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Management Data Series Number 75
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Texas Parks and Wildlife Department
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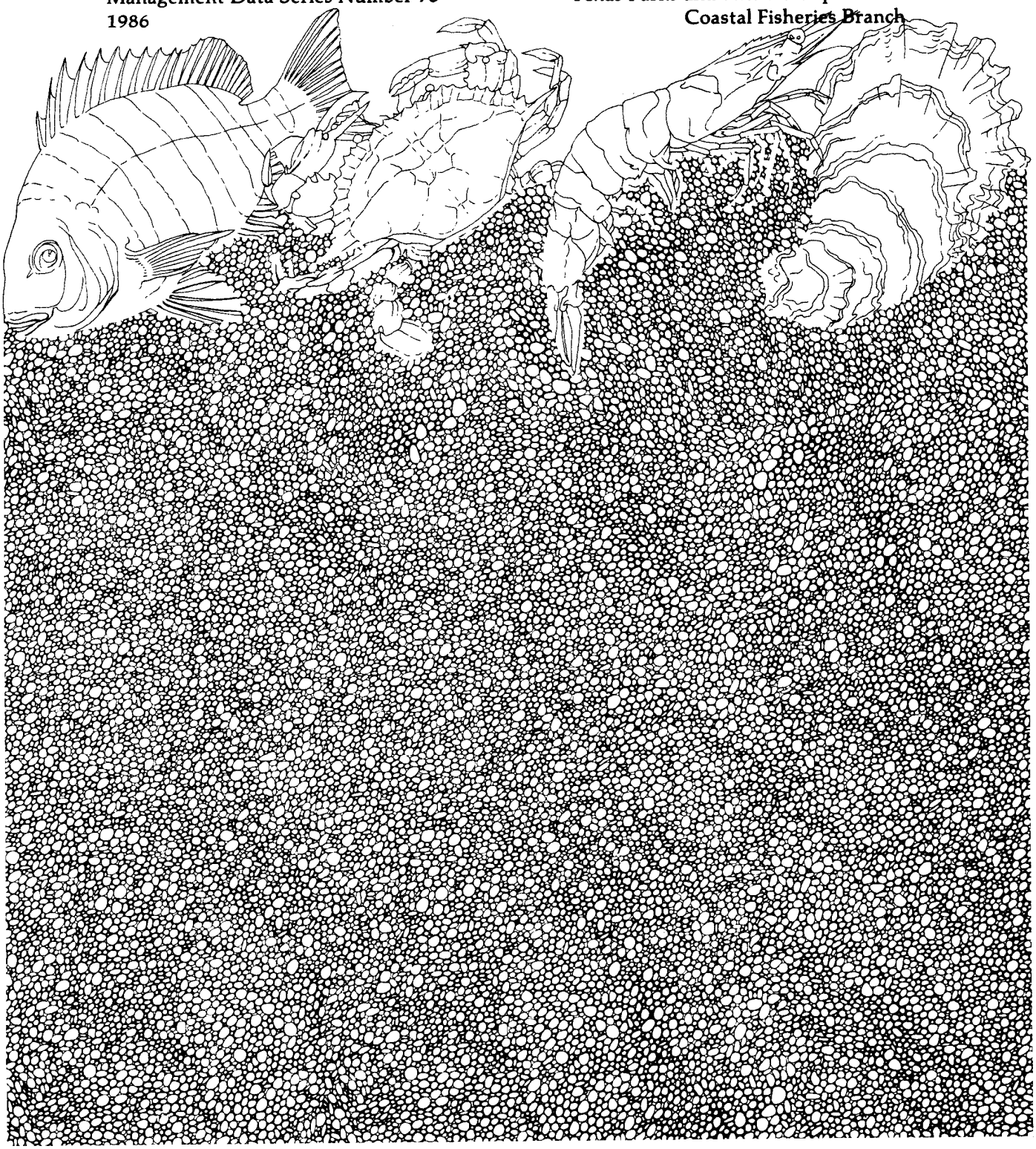

STOCKING AS A MANAGEMENT TOOL FOR A RED DRUM FISHERY, A PRELIMINARY EVALUATION

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ABSTRACT

Red drum (Sciaenops ocellatus) fingerlings were stocked into a small (3,400 hectares) semi-enclosed, tertiary Texas bay in each of 3 years to determine if stocked fish enhanced overfished native populations. Almost 2 million fish were stocked with 38,236 of them being tagged with coded magnetic wire tags, and 1.6 million were identifiable by size because they were smaller than all naturally spawned red drum at times of stocking. Collections after stocking indicated that stocked fish enhanced native populations because their growth rate after stocking was equal to that of native fish. They remained in the stocked bay for at least 1 year and the yearling populations were significantly larger in the stocked bay than populations in a nearby unstocked bay. The success of stocking apparently depends, in part, on the number of fish stocked and the environmental conditions encountered immediately after stocking.

INTRODUCTION

Stocking cultured species is a fisheries management tool with a history progressing from the mid-eighteenth century when the first trout hatchery was established in Germany. Stocked fish have been employed worldwide in both fresh and salt waters either to enhance native populations of economically important fish (Swingle 1957, Bardach et al. 1972, Bason 1980, Tatum 1981) to control forage species (Stevens 1966, Harper and Jarman 1971, Bailey 1975) or establish fisheries for non-native species (Stevens 1974, Bason 1980, McIlwain 1980, Carter 1982). Stocking efforts along the Gulf of Mexico coast of the United States have been limited almost completely to re-establishing the striped bass (Morone saxatilis) fishery in northwest Florida (Wigfall and Barkuloo 1975), Alabama (Swingle 1971, Powell 1972, McIlwain 1980) and Mississippi (McIlwain 1980). Limited striped bass stocking also has been carried out in Louisiana (Hein et al. 1982) and Texas (Matlock et al. 1984). Further stocking of the species depends on improved culture technology to produce large numbers of fingerlings (Bason 1980). In addition, the need for and potential success of stocking for marine population enhancement has not been clearly demonstrated (Tatum 1981).

