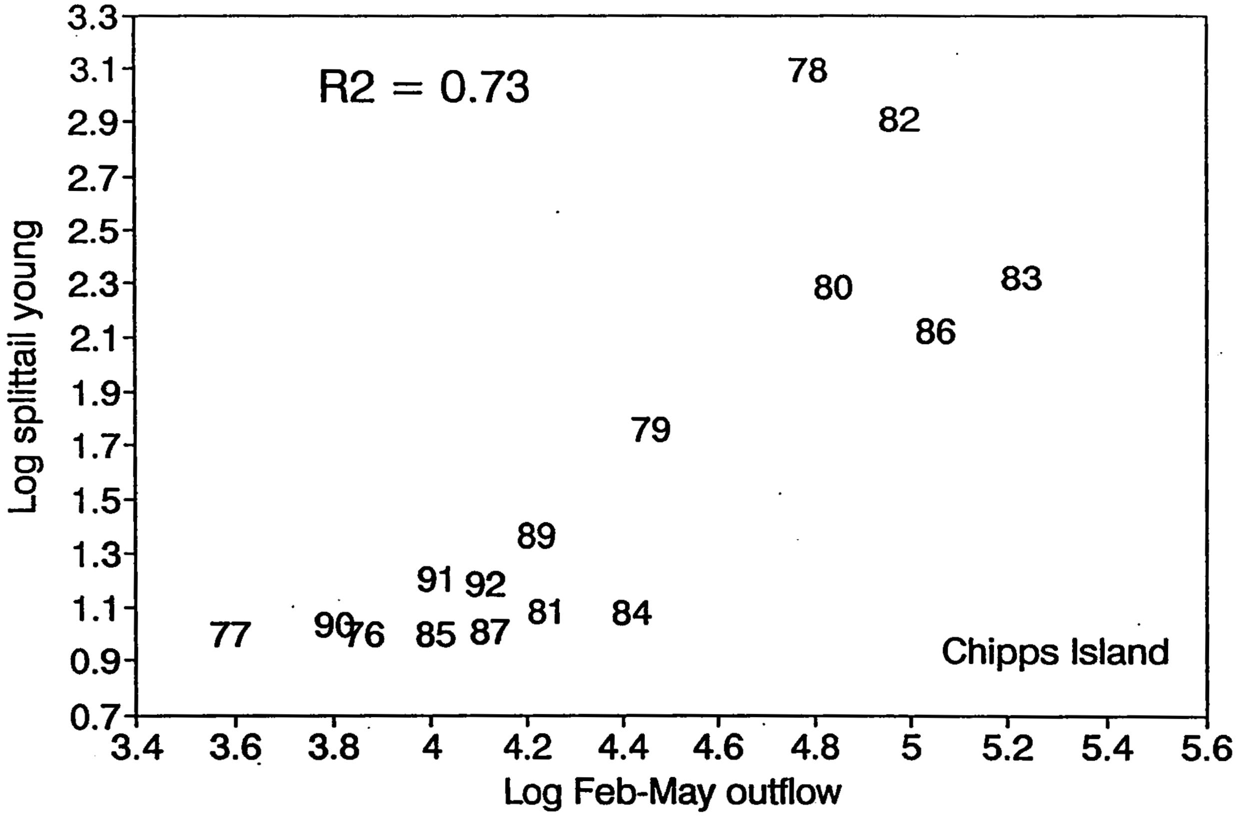


Figure 9. Relationship between splittail young and February-May outflow (Chipps Island trawl). Equation for regression is Y = 1.2X - 5.8. Numbers in graph denote years.

