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APPENDIX 1-A

EXAMINATION OF THE RELATIONSHIP BETWEEN DELTA SMELT GEOGRAPHIC DISTRIBUTION DURING JUVENILE REARING AND FALL INDICES OF ADULT ABUNDANCE

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INTRODUCTION

A series of hypotheses have been developed regarding the geographic distribution of juvenile Delta smelt during the summer rearing period and the corresponding number of adults surviving until the fall and winter. The importance of the geographic distribution of Delta smelt during the rearing period has been linked to (1) the transport and distribution of early lifestages into areas downstream of the Sacramento - San Joaquin confluence thereby reducing their risk and susceptibility to entrainment losses at the State and Federal water projects (SWP and CVP) and at a number of other water diversions located throughout the Delta, and (2) the importance of habitat within productive shallow-water areas in Suisun Bay where food supply is abundant, the risk of predation losses is reduced, and therefore growth and survival of juveniles during the rearing period is increased. Under these hypotheses the reduction in entrainment mortality and increased food availability and habitat quality promoting growth and survival of juvenile Delta smelt rearing in areas downstream of the confluence and within Suisun Bay are expected to result in increased abundance of sub-adult and adult Delta smelt the following fall.

Data are available from long-term studies conducted by the California Department of Fish and Game (CDFandG) which can be used to evaluate the geographic distribution of juvenile Delta smelt during the summer rearing period (based on results of summer tow net surveys) and indices of adult abundance immediately preceding spawning in the fall and early winter (fall mid-water trawl surveys). The summer

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tow net surveys, which have been conducted since 1959, sample a large number of locations throughout the Delta and Suisun Bay (Figure 1) and therefore provide valuable information on the geographic distribution of juvenile Delta smelt during the summer rearing period. CDFandG summer tow net surveys have been conducted during June, July, and August, although the timing and number of surveys may vary among years.

Fall mid-water trawl surveys have been performed since 1967 at locations throughout the Delta and Suisun Bay (Figure 2) which encompass the geographic range of sub-adult and adult Delta smelt prior to spawning. The fall mid-water trawl surveys are conducted in September - December with the resulting catches of Delta smelt used to calculate an index of Delta smelt abundance each year. Calculation of the fall index of abundance uses a series of volumetric weighting factors to adjust Delta smelt collections within various regions of the Delta to account for the volume of potentially available habitat. The fall mid-water trawl indices of abundance have been generally recognized as the best available scientific data on adult Delta smelt abundance trends. Annual indices of Delta smelt abundance from the fall mid-water trawl surveys are summarized in Figure 3.

To test the hypothesis regarding the importance of juvenile Delta smelt geographic distribution on their survival, and the subsequent abundance of adult Delta smelt, a series of analyses were performed using data derived from the CDFandG summer tow net and fall mid-water trawl surveys. Based on the geographic distribution hypothesis for juvenile rearing it was expected that high indices of adult abundance during the fall should occur in those years in which a large percentage of the juvenile Delta smelt were rearing (1) downstream of the confluence between the Sacramento and San Joaquin rivers, and (2) within Suisun Bay. Correspondingly, in those years in which a majority of the juvenile Delta smelt were rearing within the Delta (upstream of the confluence between the Sacramento and San Joaquin rivers) the resulting index of adult abundance in the fall is expected to be low.

CALCULATION OF THE DELTA SMELT GEOGRAPHIC DISTRIBUTION DURING JUVENILE REARING AND ADULT INDICES OF ABUNDANCE

Data on the numbers of juvenile Delta smelt collected at each sampling station during each CDFandG summer tow net survey were compiled (J. Buell, personal communication). Estimates of the geographic distribution of juvenile Delta smelt were prepared during each monthly survey based on the percentage of the total catch downstream of the confluence of the Sacramento and San Joaquin rivers (sampling stations numbered less than 700) and for those sampling locations within Suisun Bay (sampling stations 300's, 400's, and 600's; see Figure 1). Estimates of the geographic distribution were calculated based on the simple percentage of the total number of Delta smelt collected during each survey occurring within the designated regions and based on volume weighted indices of juvenile abundance by area during each survey. After adjusting catches for the volumetric weighting factor the percentage of Delta smelt collected in each of the designated regions was then calculated. Results of individual surveys were excluded from subsequent statistical analysis in the event that either (1) the total number of Delta smelt collected used in determining the geographic distribution for a survey was less than 100, or (2) no index of abundance of adult Delta smelt is available for a given year from the fall mid-water trawl surveys (surveys were not conducted in all years).

The annual index of adult Delta smelt abundance (Figure 3) was calculated by CDFandG based on results of mid-water trawl surveys conducted from September through December and the volumetric weighting factors to account for available habitat within various regions of the survey area.

RESULTS

Statistical analyses were performed separately for the relationship between the geographic distribution of juvenile Delta smelt and fall adult abundance indices for tow net surveys conducted during June, July, and August. Analyses used both unweighted Delta smelt catches by sampling location and volumetric weighting of juvenile catches to estimate the percentage of juveniles occurring downstream of the Sacramento - San Joaquin river confluence and within Suisun Bay. Data on the geographic distribution of juvenile Delta smelt and the corresponding fall mid-water trawl abundance index used in these analyses are presented in Table 1 for that portion of the geographic distribution of juvenile Delta smelt occurring downstream of the Sacramento - San Joaquin river confluence and Table 2 for the proportion of juvenile rearing occurring within Suisun Bay.

No significant relationship was detected between the percentage of the juvenile Delta smelt collected downstream of the confluence between the Sacramento and San Joaquin rivers and the corresponding fall mid-water trawl abundance index for either the unweighted catch distribution (Figures 4-6) or the volume weighted indices (Figures 7-9). Results of the correlation analyses for these datasets are summarized below:

Correlation coefficient (r) between the percentage of juvenile smelt downstream of the confluence and fall mid-water trawl index.

Smelt Catch	r	Number	Significance
June	-0.12	11	ns
July	-0.05	16	ns
August	0.00	11	ns

Volume weighted index

June	-0.11	11	ns
July	-0.05	16	ns
August	0.00	11	ns

Similarly, no significant relationship was detected between the percentage of juvenile Delta smelt collected within Suisun Bay and the corresponding fall mid-water trawl abundance index for either the unweighted catch distribution (Figures 10-12), or the volume weighted indices (Figures 13-15). Results of correlation analyses for these datasets are summarized below:

Correlation coefficient (r) between the percentage of juvenile smelt in Suisun Bay and fall mid-water trawl index.

Smelt Catch	r	Number	Significance
June	0.10	11	ns
July	-0.33	14	ns
August	-0.27	11	ns

Volume weighted index

June	0.18	11	ns
July	-0.34	14	ns
August	-0.15	11	ns

CONCLUSION

Results of these analyses provide no evidence of a significant relationship between the percentage distribution for juvenile Delta smelt downstream of the Sacramento - San Joaquin river confluence during the summer rearing period and the corresponding index of adult Delta smelt abundance during the fall and early winter. Results of these analyses do not support the hypothesis that the index of adult Delta smelt abundance is high in those years during which a large percentage of the juvenile Delta smelt rearing occurred downstream of the confluence or within Suisun Bay. Although a variety of biological and environmental factors are known to influence the survival and population abundance of Delta smelt, results of these analyses failed to demonstrate a significant relationship between the geographic distribution of juvenile Delta smelt during the summer rearing period and the corresponding index of adult abundance during the fall and winter prior to spawning.

Table. 1. Data used to evaluate the relationship between the percentage of juvenile Delta smelt collected downstream of the confluence during summer rearing and the fall mid-water trawl index of adult abundance.

Year	Month	Percent Downstream of Confluence		Fall Mid-water Trawl Index
		Catch	Index	
70	June	3	3	1678
71	June	34	34	1306
72	June	7	5	1267
73	June	68	68	1146
77	June	1	1	480
78	June	39	35	572
81	June	25	21	375
82	June	89	90	346
86	June	22	19	212
89	June	20	16	366
92	June	12	12	157
69	July	93	94	316
70	July	8	8	1678
71	July	89	89	1306
72	July	2	1	1267
73	July	66	67	1146
75	July	89	86	698
76	July	9	7	338
77	July	1	2	480
78	July	44	38	480
80	July	60	57	1651
81	July	26	22	375
82	July	96	96	346
83	July	99	99	132
86	July	13	13	212
87	July	2	0	280
91	July	1	1	689

Table 1. Con't.

Year	Month	Percent Downstream of Confluence Catch	Index	Fall Mid-water Trawl Index
69	August	60	60	316
70	August	38	35	1678
71	August	84	89	1306
72	August	14	12	1267
75	August	91	88	698
76	August	95	94	338
77	August	2	2	480
80	August	94	94	1651
82	August	89	87	346
83	August	100	100	132
88	August	0	0	126

Table 2. Data used to evaluate the relationship between the percentage of juvenile Delta smelt collected within Suisun Bay during summer rearing and the fall mid-water trawl index of adult abundance.