Red drum (Sciaenops ocellatus) populations in Texas have been severely overfished (Matlock 1983). In 1981, the sale of native red drum was prohibited in a drastic effort to reduce overfishing. The development of methods to induce spawning and rear fry in captivity (Arnold et al. 1977) provided an opportunity to use stocking as a management tool in the red drum fishery. This study was conducted in St. Charles Bay and Aransas Bay to determine if these stocked fish could potentially enhance native populations in these waters.

MATERIALS AND METHODS

Adult red drum were artificially induced to spawn by injecting human chorionic gonadotropin or manipulating temperature and photoperiod (Bishop 1974, Arnold et al. 1977) at the Texas Parks and Wildlife Department's (TPWD) Marine Fisheries Research Station at Palacios, Texas. Fry (2 days old) were placed into earthen ponds where they were held for about 30 days (Colura et al. 1976). Fish were fed commercially produced food until harvested. Fingerlings 35-102 mm long (total length [TL]) were released in to St. Charles Bay at Cavasso Creek, Big Tree, and Little Devil Bayou in June-July 1979 and Little Devil Bayou in August-September 1980 and May 1981 (Fig. 1). When bay salinities varied by more than 5.0 o/oo from those in the hauling trailer, trailer water was gradually tempered to approximate that of the stocking site; minimum time of acclimation of fingerlings was 1 hour. These fish were identifiable by size because naturally spawned red drum either were larger or smaller than stocked fish at stocking (Matlock 1984a). Over 38,000 fish were tagged with metal tags inserted into the snout, magnetized, and the procedure verified as described by Gibbard and Colura (1980)--26,174 in 1979 and 12,062 in 1980 (Table 1). After harvest on 13 June 1979, all but 24,829 tagged fish were stocked into the bay. The remaining 24,829 fish were reared in ponds from 25 June to 5 July, then tagged and released at Big Tree (Table 1). Fish were stocked into the bay within 5 days after tagging both in 1979 and 1980.

Information on survival, growth, movement, and impact on native fish was obtained using bag seines and gill nets primarily at stocking sites but also in Aransas Bay. Pre-stocking bag seine collections in St. Charles Bay began in November 1978 at 2 to 10 randomly selected shoreline sites per month from the 15 available sites (Matlock and Weaver 1978). Post-stocking collections began on 25 June 1979 at 14 possible sites (labeled 1-14 in Fig. 1); another 13 possible sites were added in September 1980. During the post-stocking period, 10 to 35 seine hauls were made monthly except in July and August 1980. Each stocking site was visited at least once each month, and at least three other randomly selected sites were visited each month. One to three replicate hauls were made at stocking sites only. Bag seine collections also were made at 8 to 10 randomly selected sites per month throughout the adjacent unstocked Aransas Bay system during the entire study period (Hegen 1982). Seines were pulled parallel to shore for 15 to 30 m with one end on shore following the procedures described by Hegen (1982). All captured red drum were counted and measured to the nearest millimeter (TL). Bag seines (18.3 m long) with 12.7-mm stretched mesh in a 1.83-m bag and 19.0-mm mesh in the remainder were used during November 1978-September 1979 and May 1981-March 1982. Seines (30.5 m long) with 19.0-mm stretched mesh throughout were used during October 1979-April 1981 in St. Charles Bay only.

As stocked fish grew they were able to elude the bag seines. Monofilament gill nets (46 m long with 5.1-cm stretched mesh) were incorporated in the sample gear after 15 August 1979 to catch these larger fish. Two to seven sites were visited monthly with at least one set being made at one of the stocking sites. Nets were set overnight following the procedures of Matlock et al. (1978).

Surface water salinity, temperature, and dissolved oxygen were measured with each fish collection. Salinity was measured to the nearest part per thousand using an American Optical refractometer; temperature was recorded to

the nearest 0.5 C using a laboratory grade thermometer; and dissolved oxygen was measured to the nearest 1.0 ppm using a Hach kit. Mean monthly values were calculated using data collected during this study and associated TPWD studies by weighting each measurement equally. The number of monthly observations ranged from 15 to 42.

Mean bag seine catch (number/hectare) in the stocked St. Charles Bay was compared to that in the remainder of the unstocked Aransas Bay system during summer (May-July) and fall (October-December) in 1979, 1980, and 1981 to determine if stocked red drum supplemented native yearling populations. The catch at each site was divided by the area covered, following Hegen (1982), and transformed into common logrithms before being tested for significant differences (P=0.05) using a two-way analysis of variance (Overall and Spiegel 1969).

The growth rate (TL/day) of three recaptured red drum stocked into St. Charles Bay in 1979 was determined using the formula:

$$G = \frac{L_f - L_i}{T}$$

where

G = growth rate,

L_f = total length at recapture,
L_i = mean total length at stocking determined at harvest using at least 20 randomly selected fish from each pond,
T = days between stocking and recapture.