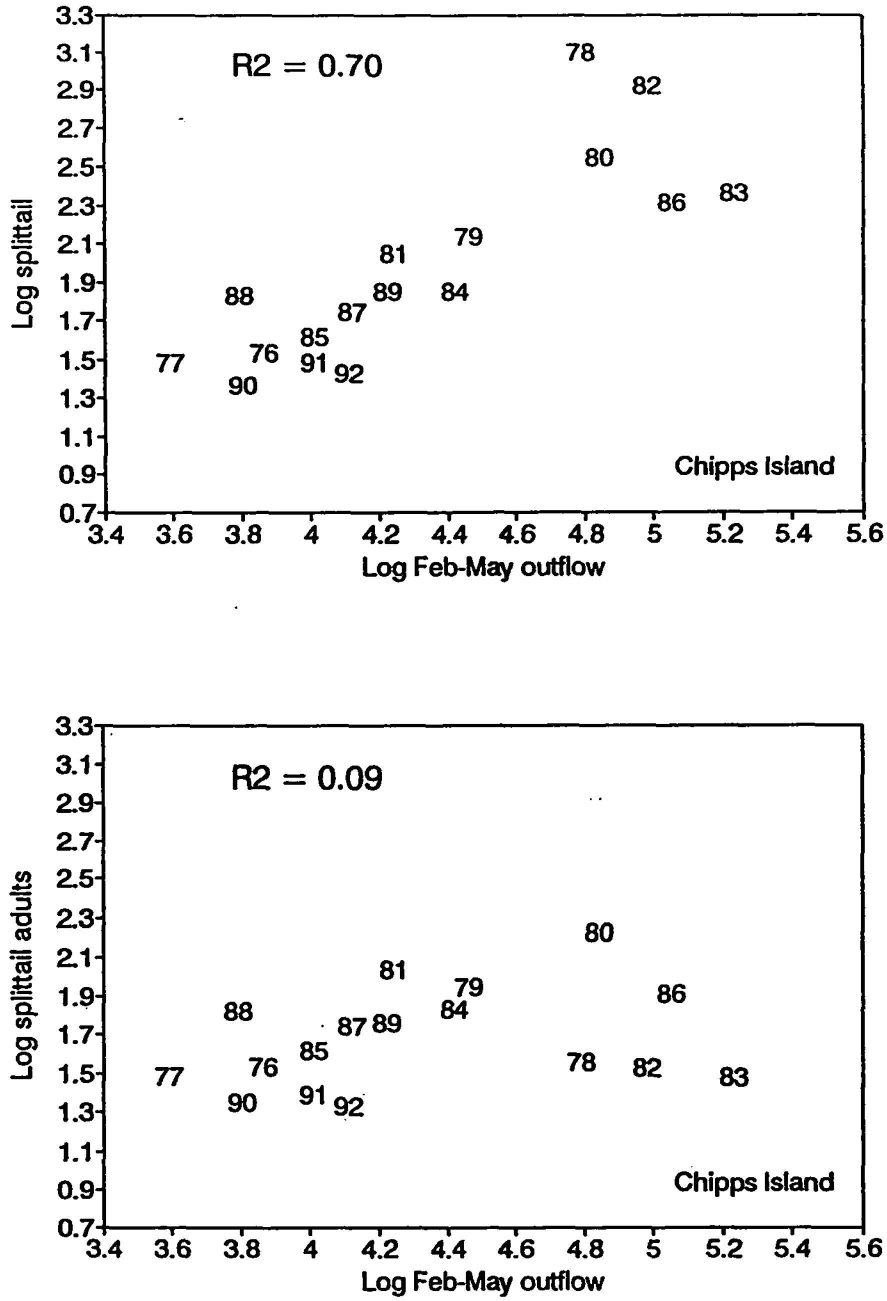


Figure 10. Relationships between splittail (all size classes) and splittail adults and February-May outflow (Chipps Island trawl). Equation for splittail is Y = 0.88X - 1.83. Equation for splittail adults is Y = 0.15X + 1.0. Numbers in graph denote years.

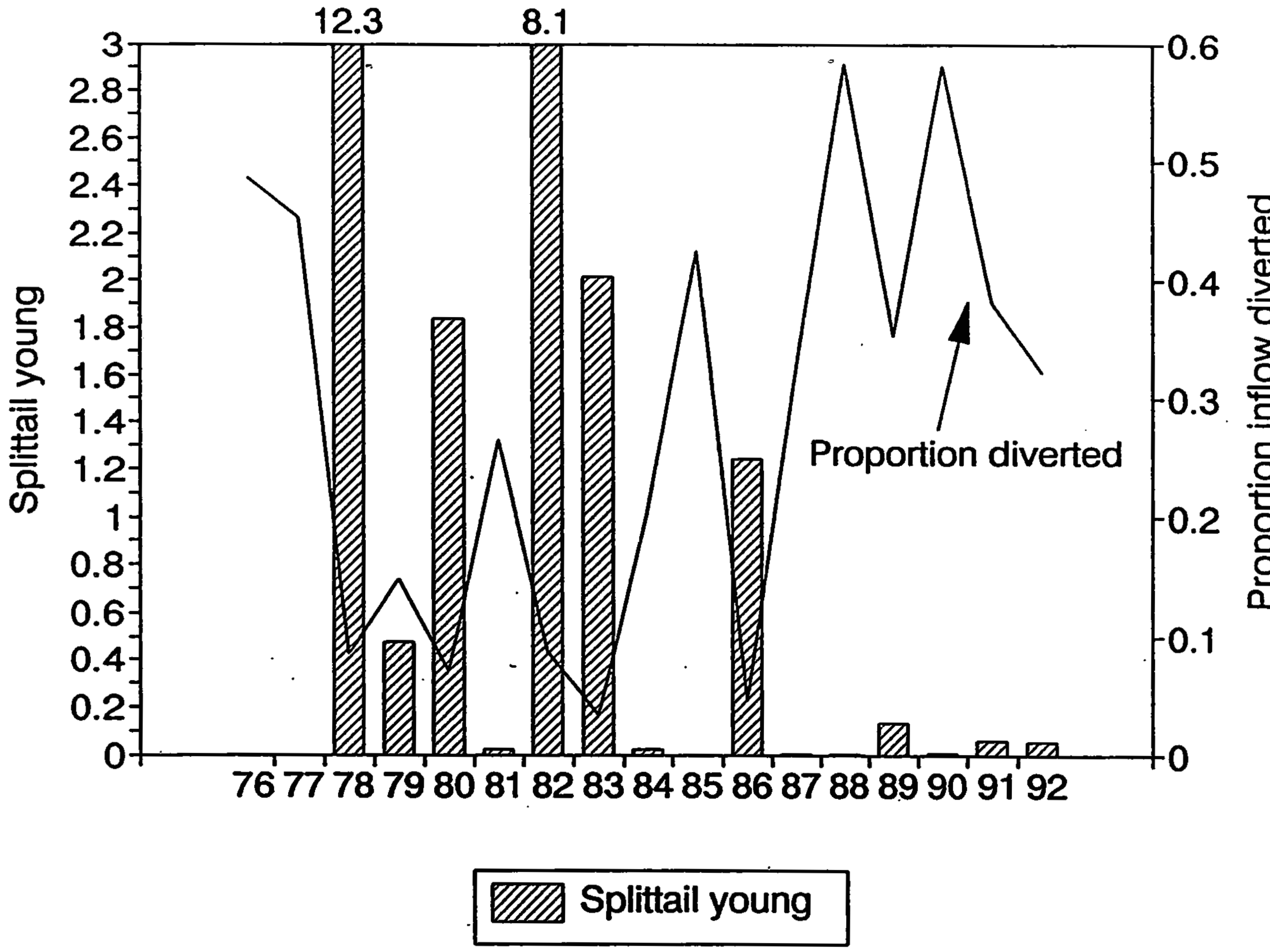


Figure 11. Splittail young abundance and proportion inflow diverted. Note increases in proportion of inflow diverted since 1984.