Year	Month	Percent Downstream Within Suisun Bay Catch	Index	Fall Mid-water Trawl Index
70	June	0	0	1678
71	June	0	0	1306
72	June	2	0	1267
73	June	38	36	1146
77	June	0	0	480
89	June	10	5	-572
81	June	8	3	375
82	June	0	0	346
86	June	7	4	212
89	June	10	5	366
92	June	0	0	157
69	July	67	68	316
70	July	1	0	1678
71	July	46	38	1306
72	July	1	0	1267
73	July	12	13	1146
75	July	44	25	698
76	July	3	2	338
77	July	0	0	480
78	July	39	32	572
80	July	17	9	1651
81	July	5	0	375
82	July	39	35	346
83	July	95	96	132
86	July	1	0	212
87	July	2	0	280
91	July	0	0	689

Table 2. Con't.

Year	Month	Percent Downstream Within Suisun Bay Catch	Percent Downstream Within Suisun Bay Index	Fall Mid-water Trawl Index
69	August	29	29	316
70	August	7	2	1678
71	August	51	66	1306
72	August	2	0	1267
75	August	41	21	698
76	August	31	12	338
77	August	0	0	480
80	August	17	19	1651
82	August	26	15	346
83	August	86	89	132
88	August	0	0	126

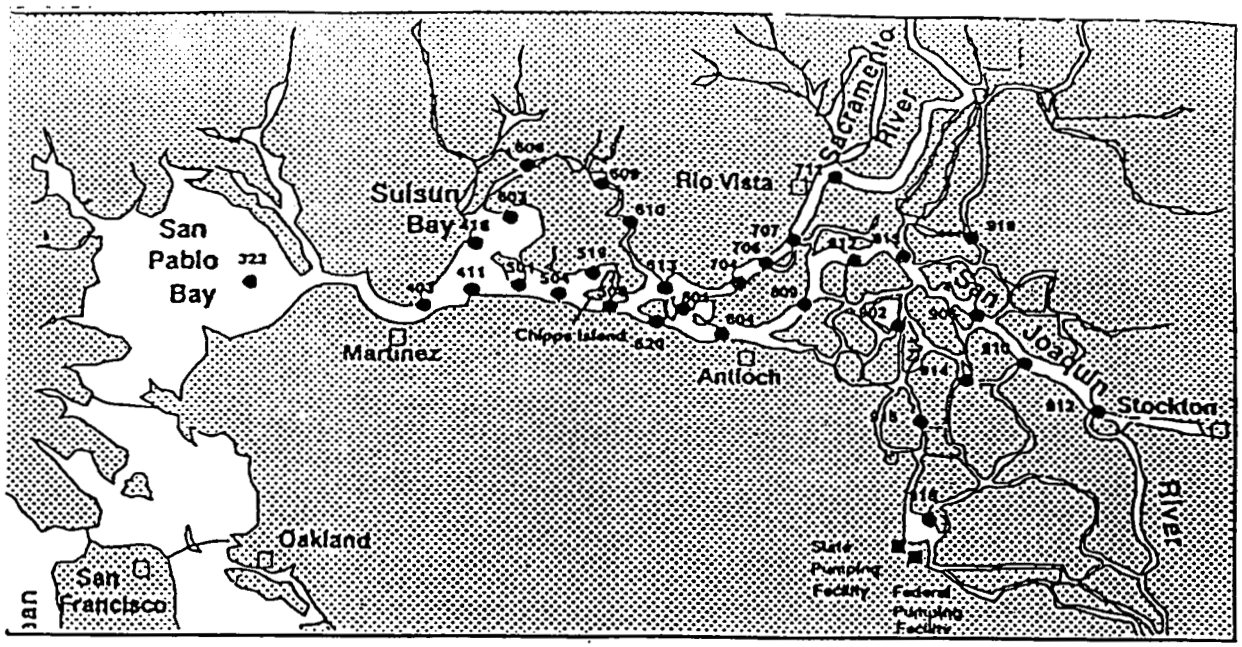


Figure 1. CDFandG summer tow net sampling locations.

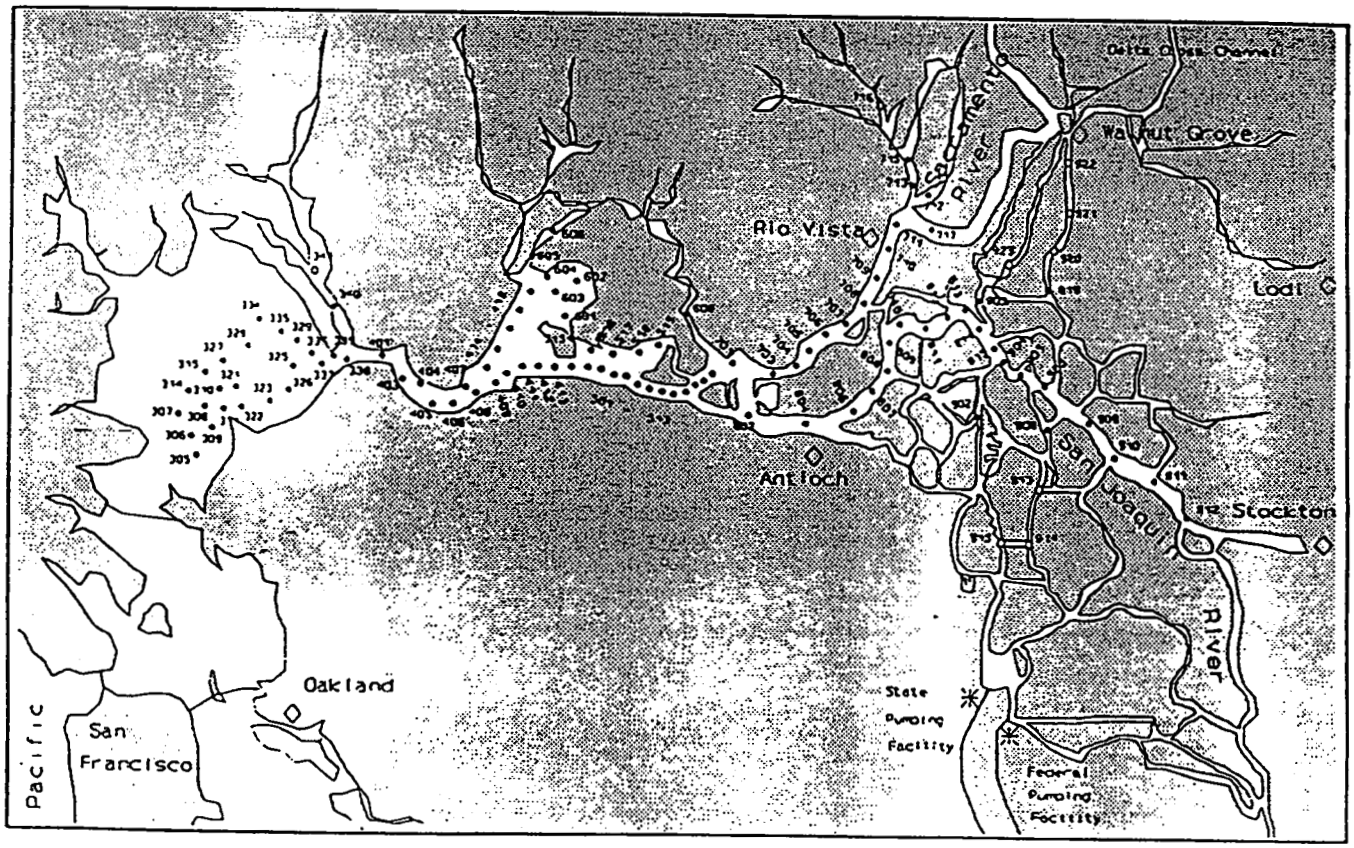
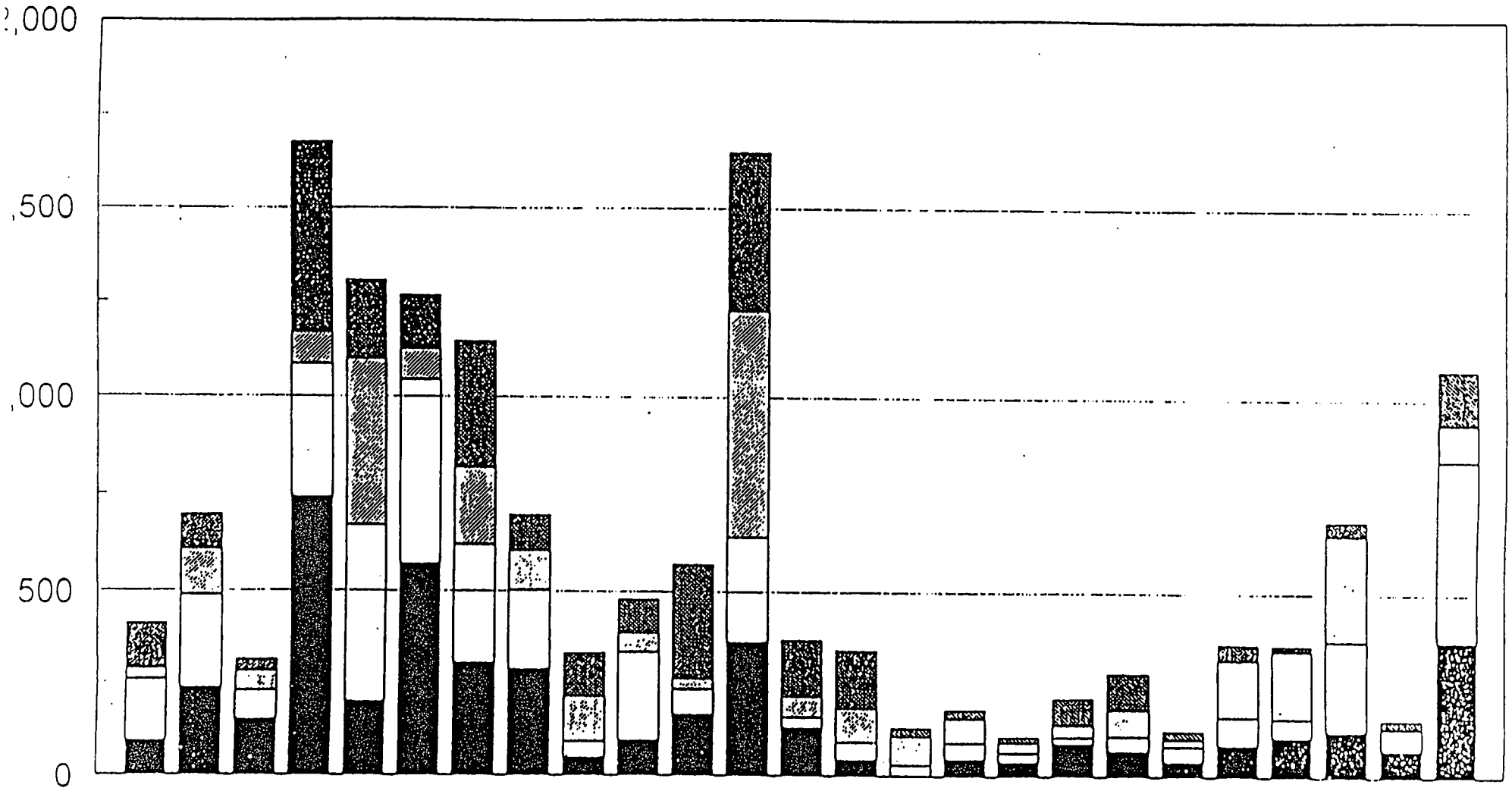


