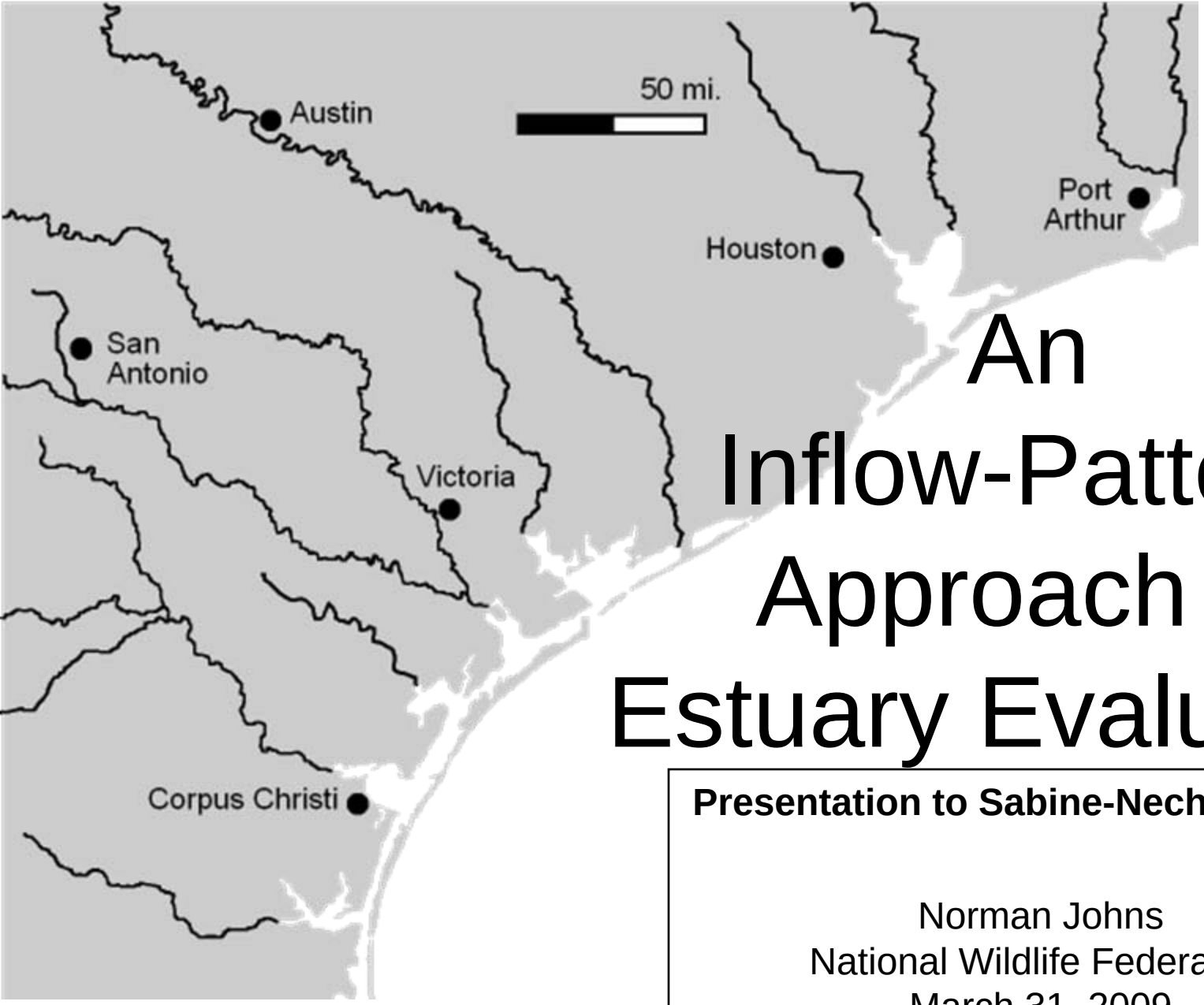
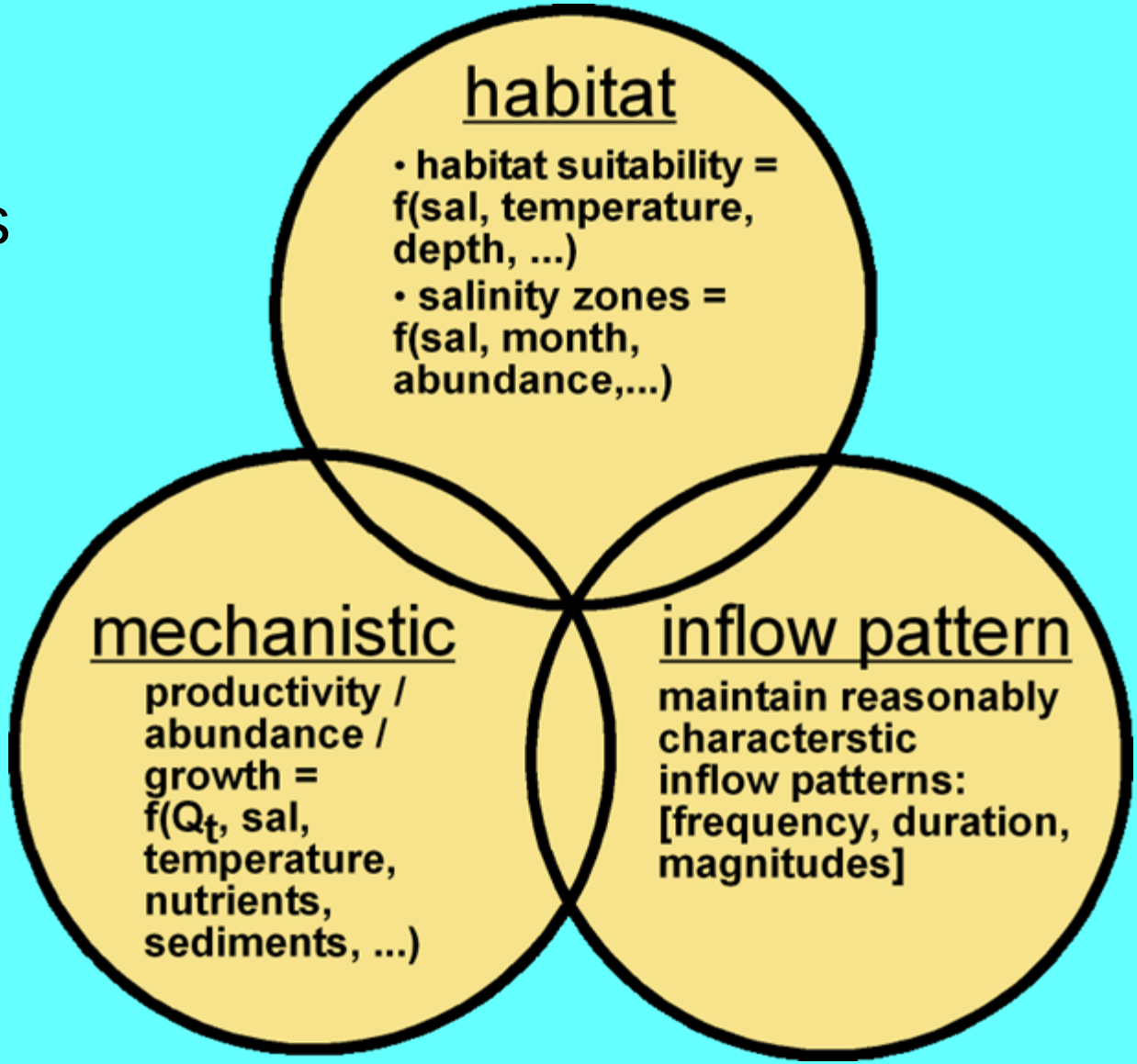



# An Inflow-Pattern Approach to Estuary Evaluation

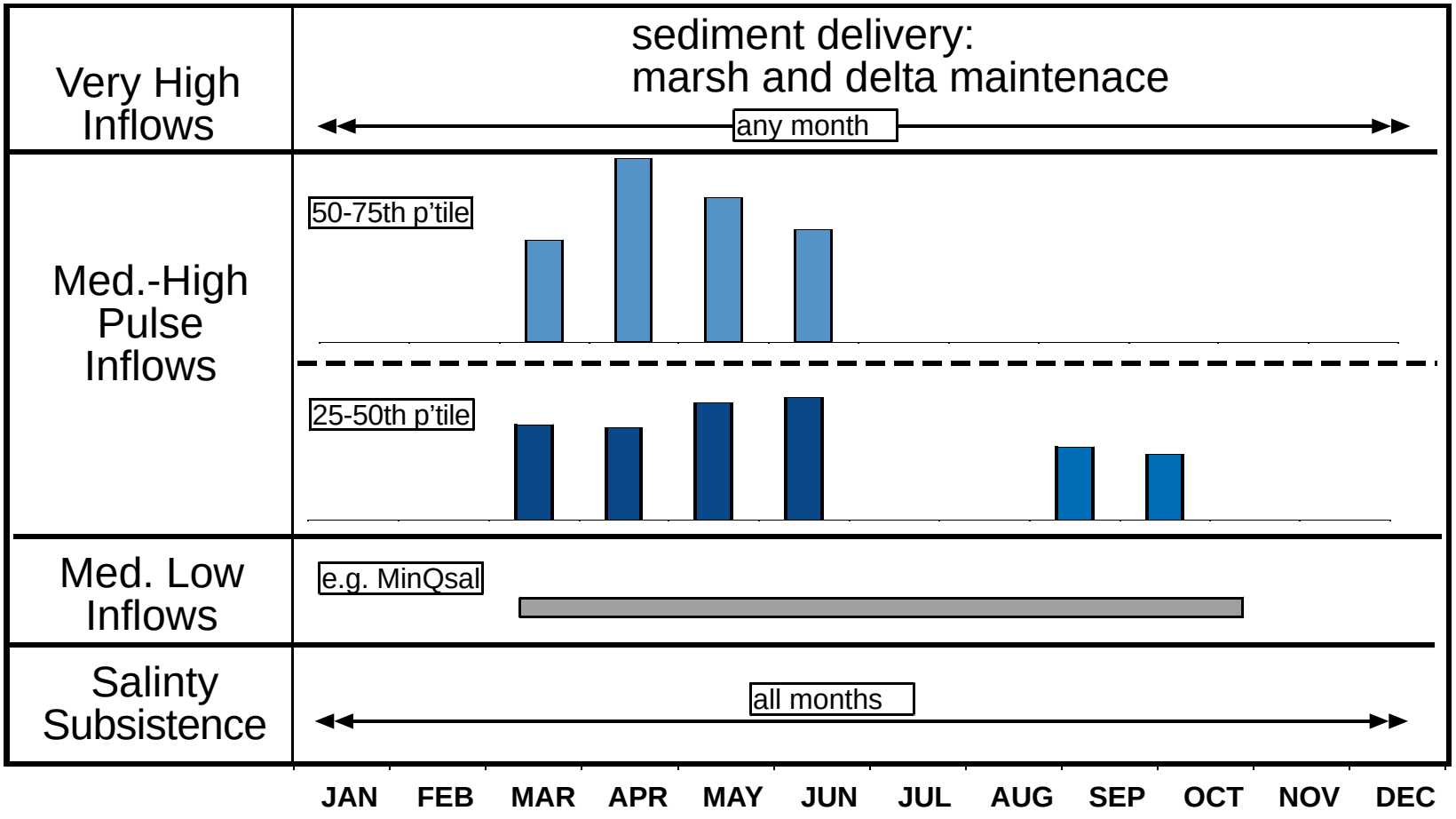
**Presentation to Sabine-Neches BBEST**

Norman Johns
National Wildlife Federation
March 31, 2009

Major Scientific Approaches to Texas Estuary Inflows Evaluation [Proposed]



