mp-780

PREDATION STUDY REPORT - 1966-1967

by James J. Orsi

Introduction

When young fish are separated from the Peripheral Canal waters and returned to the Sacramento River, piscivorous fish may be attracted to the release point and may prey upon them. To determine if this will happen, how serious the predation will be, and how it may be lessened or eliminated, I carried out predation tests at a fish release site used by the U. S. Bureau of Reclamation.

There were three central questions to be answered: 1) Would predatory fish be attracted to and held at the fish release point? 2) What is the magnitude of the predation, i.e., what percentage of the released fish are eaten? 3) Would several daily fish releases cause greater predation than single releases? The answer to this last question might enable us to decide how many exits the future return system should have.

Description of the Test Areas

The Bureau of Reclamation's Tracy pumping plant releases salvaged fish at 5 sites on the Sacramento and San Joaquin rivers. I chose the site at Jersey Island on the San Joaquin River as most suitable for a predation study. This area is south of Jersey Point, where the shore forms a 3200 foot long concavity. The 30 foot deep main channel, which passes 100-150 feet offshore up and downstream from this concavity, is here 600 feet offshore (Figure 1). The bottom is rocky near the bank, changing to mud approximately 100 feet out. The levees are rock reveted, have little vegetation and are cluttered with driftwood. Ten feet from shore a row of wooden pilings parallels the bank for several hundred feet above and below the release point.

In 1966 I fished for predators at a control site where no small fish were released. This site was on the opposite side of the river (Sherman Island) 400 feet north of the test area (Figure 1). The river is 2800 feet wide at this point. At the control location the bank and bottom are mud with tule beds on shore. The 30 foot contour lies 200-400 feet offshore at low tide.

In 1967 a control site more similar to the test area was used. It is an old, out of use landing, (Curtis Landing) a quarter mile upriver from the Antioch Bridge on Sherman Island and 2.5 miles downstream from the previous control site. It is much smaller than the test area with a 100 foot long row of closely-spaced pilings, 10 to 15 feet from shore. The mud bottom drops to a depth of 20 feet, 100 feet off shore

Methods

The basic method was to release small fish at the test site and gill net for predators both there and at the control sites. To determine if and how the predators would react to different concentrations of fish, two release patterns, single and multiple, were used. During single releases, one truckload of from 10,000 to 100,000 fish was emptied into the river each day whether gill nets were fished or not. Multiple releases consisted of 4 to 11 truckloads and 112,000 to 1,780,000 fish each day (Table 1). The trucks poured the fish into the river 4 feet from shore.

Initially, at the test site, I used a 450 foot long gill net set in a semicircle with its center 150 feet from shore. Predators caught in this net rarely had fish remains in their stomachs. Therefore, I switched to a 250 foot net and set it alongside the pilings from 100 feet above the release point to 130 feet below. Its center was 10-15 feet from shore at the release point (Figure 1). The net was 12 feet deep and was divided into 50 foot long panels each of a different mesh size. The stretched mesh sizes ranged from 2-1/2 to 4-1/2 inches by 1/2 inch increments. At the Sherman Island control site I fished the same net parallel to and 100 feet from shore. The water was too shallow to place it any closer.

Two days a week I set the net in the test area at the same time fish were released from the tank trucks. I then took Secchi disc readings, water temperature and water samples and noted tide and weather conditions. Current meter readings were made several times in 1967. These same observations were made at the control site and a net set there 15 minutes after the test area.

After two hours, I would retrieve the nets, measure the fork lengths of fish of predatory species, dissect them, preserve in formalin the remains of small fishes eaten, and note the presence of other food. Number, species, and total lengths of fish eaten were determined when possible.

I wanted to electrofish to determine the total number of predators in the area. However, in 1966, salinity was too high for this method to work. In 1967, electrofishing was carried out on one occasion.

Six net sets were made during the multiple release period and 7 during single releases. That more sets were made during single releases should be kept in mind when reading the results for multiple and single releases.

1966 Results

Predation: Test vs. Control Site

Predation was greater at the test site during the entire sampling period as regards both predators caught and fish eaten. More than 7 times as many predators were caught at the test location as at the control, and there were almost 80 times as many fish in predator stomachs at the test site (Table 3).