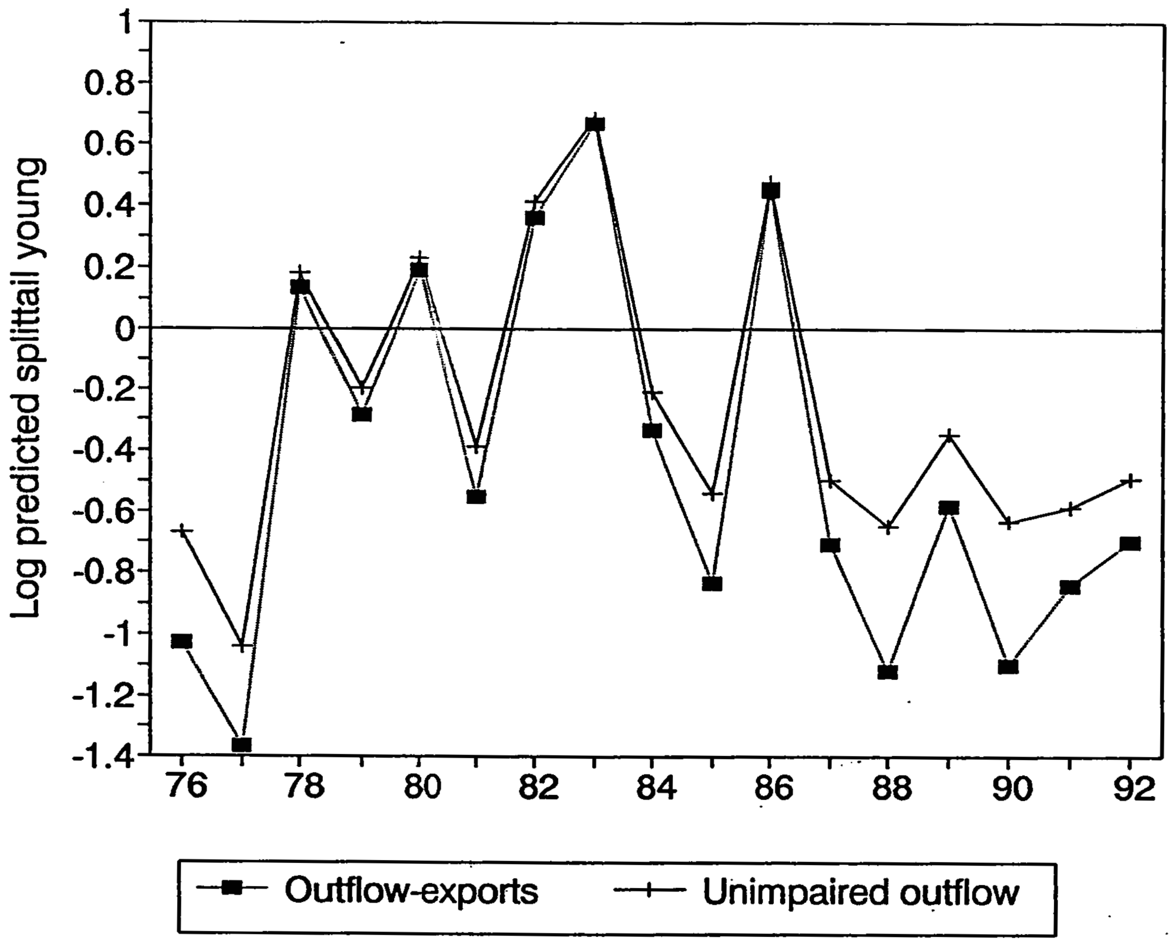
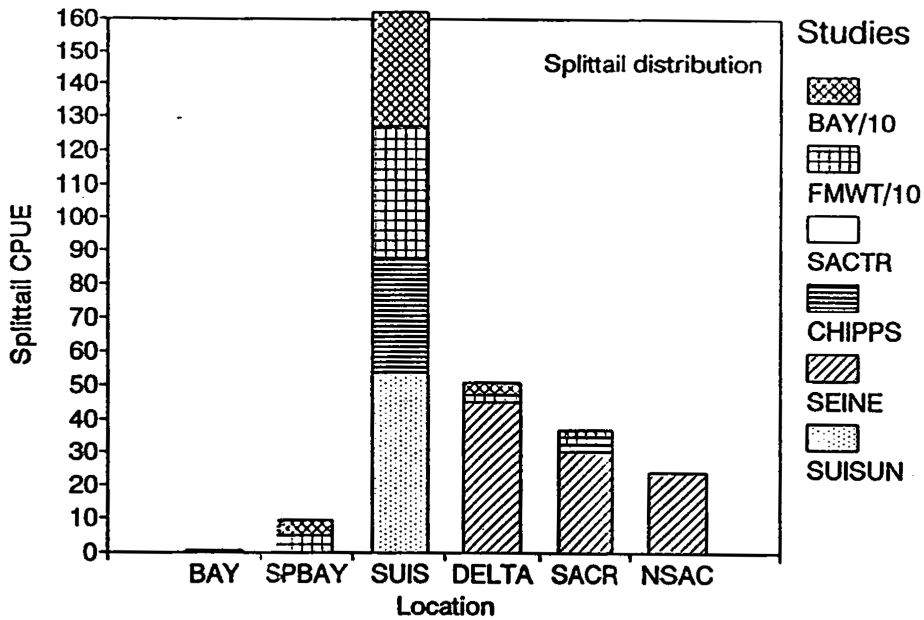


