
Estuarine Link

Where the river meets the sea…

- Semi-enclosed body of water
- Seawater (35 ppt) is diluted by freshwater from a land drainage
- Mixing facilitates key habitats and productivity (e.g., fisheries)
- Laguna Madre/Baffin Bay are “Negative” estuaries a.k.a. Lagoon

Common Estuarine Habitat Types:

Oyster Reef

Salt Marsh

Mangrove

Mudd Bottom

Seagrass Meadows

Upland Marsh

So…, why do should we care about estuaries?

Estuarine Dependence


REDHEAD CENTRAL

Sound Ecological Environment

Sound Ecological Environment

"A schedule of flow quantities that reflects seasonal and yearly fluctuations that typically would vary geographically, by specific location in a watershed, and that are shown to be adequate to support a sound ecological environment and to maintain the productivity, extent, and persistence of key aquatic habitats in and along the affected water bodies."

According to SAC guidance (SAC 2009a), a sound ecological environment is one that:

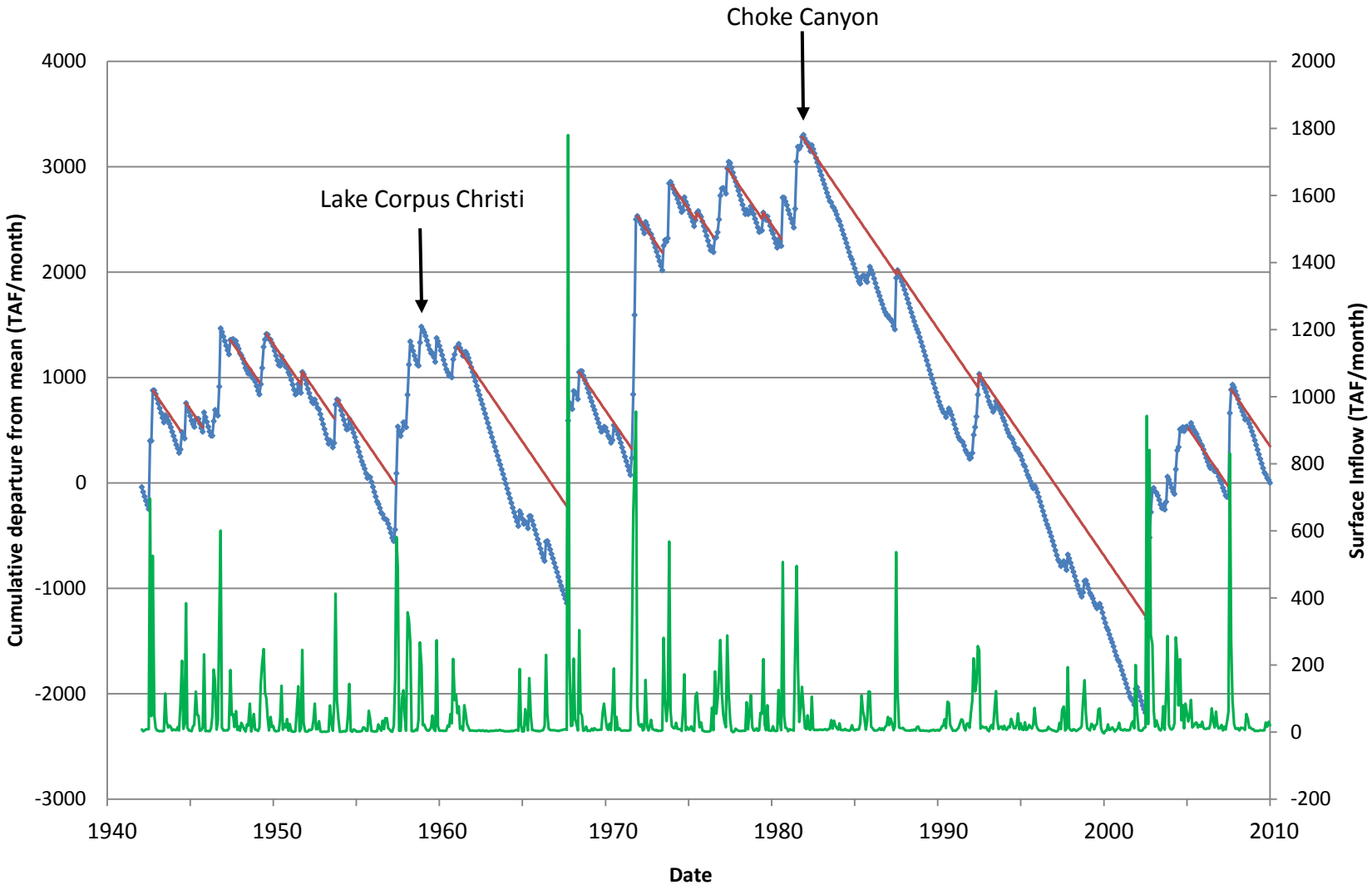
- sustains the full complement of native species in perpetuity,
- sustains key habitat features required by these species,
- retains key features of the natural flow regime required by these species to complete their life cycles, and
- sustains key ecosystem processes and services, such as elemental cycling and the productivity of important plant and animal populations.

- **1.2M cu yd from Nueces Bay ’58 alone (probably and underestimate)**

- **30’s oyster harvest ended → shell harvest → considered totally fished out (live and substrate) by 1967**

- **300’ rule but dredgers took advantage of “live” reefs during drought years of ‘50 and 60 ‘s**

Rangia cuneata


Choke Canyon
Lake Corpus Christi
Cumulative departure from mean (TAF/month)
Surface Inflow (TAF/month)
Date
4000
3000
2000
1000
0
-1000
-2000
-3000
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-200
1940
1950
1960
1970
1980
1990
2000
2010

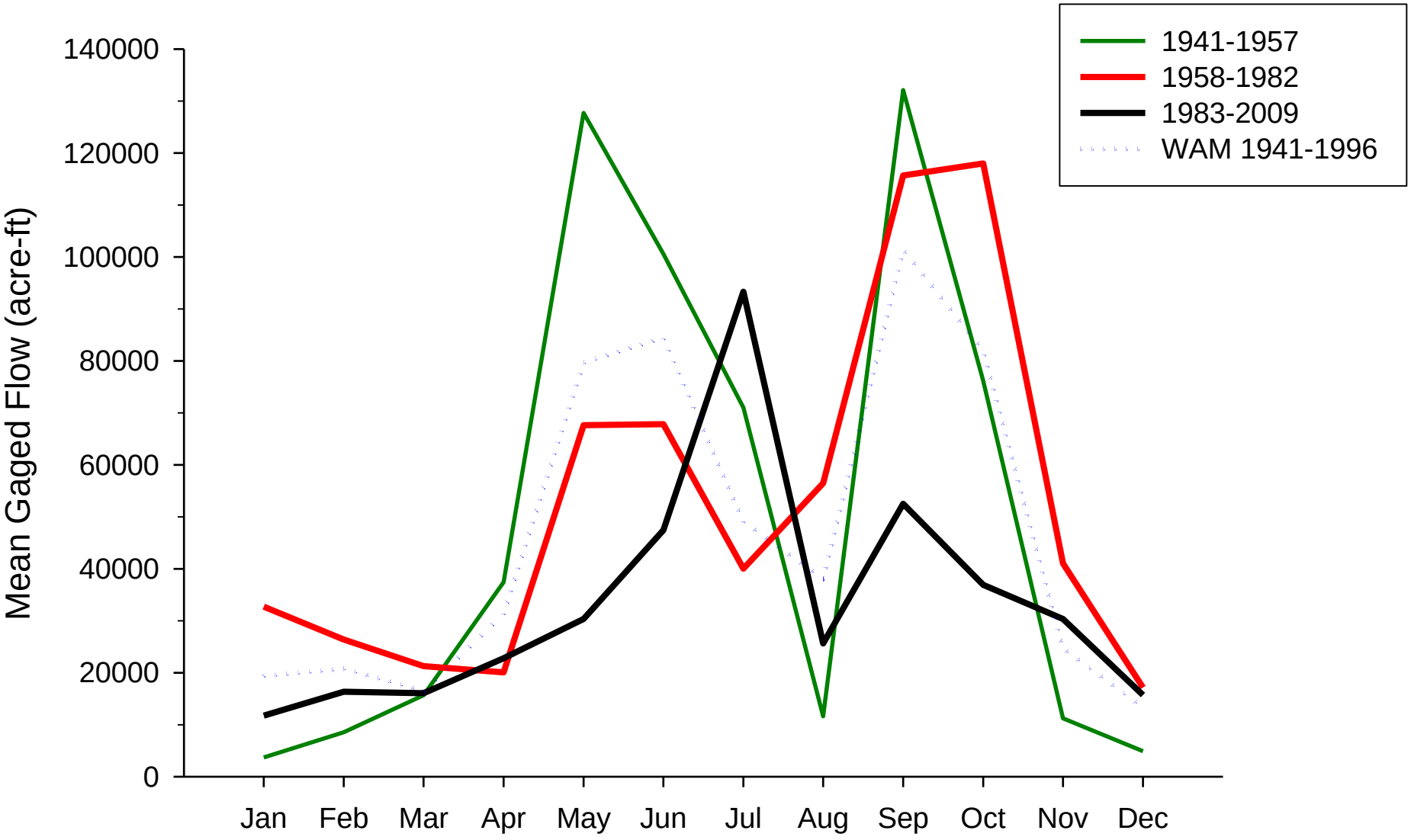

1941-1957
1958-1982
1983-2009
WAM 1941-1996
Mean Gaged Flow (acre-ft)
140000
120000
100000
80000
60000
40000
20000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Table 2-1: Summary of mean annual flow of the Nueces River into the Nueces Estuary (1940 to 1996)[1] and upper Nueces Delta (1940 to 1999)[2]. Time periods in both studies were based upon the construction dates of large reservoirs in the watershed.