Large black crappie catches (115) accounted for the heavy test site predation. Aside from crappie, predator catches were similar at both sites. Eleven striped bass and 6 squawfish were taken at the test and 11 bass and 5 squawfish at the control. Only two black crappie were found at the latter site (Table 2).

Most of the predators at the test location (89%) had eaten recently whereas at the control only 39% contained fish remains. Disregarding black crappie, the proportion of actual predators (those containing fish remains) was similar at both sites (Table 2).

There were no meaningful differences in the sizes of predators caught at each site. Crappie ranged from 13 to 28 cm fork length, all but two were longer than 16 cm. Squawfish measured from 33 to 61 cm, except for a single 26 cm individual. Fifteen of the 22 striped bass were immature and ranged between 25 and 36 cm fork length. The length distribution of striped bass at the two sites was very similar.

Predation: Multiple vs. Single Releases at the Test Site

The number of predators caught and the number of fish eaten were significantly higher during multiple than during single releases (Tables 4 and 5). The differences in the number of predators captured, actual predators, total number of fish eaten and average number of fish eaten per predator were all statistically significant at the 1% level using a test for the difference in sample means. t-test

- Species Composition of Prey

There was no indication of selective predation. True, during multiple releases at the test site 90% of the prey were striped bass. But this reflects the approximate percentage of striped bass among the fish released. During single releases the percentage of bass among released fish declined to an average of 80%, and correspondingly to 75% among fish consumed by predators. Other small fish eaten were, in order of importance, white catfish, American shad, threadfin shad and carp.

refers to test site releases?

At the control location, striped bass were the only fish eaten during multiple releases. Predator stomachs were always empty during single releases.

Prey Size

The size of the prey fish increased as the summer wore on. During multiple releases at the test site, the prey averaged 23 mm total length (range 12 to 65 mm). During single releases the average rose to 33 mm (range 15 to 115 mm). Growth of striped bass and the appearance of large American shad in the releases caused this size increase.

On July 12 we obtained indirect evidence that released fish were the principal source of prey. No fish were liberated on this day and none of the 39 predators netted contained small fish.

Environmental Factors

Other variables may have affected the size of the predator population at the test site. Chief among these is TDS or total dissolved solids (Table 6). The TDS level increased as the summer went on, and fluctuated daily with the tide. TDS might have affected predator abundance because black crappie are freshwater fish, and hence might be repelled by high TDS concentrations. However, the correlation coeffiicent for the relation between TDS and predator catch is -0.14, which is not significant at the 5% level. In addition, no TDS level encountered appeared to cause a decline in predator catches.

Water temperature and visibility (Table 6) varied little during the sampling period. Average temperature held fairly constant near 22°C. during both heavy and light releases and between the two sites. Visibility was very limited. It varied more than temperature but not enough to explain the catch differences between heavy and light releases and between the test and control sites. Nor did it change enough to determine its affects on predation, if any. It is noteworthy that predatory fishes fed effectively despite the poor visibility (Table 6).

The weather was almost always sunny and clear. I did not measure current velocity in 1966 (dependent upon tidal stage), but the consistent catches of predators under different tidal conditions during multiple releases indicate it was not a significant factor.

1967 Results

Fishing Schedule

Twelve nettings were made in 1967 from June 13 to July 28. The first two before fish releases began, four each during single and multiple releases and two more after releases ended. The sets before releases started caught one empty squawfish. Those made after releases stopped captured none (Table 7).

Predation: Test vs. Controls

Because of the clear-cut difference in predation between test and control sites in 1966 only two sets were made at the Sherman Island control and one at the Curtis Landing control, plus one electroshock sampling at the latter site.

As in 1966, predation at the test site was much greater than at either control. The two nettings at Sherman Island landed one squawfish and one small striped bass, neither of which had fish in their stomachs. At the Curtis control, one tule perch was caught and one white catfish was electroshocked.

This contrasts with the test location catches of 44 predators on the two days the Sherman Island control site was fished and 105 predators the day Curtis Landing was sampled with nets. Electrofishing at the test yielded 4 predators.

The major predator species at the test location was striped bass. Black crappie ranked second, followed by white catfish, squawfish, largemouth bass, and bluegill, in that order (Table 8).

Although the striped bass and crappie were similar in length to those caught in 1966, the bass showed marked size variations from catch to catch during 1967. On July 4, the first day striped bass were netted in large numbers, the median length was 30 cm. On July 10 and 14, bass over 30 cm accounted for only 10 and 13% of the catch respectively. But July 19 results revealed an influx of large bass: 65% were larger than 30 cm and 22% were over 40 cm.