Figure 12. Splittail young numbers predicted for outflow (minus exports) and unimpaired outflow (Chipps Island trawl equation).



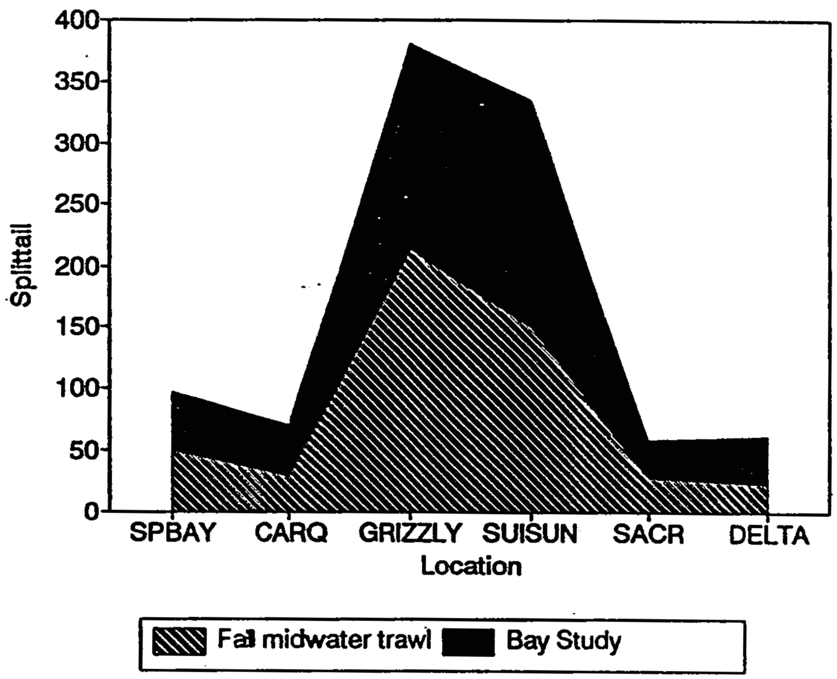


Figure 13. Splittail distribution and numbers of splittail caught by each study. Abbreviations for locations are: BAY = San Francisco Bay; SPBAY = San Pablo Bay; SUIS = Suisun Bay; DELTA = central Delta; SACR = Sacramento River; NSAC = north of Sacramento on the Sacramento River; CARQ = Carquinez Straits area; GRIZZLY = Grizzly Bay.