Time Period	Mean annual river flow into Nueces Estuary (acre-ft)	Percent change from Period I	Mean annual river flow into upper Nueces Delta (acre-ft)	Percent change from Period I
1940-1957	619,000	—	127,997	—
1958-1982	614,000	-0.8%	77,989	-39.1%
1983-1996(9)	279,000	-54.9%	537	-99.6%

[1] Source: Asquith *et al.* 1997.
[2] Source: Irlbeck and Ward 2000.

Note: 1 acre-ft = 1.2336 10^3 m^3

- **1958 – Lake Corpus Christi → 1 Overbanking per year**
- **1982 – Lake Choke Canyon → 1 Overbanking every 3 years**
- **Major modifications and channelization of river preventing OB**

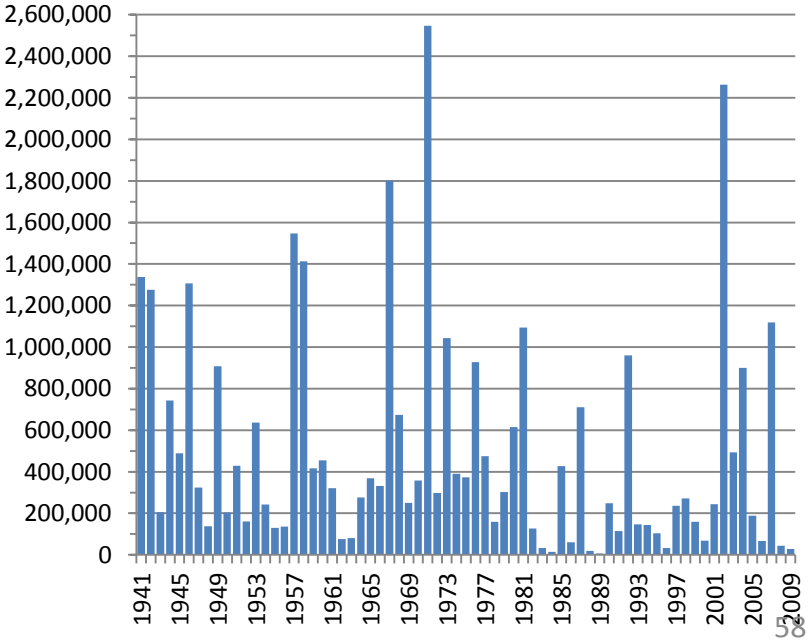
Unsound because…

- Loss/alteration of key habitat features and natural flow regimes required by indicator species

- Nutrient elemental cycling and sediment loading are compromised

- **<u>KEY POINT</u>: A modification of flow regime is required to rebuild these species and processes to sound levels**

Freshwater Inflow Analyses



Steps:

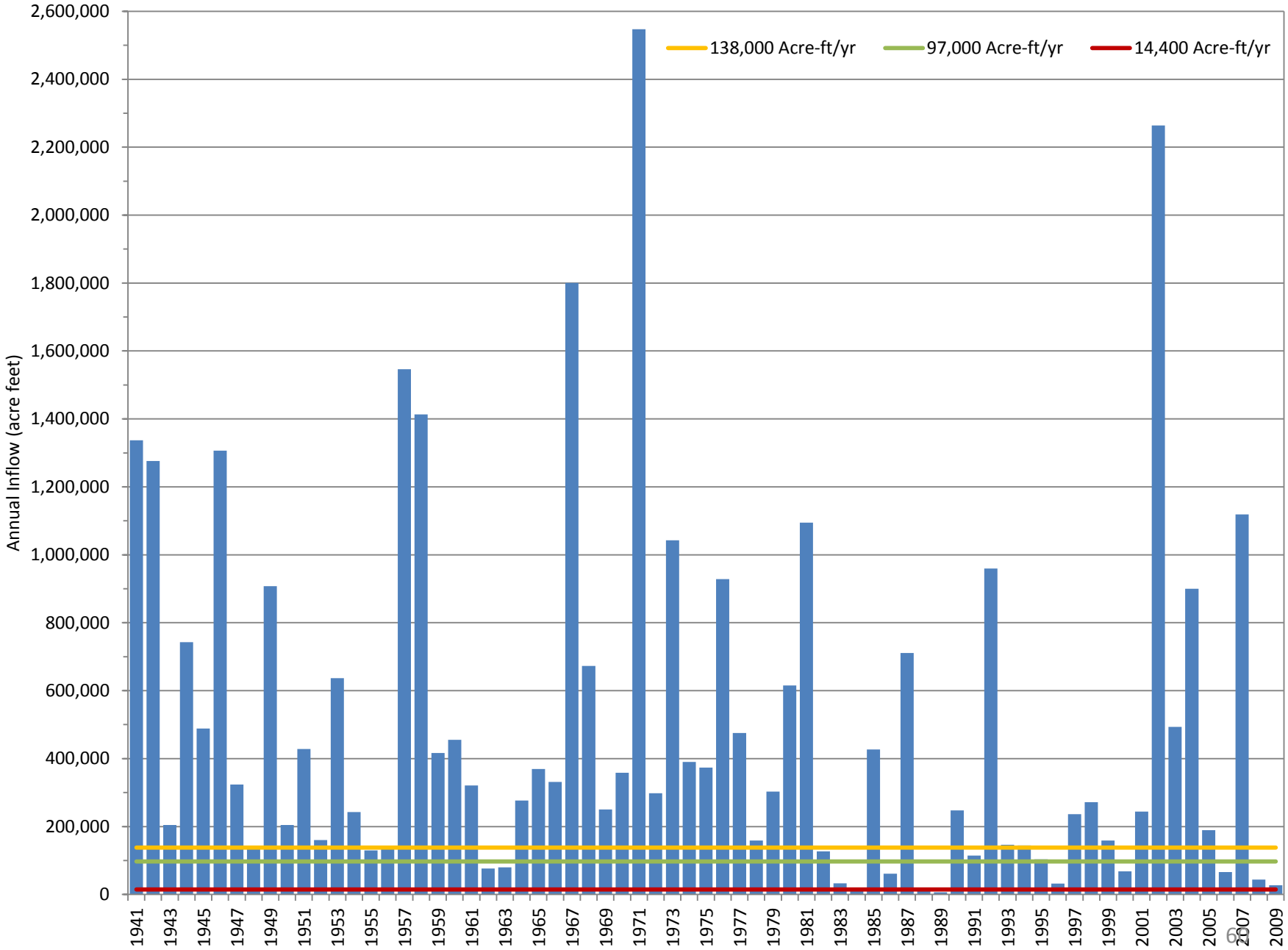
1. Characterize historical water availability patterns

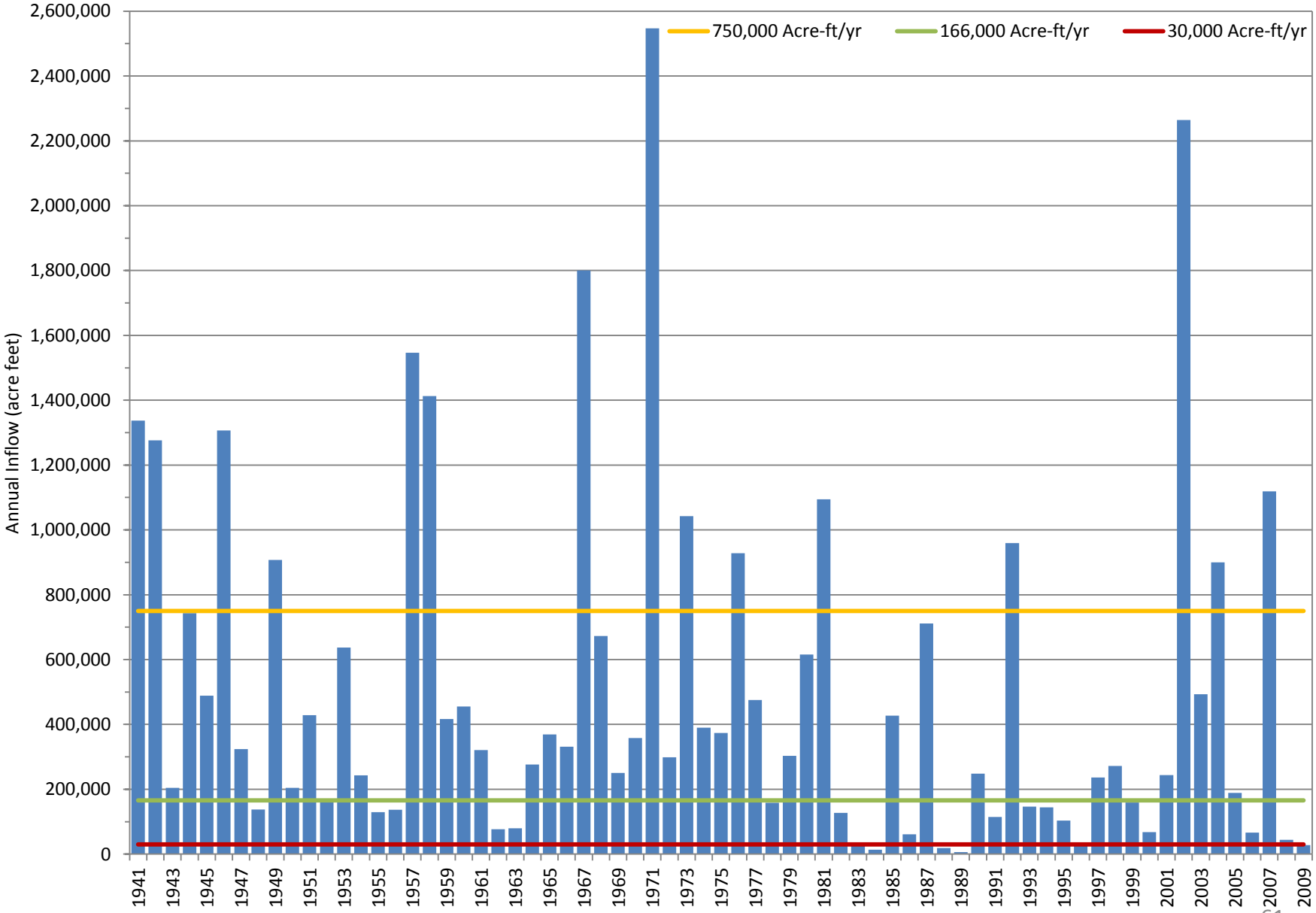
2. Examine flow and salinity relationships