# For Discussion-
# possible estuary inflows framework



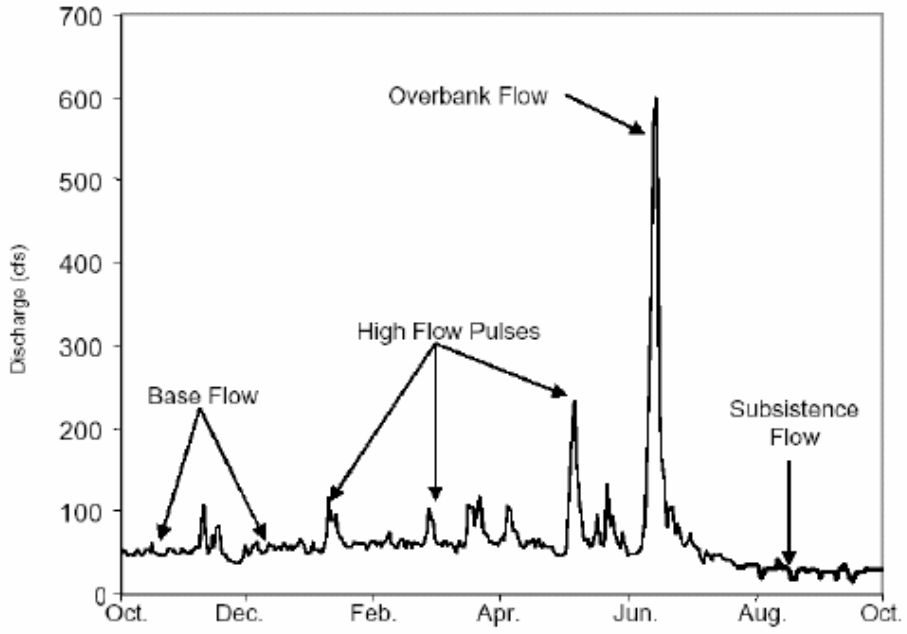
# Instream flows analog HEFR results

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Overbank Flows** | Return Period (R) : 0.7 (years) | | | | | | Duration (D) : 23 (days) | | | | | |
| | Volume (V) : 489751 (ac-ft) | | | | | | Peak Flow (Q) : 40790 (cfs) | | | | | |
| **High Flow Pulses** | F: 1 | D: 8 | | F: 1 | D: 8 | | F: 1 | D: 7 | | F: 1 | D: 7 | |
| | Q: 8207 | V: 70612 | | Q: 8071 | V: 59571 | | Q: 6641 | V: 54290 | | Q: 7314 | V: 53442 | |
| | F: 1 | D: 6 | | F: 1 | D: 5 | | F: 1 | D: 5 | | F: 2 | D: 5 | |
| | Q: 4747 | V: 35030 | | Q: 4009 | V: 30924 | | Q: 3840 | V: 30742 | | Q: 4709 | V: 31776 | |
| | F: 1 | D: 4 | | F: 1 | D: 4 | | F: 1 | D: 3 | | F: 2 | D: 3 | |
| | Q: 3296 | V: 18124 | | Q: 3280 | V: 18058 | | Q: 2207 | V: 13000 | | Q: 3205 | V: 13893 | |
| **Base Flows (cfs)** | 2126 | 2021 | 1847 | 2137 | 1925 | 1758 | 1869 | 1651 | 1937 | 1789 | 1772 | 1677 |
| | 1447 | 1454 | 1547 | 1484 | 1301 | 1267 | 1202 | 1116 | 1194 | 1209 | 1301 | 1287 |
| | 1010 | 1177 | 1111 | 1101 | 1031 | 1014 | 863 | 835 | 887 | 827 | 910 | 883 |
| **Subsistence Flows (cfs)** | 827 | 827 | 827 | 827 | 827 | 827 | 827 | 827 | 827 | 827 | 827 | 827 |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| | Winter | | | Spring | | | Summer | | | Fall | | |

| Hydrologic Conditions | |
|---|---|
| | Wet |
| | Average |
| | Dry |
| | Subsistence |

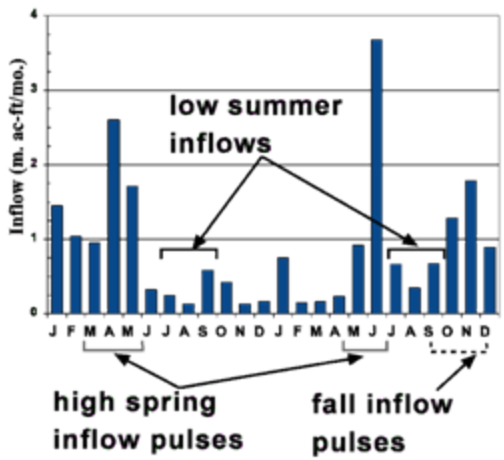
| High Flow Pulse Characteristics | |
|---|---|
| | F = Frequency (per season) |
| | D = Duration (days) |
| | Q = Peak Flows (cfs) |
| | V = Volume (ac-ft) |

# Instream Flow Components



# The Inflow-Pattern Approach for establishing freshwater inflow regimes for Texas estuaries.

**1) Identify Key Hydro-ecological Inflow Events**




**2) Develop Specific Inflow Criteria**

*[timing, volume, frequency, duration]*

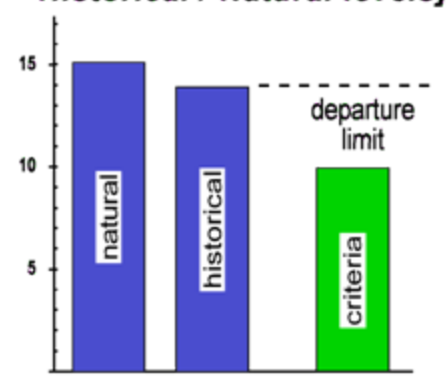
a) Mechanistic
- TxEMP inference

b) Statistics
- Natural
- Historical

c) Other
- Salinity maintenance
- Nutrient flux

**3) Determine Attainment Criteria for Key Events**

*[long-term departure from Historical / Natural levels]*




***"ecologically relevant criteria"***

# Deciding on how much change to accept:

## Florida's across the board 10% decline rule

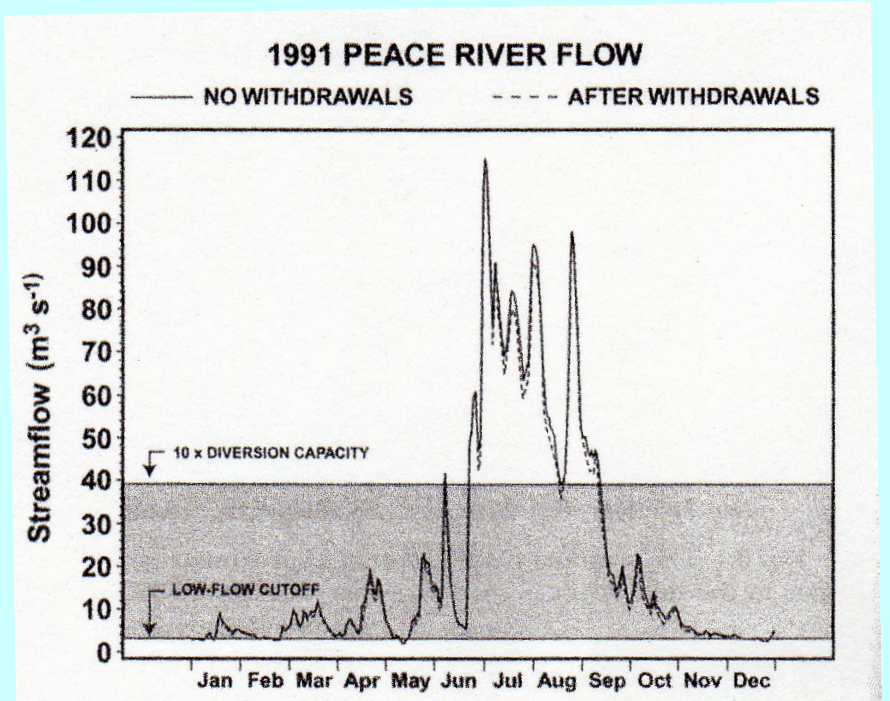



Fig. 10. Daily streamflow values for the Peace River during 1991 (U.S. Geological Survey gauge 02296750), with and without maximum possible withdrawals calculated using the 10% of flow daily limit, combined with a low-flow cutoff of 3.7 $m^3 s^{-1}$ and a diversion capacity of 3.9 $m^3 s^{-1}$. The shaded area represents the range of flows over which a full 10% of streamflow can be diverted.