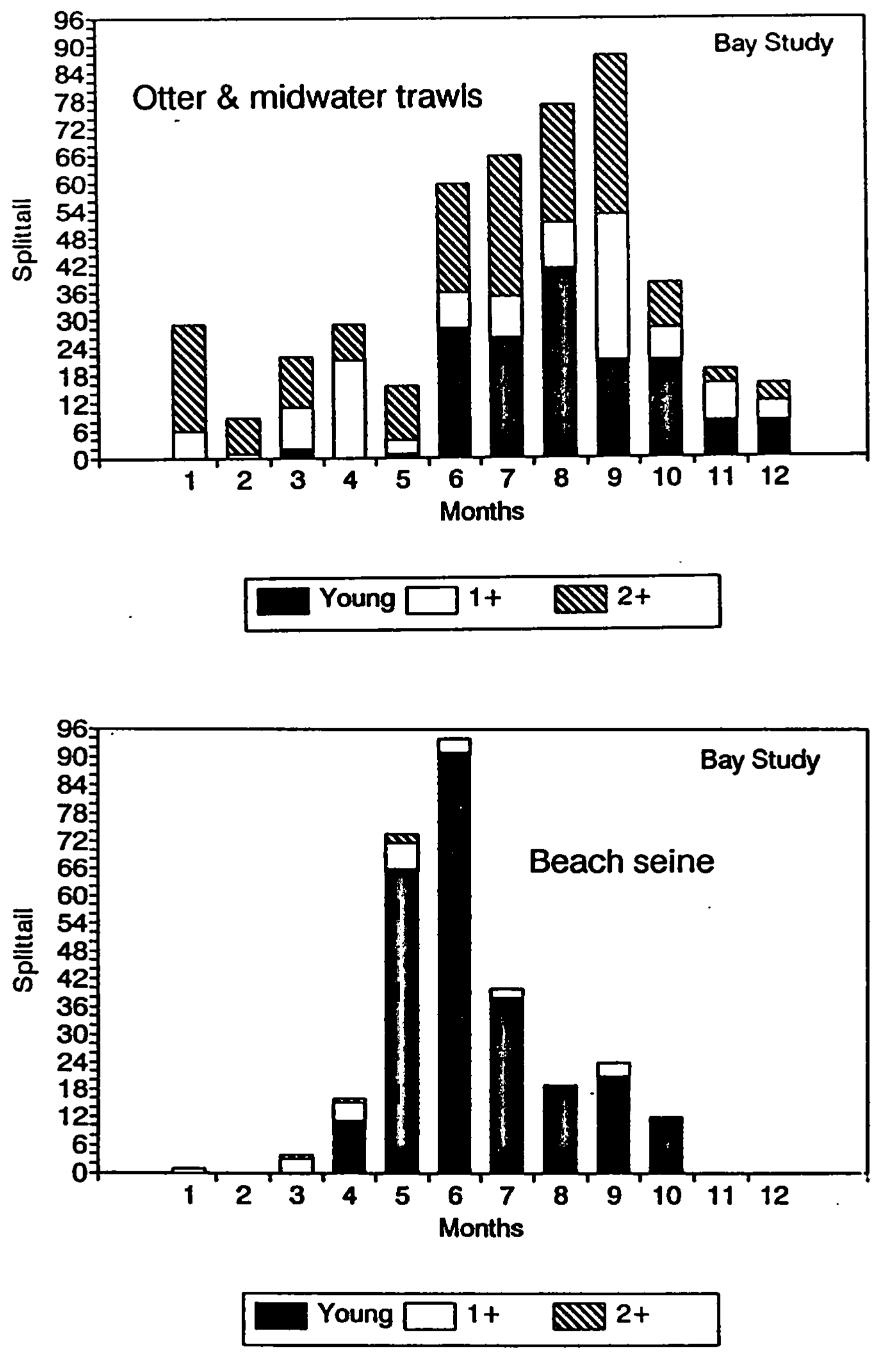


Figure 14. Splittail captured by different gear types.