Growth rate was also estimated for fish stocked into St. Charles Bay in June 1979 and May 1981 by fitting a linear regression (Sokal and Rohlf 1969) to total length (y) obtained from fish identified as stocked fish caught in bag seines and 5.1-cm stretched mesh gill nets vs the number of days after release (x). Stocked fish were identified by visually inspecting a plot of the total length of each fish on each date. Cohorts of yearling native fish (spawned the previous fall) were identified (larger than stocked cohort) and any fish at least 20-mm larger than the younger or older native cohort were considered stocked fish. The stocking date in 1979 for all recaptured fish was considered to be 13 June, while the 1981 stocking date was 11 May. Regressions also were fit to the length data for the native fish (larger than stocked fish) caught during these same periods. The y-intercepts for the two groups of fish represented the size of fish on the date of stocking; i.e., the time scale did not represent true age. Therefore, a comparison of y-intercepts was not appropriate.

All red drum caught in the unstocked Aransas Bay system by TPWD through regular sampling described by Hegen (1982) were examined during June 1979-March 1982 for magnetic tags using a magnetic detector. Additionally, all red drum seen by TPWD during interviews with recreational and commercial fishermen from the Aransas Bay system through the regular sampling system described by McEachron and Green (1982) were examined for magnetic tags.

RESULTS

First Year Survival

Many red drum stocked into St. Charles Bay in summer 1979 and 1981 survived, but the percent survival was unknown. Based on size, stocked fish were recaptured in St. Charles Bay in bag seines and gill nets during 7-9 months after stocking in 1979 (Fig. 2) and in 1981 (Fig. 3). In addition, three fish bearing magnetic tags were recaptured by TPWD in 1979. Fish stocked in August 1980 apparently did not survive because no fish 50-100 mm long were caught during mid-September to mid-October 1980 (Fig. 3). The red drum stocked in 1979 and 1981 enhanced the native yearling populations, but these additional fish were not identified in fishermen catches in subsequent years.

The mean seine catch of red drum (Table 2) was significantly (Tables 3 and 4) greater (5 to 10 times) in St. Charles Bay in the summer than in the adjacent unstocked Aransas Bay after the summer stockings in 1979 and 1981. However, the summer catch was similar in both areas in 1980 when only native fish were present. Stocking was not done until August 1980.

Almost 6,800 fish were examined for magnetic tags during June 1979-March 1982, (Table 5). None of the 1,668 fish caught by anglers contained tags.

Environmental Parameters

Mean monthly water temperature fluctuated cyclically between about 10 and 30 C. Although the winter monthly means were lower in 1980-1981 (11-13 C), the range of measurements overlapped those in the winters of 1979-1980 and 1981-1982 (Fig. 5). Mean monthly dissolved oxygen exceeded 6 ppm and was generally inversely related to temperatures (Fig. 5). Lowest oxygen values (1 ppm) were recorded in July 1980. Mean monthly salinities varied between 0.5 and 19.6 o/oo. However, salinities generally increased from 0.5 o/oo in 1979 to 15-20 o/oo during 1980 and mid-1981, then declined sharply in May 1981 to 0-5 o/oo thereafter (Fig. 5). The passage of Hurricane Allen in August 1980 caused salinities to drop from 25 o/oo to 9 o/oo almost overnight.

Yearling Growth

Untagged red drum stocked in 1979 grew 1 mm/day in St. Charles Bay with no apparent change in growth rate during the first year after stocking (Fig. 4). The mean growth rate of the three recaptured tagged red drum was 0.6-0.8 (± 0.1) mm/day. Stocked red drum grew at a rate similar to that of native fish (Table 7). Native fish grew 0.8-0.9 mm/day during the same period.

Movement

Fish stocked in St. Charles Bay remained there throughout the first year after stocking. Bag seine collections (6 hauls/month) outside St. Charles Bay did not contain any tagged red drum or stocked fish (based on length) but

stocked fish were caught throughout St. Charles Bay in both bag seines and gill nets, some as far as 6.0-6.4 km from the stocking sites (Tables 8 and 9).

DISCUSSION

This study indicates that stocking of artificially propagated red drum can enhance a native population, at least for 1 year. However, success of introducing hatchery-reared fish is dependent on environmental conditions after stocking and the number of fish stocked. This is also true for native fish because a year class is affected by size of the spawn and conditions after hatching (Matlock 1984b). An abrupt reduction in salinity in St. Charles Bay on 10 August 1980 from rainfall associated with Hurricane Allen occurred within a few days following the stocking, and no identifiably stocked fish were collected thereafter. Post-stocking surveys indicated that fish stocked in 1979 and 1981 enhanced the native population to different degrees, undoubtedly because almost twice as many fish were stocked in 1979 than in 1981. Therefore, future evaluations should concentrate on repeated stockings into limited areas to determine the relationship between stocking rate and enhancement.

The marking procedure utilizing magnetic nose tags was not successful. Only 3 of 38,000 tagged fish were recovered. This was probably due to rapid tag loss because the magnetic tags were subject to loss rates ranging from 59% within 3 months to 73% at 12 months Gibbard and Colura (1980). Additional research is needed to determine if tags placed in other parts of the fish would be retained longer.

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Table 1. Number and size of red drum fingerlings released into St. Charles Bay on each stocking date.