Statistical analysis revealed that the average lengths differed significantly between several sampling days, for instance, between July 10 and July 19.

Predation: Multiple vs. Single Releases at the Test Site

In 1967, as in 1966, predation was again greater during multiple than during single releases. Significant differences occurred in the number of bass and crappie caught, in the number of actual predators, and in total number of fish eaten. However, the average number of fish eaten per predator dropped from 6.0 during single to 4.1 during multiple releases (Table 7).

Species Composition of Prey

As in 1966 there was no evidence of selective predation. In 1967 the Tracy facility collected few small striped bass. The Tracy personnel classified most of the fish (50-70%) as miscellaneous species. This category includes carp and other cyprinids which were present in high percentages (50%+) in predator stomachs. Other species found in predator stomachs were threadfin and American shad, hitch, striped bass and black crappie.

Prey Size

The average size of the fish eaten increased slightly during multiple releases, rising from 48 to 54 mm total length. In 1966 the size increase was greater (10 mm) and the prey were smaller (23 to 33 mm). The large numbers of carp in 1967 accounted for the greater size of prey fish in this year and the nearly complete absence of American shad explains the small increase in size during multiple releases.

Predation Differences between 1966 and 1967

The major predation difference between the two years was a 1967 average of 21.6 striped bass caught per net set versus a 1966 average of 0.9. In addition, in 1966, the mean number of fish found in predator stomachs was substantially greater during multiple releases (21.9 vs. 3) (Table 4). In 1967, more fish were eaten per predator during single releases (6 vs. 4.1) (Table 7). Minor variations included 8 actual predators among the 15 white catfish landed in 1967, as compared to none in 1966 (nonpredatory catfish were present in 1966), and an average of 5.2 crappie landed per net set in 1967 versus 8.7 in 1966.

Environmental Factors

In 1967, the average temperature was virtually the same as in 1966, i.e., 22°C. Visibility was somewhat better, about 31 cm as compared to 27 in 1966. Due to high river flows however, the TDS was much lower, averaging 161 ppm for the entire sampling period versus 953 ppm in 1966. There was once again no correlation between TDS and predator catch and it is doubtful that the different TDS values between 1966 and 1967 can explain the catch differences in these years. Current velocities were below 0.4 fps, not strong enough to discourage predation.

Discussion

Explanation of Predation Differences

Why were there so many bass at the test site in 1967? It is possible that chance movements of migrating bass brought them to the test area independently of fish releases. The changing size composition of the bass catches points towards an unstable population. Quite possibly fish were moving into and out of the test area. The sudden disappearance of almost all of the bass on July 20 (before releases ended) supports the migration hypothesis.

Why white catfish added fish to their diet only in 1967 is difficult to explain. Possible reasons are a scarcity of other food and greater vulnerability of carp to predation.

The higher average black crappie catches in 1966 may have been caused by the longer multiple release period of that year, which might have allowed the crappie population to reach greater levels.

Two facts may be responsible for the drop in the average number of fish eaten per predator during multiple releases in 1967. The number of prey released increased only three times over single releases whereas the predator population rose six times. Thus, competition for prey must have been greater and may well have caused the number of fish eaten per predator to decline.

Answers to the Three Basic Predation Questions:

Question 1: Were predators brought to the release point and held there by the release of young fish?

It is not reasonable to believe that predatory fish a considerable distance away from the release point (more than a quarter mile for instance) would follow the young fish back to their point of origin. If predators find good feeding on young Tracy fish downstream from the release site, what would make them swim upstream to the release area itself? A concentration gradient of fish perhaps, but it would have to be well defined to provide any strong directional attraction. During single releases such a gradient would not exist. During multiple releases it might, but only in the immediate release area.

The gill net catches sometimes showed a clumping of predators at the middle of the net where the young fish were released. But predators so caught were probably within a hundred feet or so when the trucks poured the fish into the water and attracted them.

However, predatory fish randomly moving along the river will eventually strike the release zone. Once in it, they may stay there because of the good feeding, and a resident predator population will develop.

The answer to the question is, therefore, predators are not attracted to the release area but once in it they are more likely to remain there than to move away.