Figure 15. LONGFIN SMELT ABUNDANCE

Striped Bass Fall MWT Index

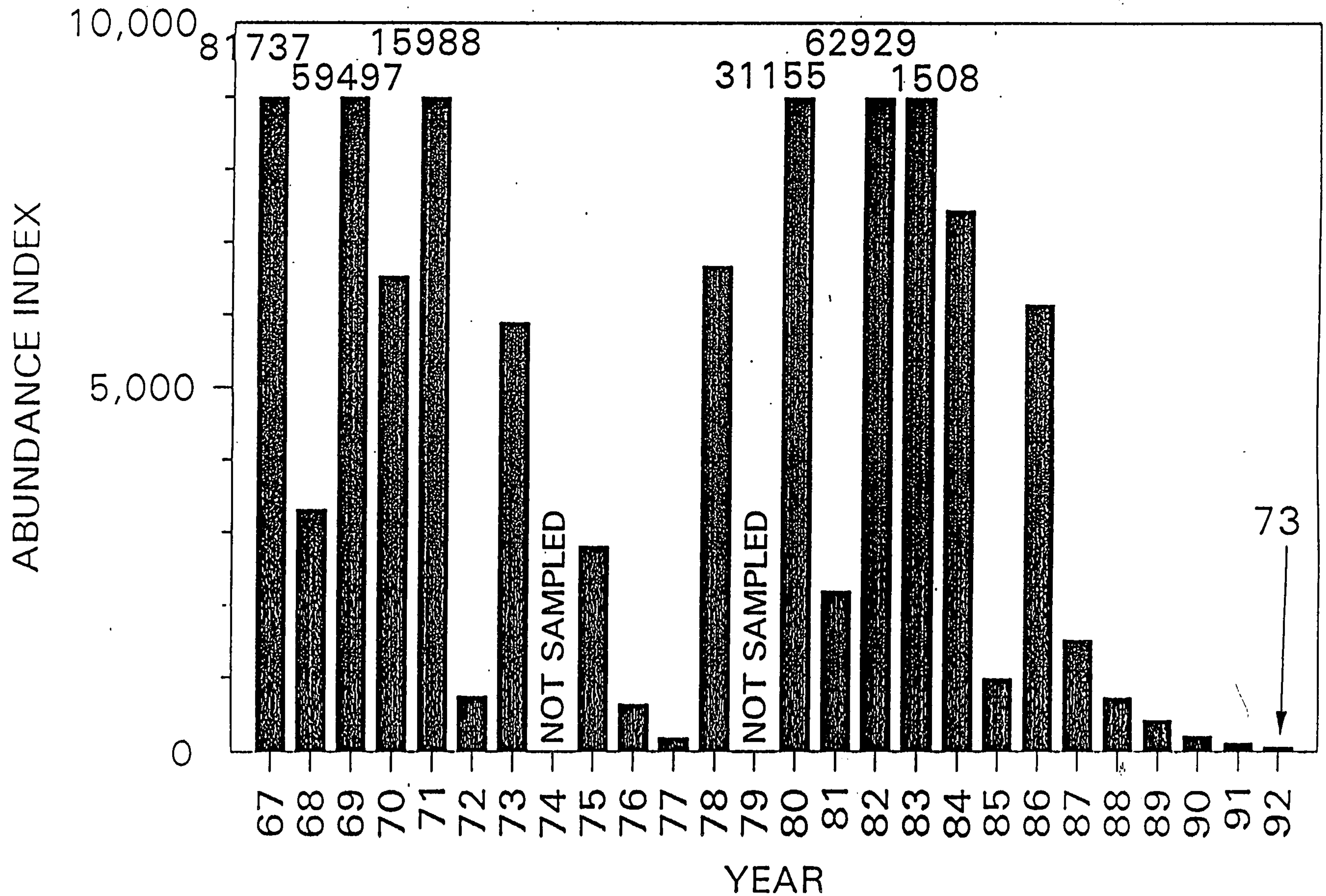
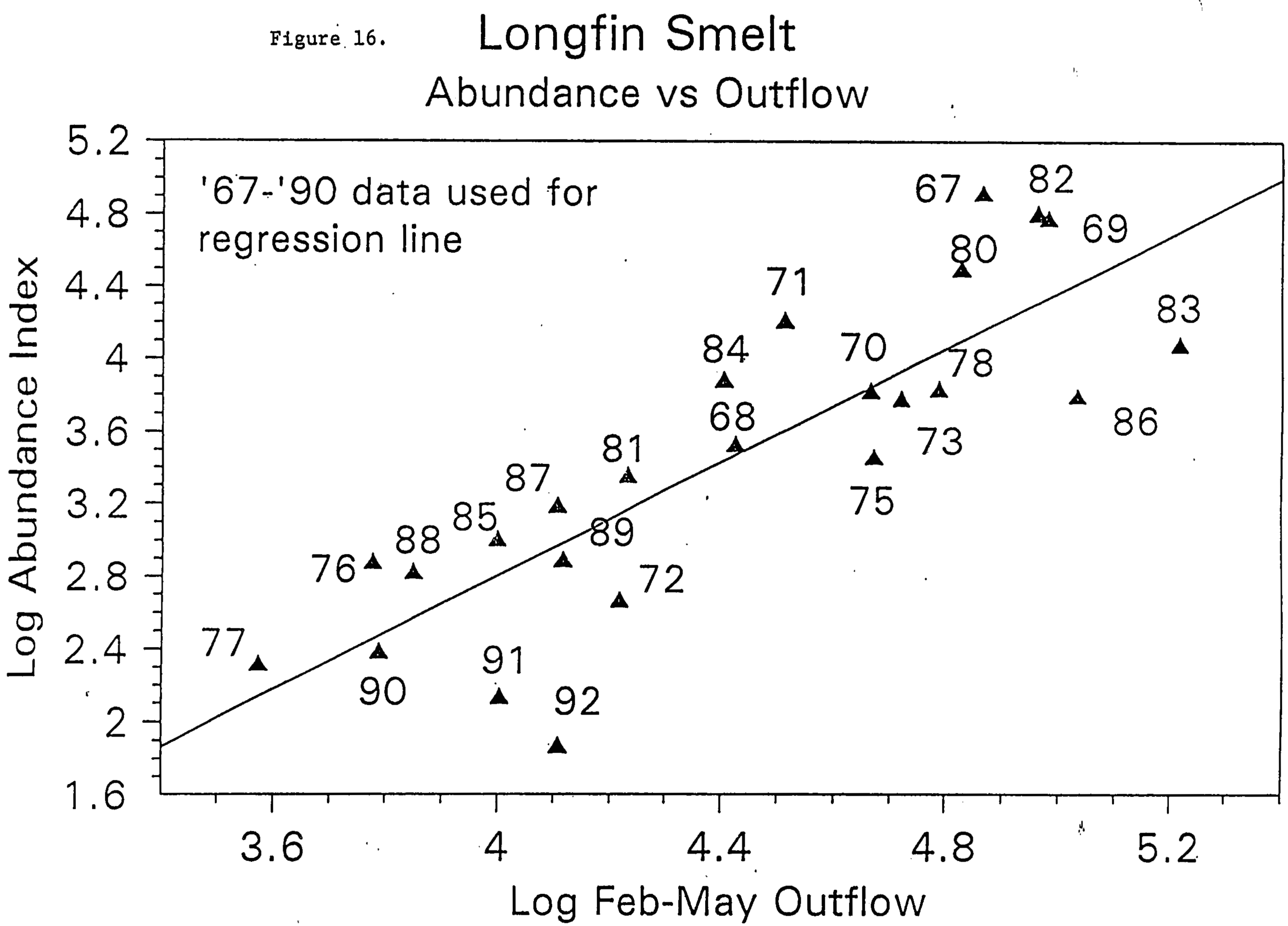
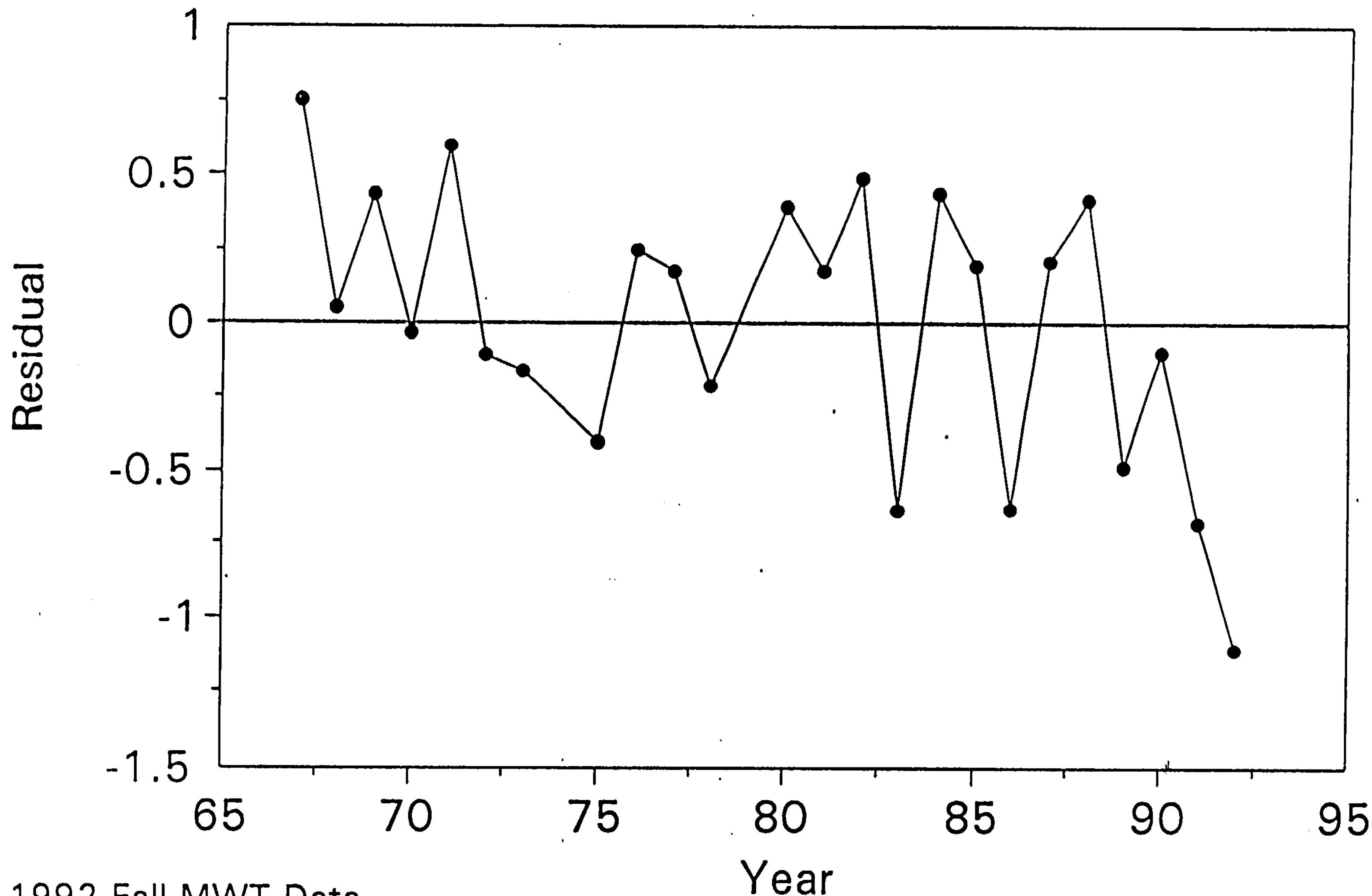