3. Indentify focal species (Canaries)

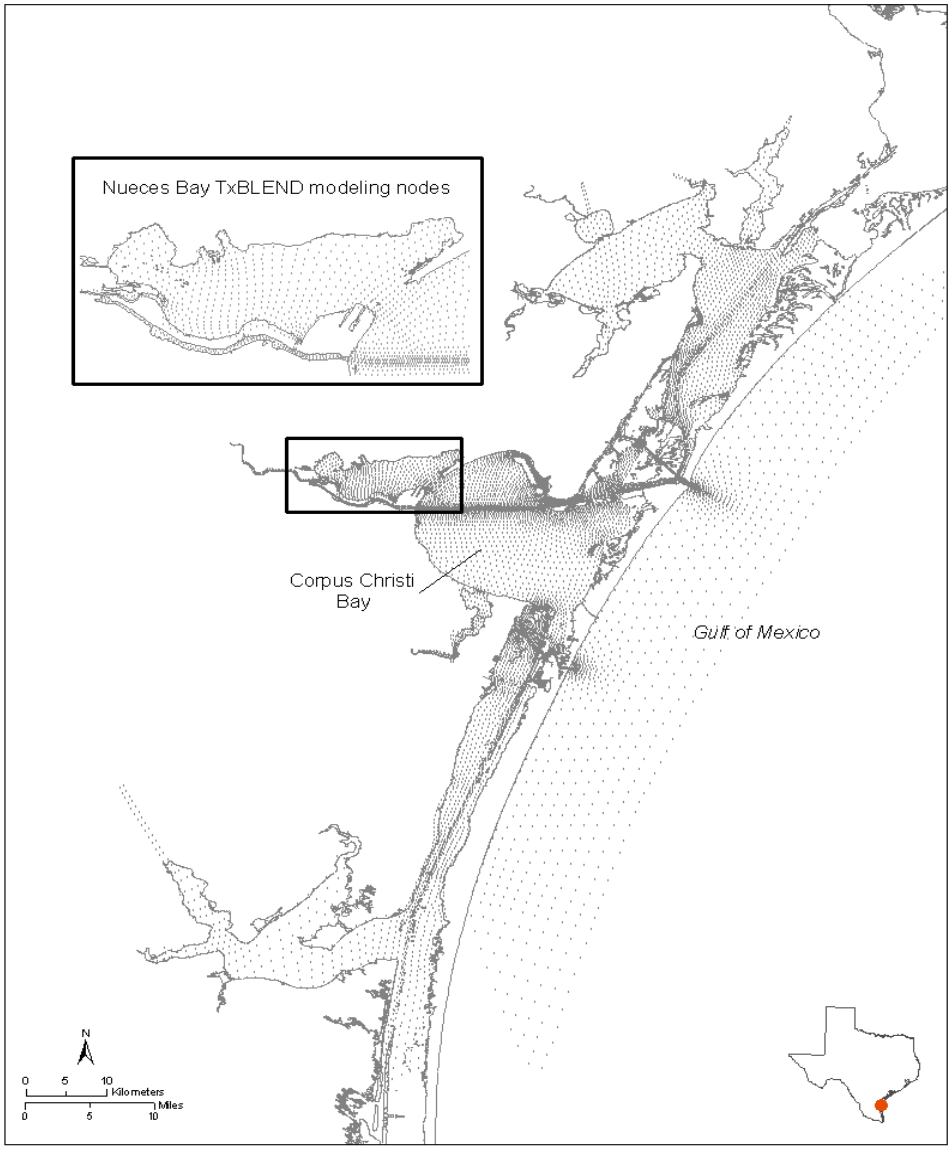
4. Recommend flow that will create a sound environment