Young striped bass may be an exception to the above statement. They are migratory and may not stay in one area very long even when they find good forage. The 1967 catches showed an arrival of stripers on or before July 4 and a sudden departure on July 20. In addition, the size composition of the bass catches changed significantly during this period. The conclusion I draw from these size changes is that the bass population was in flux, that the fish were moving into and out of the release area. Hence, there was no resident striped bass population; the bass were not held in the release area in spite of the presence of forage fish.

Question 2: What is the magnitude of the predation? What percentage of the released fish are eaten?

The question cannot be answered with precision because: (1) the size of the predator population is unknown; (2) the average number of fish a black crappie or striped bass can eat in one day is unknown. On the grounds that a reasonable predation estimate is better than none, I will give such an estimate.

Size of the Predator Population

We must first consider the size of the predator population. Electroshocking at the test area came too late to make a population estimate. Special sets in 1966 to mark crappie in order to obtain an index of abundance caught 18 crappie, none of which were recaptured. We must therefore use the regular catch figures. The largest single catch of crappie in either year was 38 in 1966. The peak single catch of striped bass was 98 in 1967. Assuming that we catch 1 in every 10 fish present in the area, we obtain a maximum population estimate of 380 crappie and 1,000 bass. The average population is lower: 100 black crappie and 550 striped bass.

Average Number of Fish Eaten per Predator per Day

A second important factor is the number of fish eaten per predator. The size of the fish eaten regulates the number of fish a predator can eat. In 1966 the major prey species was striped bass, 23 mm average total length. In 1967 carp predominated in the predator stomachs. They averaged about 52 mm total length. Volume increases with the cube of the length and the prey length more than doubled in 1967 over 1966. Hence, a 52 mm carp would equal more than eight 23 mm striped bass. Therefore, the mean number of 2.6 fish eaten per black crappie (actual predators) in 1967 during multiple releases, approximately equals the mean number of 24 per crappie found in 1966.

Not enough striped bass were captured during multiple releases in 1966 to compare with 1967 catches. However, bass ate an average of 8.4 fish during single releases which can be compared with the crappie average of 3.3 for this same period. Hence, bass between 22 and 40 cm fork length can consume 2.5 times as many fish as crappie on the average.

Since young striped bass are much more important to the Delta fisheries than carp, we will concern ourselves with the probable number of small stripers that black crappie and striped bass can eat in a day. In 1966, the maximum number of fish in a crappie stomach was 87; counts of 40 and 50 were common. Most of the fish eaten were undigested, hence not in the stomachs very long. Therefore, an individual crappie could presumably eat several times the average figure in one day, perhaps 100 or 150 fish. The average numbers for striped bass will be 200 to 300 fish, on the conservative side.

Some Predation Estimates

Population Size*		Average Number Fish Eaten/Predator	Total Eaten
Maximum	1400	171 to 257	240,000 to 360,000
Average	650	171 to 257	111,000 to 167,000

*Black crappie and striped bass.

These totals amount to over 10% of the fish released per day during multiple releases of 1 million fish/day. However, over 80% of this predation is caused by striped bass, and as in 1966 they may not enter the release area in large numbers. If they do, then they may simply stay for a time and leave as they did in 1967. Thus, the predation figures are probably high.

These predation estimates must be viewed with caution. They are reasonable estimates for the Jersey area. Their accuracy depends heavily upon the 10 to 1 predator present to predator caught ratio. This ratio is a reasonable guess but nothing more. Even if the estimates are good for Jersey we still do not know how large a predator population can build up on the Sacramento River where environmental conditions are different.

We do have some information on striped bass predation at the Courtland Bridge on the Sacramento River. Don Stevens (personal communication) noted large numbers of sublegal bass feeding on salmon during June, July and early August of the years 1961 and 1963. The salmon came from Nimbus Hatchery on the American River 30 miles upstream from Courtland. The striped bass massed in schools of several hundred individuals spread across the surface of the river, except during peak currents when high velocities pushed them out of the midstream area where they usually concentrated. Stevens marked approximately 500 of these bass in 3 days but recovered only 1 and that downstream from the bridge.

This data indicates that heavy striped bass predation can occur in the Sacramento River in the region of the future exits; that predation can be serious downstream as well as at the release point; that high current velocity discourages predation.