Figure 16.



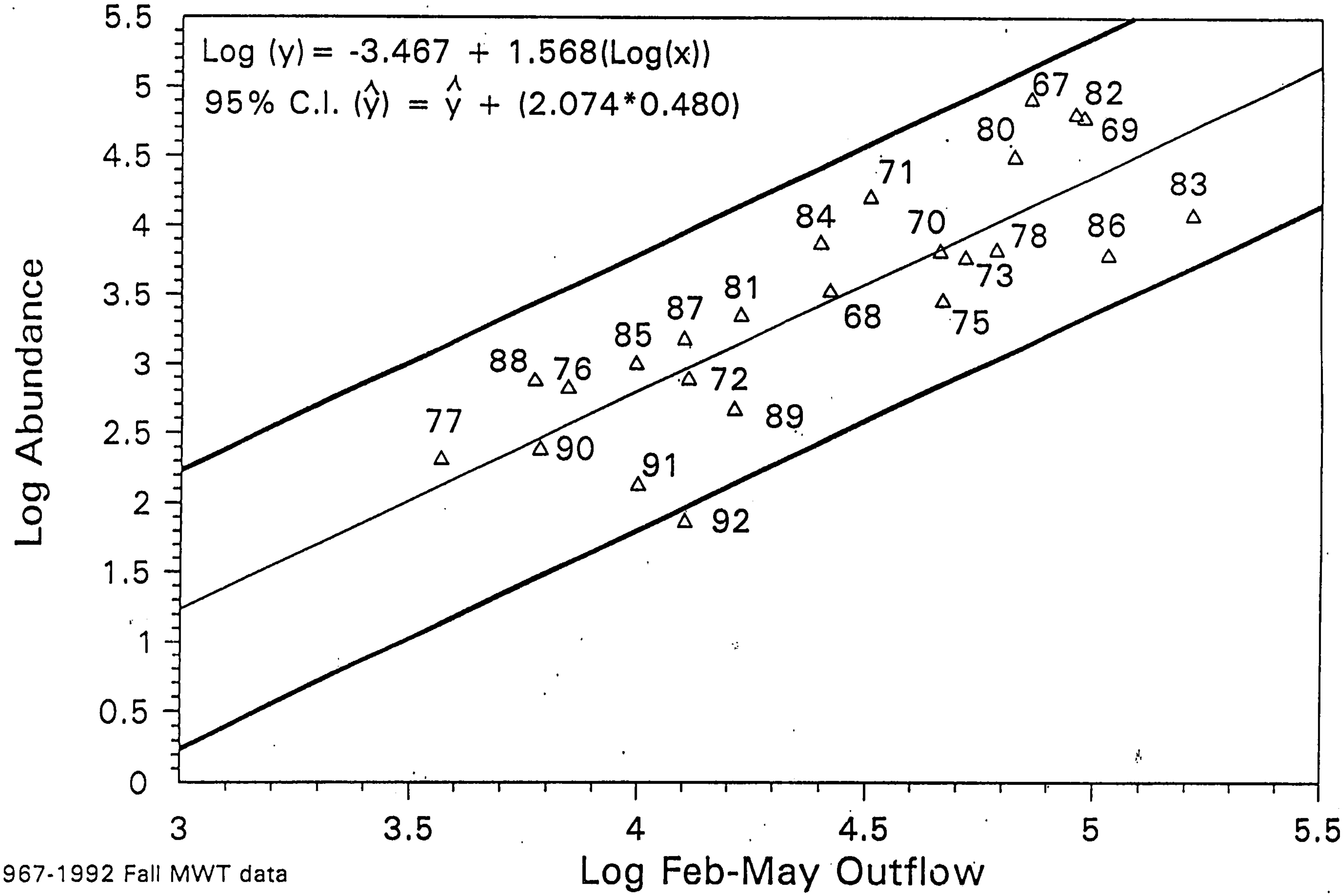
Longfin Smelt
Abundance vs Outflow
'67-'90 data used for regression line
Log Abundance Index
Log Feb-May Outflow
5.2
4.8
4.4
4
3.6
3.2
2.8
2.4
2
1.6
3.6
4
4.4
4.8
5.2
67
82
69
80
71
83
84
70
78
68
86
73
81
87
75
85
89
88
76
72
77
91
90
92