Figure 2. CDFandG fall mid-water trawl sampling locations.

Figure 3. CDFandG Delta smelt fall-midwater trawl abundance index.



Year	67	68	69	70	71	72	73	75	76	77	78	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Sept	90.4	234.7	149.8	741.6	197.4	571.6	307.9	290.5	49.8	97.5	166.9	368.6	132.4	44.8	2.1	47.0	40.7	92.1	71.0	41.6	88.1	109.5	125.9	71.5	374.6
Oct	165.2	253.4	76.8	343.0	473.1	472.0	312.4	213.7	42.2	242.5	64.7	273.7	27.3	47.4	28.0	43.7	23.6	15.1	39.6	40.7	74.7	49.7	249.2	3.5	470.0
Nov	31.1	119.9	55.3	83.1	427.7	81.1	198.2	102.3	120.9	51.7	31.1	586.2	54.2	91.8	77.9	66.6	28.0	33.8	69.5	19.1	157.9	187.6	279.0	57.5	94.4
Dec	12.5	88.7	33.7	509.9	207.7	142.3	327.4	91.3	125.0	87.8	308.9	422.9		162.0	24.3	24.2	16.9	70.9	100.1	24.8	45.5	16.6	35.0	2.4	130.4
Annual	414.9	696.7	315.6	1,677.6	1,305.9	1,267.0	1,145.9	697.8	337.9	479.5	571.6	1,651.4	375.0	346.0	132.3	181.5	109.2	211.9	280.2	126.2	366.2	363.4	689.1	156.8	1,029.4

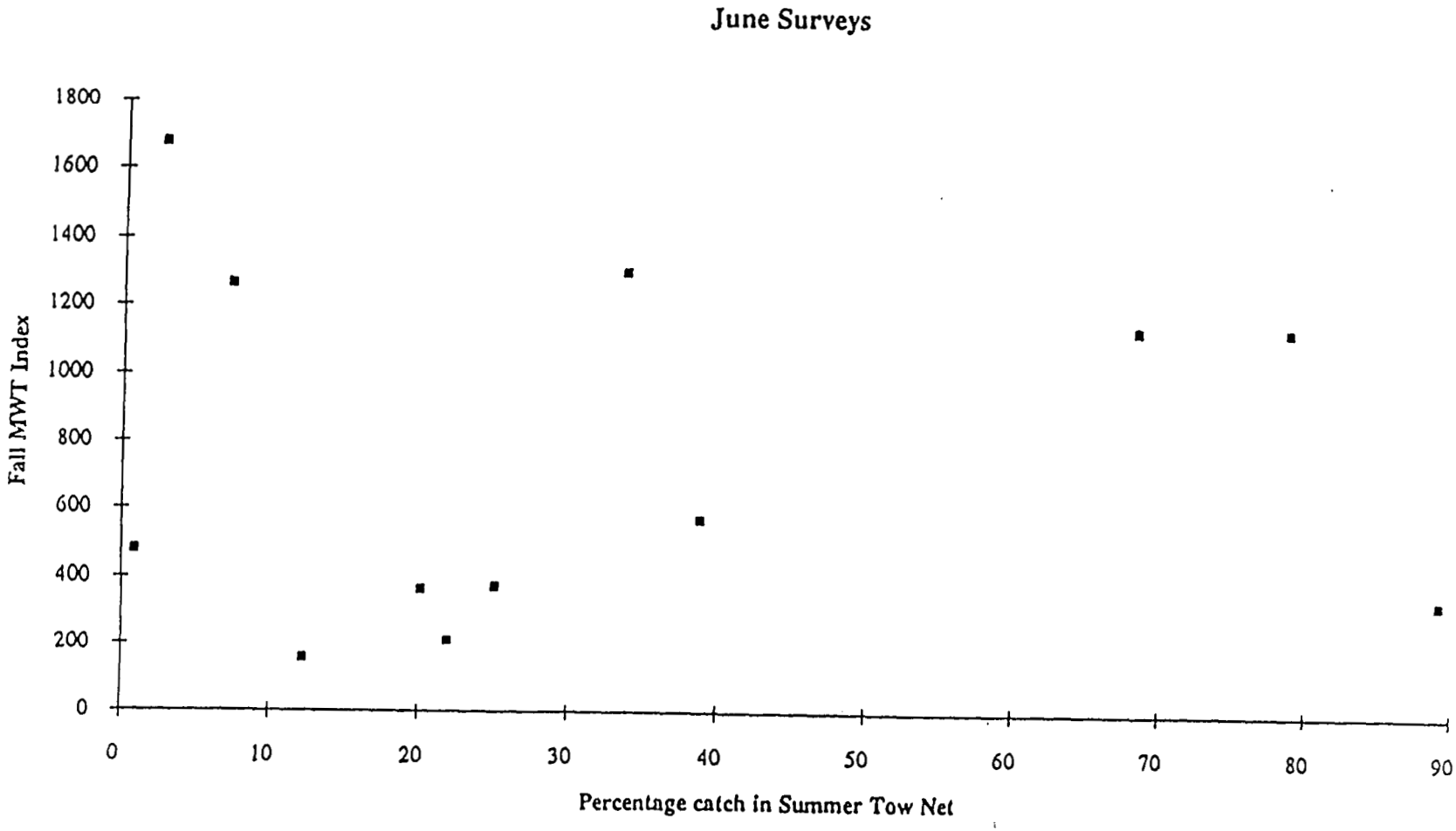


Figure 4. **Percentage of juvenile Delta smelt collected downstream of the Sacramento and San Joaquin River confluence during summer tow net surveys in June and the fall mid-water trawl abundance index.**