Nueces Bay inflow – Agreed Order

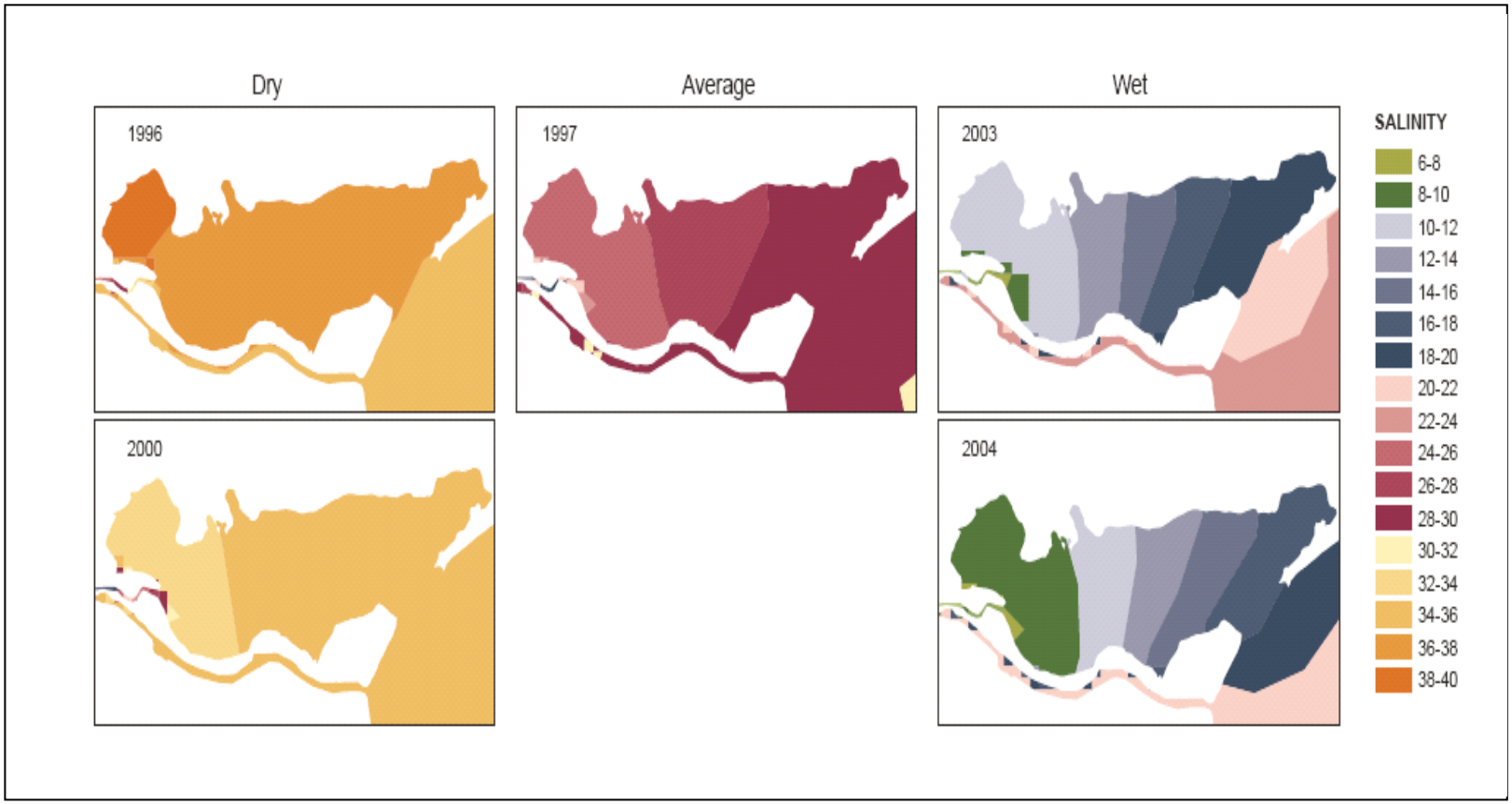


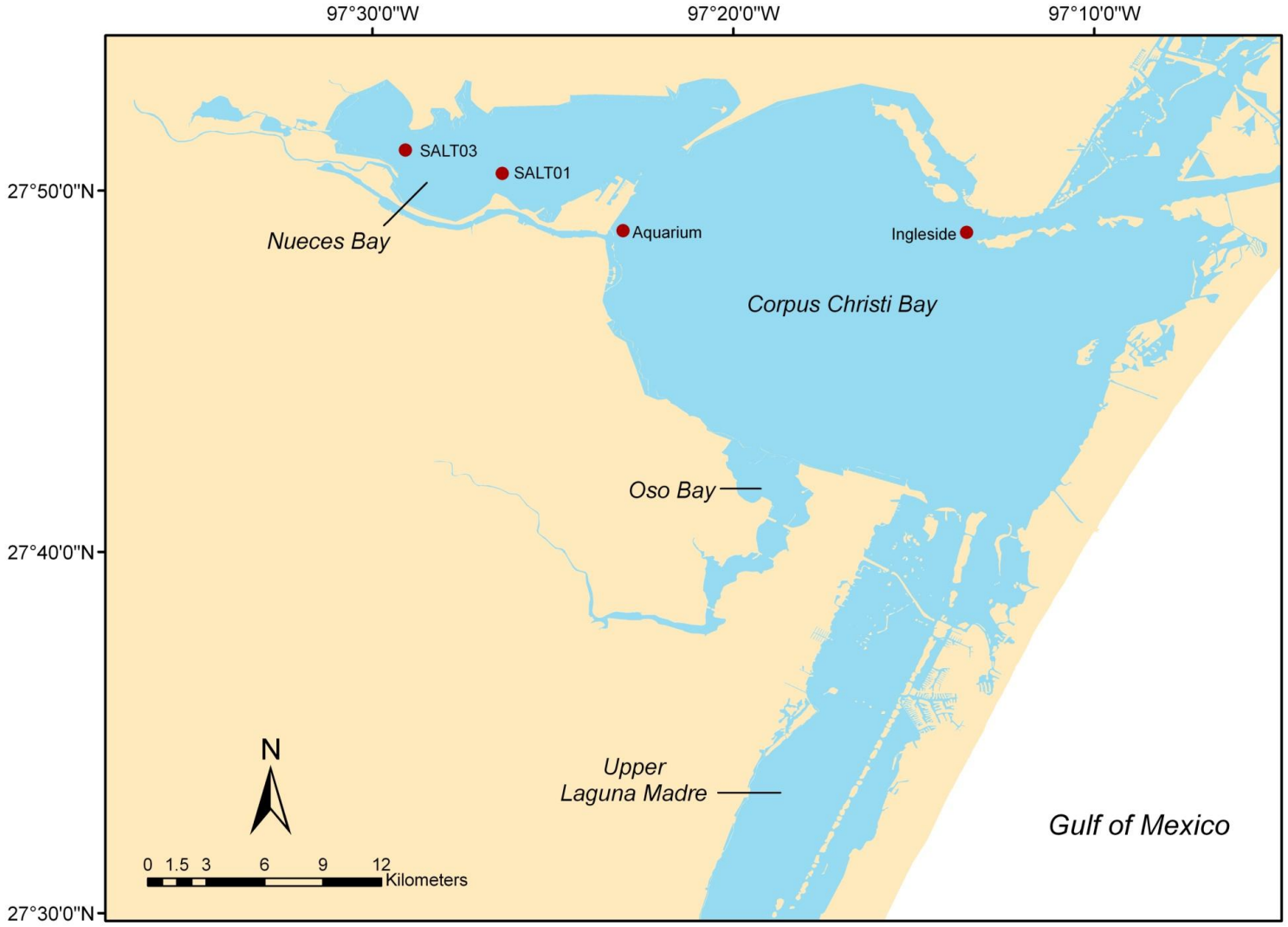

750,000 Acre-ft/yr
166,000 Acre-ft/yr
30,000 Acre-ft/yr
Annual Inflow (acre feet)
2,600,000
2,400,000
2,200,000
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
1941
1943
1945
1947
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009

How does the bay respond to inflow?



TxBLEND modeled salinity, August 2011 TWDB J. Matsumoto, GIS post processing TPWD L. Hamlin


Dry
Average
Wet
1996
1997
2003
2000
2004
SALINITY
6-8
8-10
10-12
12-14
14-16
16-18
18-20
20-22
22-24
24-26
26-28
28-30
30-32
32-34
34-36
36-38
38-40


97°30'0"W
97°20'0"W
97°10'0"W
27°50'0"N
27°40'0"N
27°30'0"N
SALT03
SALT01
Nueces Bay
Aquarium
Ingleside
Corpus Christi Bay
Oso Bay
Upper
Laguna Madre
Gulf of Mexico
N
0 1.5 3 6 9 12
Kilometers

Steps:

1. Characterize historical water availability patterns

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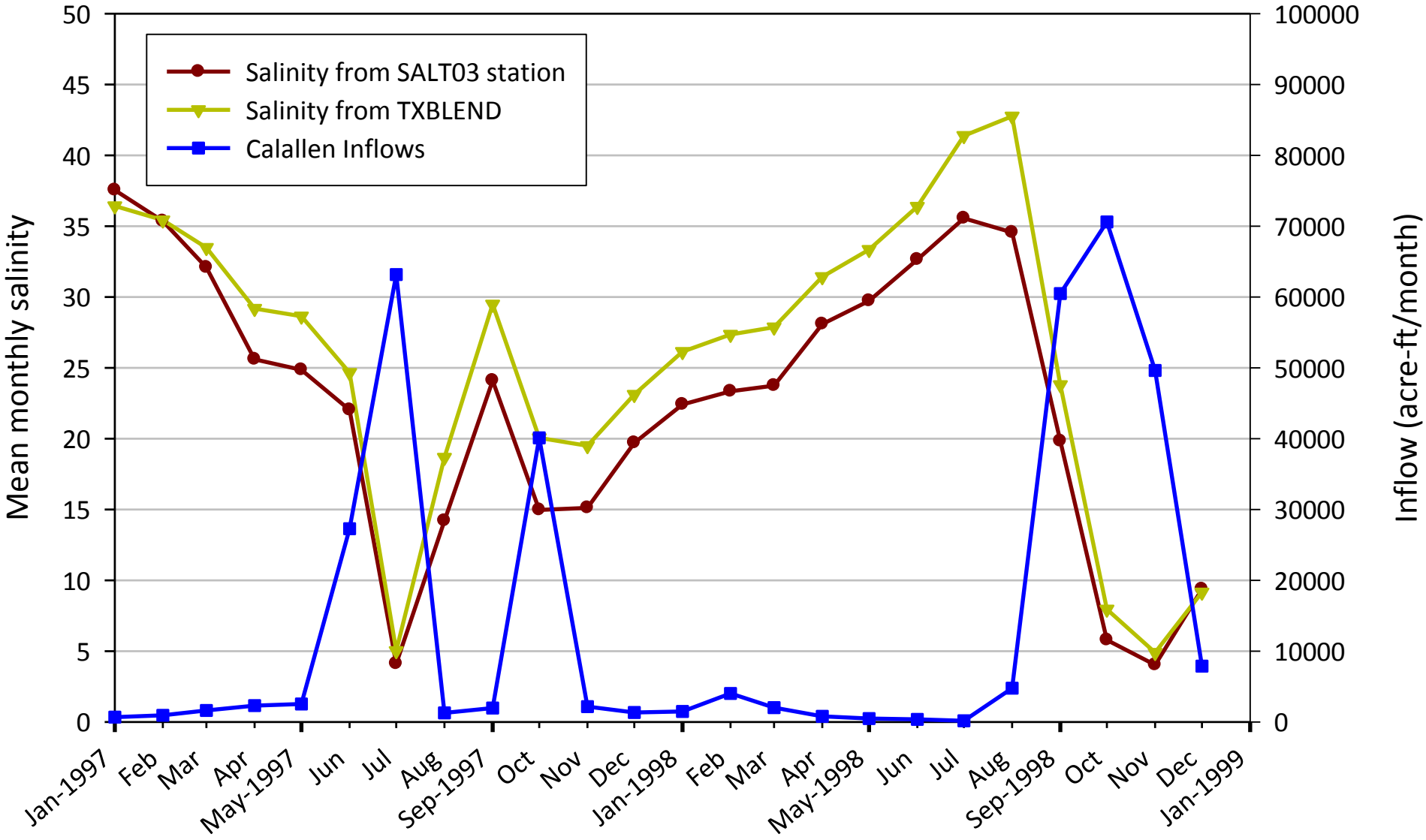
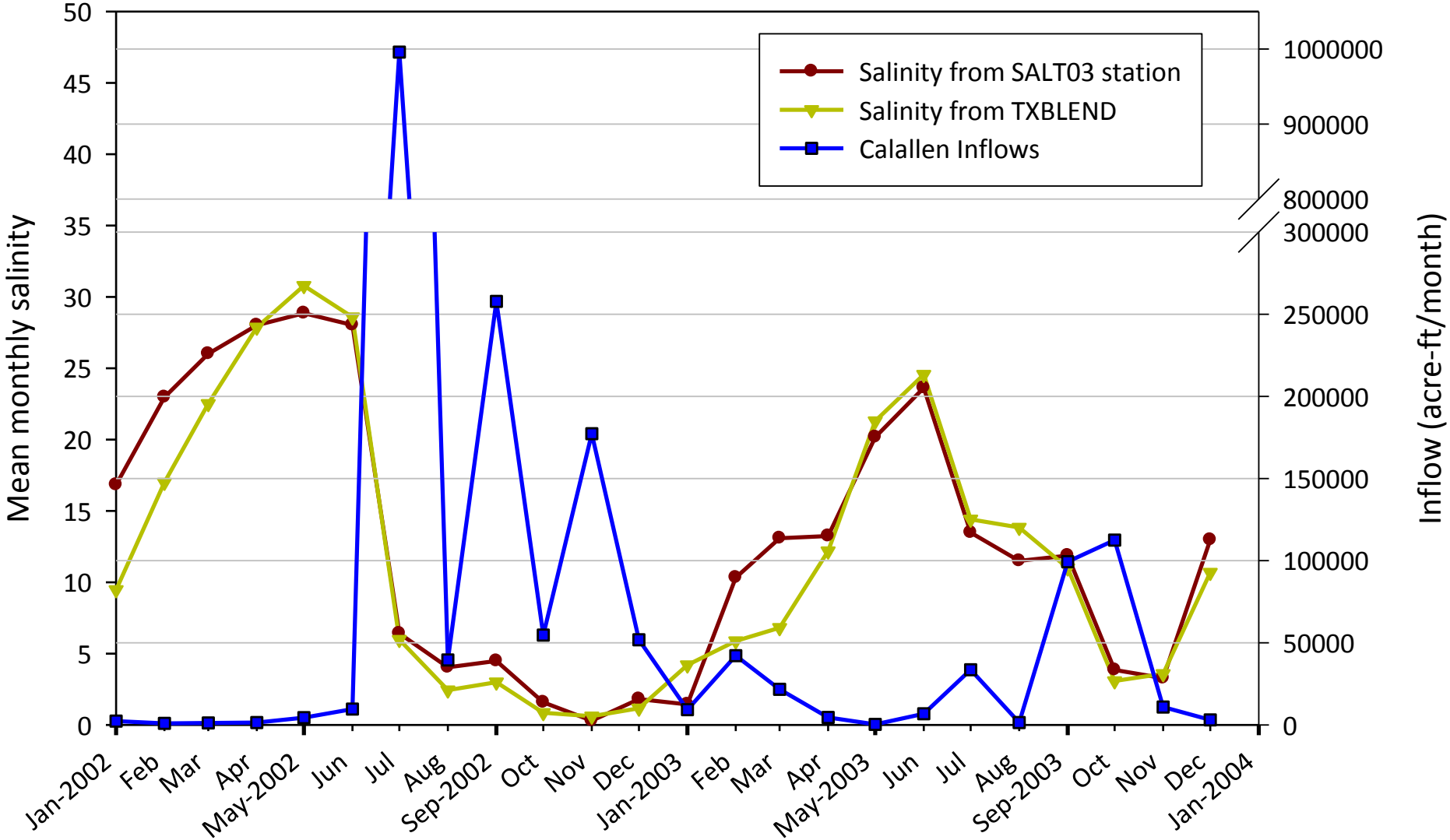
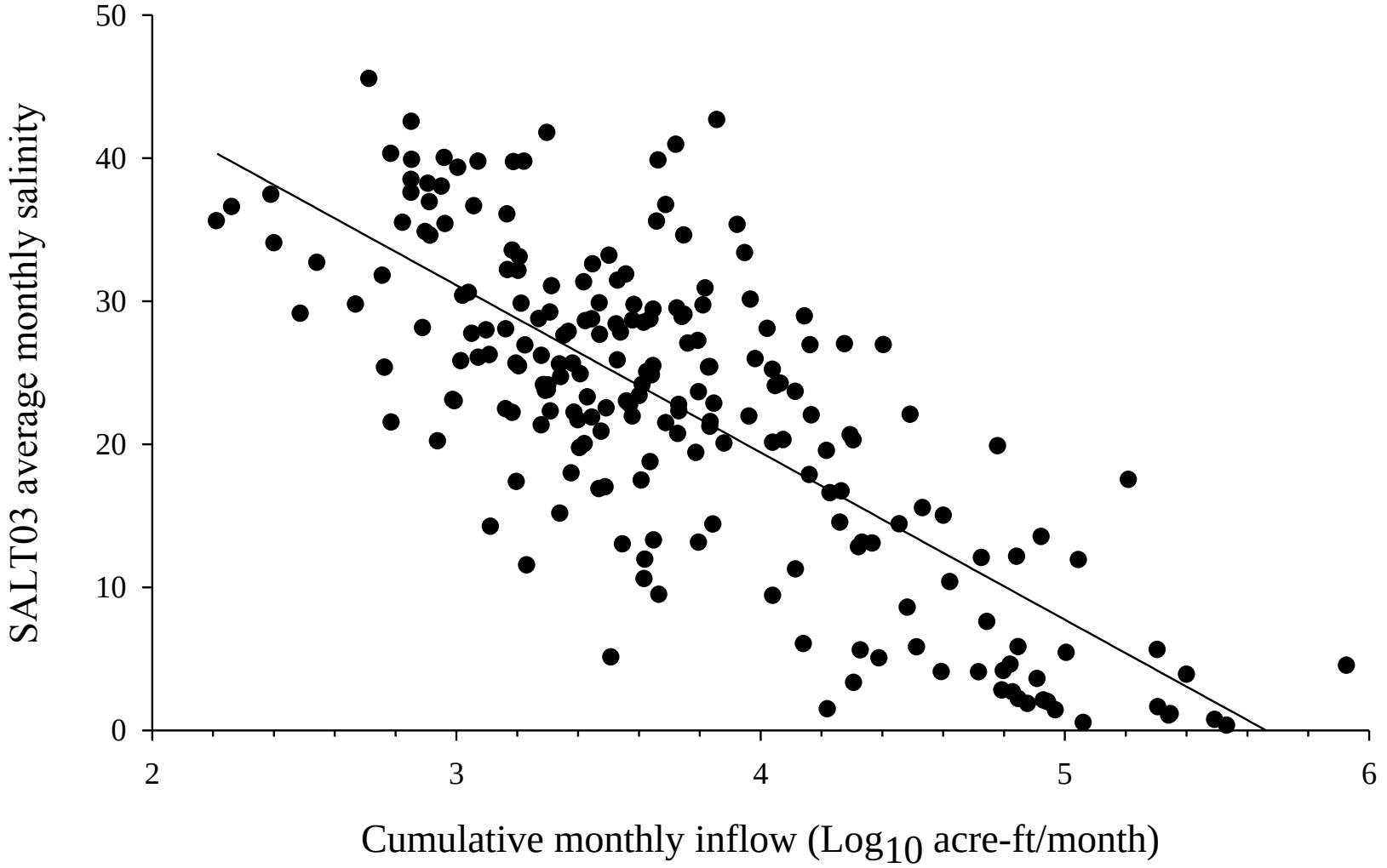
Average Years: 1997-1998



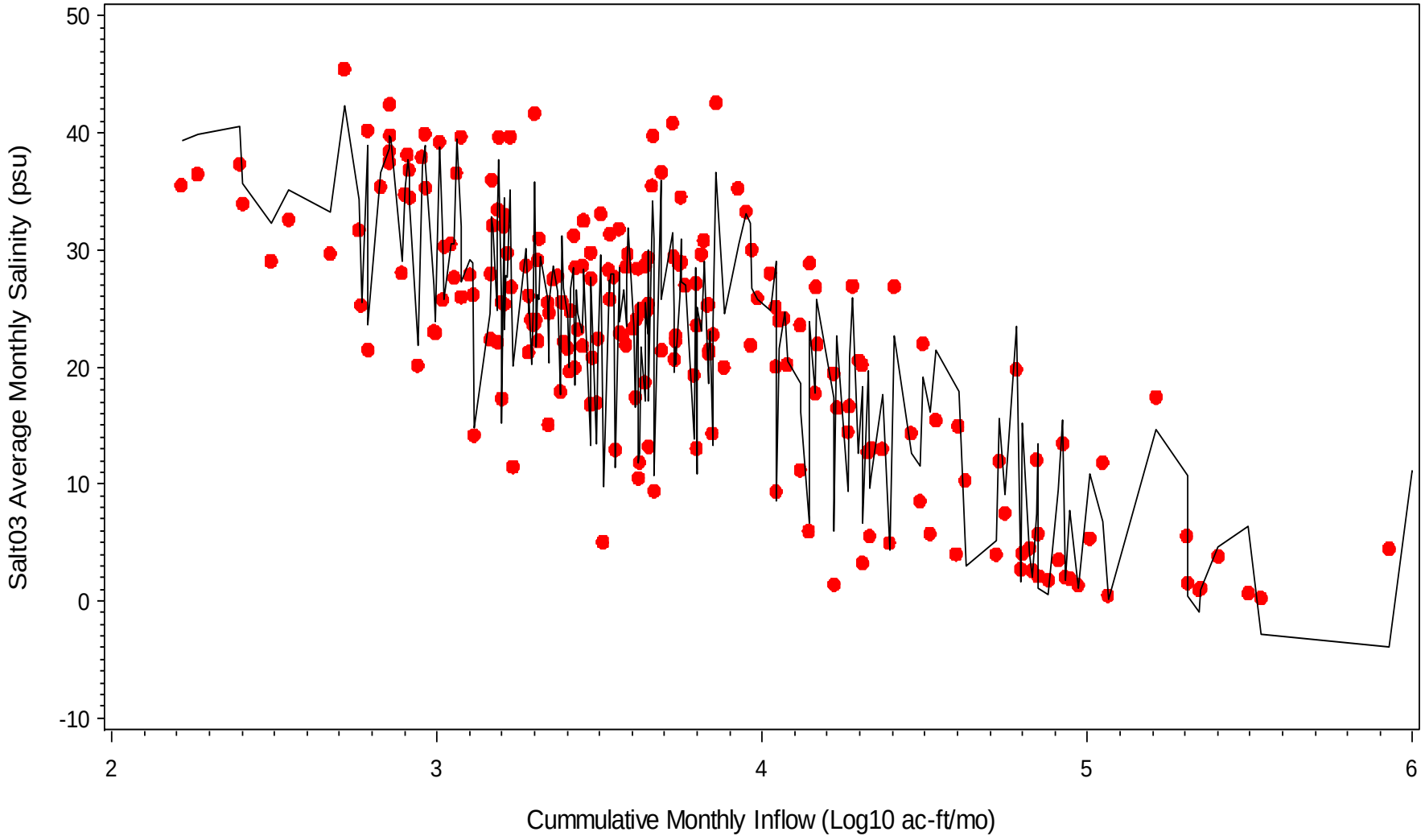
Wet Years: 2002-2003



A flow-salinity "key"…



Salinity = 66.183 – (11.690 x $\log_{10}$(inflow)); R^2 = 0.58.