Question 3: <u>Will multiple daily releases cause greater predation than single daily releases, and how will this determine the number of exits in the future return system?</u>

<u>1966 Data</u>:

When the average number of fish released/day increased	16x
the average number of predators caught/day increased	2x
while the average number of fish eaten/predator/day increased	7x
and the average number of fish eaten/day increased	14x

Therefore: 1) the predator population (black crappie) did not increase in proportion to the increase in prey population.

2) but the number of fish eaten did increase in proportion to the increase in the prey population.

<u>1967 Data</u>:

When the average number of fish released/day increased	5x (most often 3x)
the average number of striped bass caught/day increased	7x
the average number of black crappie caught/day increased	4x
the combined number of predators/day increased	6x
while the number of fish eaten/day increased	4x
and the number of fish eaten/striped bass/day decreased	.37x
and the number of fish eaten/black crappie/day decreased	.04x
and the number of fish eaten/both predators/day decreased	.3x

Therefore: 1) the bass population increased more than the prey population did, but this is possibly due to chance movement of migrating bass.

2) the crappie population rose approximately as much as the prey population, contrary to 1966. But in 1966, the average number of fish released increased 16x. In 1967 the increase was only 5x.

3) the number of fish eaten per day increased in proportion to the number of fish released, as it did in 1966.

4) from the multiple and single release data of both years, we might conclude that the more fish released the more fish eaten. But the percent of fish liberated that are eaten apparently remains stable regardless of the number of fish released (within the limits of the number of fish released/day at Jersey at any rate) because the number of fish eaten per day is in proportion to the number of fish released.

Predation Model

Let us construct a predation model using the 1966 data. We may assume that the number of predators that can establish themselves at a fish release site is limited by: 1) the size of the area in which the predators can find suitable habitat; 2) the number of predators that chance to pass thru the area.

From this we might deduce that the more release points there are, the higher will be the combined number of predators.

The maximum number of release sites we could build is probably 5. The maximum number of fish we will get should be considerably higher than the 1966 high of 1 million/day at Tracy. For convenience, let us estimate an average of 3 million/day during a one month peak. This is 600,000 fish per exit, close to the 1966 Jersey Island average of 760,000 fish/day during multiple releases.

Let us assume that the predator population is at a maximum when 600,000 fish per day are released. Further increases in fish liberated will not raise the predator population size. (There is some evidence from 1966 Jersey results to support this assumption.) Then we can construct the following predation model:

Number Exits	Number Fish Released Per Day	Predator Population*	Number Fish Eaten Per Predator Per Day	Total Daily Predation Mortality
5	600,000	500 (100 each exit)	22**	11,000
1	3,000,000	100	51***	5,100

From the model we might conclude that a single exit would give significantly less predation mortality than multiple exits. However, when releases were stopped at Jersey Island on July 12, no predators were caught on July 24 and July 28. This indicates that predators may drift away when the forage becomes poor. Hence, it would be better to have multiple exits used infrequently and randomly to prevent a predator population from establishing itself.

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* Figures chosen for convenience, have no factual basis.

** Number eaten per predator per day at Jersey Island during multiple releases 1966.

*** This assumes an increase of 2.3x in number of fish eaten per predator. It is derived from Jersey Island results.

Conclusions

Two years' work on the San Joaquin River has produced some but not all of the necessary information from which to derive firm conclusions for the return system. There is good reason to believe that striped bass will be the principal predator on the Sacramento River as they were in 1967 on the San Joaquin. Black crappie and other species should be of minor importance.

We can say that black crappie habitat, i.e., pilings and similar obstructions, is an unfavorable site for return system exits. From the disappearance of predators upon the cessation of fish releases we can conclude that infrequent fish discharges are to be preferred to daily releases. The data derived from the predation model make multiple exits (more than two) unjustifiable.

However, we cannot say anything about the effects of current velocity on predation beyond noting that Stevens found high velocities (how high?) discouraged striped bass predation. Nor can we state how effective stream bottom releases would be as a predation deterrent or as a means of dispersing the small fish across the river. Finally, if a two exit system is adopted, we have no information to tell us how far apart the exits should be located.

Recommendations

I recommend a two exit system. The second exit would be a safety in case of damage or obstruction in the first. It could also be used to permit infrequent and random releases. The exits might be placed on the bottom in midstream where current velocities may be higher than along the shores and where darkness might discourage predation. Tests should be made at Horseshoe Bend in 1968 to obtain information on bottom releases. However, the large predation differences between 1966 and 1967 at Jersey Island indicate that a single year's work might not be enough to obtain a true picture of predation on the stream bottom. Nevertheless, it should be attempted.