Year	Month and day	Stocking site	Number stocked	Total length (mm)	Number tagged
1979	6-6	Big Tree	85,000	37-45	0
	6-7	Big Tree	45,000	40-50	0
	6-8	Big Tree	92,000	40-50	1,345
	6-11	Little Devil Bayou	291,000	35-40	0
	6-12	Little Devil Bayou	358,000	35-40	0
	6-13	Cavasso Creek	83,000	40-55	0
	6-25	Big Tree	1,834	64-89	1,834
	6-26	Big Tree	3,007	76	3,007
	6-27	Big Tree	5,638	76	5,638
	6-28	Big Tree	6,850	76	6,850
	7-5	Big Tree	7,500	102	7,500
	Total		978,829	35-102	26,174
1980	8-4	Little Devil Bayou	18,940	30-55	0
	8-5	Little Devil Bayou	40,100	40-55	3,974
	8-6	Little Devil Bayou	52,100	40-55	1,422
	8-7	Little Devil Bayou	45,000	45-55	6,666
	8-7	Little Devil Bayou	102,000	30-35	0
	8-27	Little Devil Bayou	9,100	66	0
	9-2	Little Devil Bayou	9,300	66	0
	Total	Little Devil Bayou	276,540	30-66	12,062
1981	5-11	Little Devil Bayou	577,500	25-32	0

Table 2. Mean number per hectare (± 1 SE) of red drum captured in bag seines during May-July and October-December in Aransas and St. Charles bays in 1979, 1980, and 1981. St. Charles Bay was stocked in June 1979, August 1980, and May 1981. Number in parenthesis represents number of samples.

Year	May-July		October-December	
	Aransas	St. Charles	Aransas	St. Charles
1979	6 ± 3 (15)	58 ± 17 (39)	13 ± 7 (27)	14 ± 5 (92)
1980[a]	9 ± 5 (29)	7 ± 3 (25)	11 ± 7 (30)	7 ± 3 (36)
1981	2 ± 1 (18)	10 ± 5 (62)	93 ± 55 (31)	9 ± 3 (62)

[a]Native fish only. See text for explanation.

Table 3. Two-way analysis of variance of mean catch (No./ha) of juvenile red drum in bag seines from St. Charles Bay and the adjacent Aransas Bay system during summer (May-July). The catch (No./ha) at each site was log transferred before analysis.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-statistic
Total	187	103.728		
Years	2	11.463	5.732	3.163
Bays	1	3.450	3.450	1.904
Years x bays	2	3.625	1.812	3.872*
Error	182	85.190	0.468	

*P<0.05.

Table 4. Two-way analysis of variance of mean catch (No./ha) of juvenile red drum in bag seines from St. Charles Bay and the adjacent Aransas Bay system during fall (October-December) 1979-1981. The catch (No./ha) at each site was log transformed before analysis.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-statistic
Total	267	141.344		
Years	2	2.673	1.336	0.530
Bays	1	0.376	0.376	0.149
Years x bays	2	5.041	2.521	4.956**
Error	262	133.254	0.509	

**P<0.01.

Table 5. Number of red drum examined for magnetic nose tags during June-May 1979-1981 (1981-1982 is from June-March).

Capture method	1979-1980	1980-1981	1981-1982	Total
TPWD bag seines	204	59	31	294
TPWD gill nets	366	712	861	1,939
TPWD trammel nets	678	1,619	553	2,850
Commercial fishermen	25	918	0	943
Sport-boat fishermen	356	343	26	725
All methods	1,629	3,651	1,471	6,751

Table 6. Minimum and maximum growth of three recaptured tagged red drum stocked during 25 June 1979-5 July 1979 (exact date each fish was stocked is unknown) into St. Charles Bay at 61-107 mm total length.

Fish no.	Date	Total length[a] (mm)	Days free	Growth (mm)	Growth rate mm/day	
					Minimum	Maximum
1	10-02-79	144	89-99	37-83	0.4	0.8
2	01-25-80	255	204-214	148-194	0.7	0.9
3	01-31-80	220	210-220	113-159	0.5	0.7
Mean ± 1 SE					0.6 ± 0.1	0.8 ± 0.1

[a]Total length calculated from measured standard length using equation of Harrington et al. (1979).

Table 7. Comparison of growth equations (Y = TL and X = days after stocking) of stocked red drum in June 1979 and June 1981 with larger native fish in St. Charles Bay.

Stocking date	Growth period	Source of fish	N	Y-intercept (mm)	Slope	r	Standard error of slope
June 1979	6/79-5/80	Stocked	48	30.33	1.03	0.947	0.05
		Native	52	182.48	0.82	0.893	0.06
June 1981	6/81-1/82	Stocked	28	29.96	0.74	0.990	0.02
		Native	14	149.72	0.87	0.897	0.13

Table 8. Mean number per sample of stocked red drum caught in bag seines at sites located throughout St. Charles Bay during June 1979-November 1981.

Minimum distance (km) from stocking site	Number of samples	Number caught	Mean catch rate
0.0-0.4	196	66	0.3367
0.5-0.9	3	0	0.0
1.0-1.4	4	0	0.0
1.5-1.9	15	1	0.0667
2.0-2.4	11	0	0.0
2.5-2.9	34	7	0.2059
3.0-3.4	11	0	0.0
3.5-3.9	17	0	0.0
4.0-4.4	31	1	0.0323
4.5-4.9	20	5	0.2500
5.0-5.4	33	4	0.1212
5.5-5.9	9	0	0.0
6.0-6.4	36	6	0.1667
$\geq$ 6.5	19	2	0.1053
Totals	439	92	0.2096

Table 9. Mean number per sample of stocked red drum caught in gill nets at sites located throughout St. Charles Bay, August 1979-March 1982.