Salinity = 32.85 - (6.648 * Log10(Inflow)) + 0.6480*PrevSal, R^2=0.90

Steps:

1. Characterize historical water availability patterns

2. Examine flow and salinity relationships

3. Indentify focal species (Canaries)

4. Recommend flow that will create a sound environment

Species

Spartina alterniflora

Benthic Infauna

Crassostrea virginica

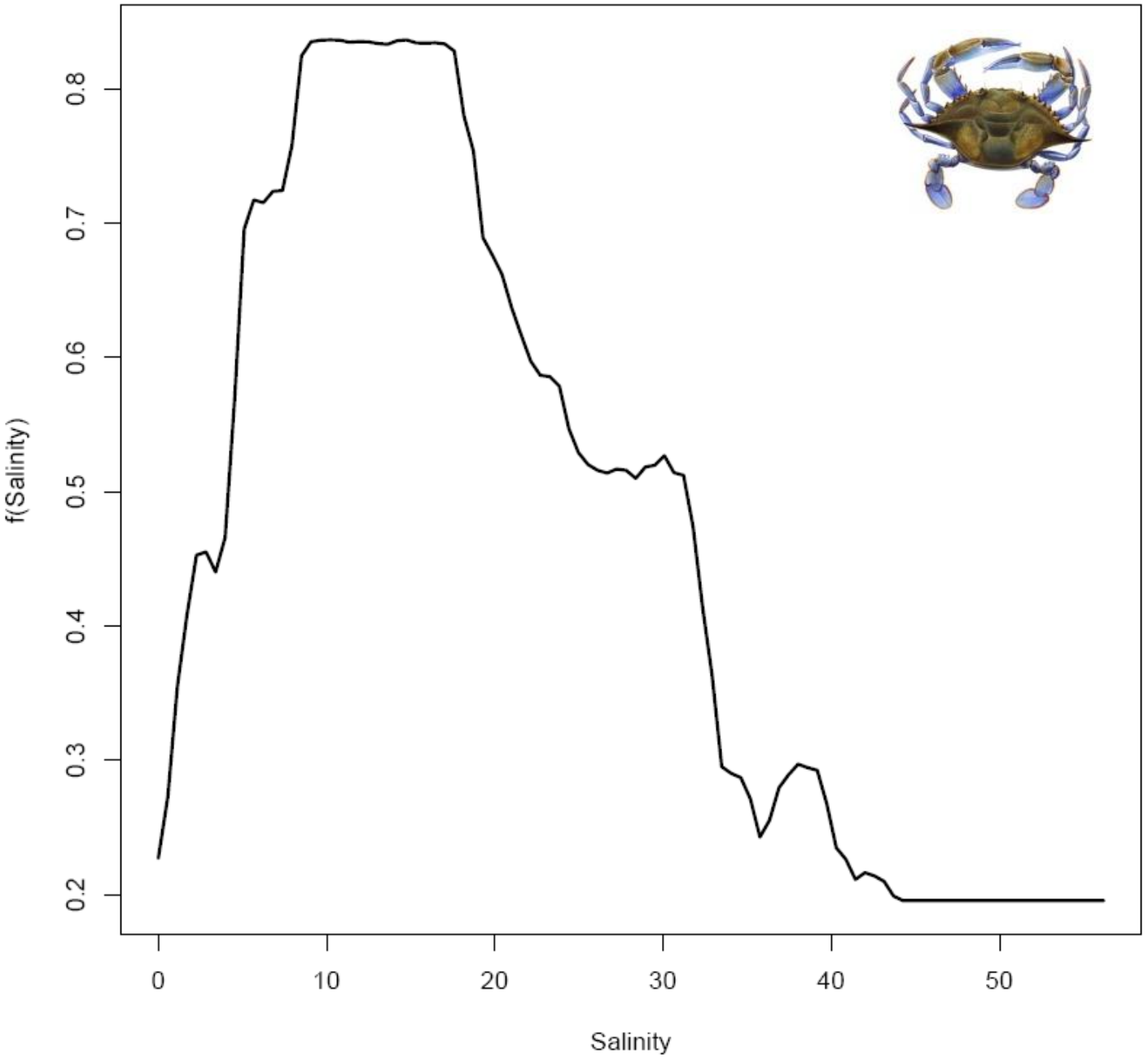
Callinectes sapidus

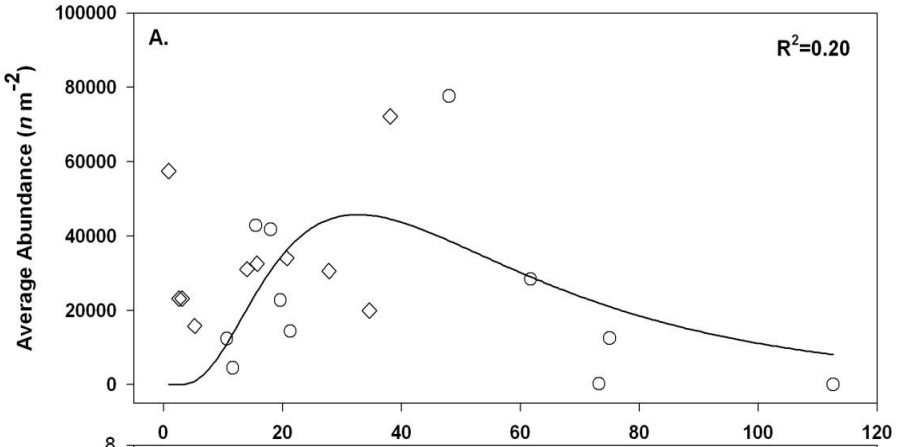
Micropogonias undulatus

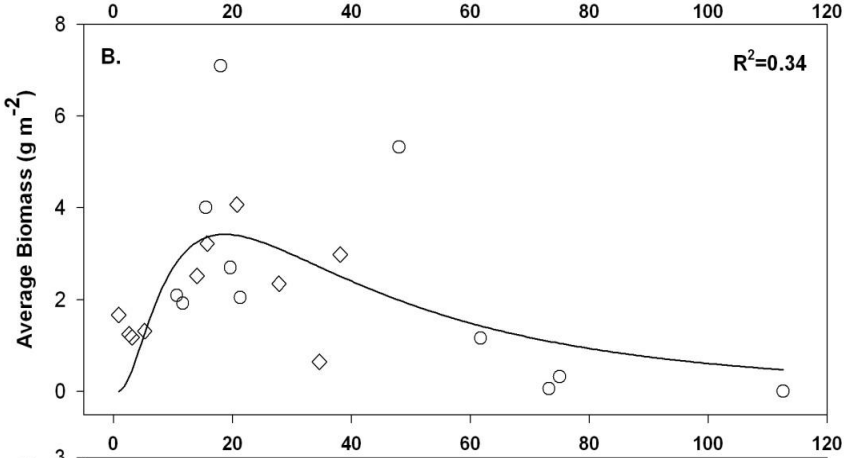
Key Indicator Species

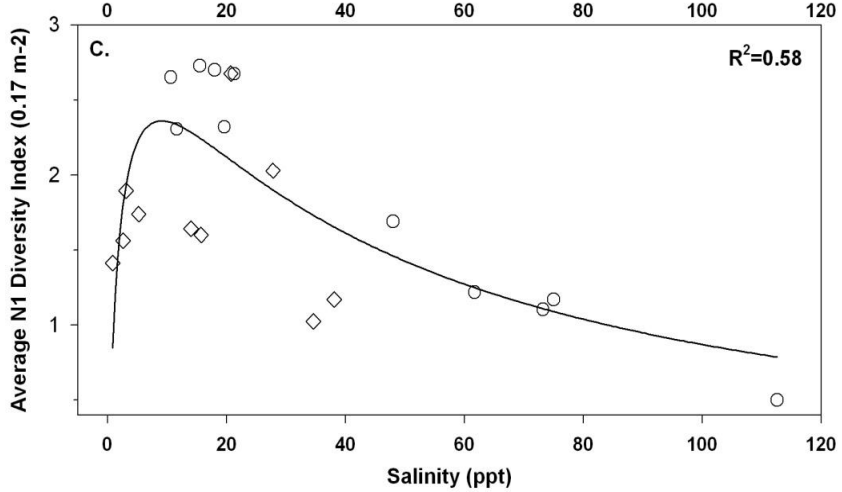
0 5 10 15 20 25 30 35 40

Salinity


f(Salinity)
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
10
20
30
40
50
Salinity