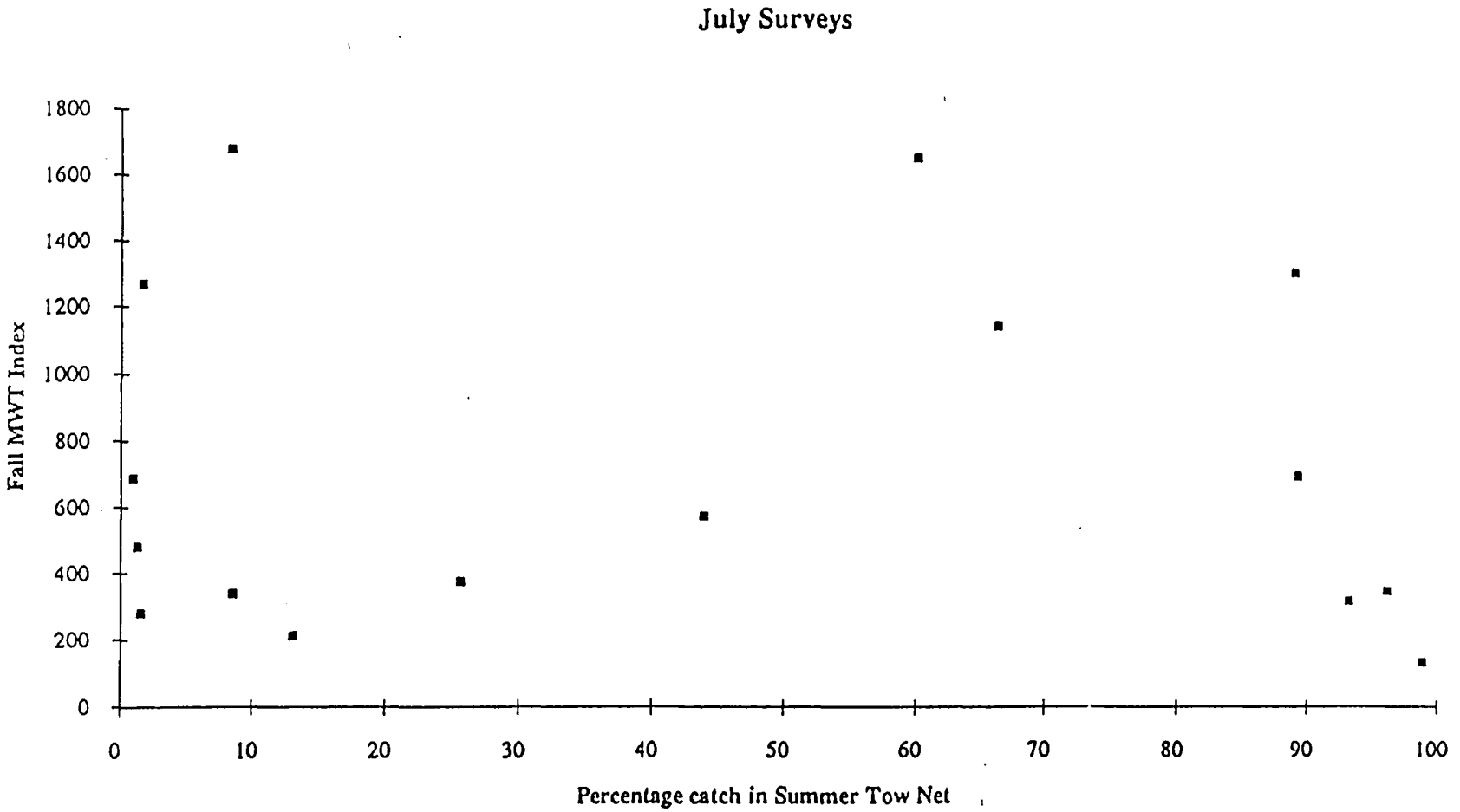


Figure 5. **Percentage of juvenile Delta smelt collected downstream of the Sacramento and San Joaquin River confluence during summer tow net surveys in July and the fall mid-water trawl abundance index.**

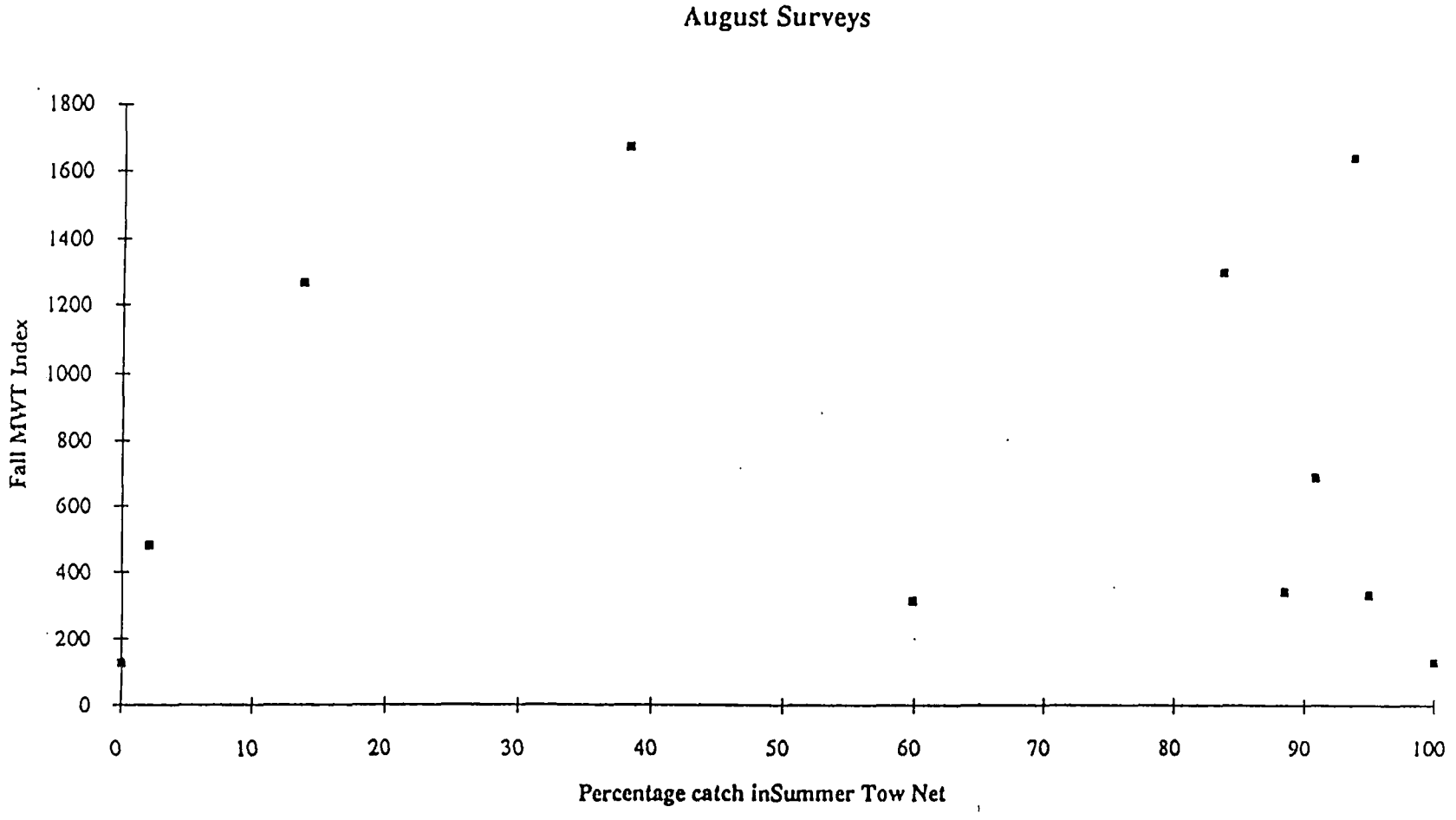


Figure 6. **Percentage of juvenile Delta smelt collected downstream of the Sacramento and San Joaquin River confluence during summer tow net surveys in August and the fall mid-water trawl abundance index.**