The following recommendations are my opinions rather than conclusions based on my work at Jersey. They should be verified where possible.

If the exits are placed on the bottom, they should be a quarter mile apart at a minimum and in a stretch of river where current velocities are considerably higher than the average. In addition, a third "sampling" exit might be built on shore in order to check fish survival, species composition and other information of interest.

If the release points are constructed on shore, they should be on opposite banks, a minimum of a quarter mile apart, in a region of high current velocities and unfavorable crappie habitat (this last recommendation is based on Jersey Island data).

Summary

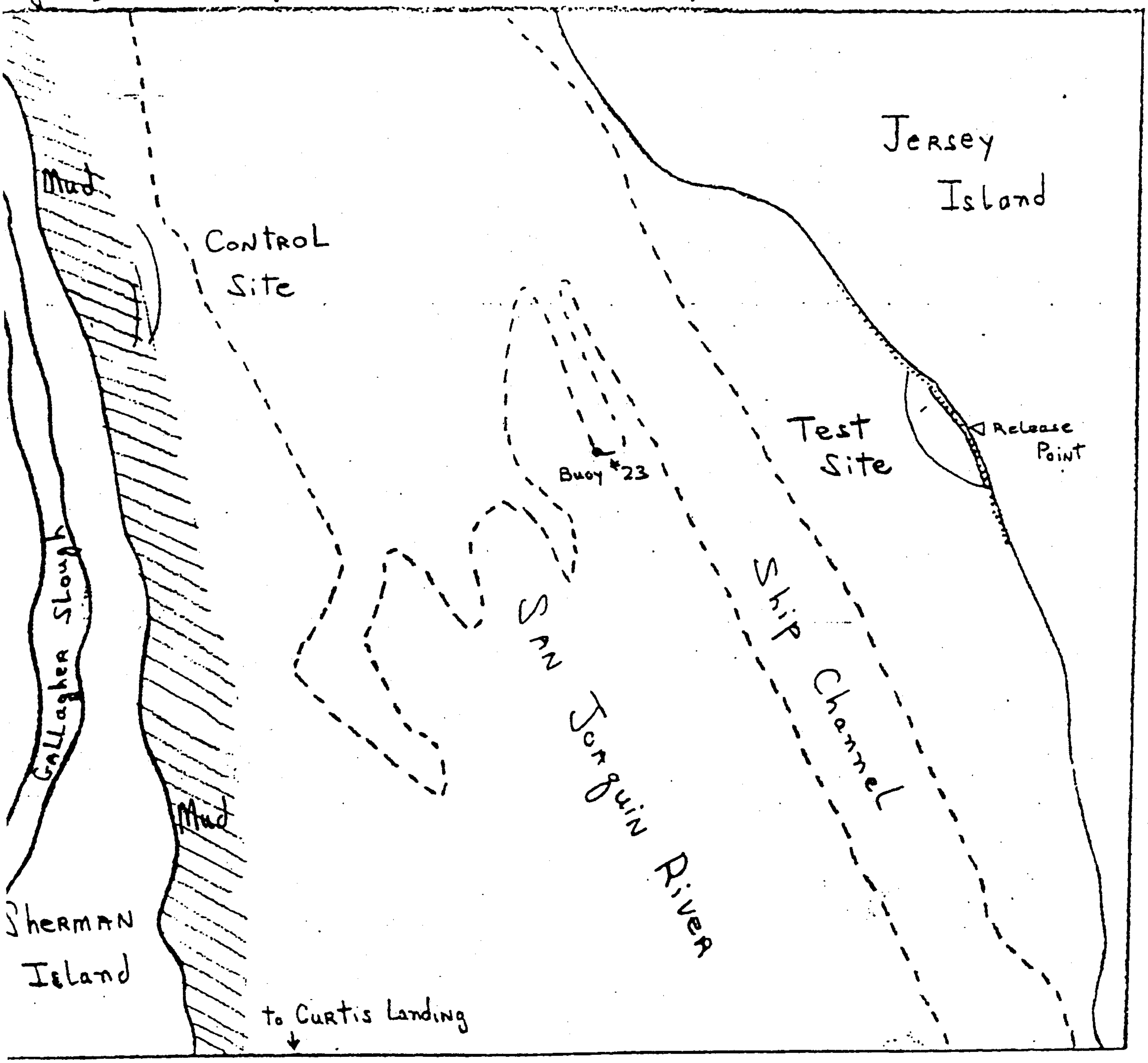
To evaluate the potential predation problem at the exits of the Peripheral Canal fish return system, small fish were released into the San Joaquin River at Jersey Island (test site) and gill nets were used to catch predators both there and at two control sites where no small fish were liberated. Comparisons of predation were made between the test and control sites and between two fish release patterns, multiple and single.