Minimum distance (km) from stocking site	Number of samples	Number caught	Mean catch rate
0.0-0.9	33	13	0.3939
1.0-1.9	33	1	0.0303
2.0-2.9	34	8	0.2353
3.0-3.9	1	0	0.000
Totals	101	22	0.2178

Figure 1. Map of study area showing number of fish stocked in St. Charles Bay each year at Big Tree, Little Devil Bayou, and Cavasso Creek.

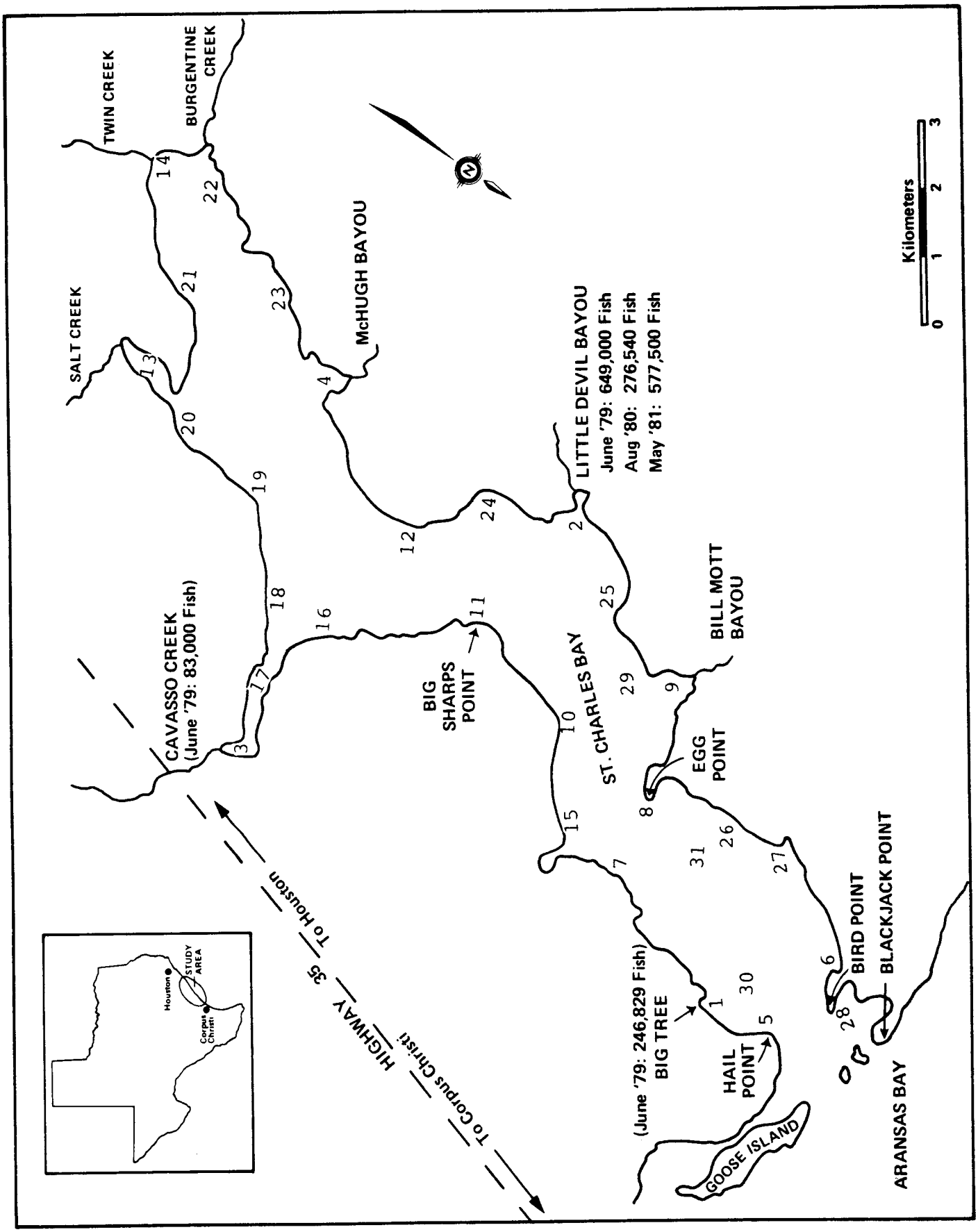
TWIN CREEK
BURGENTINE CREEK
SALT CREEK
McHUGH BAYOU
CAVASSO CREEK
(June '79: 83,000 Fish)
BIG SHARPS POINT
LITTLE DEVIL BAYOU
June '79: 649,000 Fish
Aug '80: 276,540 Fish
May '81: 577,500 Fish
ST. CHARLES BAY
BILL MOTT BAYOU
EGG POINT
(June '79: 246,829 Fish)
BIG TREE
HAIL POINT
GOOSE ISLAND
BIRD POINT
BLACKJACK POINT
ARANSAS BAY
HIGHWAY 35
To Houston
To Corpus Christi
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Figure 2. Total length of individual red drum caught in bag seines (circles) and 5.1-cm stretched mesh gill nets (x) in St. Charles Bay during the period October 1978 through June 1980.