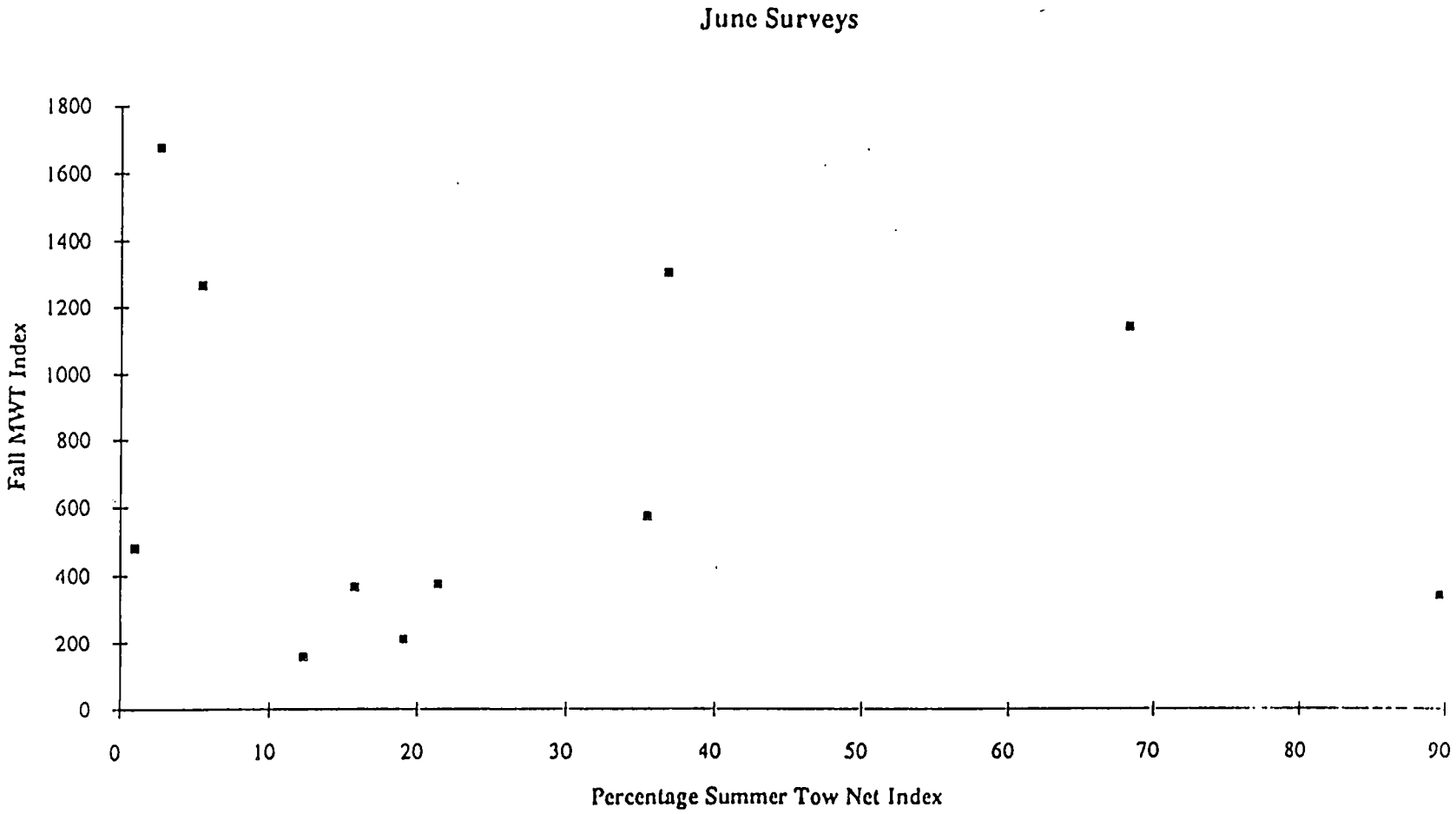


Figure 7. **Percentage of juvenile Delta smelt tow net index downstream of the Sacramento and San Joaquin River confluence during June and the fall mid-water trawl abundance index.**

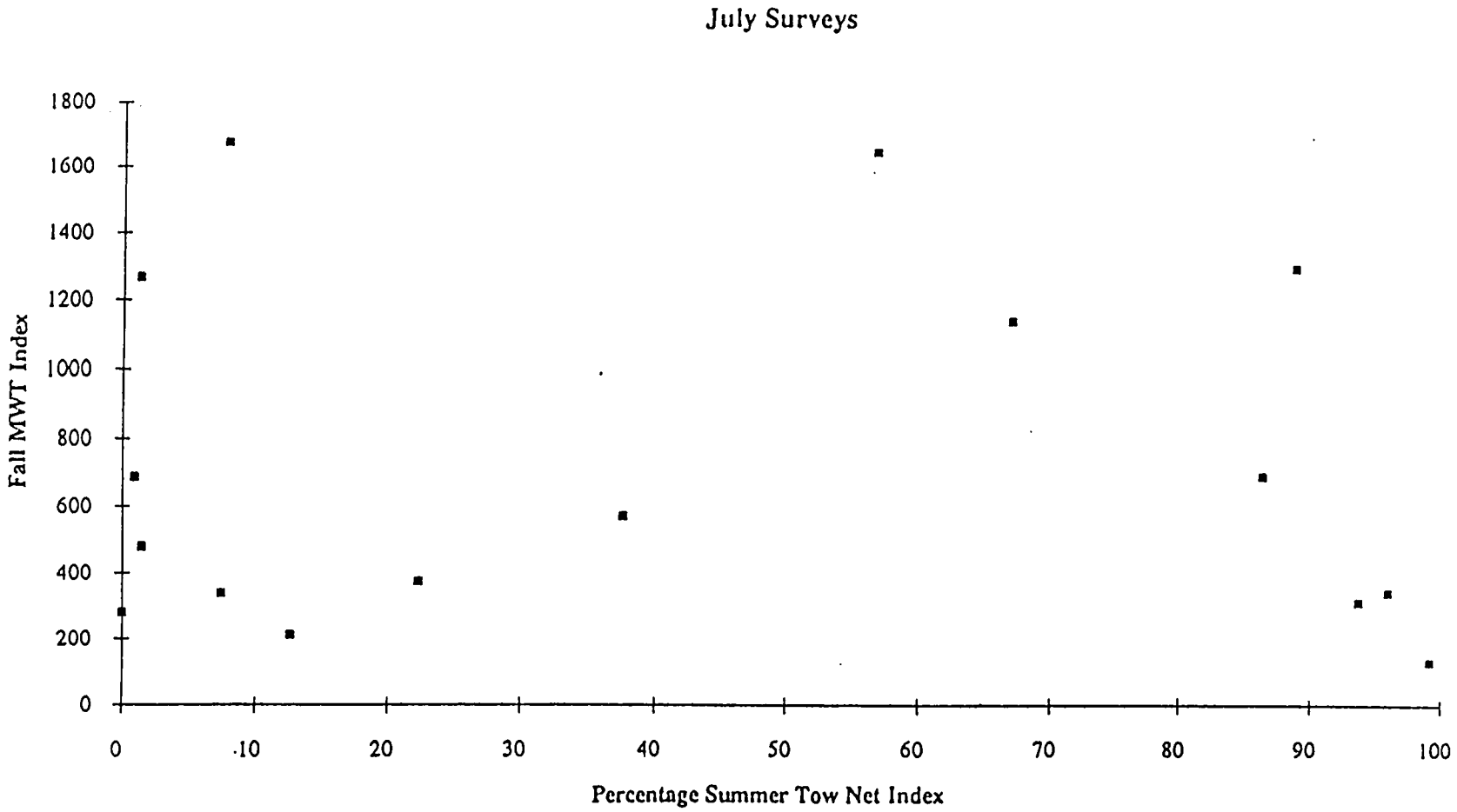


Figure 8. **Percentage of juvenile Delta smelt tow net index downstream of the Sacramento and San Joaquin River confluence during July and the fall mid-water trawl abundance index.**