Figure 17 Plot of Residuals of Longfin Smelt Abundance-Outflow Relationship against Time



1967-1992 Fall MWT Data

Figure 18. Longfin Smelt Abundance-Outflow Relationship
95% Confidence Intervals for the Estimate of Y plotted



1967-1992 Fall MWT data

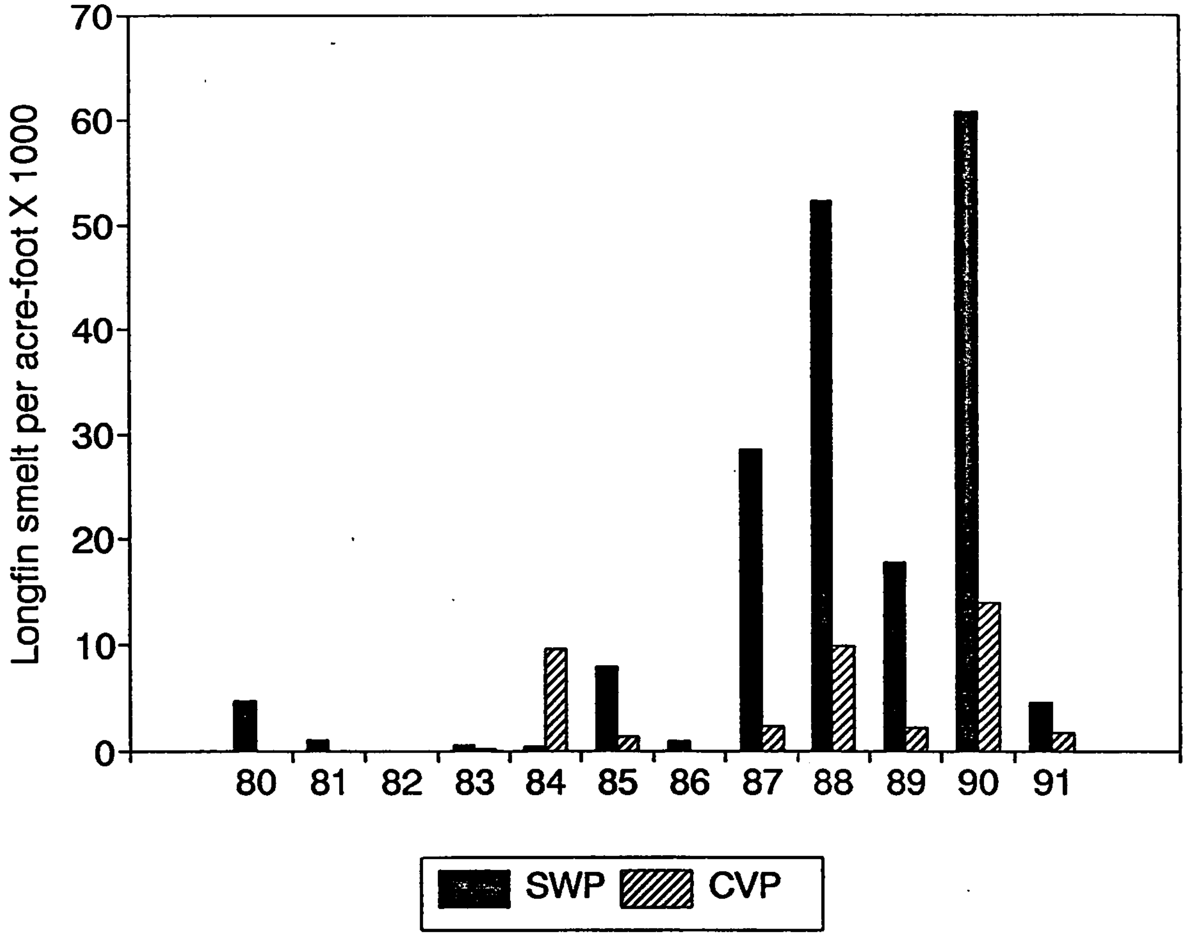


Figure 19. Longfin smelt salvaged at state (SWP) and federal (CVP) water pumps.