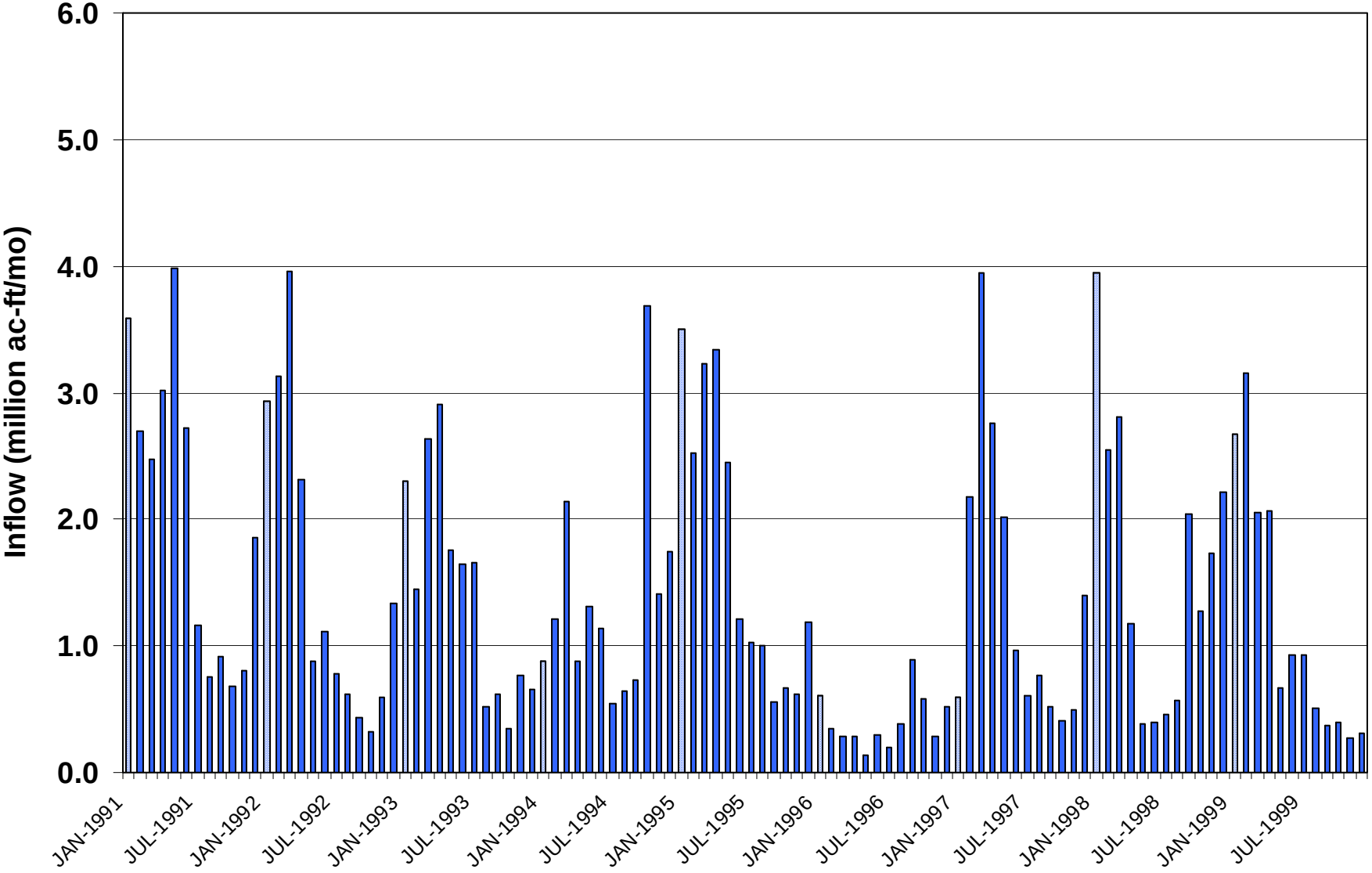
# Deciding on how much change to accept:

Galveston Bay Freshwater Inflows Group &
Region H Water Planning Group:
adopted long-term inflow recommendations

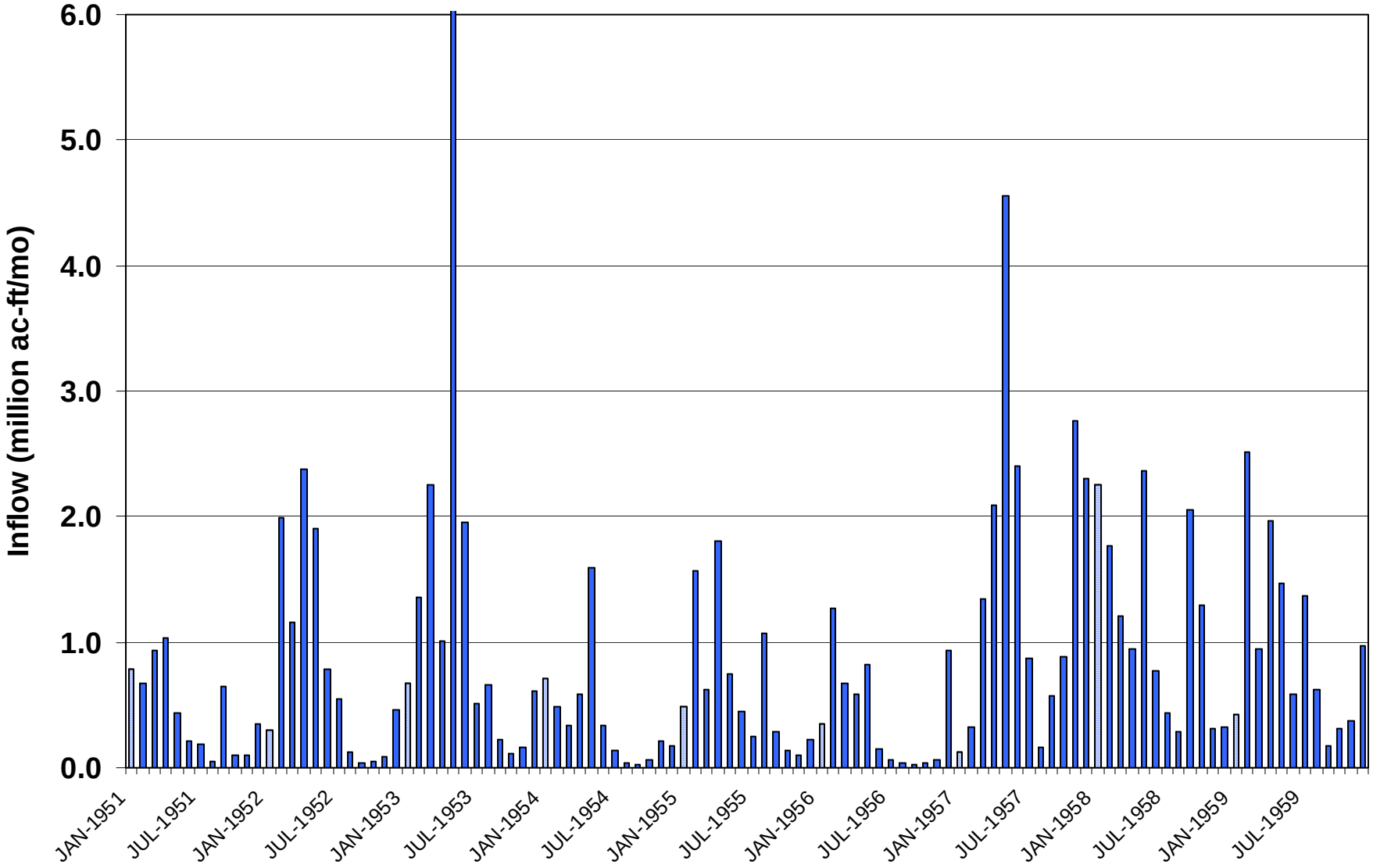
| Inflow Scenario | Quantity Needed (acre-feet/year) | Historical Frequency | Target Minimum Frequency | Calculated % departure |
|---|---|---|---|---|
| Max H | 5.2 million | 66% | 50% | -24.2% |
| Min Q | 4.2 million | 70% | 60% | -14.3% |
| Min Q-Sal | 2.5 million | 82% | 75% | -8.5% |
| Min Historic | 1.8 million | 98% | 90% | -8.2% |

Table 4.2-2 Annotated Table E-8 of the 2006 Region H Water Plan, an example determination of allowable departures for established environmental criteria Max H, Min Q, MinQ-Sal and the minimum historic inflows Min Historic.

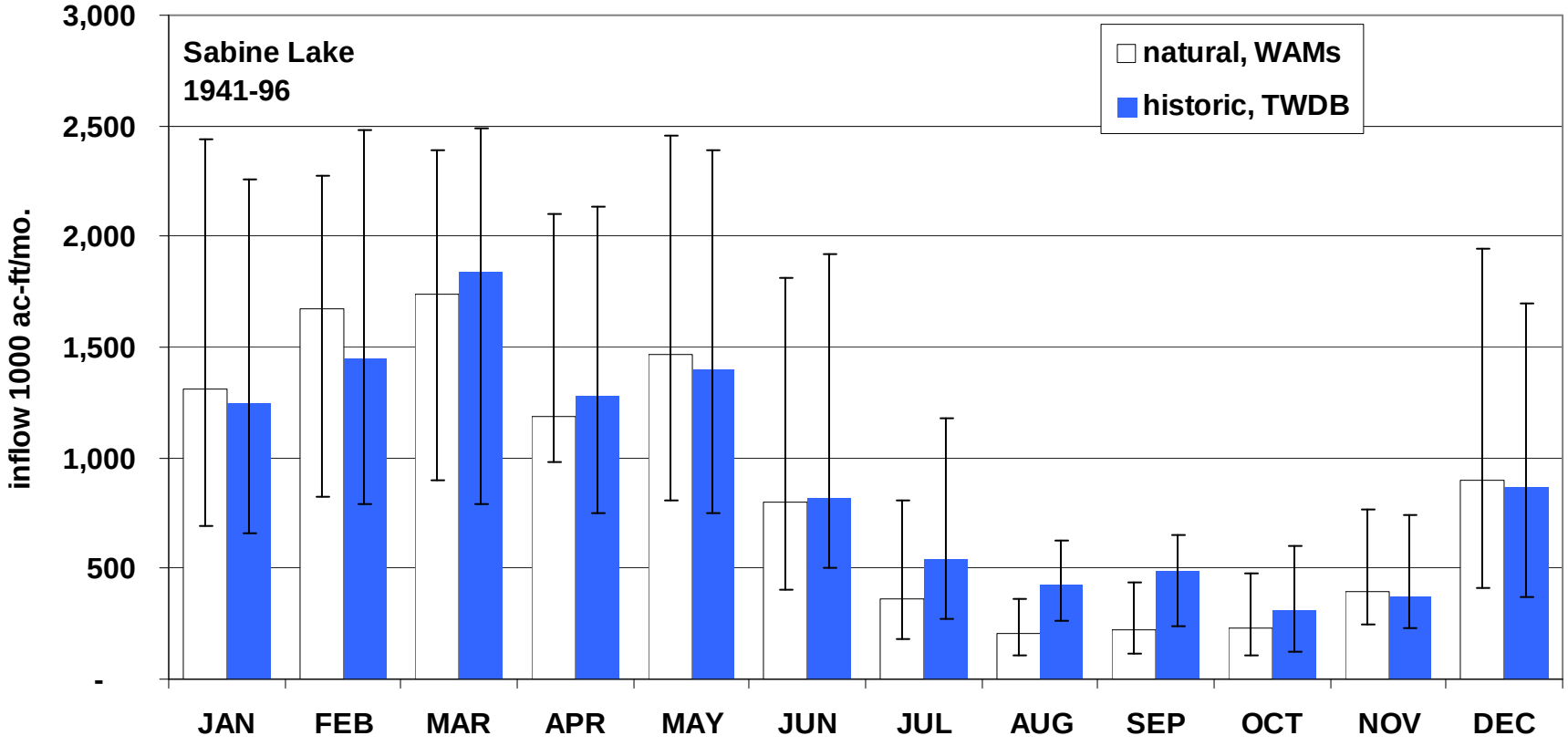
# Sabine Lake - Total Freshwater Inflow: 1990's