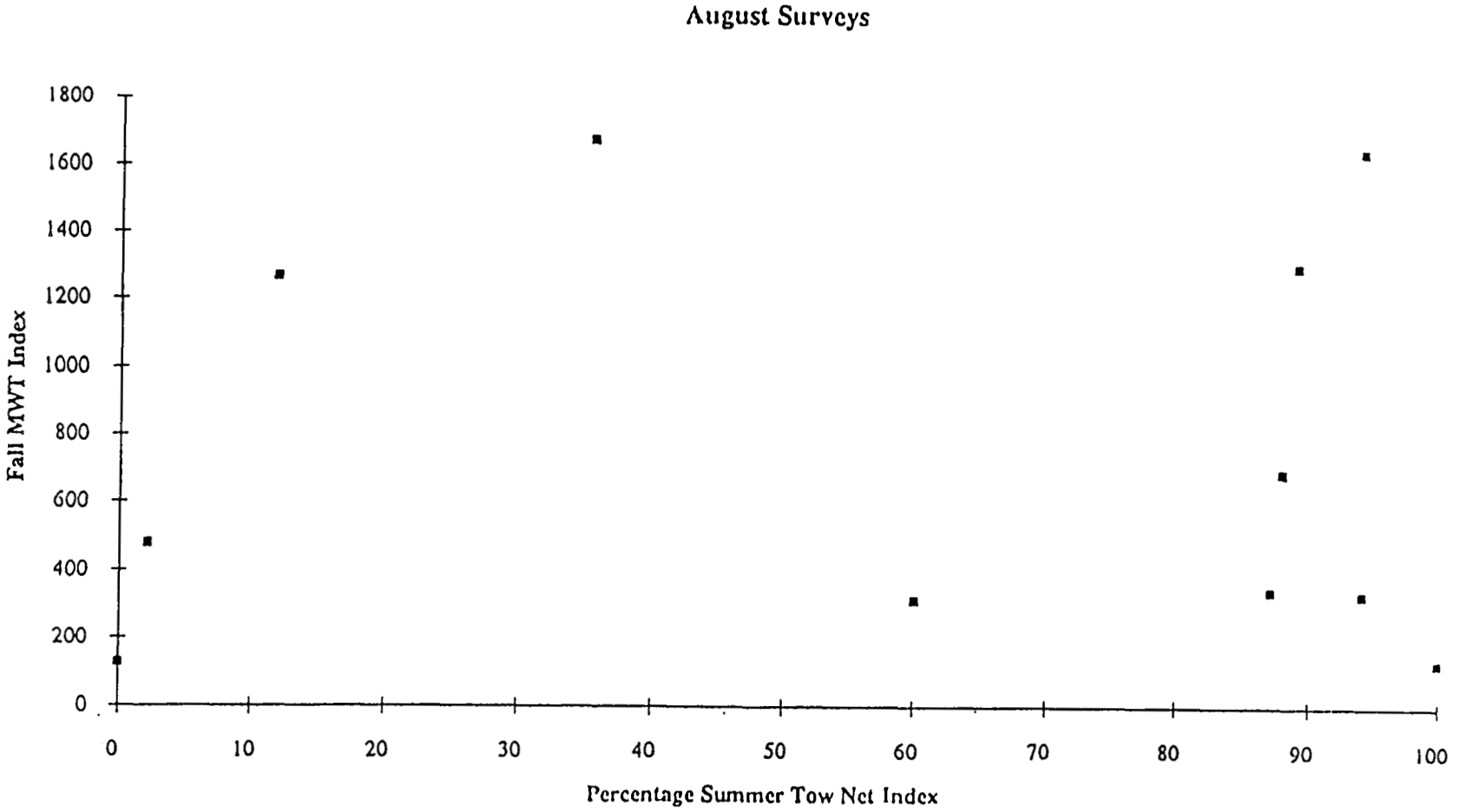


Figure 9. **Percentage of juvenile Delta smelt tow net index downstream of the Sacramento and San Joaquin River confluence during August and the fall mid-water trawl abundance index.**

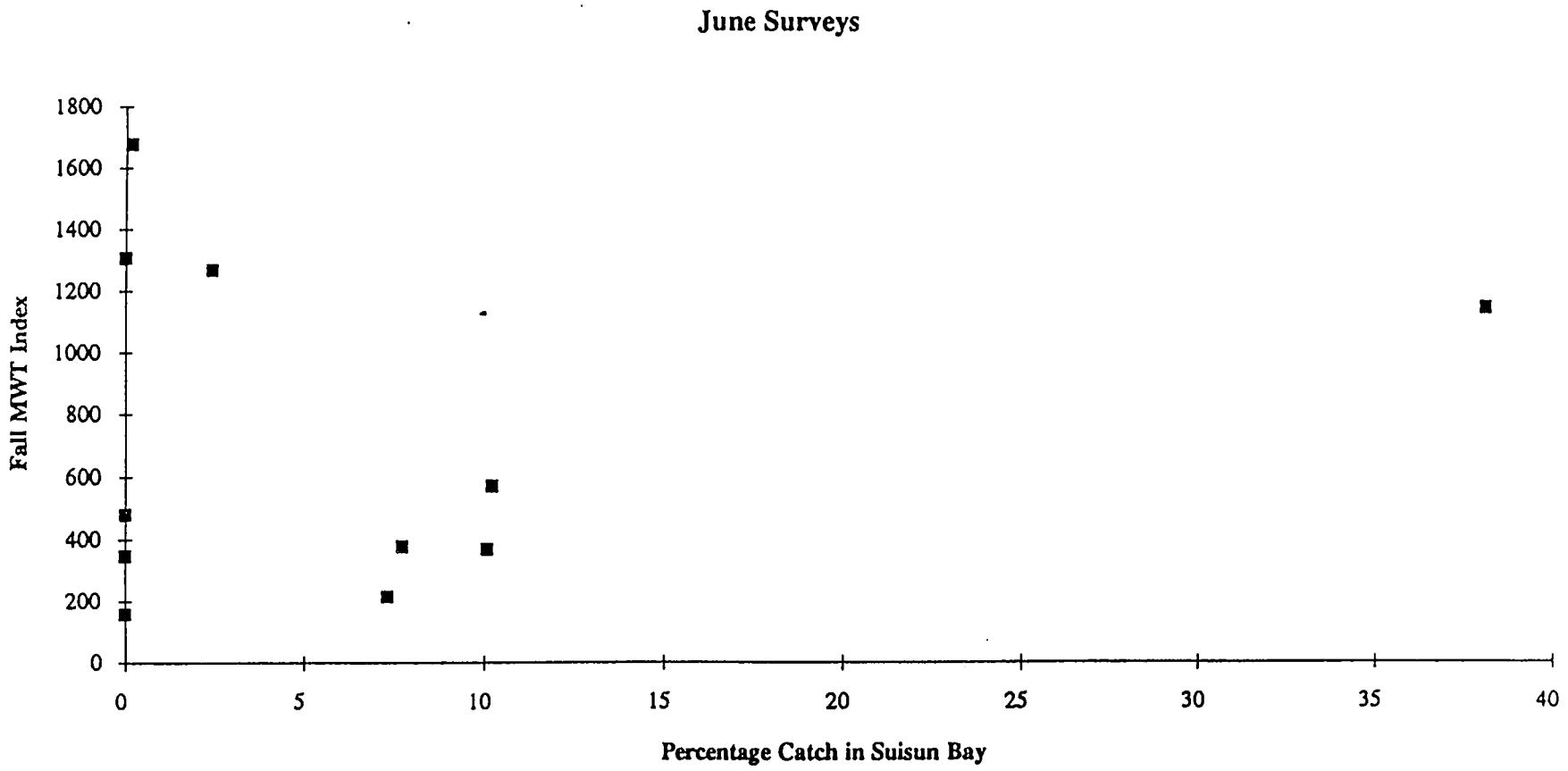


Figure 10. **Percentage of juvenile Delta smelt collected in Suisun Bay during summer tow net surveys in June and the fall mid-water trawl abundance index.**