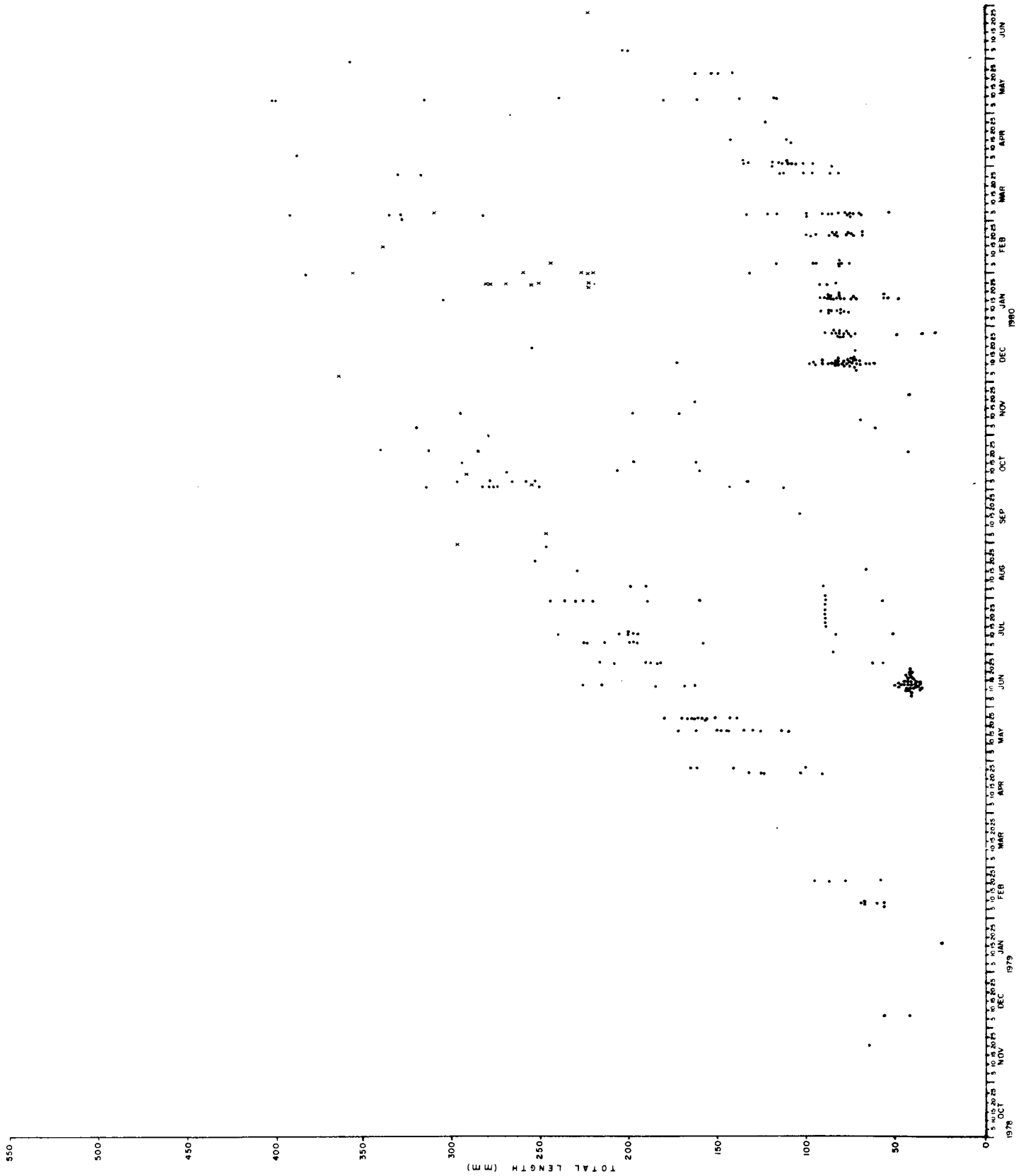
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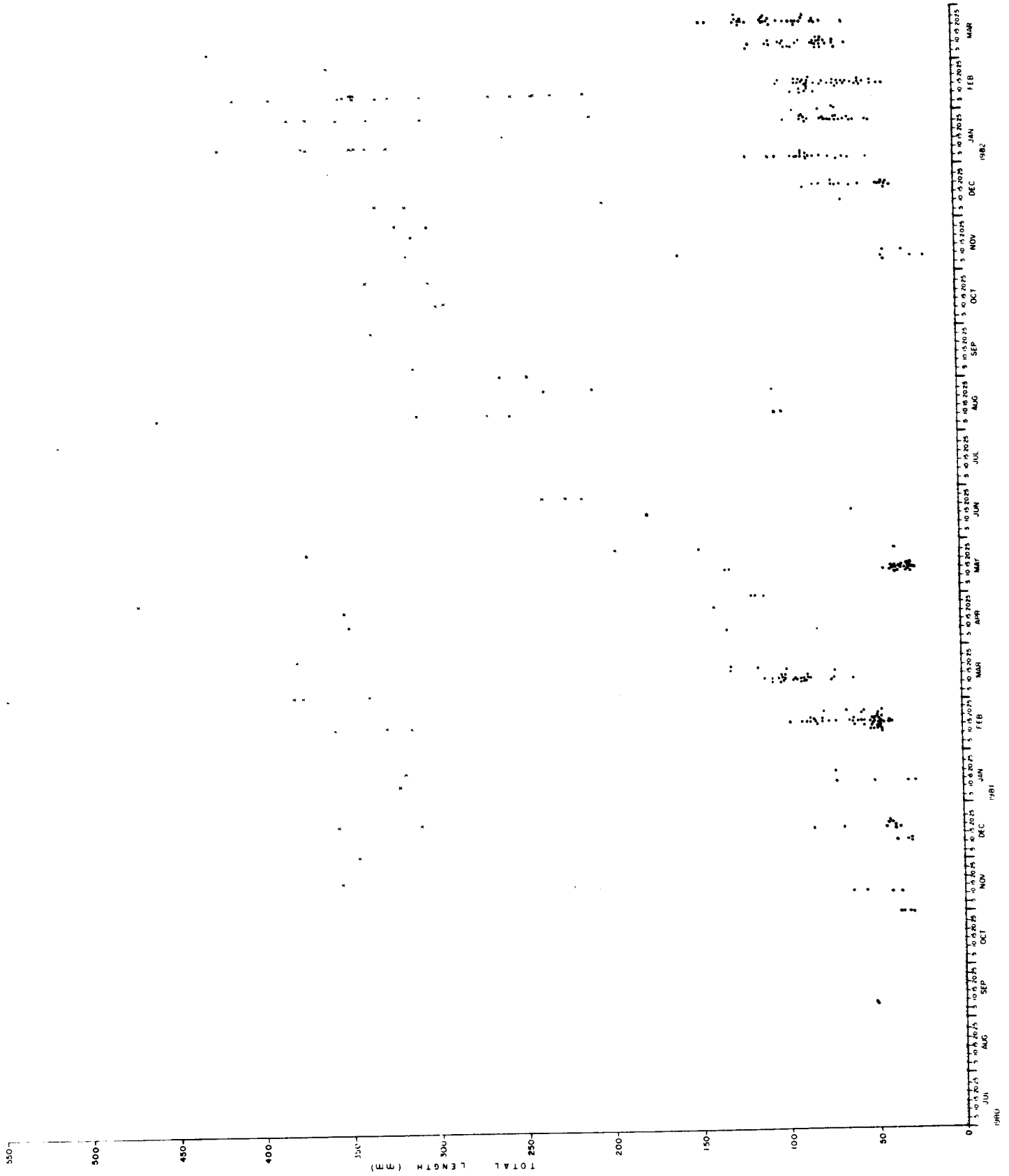
Figure 3. Total length of individual red drum caught in bag seines (circles) and 5.1-cm stretched mesh gill nets (x) in St. Charles Bay during July 1980 through March 1982.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1981
1982