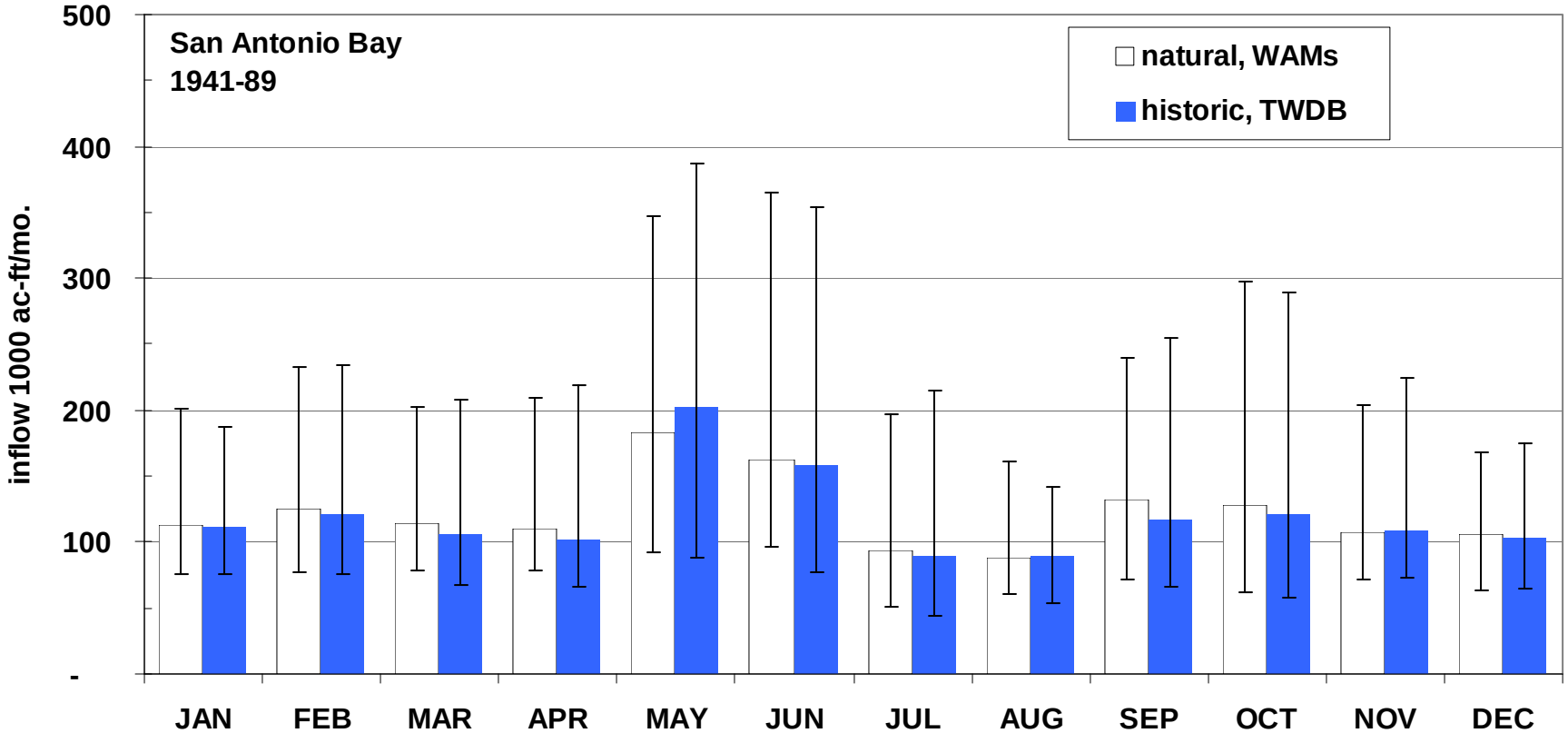
# Sabine Lake - Total Freshwater Inflow: 1950's



# Sabine Lake - Freshwater Inflow Patterns



# Guadalupe Estuary - Freshwater Inflow Patterns



# The Inflow-Pattern Approach for establishing freshwater inflow regimes for Texas estuaries.

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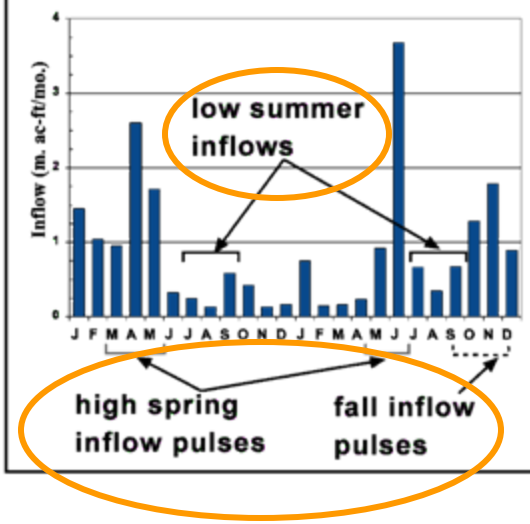


**2) Develop Specific Inflow Criteria**

*[timing, volume, frequency, duration]*

a) Mechanistic
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- Natural
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c) Other
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- Nutrient flux

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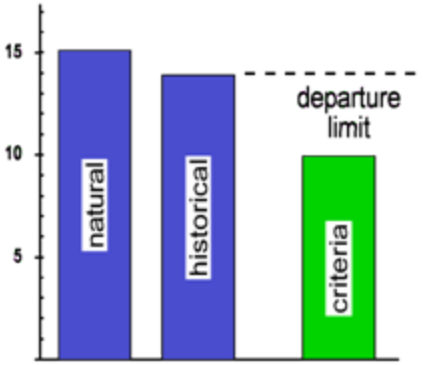
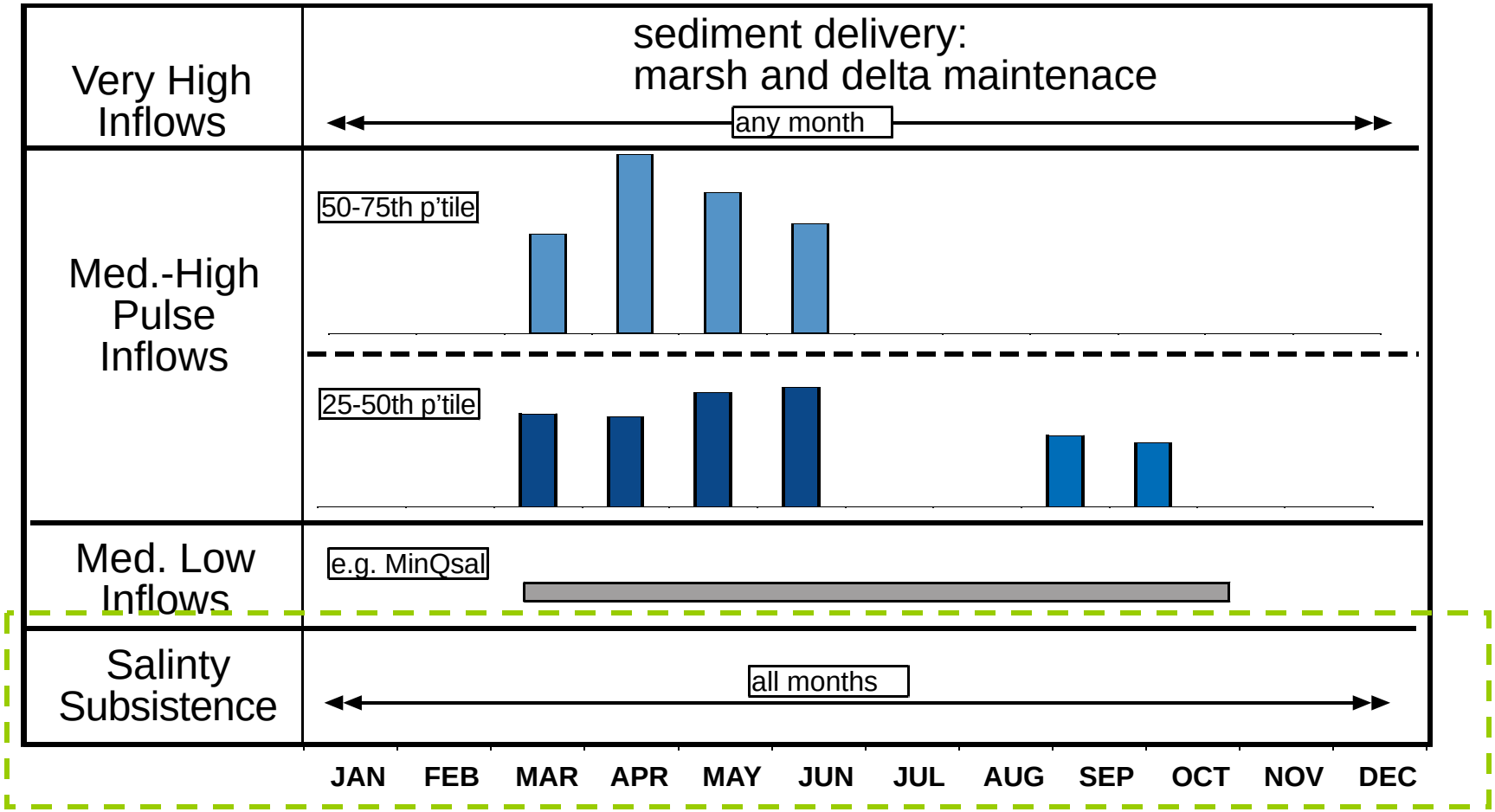
*[long-term departure from Historical / Natural levels]*



# For Discussion-
# possible estuary inflows framework



**Development of low-inflow criteria:**

**salinity-marshlands focus**

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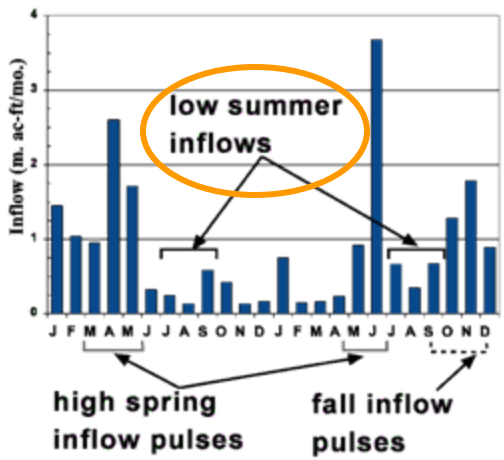