A.
R^2=0.20
Average Abundance (*n* m^{-2})
100000
80000
60000
40000
20000
0
0
20
40
60
80
100
120


B.
R^2=0.34
Average Biomass (g m^{-2})
8
6
4
2
0
0
20
40
60
80
100
120


C.
R^2=0.58
Average N1 Diversity Index (0.17 m-2)
3
2
1
0
20
40
60
80
100
120
Salinity (ppt)

Indicator Species Profiles

Species

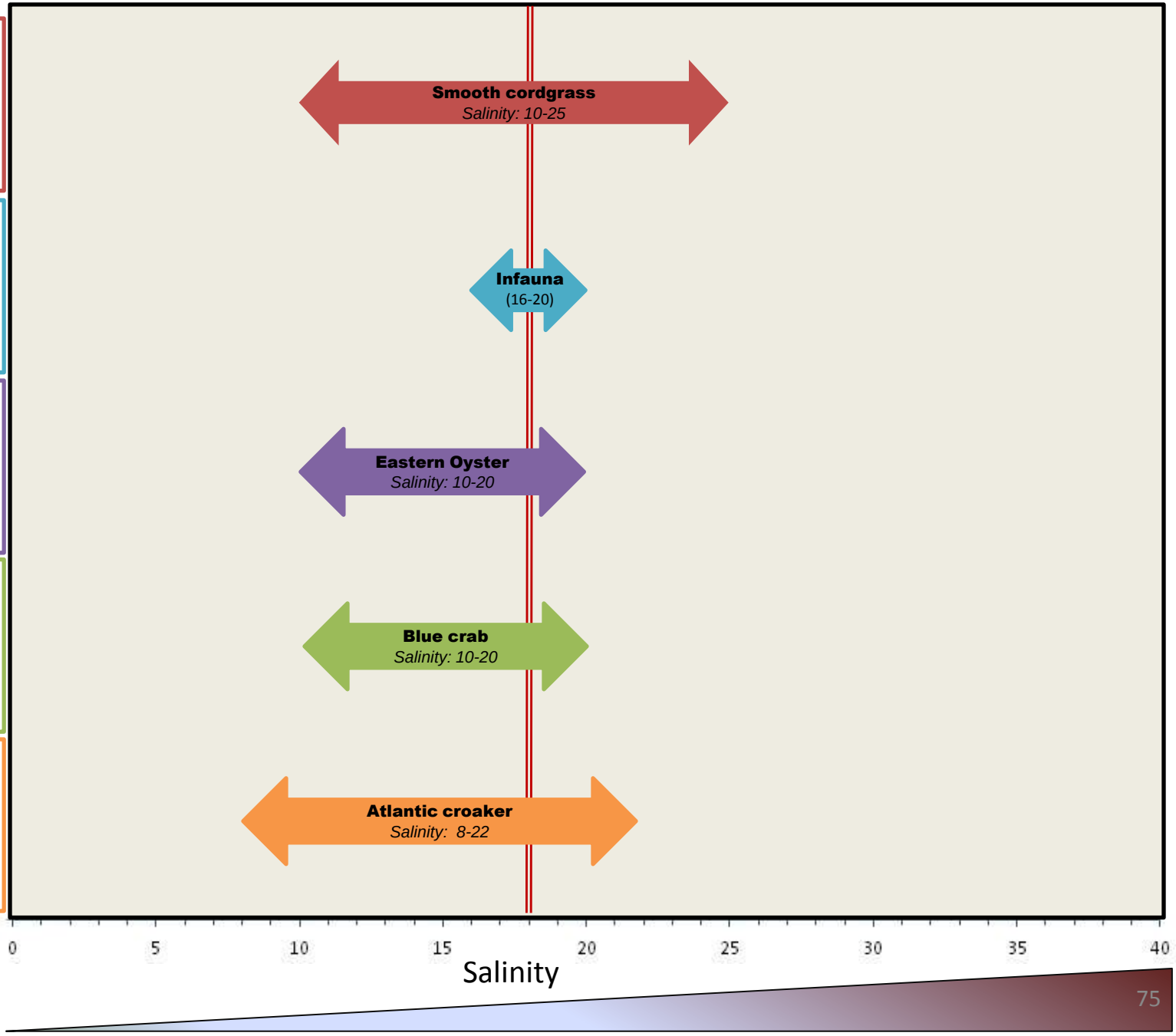
Spartina alterniflora

Benthic Infauna

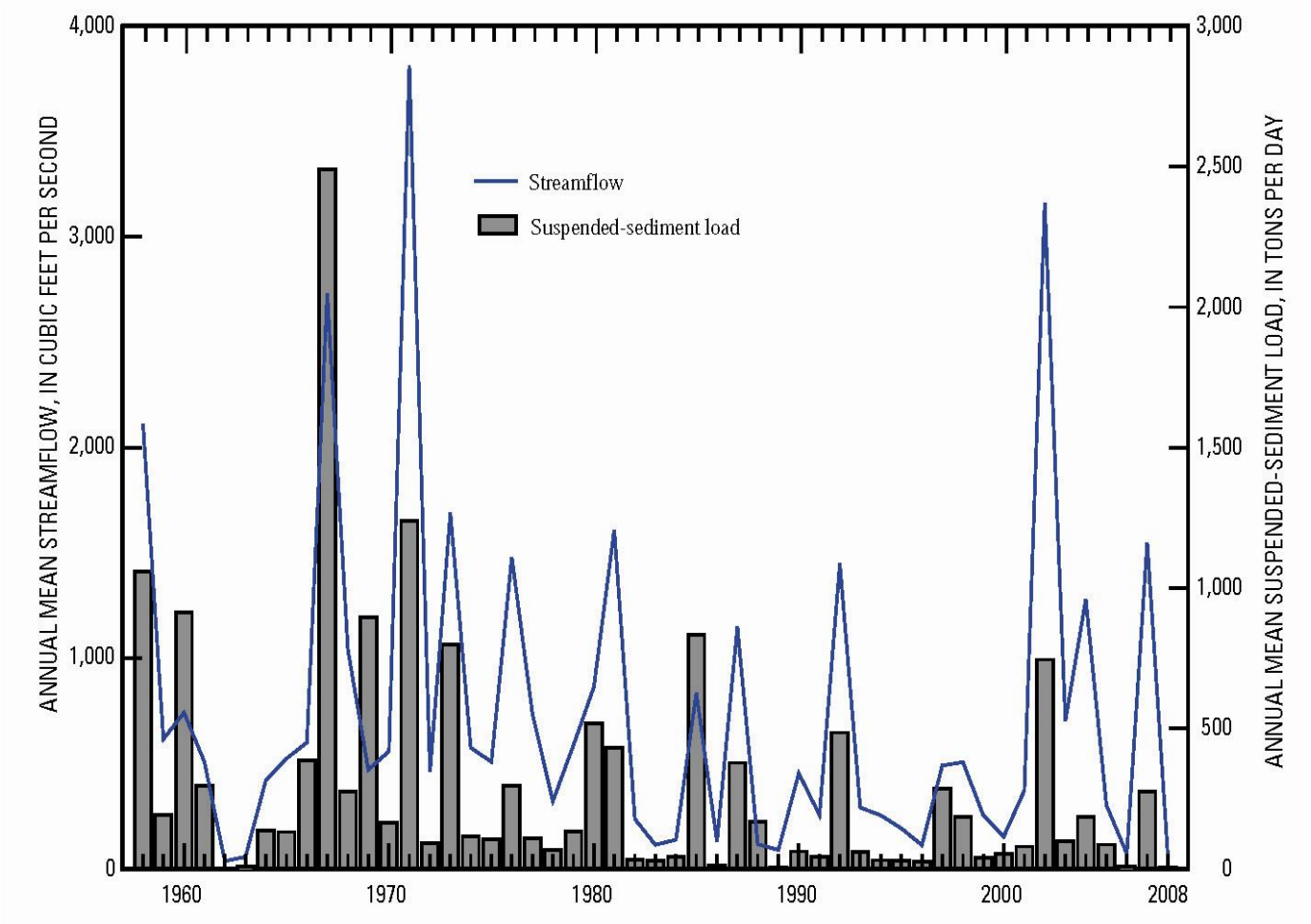
Crassostrea virginica

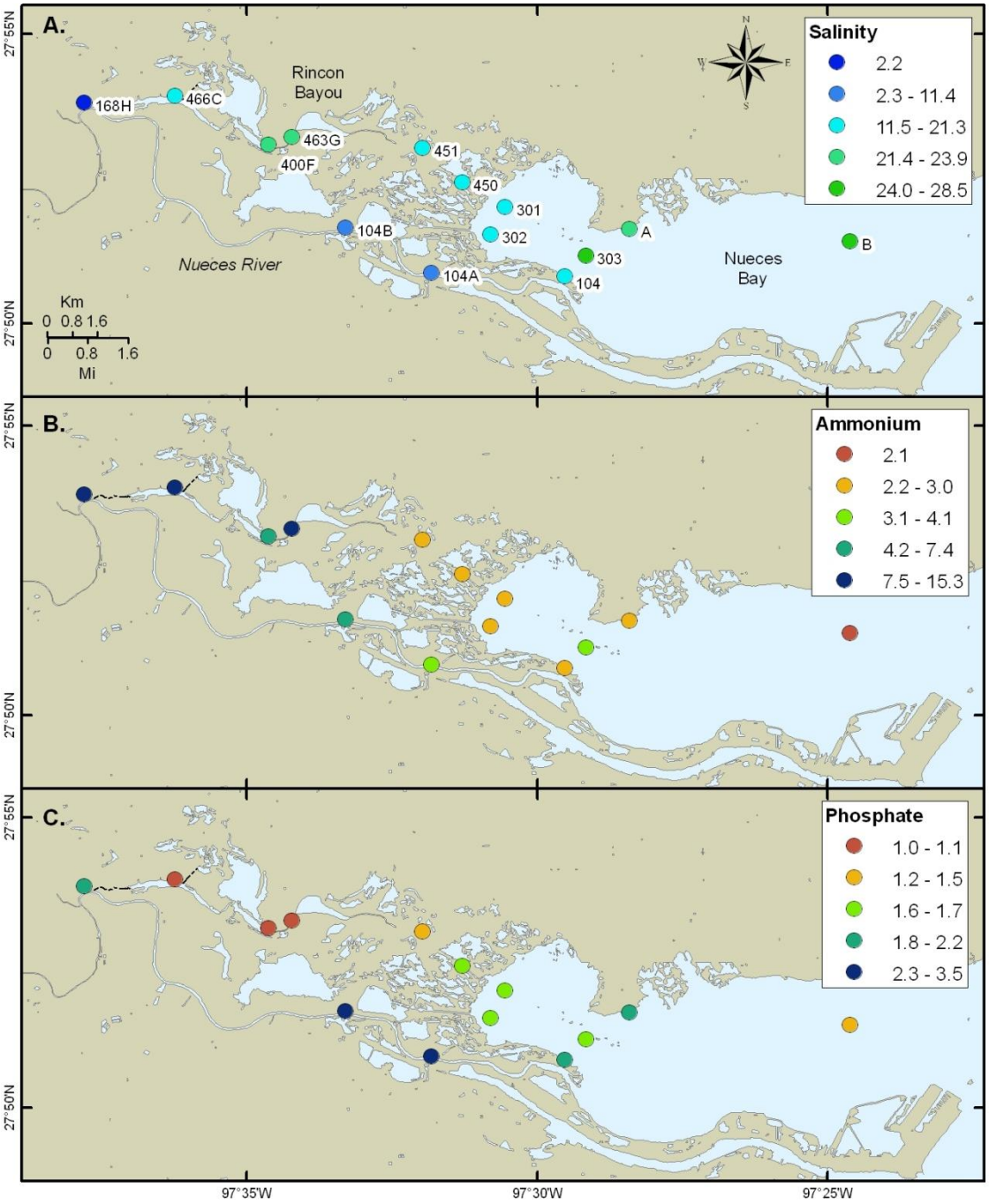
Callinectes sapidus

Micropogonias undulatus



Sediment and Nutrient Considerations




A.
B.
C.
Rincon Bayou
Nueces River
Nueces Bay
168H
466C
463G
400F
451
450
301
302
303
104
104A
104B
A
B
Km
0 0.8 1.6
0 0.8 1.6
Mi
Salinity
2.2
2.3 - 11.4
11.5 - 21.3
21.4 - 23.9
24.0 - 28.5
Ammonium
2.1
2.2 - 3.0
3.1 - 4.1
4.2 - 7.4
7.5 - 15.3
Phosphate
1.0 - 1.1
1.2 - 1.5
1.6 - 1.7
1.8 - 2.2
2.3 - 3.5
27°55'N
27°50'N
97°35'W
97°30'W
97°25'W

Steps:

1. **Characterize historical water availability patterns**

2. **Examine flow and salinity relationships**

3. **Indentify focal species (Canaries)**

4. **<u>Recommend flow that will create a sound environment</u>**

Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime (Attainment)												Recommendations		Historical Attainment		
	1 overbanking event per year of 39,000 acre-ft; maximum discharge of 3600 cfs												Annual Total	Attainment	1941-2009	1941-1982	1983-2009
High (10)	125,000 Acre-ft (20%)				250,000 Acre-ft (25%)				375,000 Acre-ft (20%)				750,000	25%	22%	26%	15%
Base (18)	22,000 Acre-ft (60%)				88,000 Acre-ft (60%)				56,000 Acre-ft (75%)				166,000	80%	67%	81%	44%
Subsistence (34)	5,000 Acre-ft (95%)				10,000 Acre-ft (95%)				15,000 Acre-ft (95%)				30,000	95%	94%	100%	85%
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct					
	Winter				Spring				Summer		Fall						