Figure 4. Regressions of total length with time of stocked red drum captured in bag seines and gill nets in St. Charles Bay during June 1979-May 1980(A) and June 1981-May 1982(B). Stocking dates (Day 0) are considered to be 13 June 1979 and 11 May 1981.

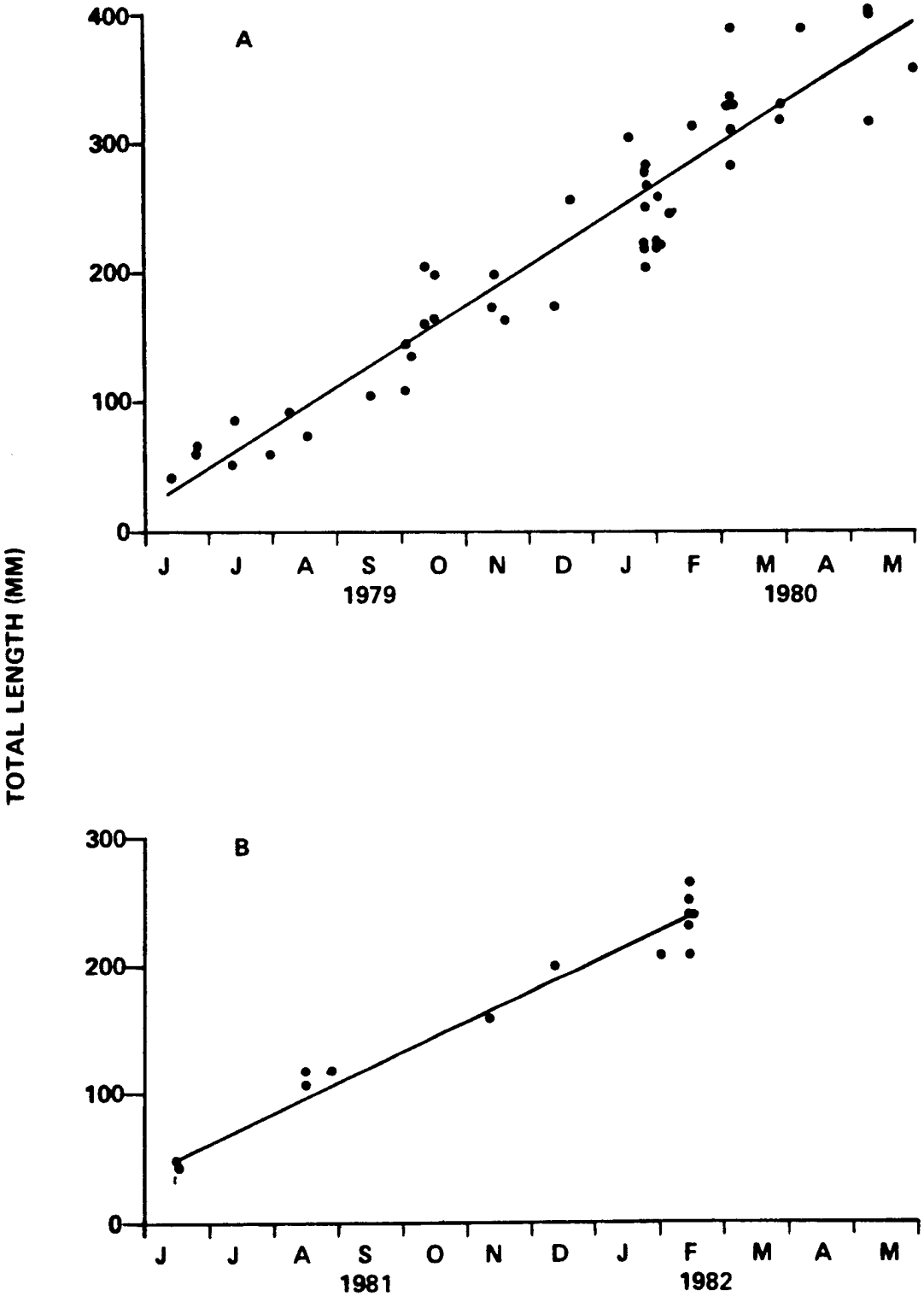
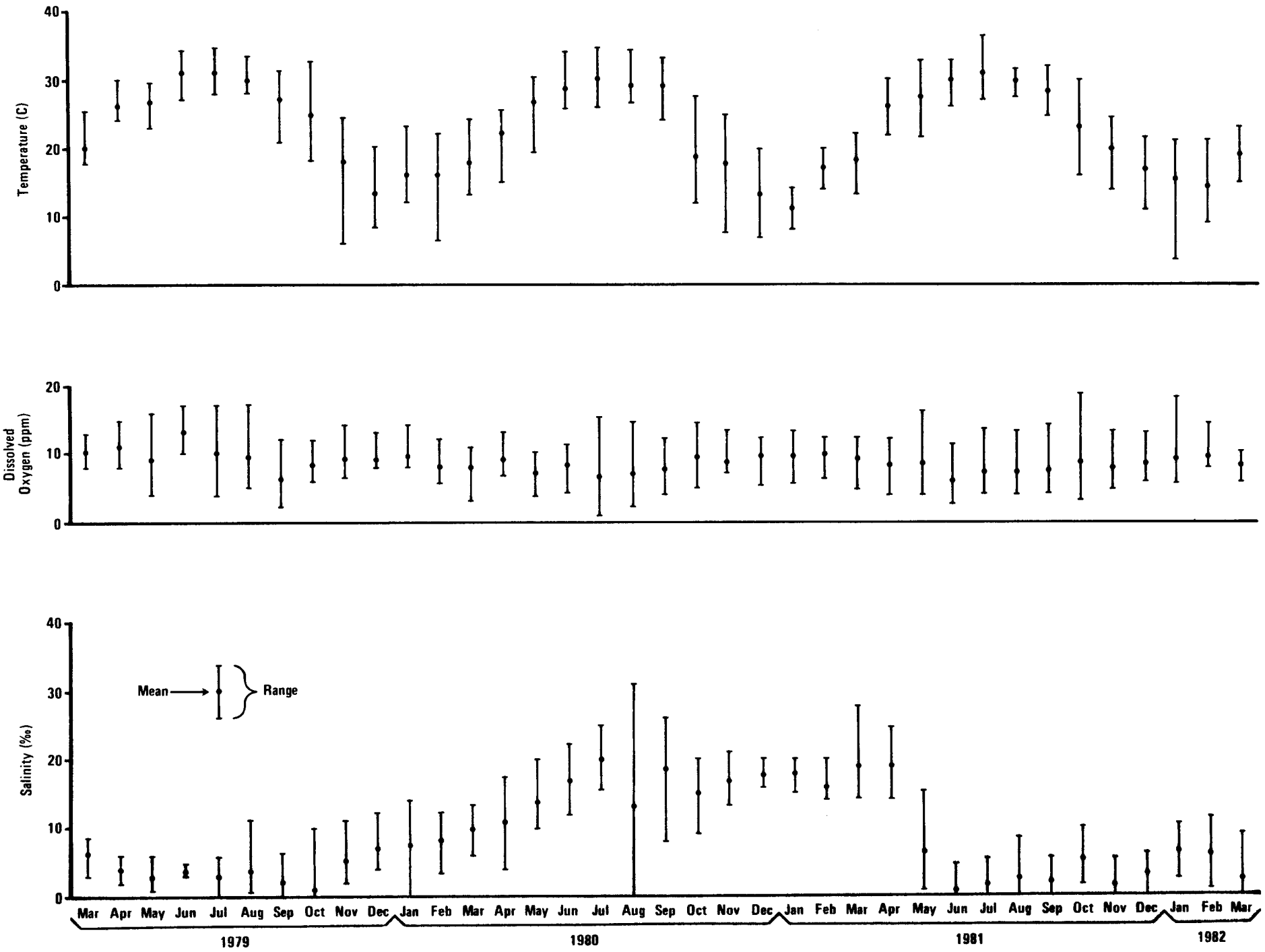

A
400
300
200
100
0
J J A S O N D J F M A M
1979
1980
TOTAL LENGTH (MM)
B
300
200
100
0
J J A S O N D J F M A M
1981
1982

Figure 5. Range and mean monthly salinity, dissolved oxygen content, and water temperature in St. Charles Bay during March 1979 through March 1982.


Temperature (C)
40
30
20
10
0
Dissolved Oxygen (ppm)
20
10
0
Salinity (‰)
40
30
20
10
0
Mean
Range
Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar
1979
1980
1981
1982