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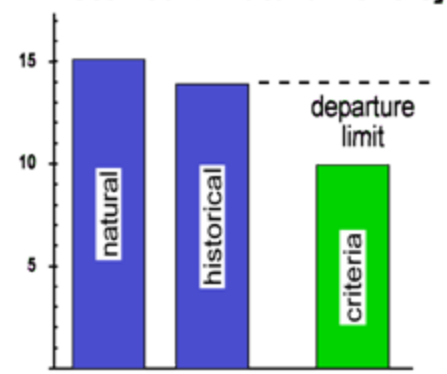
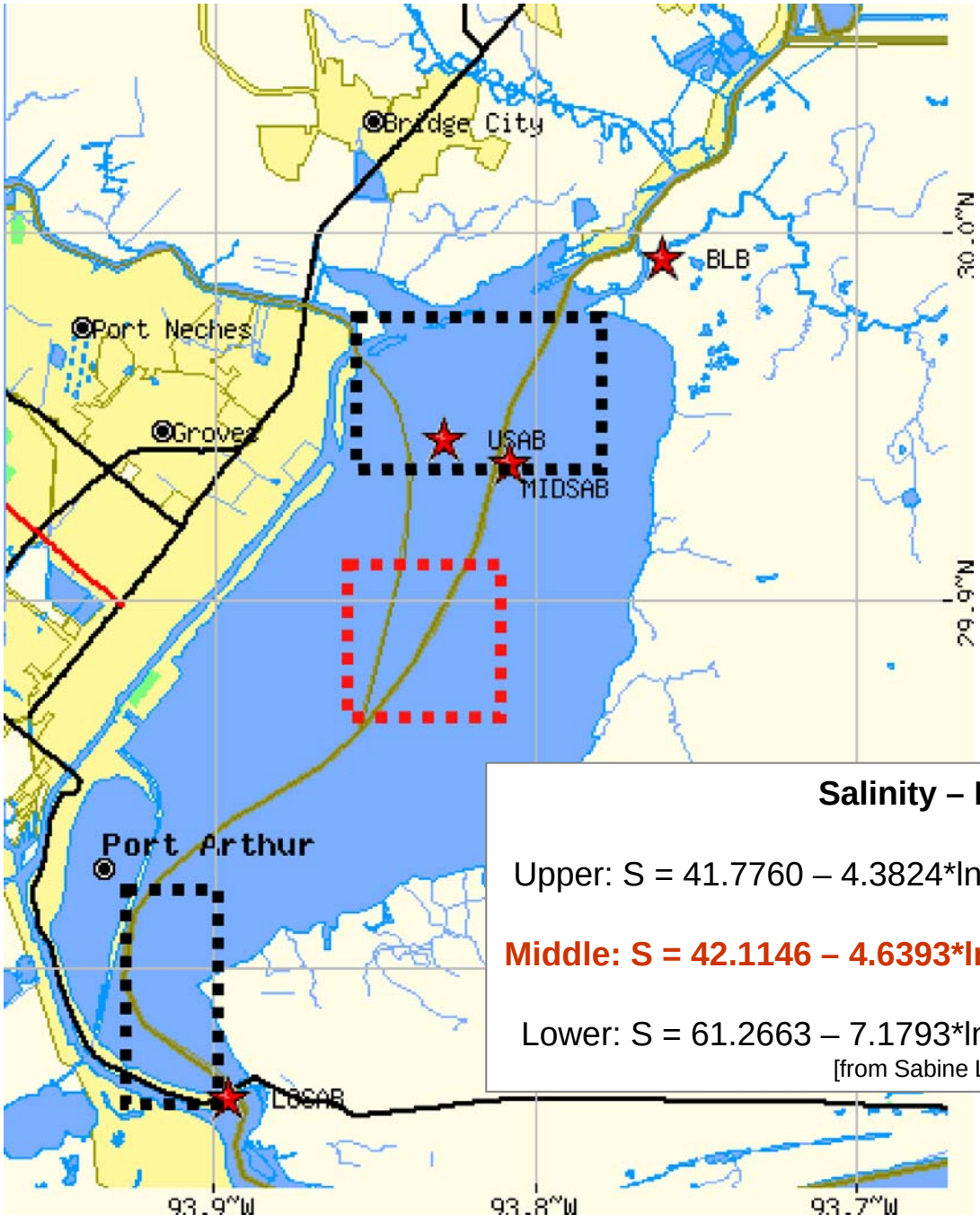





**Salinity – Inflow Equations**

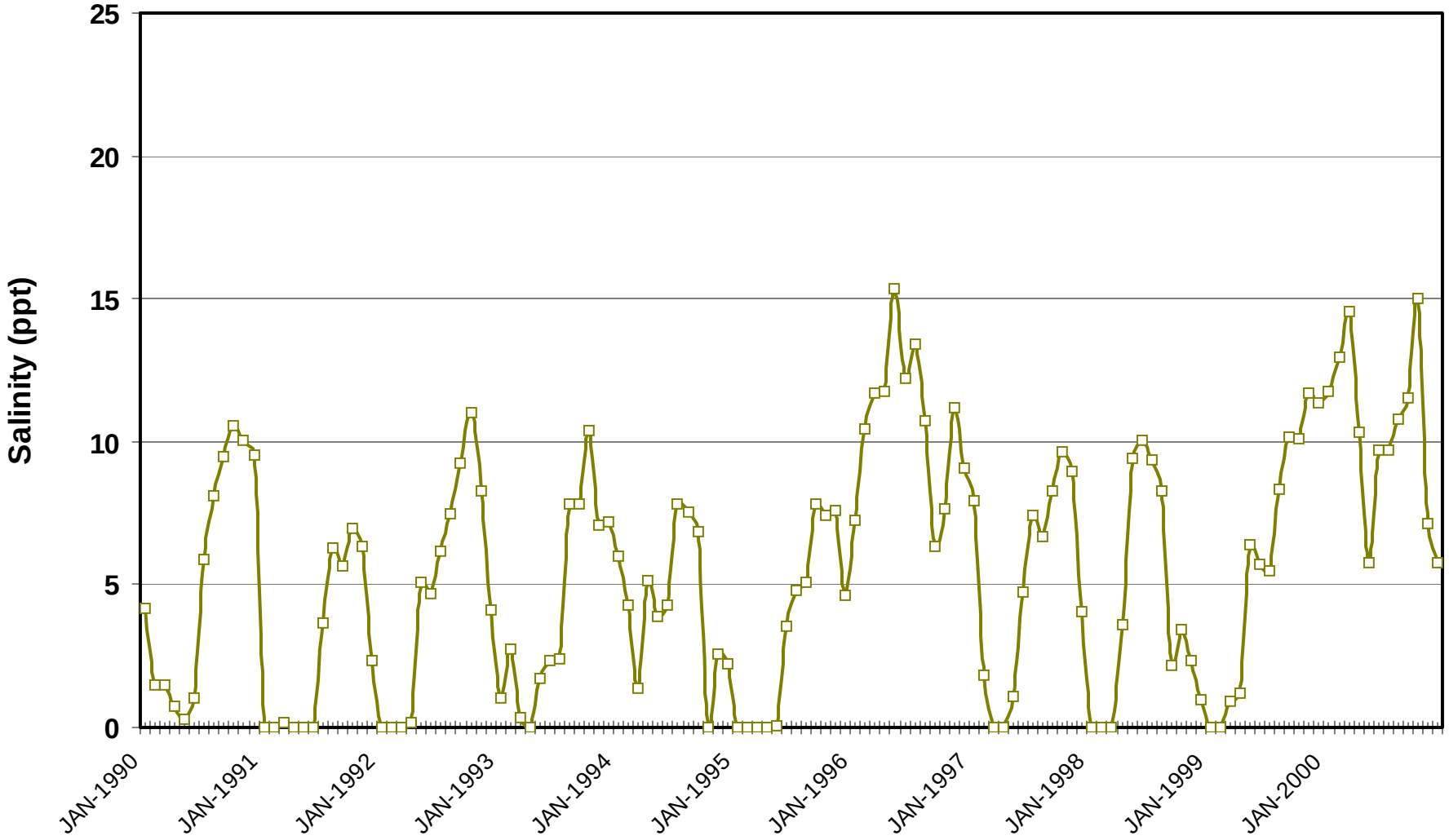
Upper: S = 41.7760 – 4.3824*ln(Q30) – 0.9153*ln(Q31-60) [r^2=0.73]

**Middle: S = 42.1146 – 4.6393*ln($Q_{30}$) – 0.7225*ln($Q_{31\text{-}60}$) [r^2=0.71]**

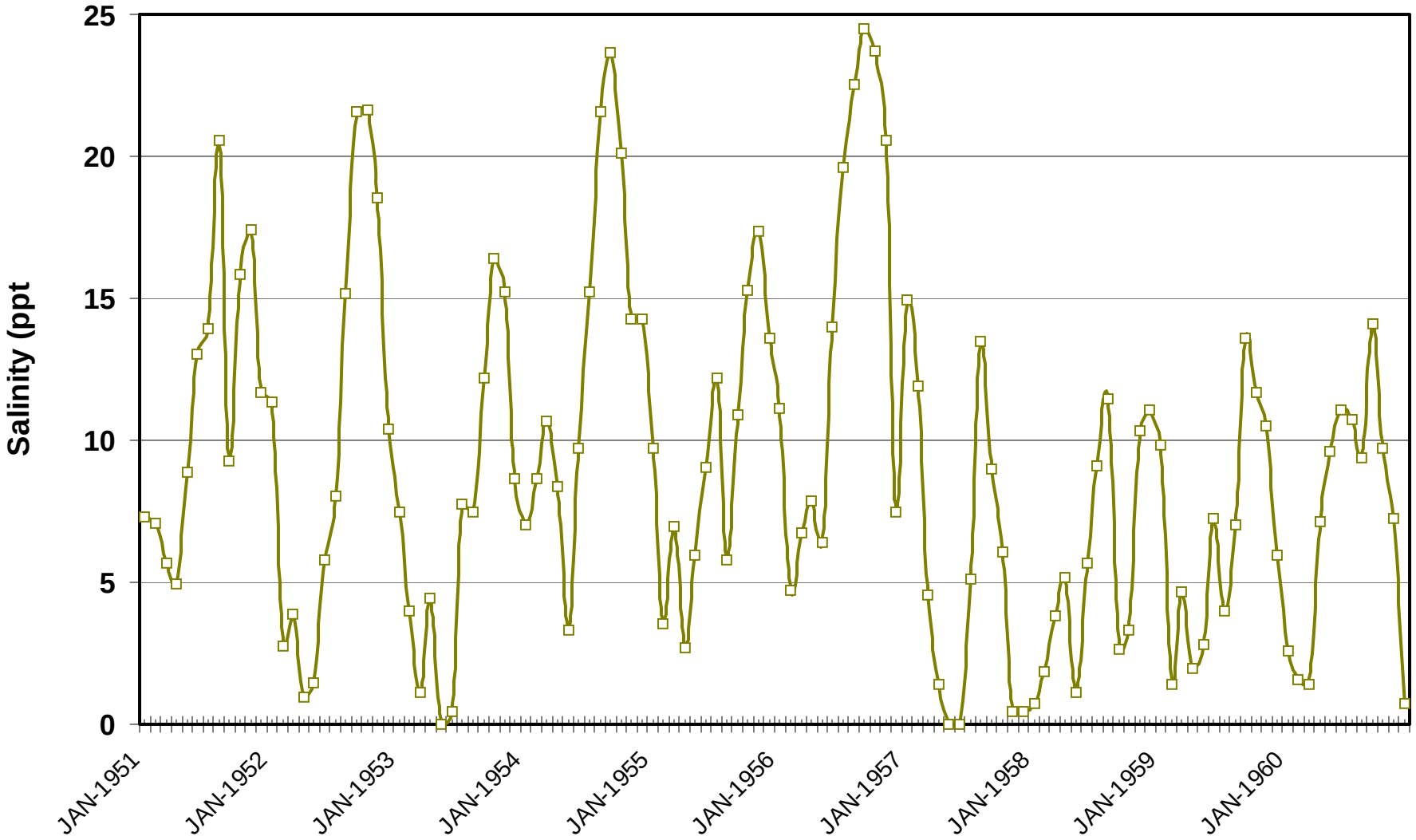
Lower: S = 61.2663 – 7.1793*ln($Q_{30}$) – 0.0521*ln($Q_{31\text{-}60}$) [r^2=0.75]