	Nueces River Flow (Acre-ft)			
Nueces Delta Porewater Target Salinity	22,000 (244/day)	88,000 (978/day)	38,000 (422/day)	18,000 (200/day)
25	**Winter**	**Spring**	**Summer**	**Fall**

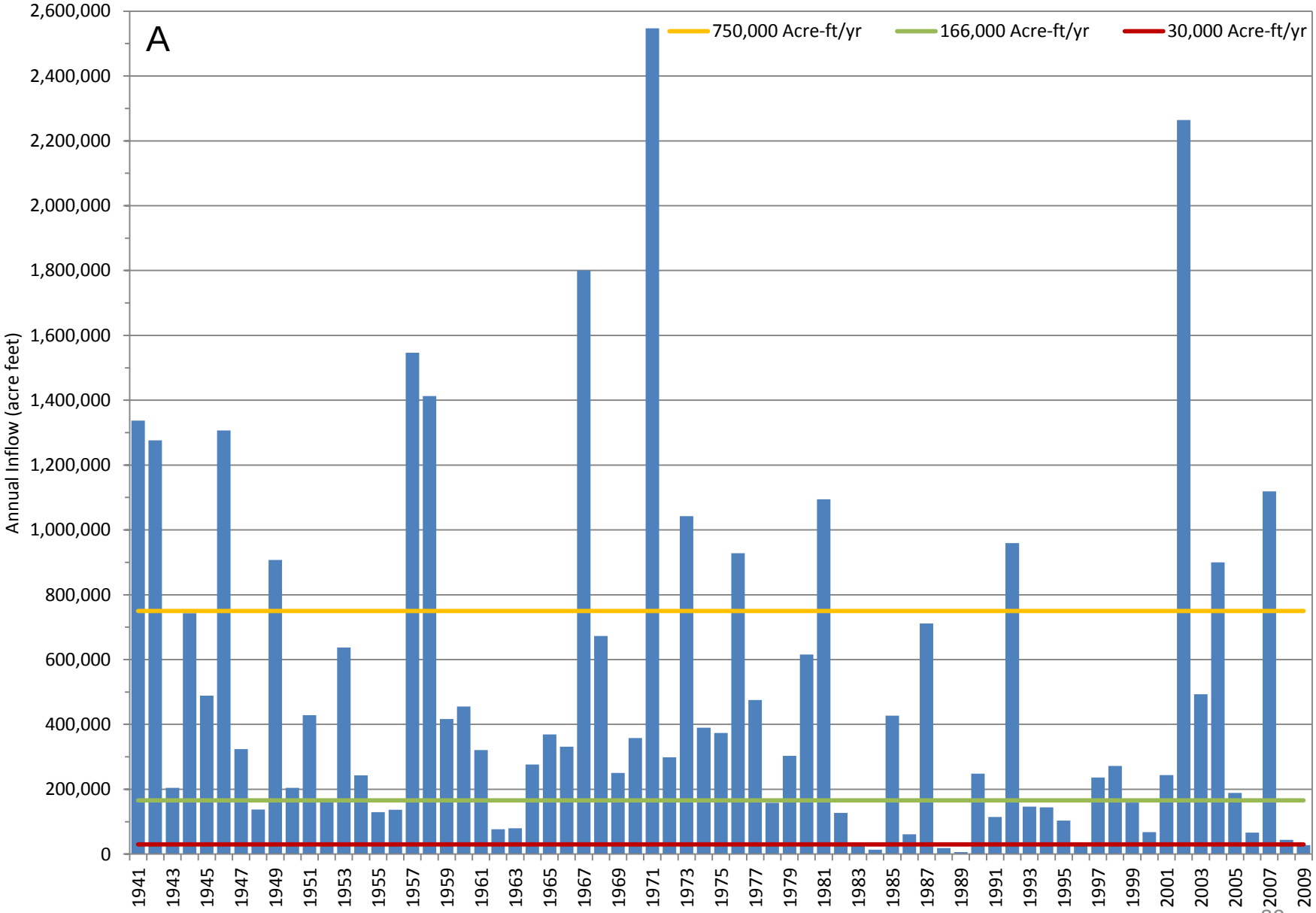
- We set target salinities based on indicator species' salinity requirements for base condition. We then used TxBLEND model outputs to generate target salinities that correspond with high and subsistence conditions.

- We used the below regression from Nueces Bay inflow and SALT03 station to calculate freshwater inflow that would generate target salinities. However, based on marsh plant salinity requirements in the delta there needs to be an annual inflow of 166,000 acre-ft. Therefore, the bay-calculated inflow of 160,000 acre-ft was increased by an additional 6,000 acre-ft to meet base conditions for marsh plants. We also examined historical inflow regimes and determined what the inflow was 95% of the time during the full period of record (1941-2009). We used that inflow as the basis for the annual recommendation for subsistence conditions.

$$\text{Salinity} = 66.183 - (11.690 \times \text{Log}_{10}(\text{Inflow}))$$

- The allocation for seasonal inflow requirements were based on meeting the biological needs of all indicator species, while accounting for historical patterns of water availability.

- Attainment recommendations were based on historical inflow patterns and how often these conditions were met taking into consideration flow regime changes pre- and post-dam flows.


A
750,000 Acre-ft/yr
166,000 Acre-ft/yr
30,000 Acre-ft/yr
Annual Inflow (acre feet)
2,600,000
2,400,000
2,200,000
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
1941
1943
1945
1947
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
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