Results in 1966 showed that black crappie were the most numerous predators at the test location. In 1967 striped bass were the dominant species. In both years significantly more predators were caught at the test site than at the controls. There was no selective predation on any species of fish. At the test site, significantly more predators were caught and more fish were eaten during multiple than during single releases in both years.

No apparent relationship existed between predation and water temperature, visibility or TDS. Current velocities in 1967 were less than 0.4 fps, not high enough to discourage predation. Predators are probably not attracted by fish releases but may be held in the release area by the presence of forage fish. Predation estimates state that at a maximum 1/3 of the fish released per day may be eaten. In the absence of large numbers of predatory striped bass less than 10% of the released fish may be consumed at a maximum. Field work indicates that the number of fish eaten per day is proportionate to the number of fish released.

A predation model was constructed from test data. It shows that a single exit return system should result in less predation mortality than a multiple exit system with all exits in constant use. However, infrequent and random releases from multiple exits should give the least predation. A two exit system is suggested. Future work to test stream bottom releases is recommended.

Figure 1. Map of Test and Control Sites.



Legend

——— shoreline

- - - - 30' depth contour

.... pilings
approximate not positions

Scale

50 100 200 500 Feet

1 inch = 500 feet

TABLE 1. Schedule of Fish Releases

Release Type	Number of Fish Released in Thousands	Time Released	Date
			1966
Multiple	340-1100	2400-1500	June 2 - July 15
Single	10-120	1000-1200	July 19 - August 15
			1967
Single	38-98	0900-1100	June 23 - July 7
Multiple	112-1780	All day	July 8 - July 21

TABLE 2. Numbers and Sizes of Predators and Their Prey in 1966.

te and ase Type	Species	Total Number Caught	Number of Actual Predators	Percent Actual Predators	$\bar{X}$ Fork Length (cm)	Number of Fish Eaten	$\bar{X}$ Number of Fish Eaten/ Predator	Total $\bar{X}$ Length of Prey (mm)
t tiple eases	Striped Bass	3	2	66.6	35.3	11	3.7	21
	Black Crappie	74	73	98.6	21.6	1763	24.1	23
	Squawfish	5	0	0	31.8	0	0	0
al		82	75			1774		
t gle eases	Striped Bass	8	2	25.0	31.9	3	0.4	20
	Black Crappie	41	32	78.0	21.5	146	3.6	33
	Squawfish	1	1	100	48.0	1	1.0	150
tal		50	35			150		
trol tiple eases	Striped Bass	7	6	85.7	33.4	24	3.4	26
	Black Crappie	1	0	0	17	0	0	-
	Squawfish	2	1	50.0	50	1	0.5	160
tal		10	7			25		
trol gle eases	Striped Bass	4	0	0	46.8	0	0	-
	Black Crappie	1	0	0	21	0	0	-
	Squawfish	3	0	0	47	0	0	-
tal		8	0	0		0	0	-

TABLE 3. Comparison of Predation between the Test and Control Sites (multiple and single releases combined), 1966.

	Test	Control
Number of Predators Caught	132	18
Number of Actual Predators Caught	110	7
Number of Fish Eaten	1924	25
Number of Fish Eaten per Predator	14.6	.1.3

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TABLE 4. Comparison of Predation during Multiple and Single Releases at the Test Site, 1966.

	Release Type	
	Multiple	Single
Number of Predators Caught	82	50
Number of Actual Predators Caught	75	35
Percent Actual Predators	91.4	70
Total Number of Fish Eaten	1774	150
Average Number of Fish Eaten per Predator	21.9	3

TABLE 5. Comparison of Predation between Single and Multiple Releases and between the Test and Control Sites-1966.