[from Sabine Lake FWI Study (2005)]

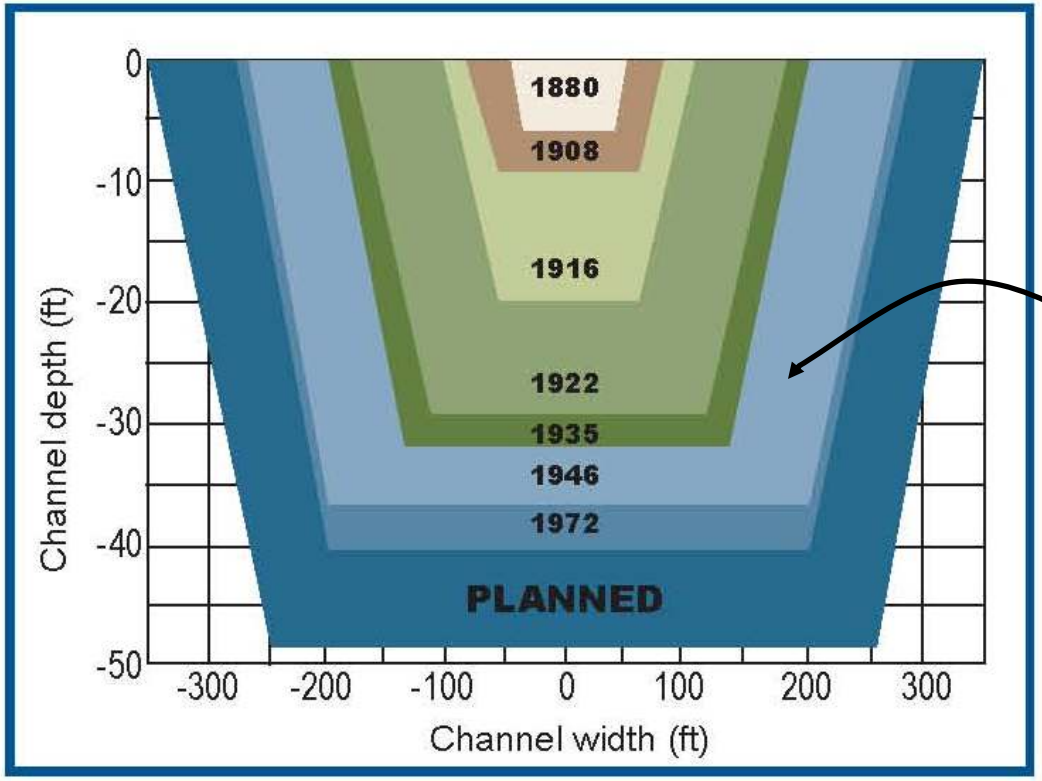
## Calculated salinty at Middle Sabine Lake site under historical inflow conditions :1990s



## Calculated salinty at Middle Sabine Lake site under historical inflow conditions :1950s



# Sabine Lake's ship channel history of enlargement

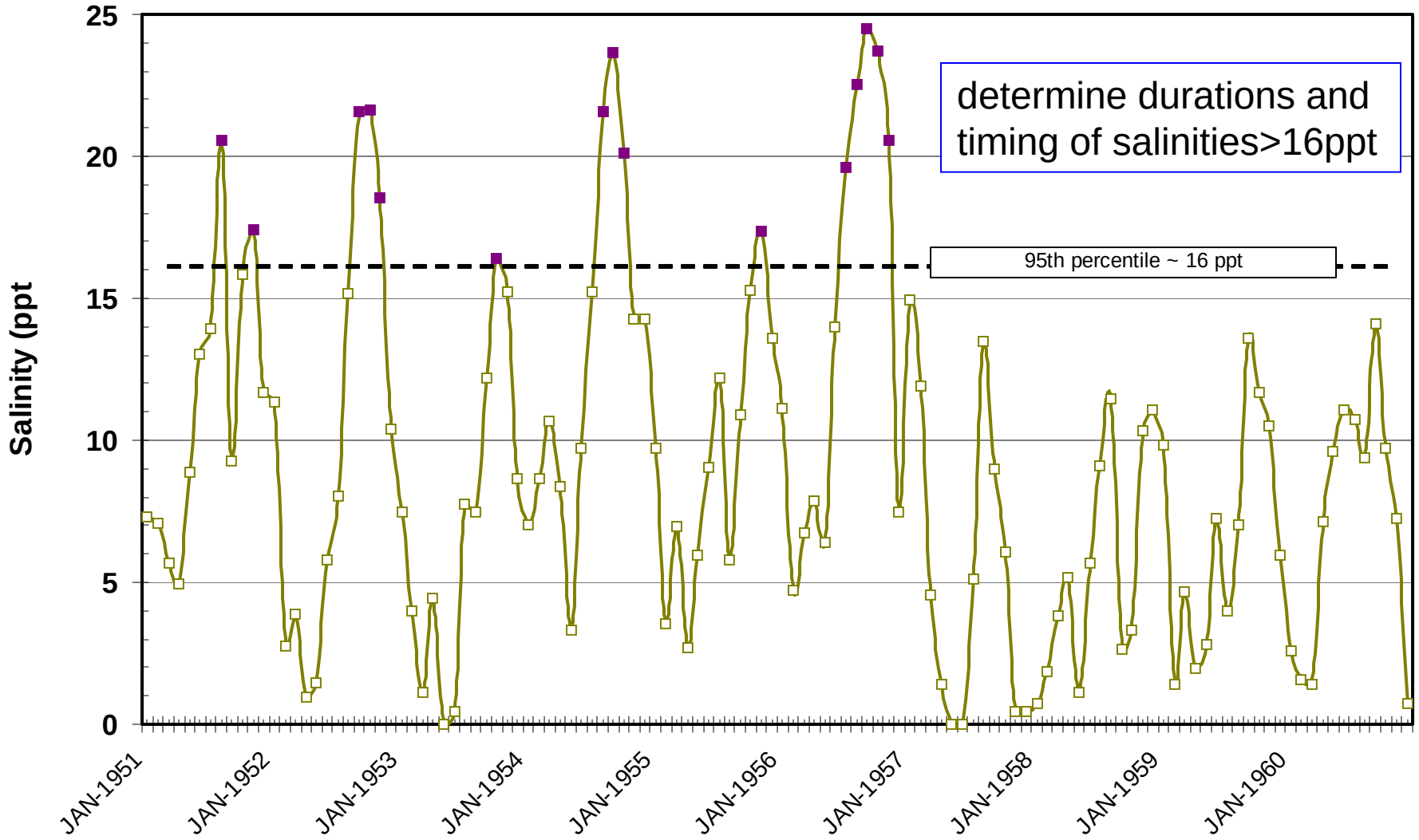



88% of current
x-sectional area

**Salinity statistics under historical inflow conditions**

| *1947-2005* | Upper | Middle | Lower |
|---|---|---|---|
| min | 0.0 | 0.0 | 0.0 |
| 10th percentile | 0.46 | 0.23 | 4.61 |
| 15th percentile | 1.27 | 1.10 | 5.62 |
| 20th percentile | 2.02 | 1.88 | 6.52 |
| 25th percentile | 2.88 | 2.72 | 7.87 |
| 30th percentile | 3.81 | 3.64 | 9.18 |
| 35th percentile | 4.42 | 4.31 | 10.23 |
| 40th percentile | 5.14 | 5.08 | 11.16 |
| 45th percentile | 5.84 | 5.73 | 12.12 |
| 50th percentile | 6.65 | 6.59 | 13.34 |
| 55th percentile | 7.52 | 7.44 | 14.66 |
| 60th percentile | 8.09 | 8.07 | 15.52 |
| 65th percentile | 8.96 | 8.90 | 16.45 |
| 70th percentile | 9.57 | 9.58 | 17.41 |
| 75th percentile | 10.33 | 10.32 | 18.49 |
| 80th percentile | 10.97 | 10.91 | 19.33 |
| 85th percentile | 11.76 | 11.70 | 20.41 |
| 90th percentile | 13.63 | 13.60 | 22.92 |
| 95th percentile | 16.25 | 16.23 | 27.27 |
| max | 24.29 | 24.49 | 35.00 |

## Calculated salinty at Middle Sabine Lake site under historical inflow conditions :1950s



**Salinity – Inflow Equation**

**Middle: $S = 42.1146 - 4.6393*\ln(Q_{30}) - 0.7225*\ln(Q_{31\text{-}60})$**

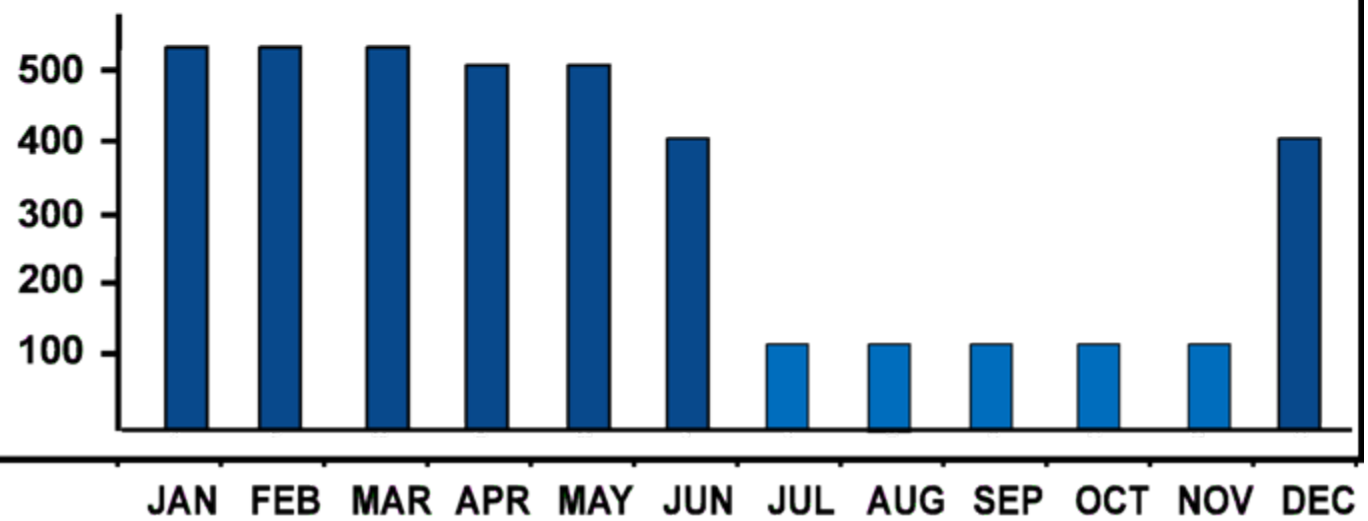
steady inflows to maintain salinity:

16ppt 130,385 ac-ft/mo

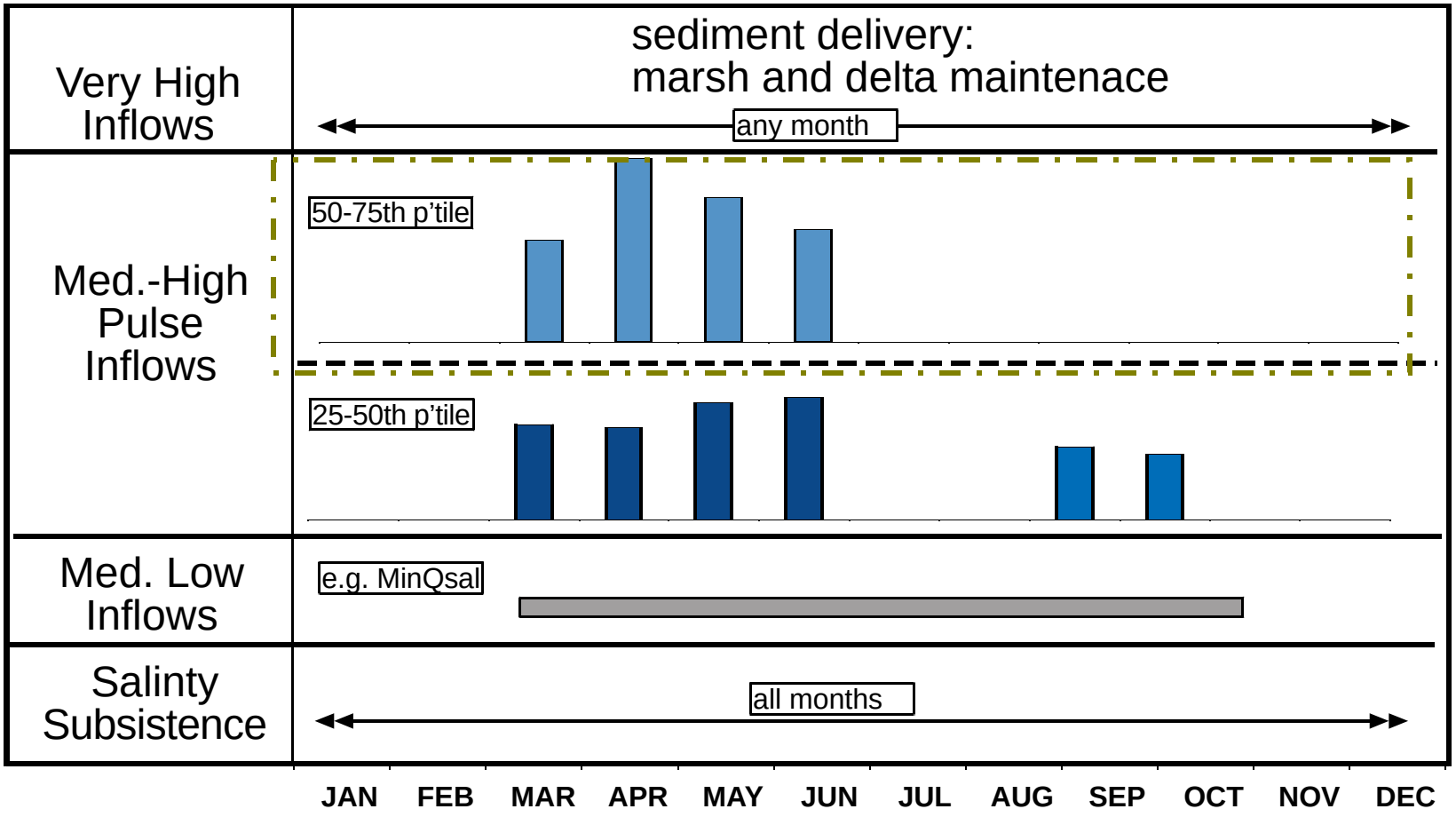
# for discussion- possible estuary inflows framework: Sabine Lake - Subsistence Inflows

DRAFT

| | % time applicable | |
|---|---|---|
| Salinty Subsistence | 5% | inflows< 130,400 ac-ft/mo. to occur no more than 5 consecutive months in Jul-Nov. [goal: keep 16 ppt at Mid Lake no more than 5 months]; other months inflow=400-550,000 ac-ft/mo, for total annual of 4.0-4.5 million ac-ft [approx. 5th percentile of annual inflows]. |



# For Discussion-
# possible estuary inflows framework



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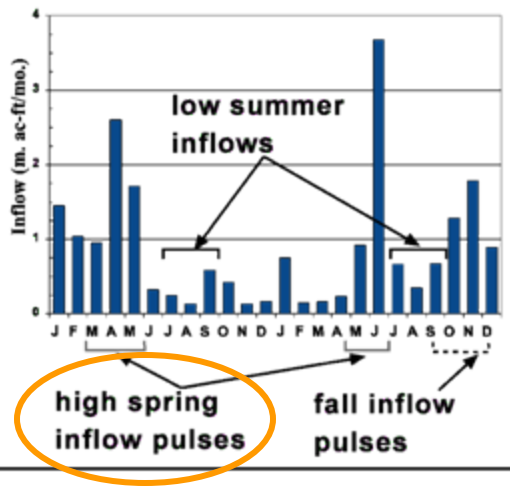


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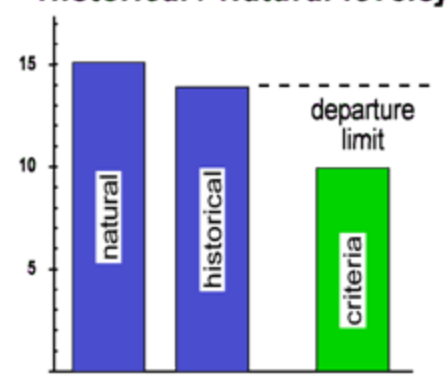
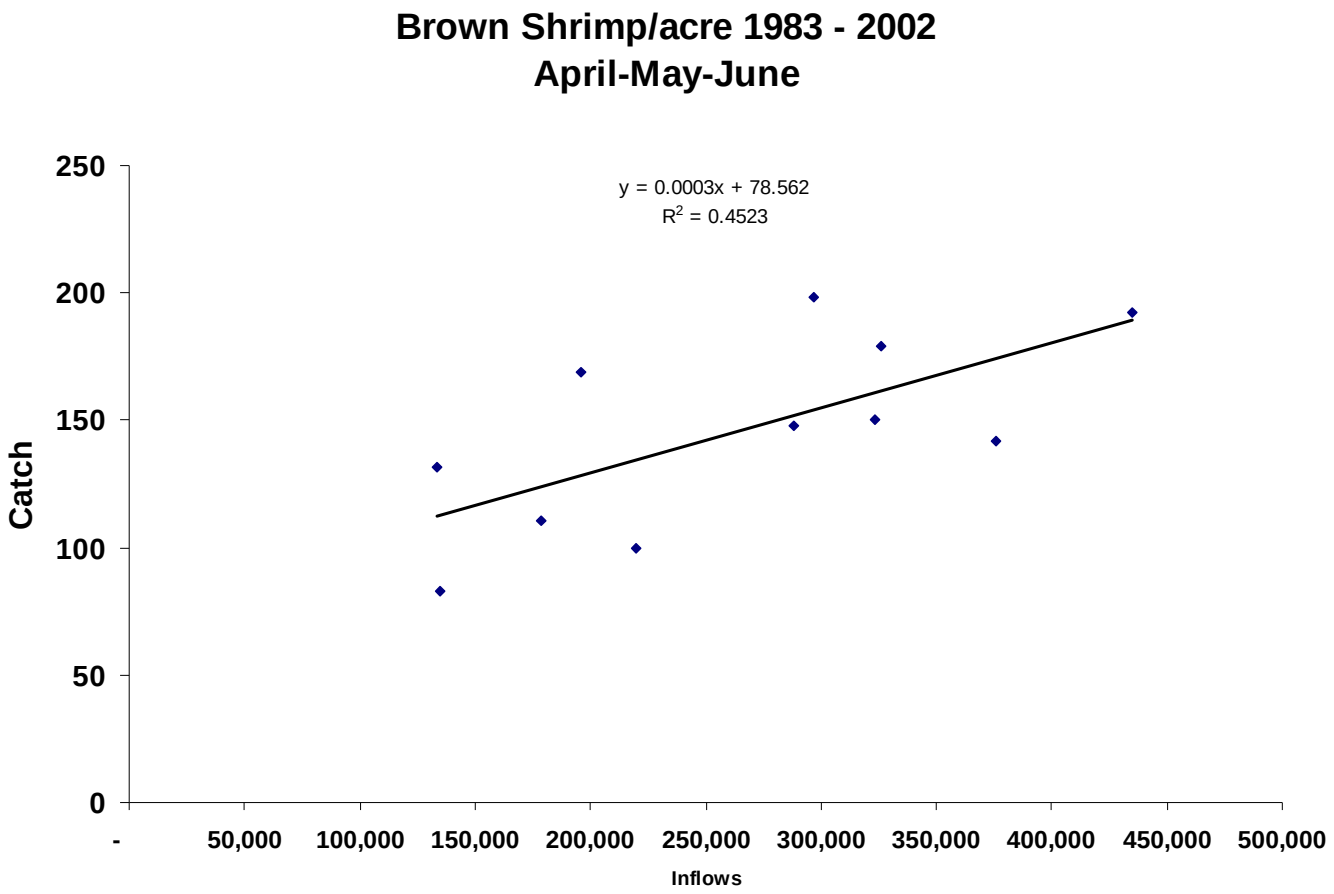