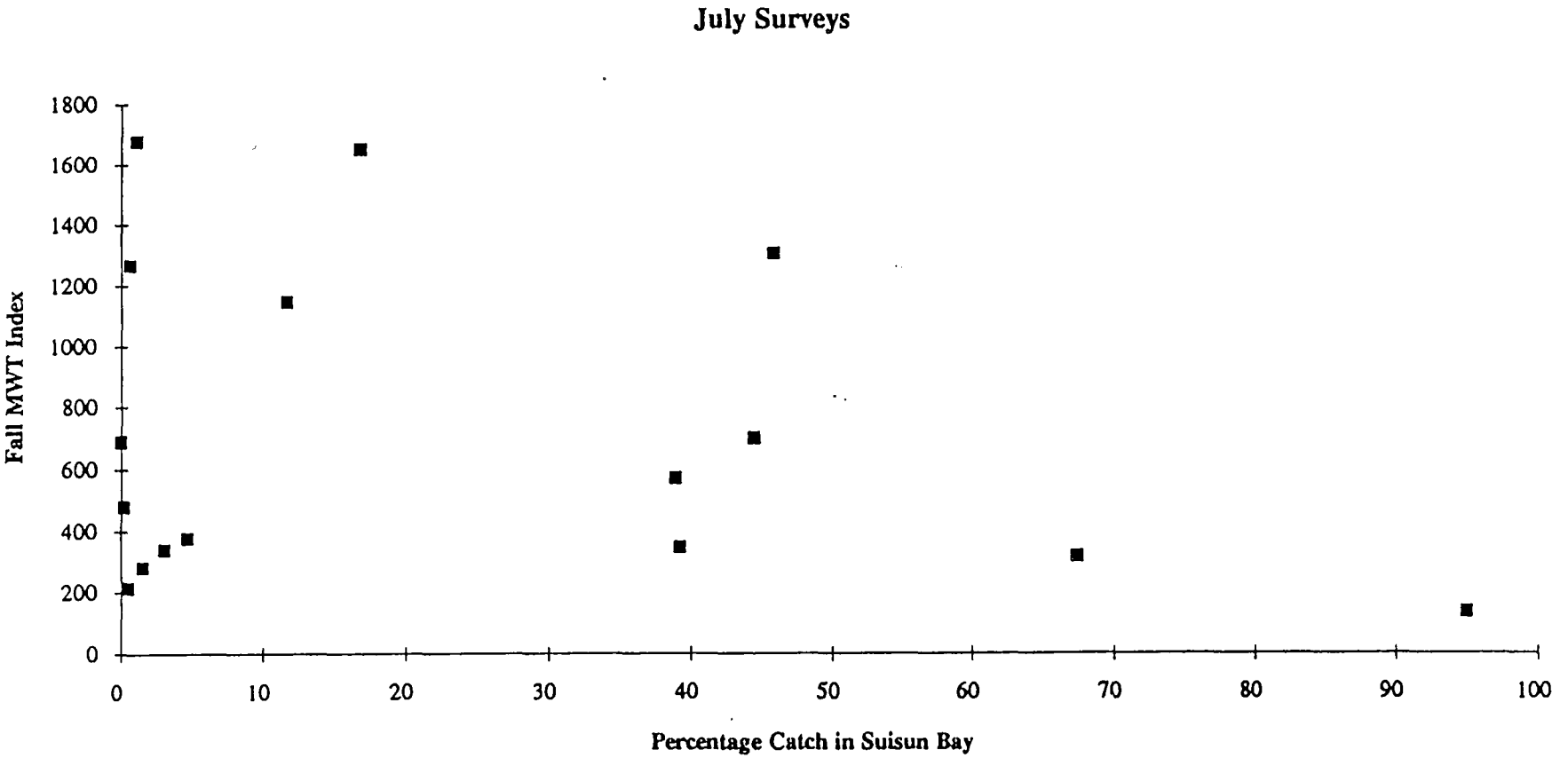


Figure 11. **Percentage of juvenile Delta smelt collected in Suisun Bay during summer tow net surveys in July and the fall mid-water trawl abundance index.**

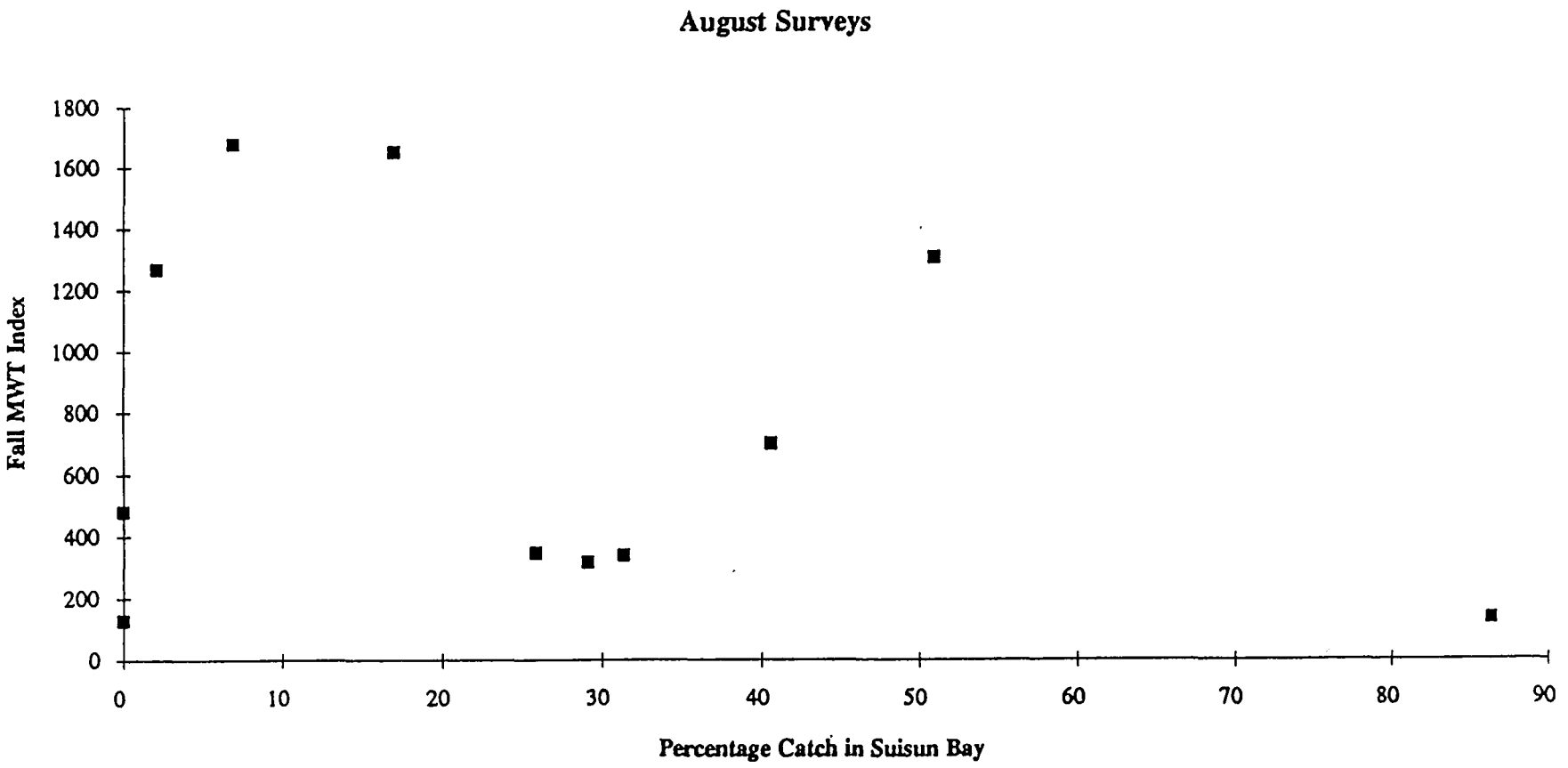


Figure 12. **Percentage of juvenile Delta smelt collected in Suisun Bay during summer tow net surveys in August and the fall mid-water trawl abundance index.**

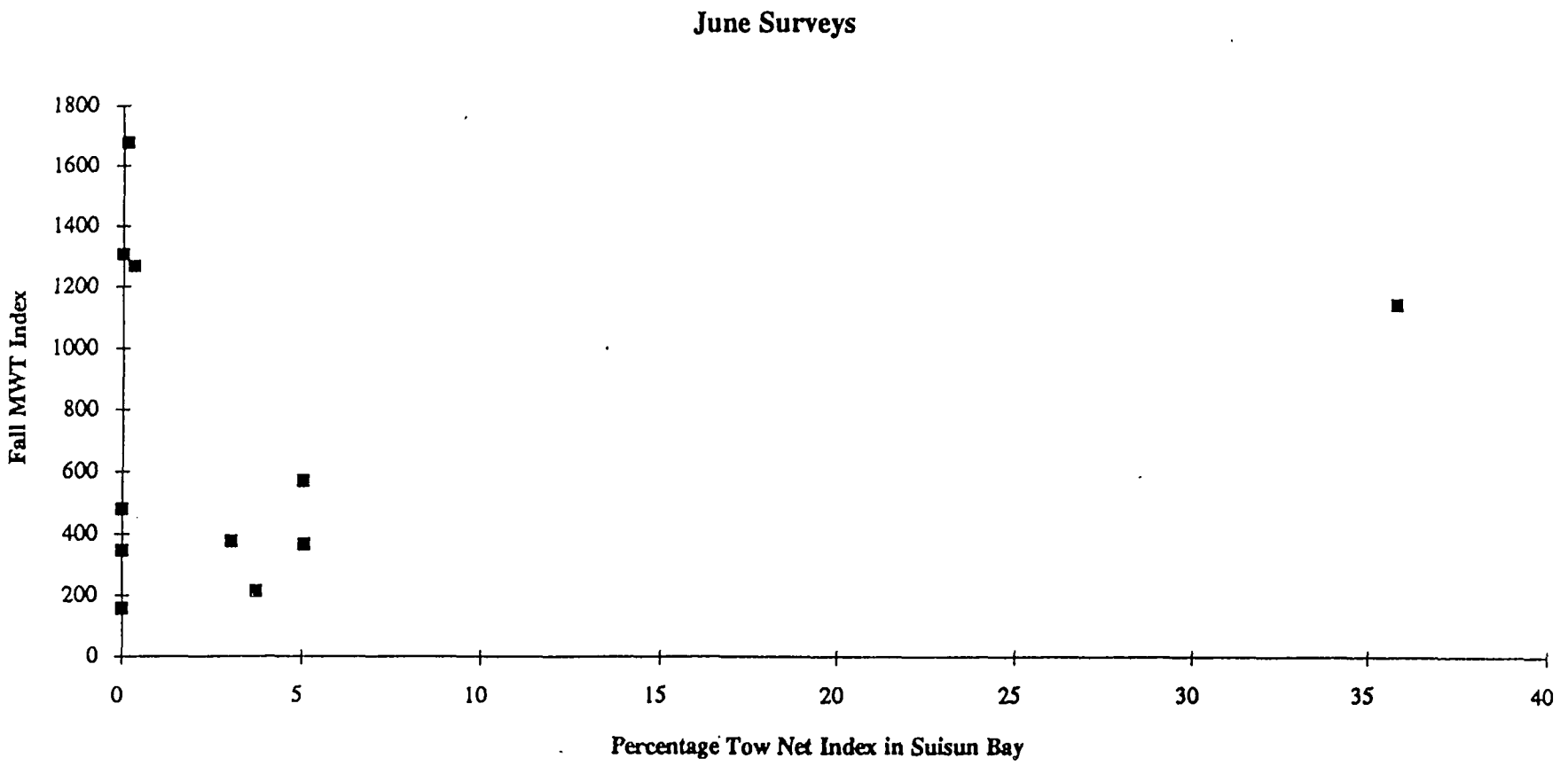


Figure 13. **Percentage of juvenile Delta smelt tow net index in Suisun Bay during summer tow net surveys in June and the fall mid-water trawl abundance index.**