Release Type	Date	Number of Fish Released (in thousands)	Number of Predators Caught: Test	Number of Predators Caught: Control	Number of Fish Found in Predator Stomachs: Test	Number of Fish Found in Predator Stomachs: Control	Average Number of Fish Remains/Predator: Test	Average Number of Fish Remains/Predator: Control
Multiple	6/17	1080	10 (9)*	1	284	0	28.4	0
	6/28	663	13 (13)	0	340	0	26.1	0
	7/1	729	10 (8)	3	290	10	29.0	3.3
	7/5	685	16 (15)	2	381	10	23.8	5.0
	7/8	520	19 (16)	2	247	1	13.0	0.5
	7/15	340	13 (13)	2	232	4	17.8	2.0
Total		4026	81 (74)	10	1774	25	-	-
Average		670	13.5 (12.3)	1.7	296	4.2	21.9	2.5
Single	7/19	43	3 (2)	0	18	0	6.0	0
	7/22	11	6 (4)	1	9	0	1.5	0
	7/26	65	14 (11)	1	43	0	3.7	0
	7/29	53	11 (10)	3	56	0	5.1	0
	8/2	28	5 (3)	2	4	0	0.8	0
	8/5	21	9 (4)	1	19	0	2.1	0
	8/9	13	2 (1)	0	1	0	0.5	0
Total		230	50 (35)	8	150	0	-	0
Average		33	7.1 (5)	1.1	21	0	3	-
Grand Total		4250	131 (109)	18	1924	25	-	-

TABLE 6. Environmental Factors - Temperature, Visibility, and Total Dissolved Solids at the Test and Control Sites. 1966.

	Release Type	Temp. (°C) Average	Temp. (°C) Range	Visibility (cm) Average	Visibility (cm) Range	TDS (ppm) Average	TDS (ppm) Range
Test Site	Multiple	22	21-22	27.4	22-31	749	302-1340
	Single	22.6	22-24	26.5	25-29	1128	731-1988
Control Site	Multiple	22	21-22	28.6	23-34	759	447-1448
	Single	22.6	22-24	24	19-27	1037	810-1438

TABLE 7. Fish Releases and Predation (Striped Bass and Black Crappie) at the Test Site - 1967.

Release Type	Date	Number of Fish Released (in thousands)	Number of Predators Caught *	Number of Fish Found in Predator Stomachs	Average Number of Fish Remains/ Predator
No Releases	6/13	0	1	0	-
	6/22	0	0	0	-
Single Releases	6/27	70	6 (5)	17	2.8
	6/29	51	1 (1)	6	6.0
	7/4	70	19 (17)	167	8.8
	7/6	86	8 (6)	14	1.8
Total			34 (29)	204	6.0
Multiple Releases	7/10	112	33 (23)	51	1.5
	7/14	255	103 (101)	591	5.7
	7/19	245	62 (55)	187	3.0
	7/21	105	7 (4)	5	0.7
Total			205 (183)	834	4.1
No Releases	7/24	0	0	0	-
	7/28	0	0	0	-

*Number of actual predators in parentheses.

TABLE 8. Species, Numbers and Sizes of Predators Caught and Numbers and Sizes of Fish Eaten in 1967.

	Species	Total Number Caught	Number of Actual Predators	Percent Actual Predators	$\bar{X}$ Fork Length (cm)	Number of Fish Eaten	$\bar{X}$ Number of Fish Eaten/ Predator	$\bar{X}$ Total Length of Prey (mm)
Single Releases	Striped Bass	26	22	84.6	27.3	184	7.1	49
	Black Crappie	9	6	66.6	21.5	20	2.2	41
	White Catfish	5	0	0	24.4	0	0	0
	Largemouth Bass	3	1	33.3	37.3	4	1.3	43
	Bluegill	1	0	0	16.0	0	0	0
Total		44	29	65.9		208	4.7	48
Multiple Releases	Striped Bass	168	151	89.8	28.6	753	4.5	56
	Black Crappie	38	31	81.6	22.5	81	2.1	48
	White Catfish	10	8	80.0	24.6	17	1.7	-*
	Bluegill	3	0	0	15.7	0	0	0
	Squawfish	5	1	20.0	41.2	1	.2	50
Total		224	191	86.0		852	3.8	55

*Too well-digested to measure.