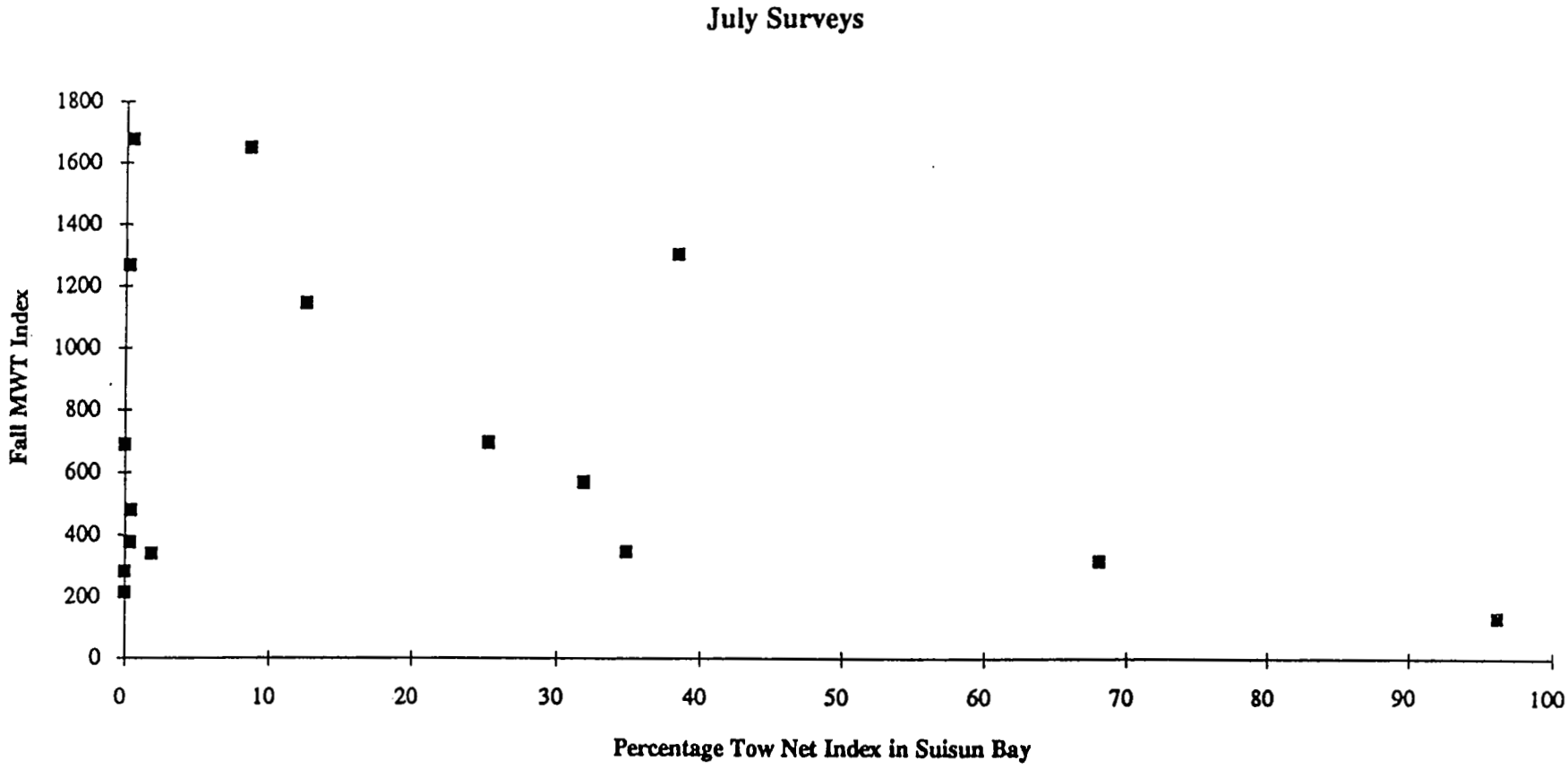


Figure 14. **Percentage of juvenile Delta smelt tow net index in Suisun Bay during summer tow net surveys in July and the fall mid-water trawl abundance index.**

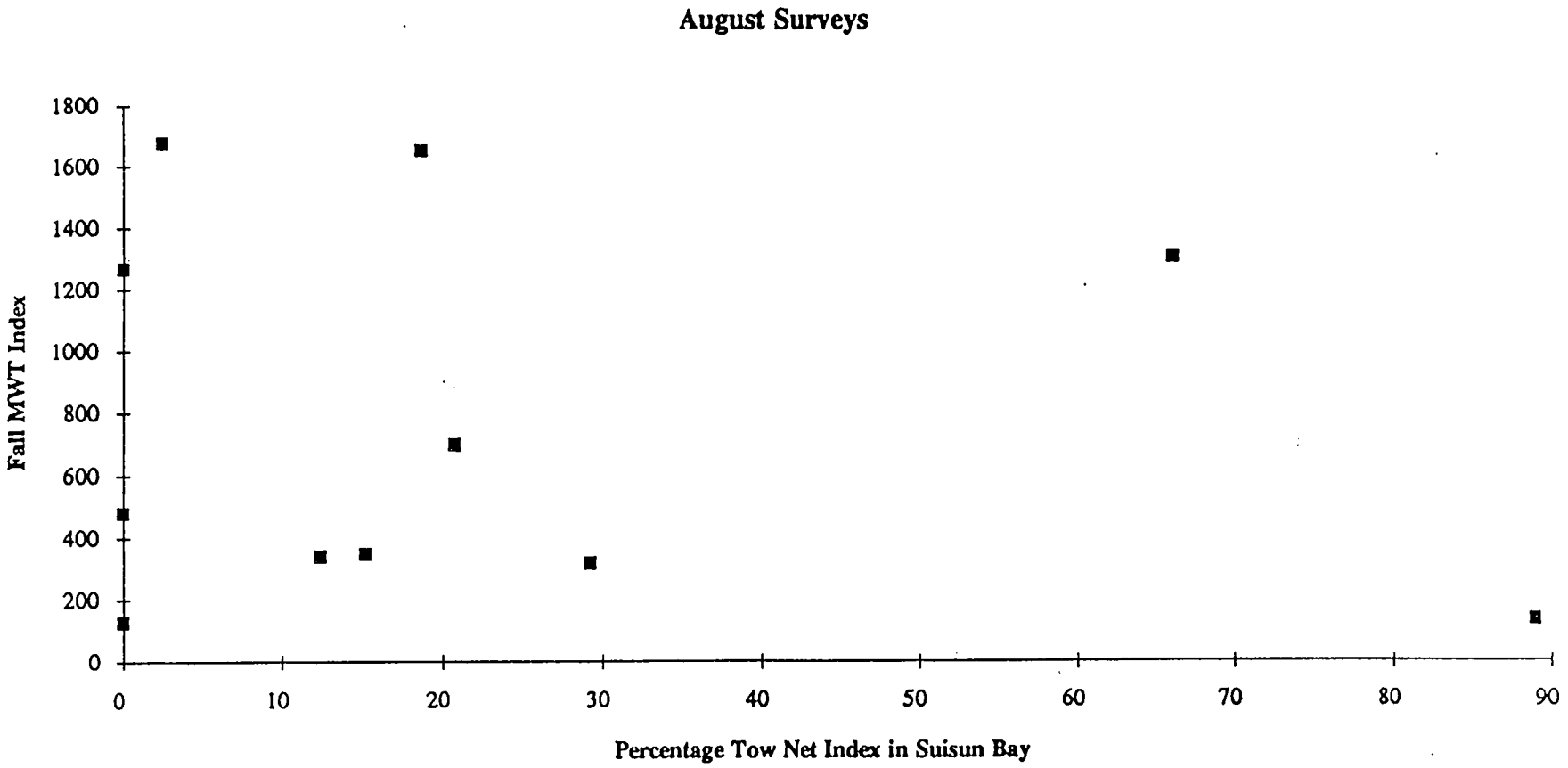


Figure 15. **Percentage of juvenile Delta smelt tow net index in Suisun Bay during summer tow net surveys in August and the fall mid-water trawl abundance index.**