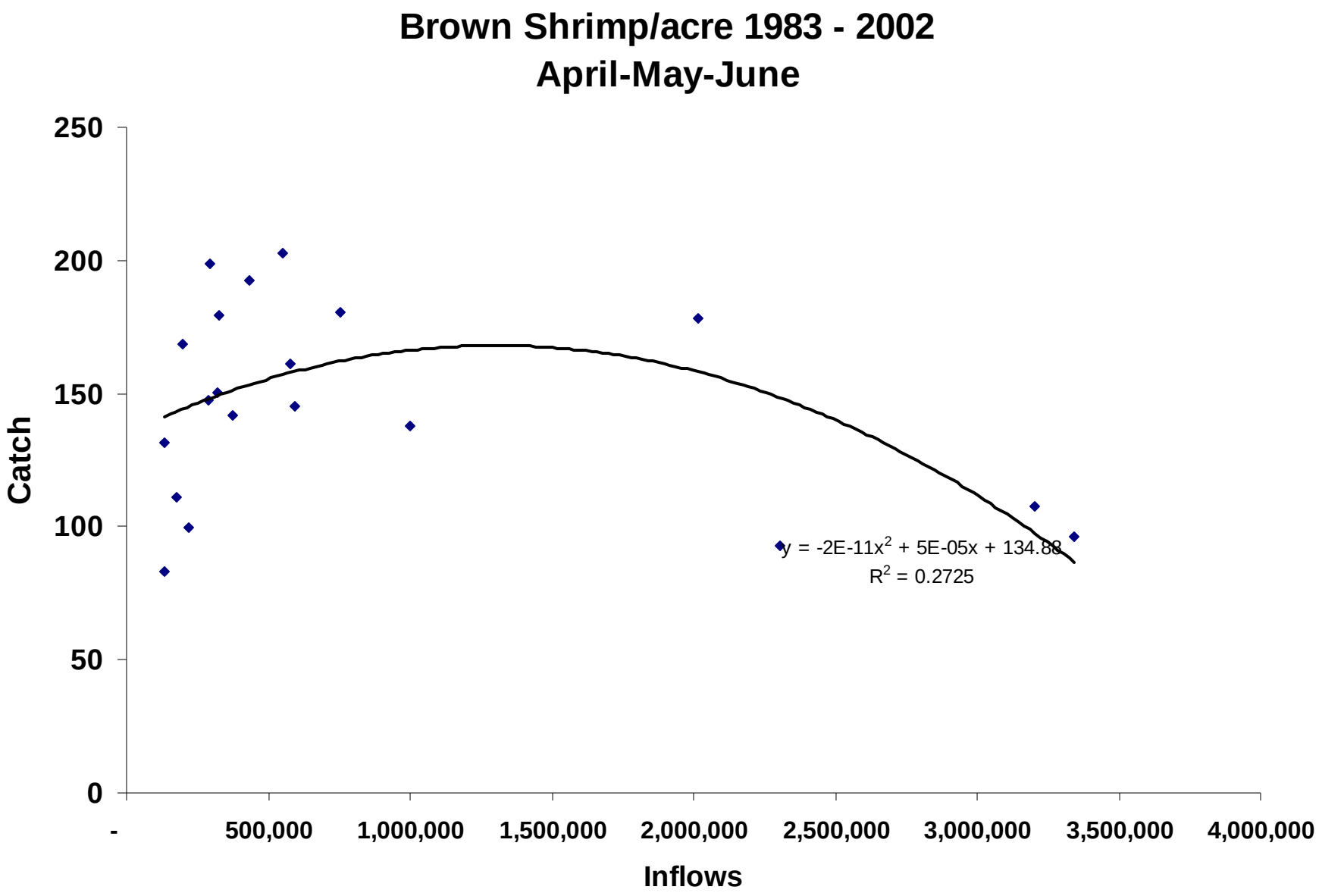
**<u>Studies reinforcing ecological relevance of “spring” freshwater pulse inflow</u>**:

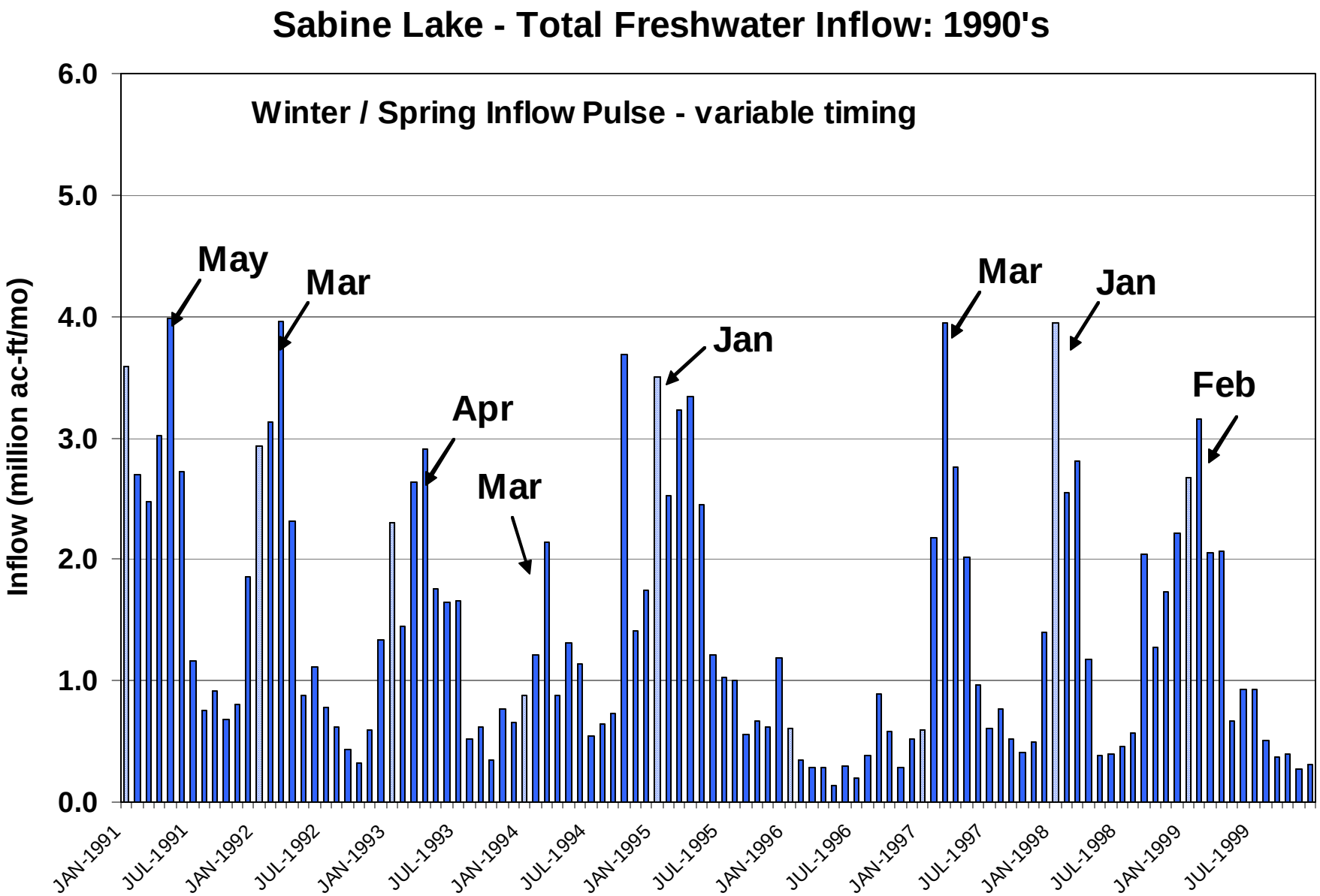
- 2002 Nueces Freshwater Inflow Needs Study (FINS)

- 2006 Matagorda Bay FINS

- 2007-8 Matagorda Bay MBHE Biostats




Brown Shrimp/acre 1983 - 2002
April-May-June
Catch
250
200
150
100
50
0
-
500,000
1,000,000
1,500,000
2,000,000
2,500,000
3,000,000
3,500,000
4,000,000
Inflows
y = -2E-11x2 + 5E-05x + 134.88
R2 = 0.2725


Sabine Lake - Total Freshwater Inflow: 1990's
Winter / Spring Inflow Pulse - variable timing
Inflow (million ac-ft/mo)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
May
Mar
Apr
Mar
Jan
Mar
Jan
Feb
JAN-1991
JUL-1991
JAN-1992
JUL-1992
JAN-1993
JUL-1993
JAN-1994
JUL-1994
JAN-1995
JUL-1995
JAN-1996
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JAN-1997
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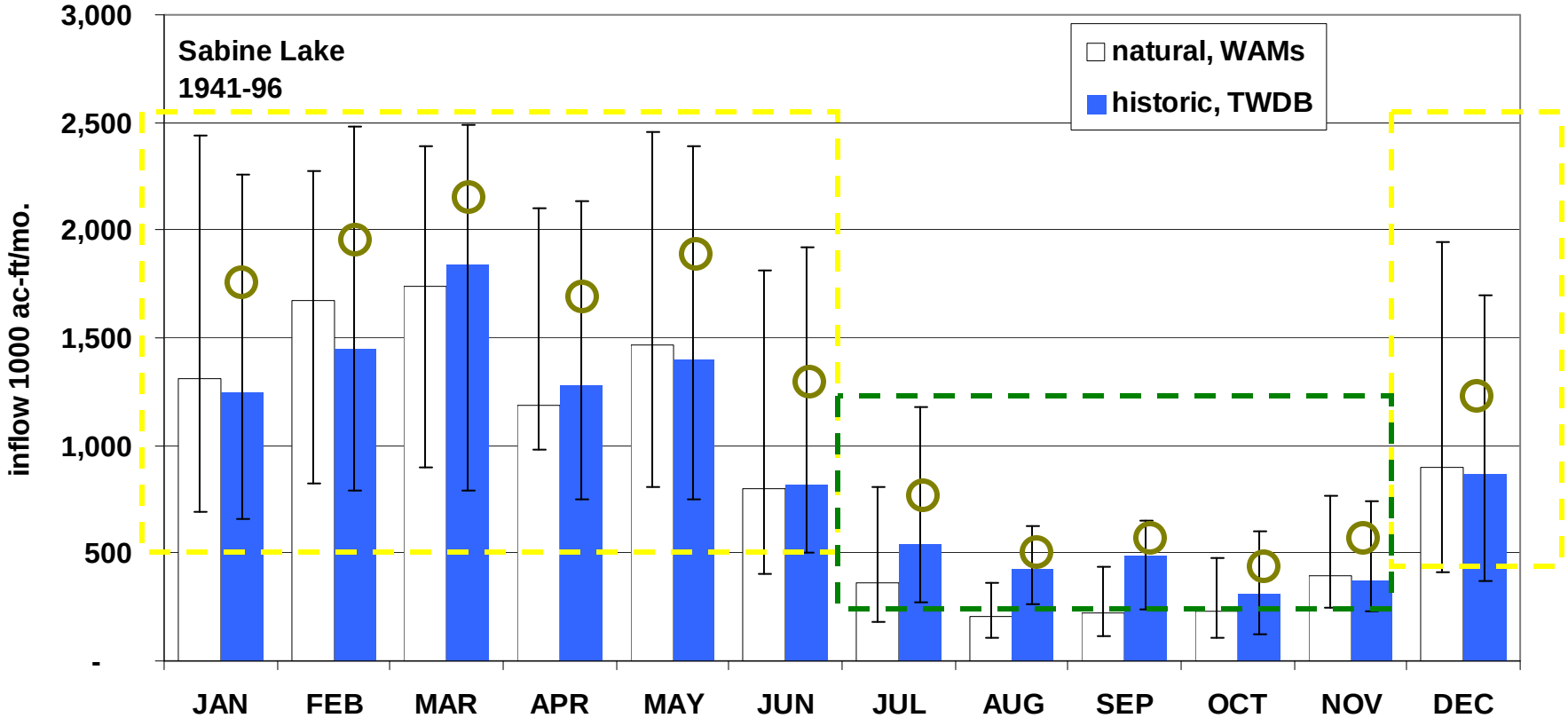
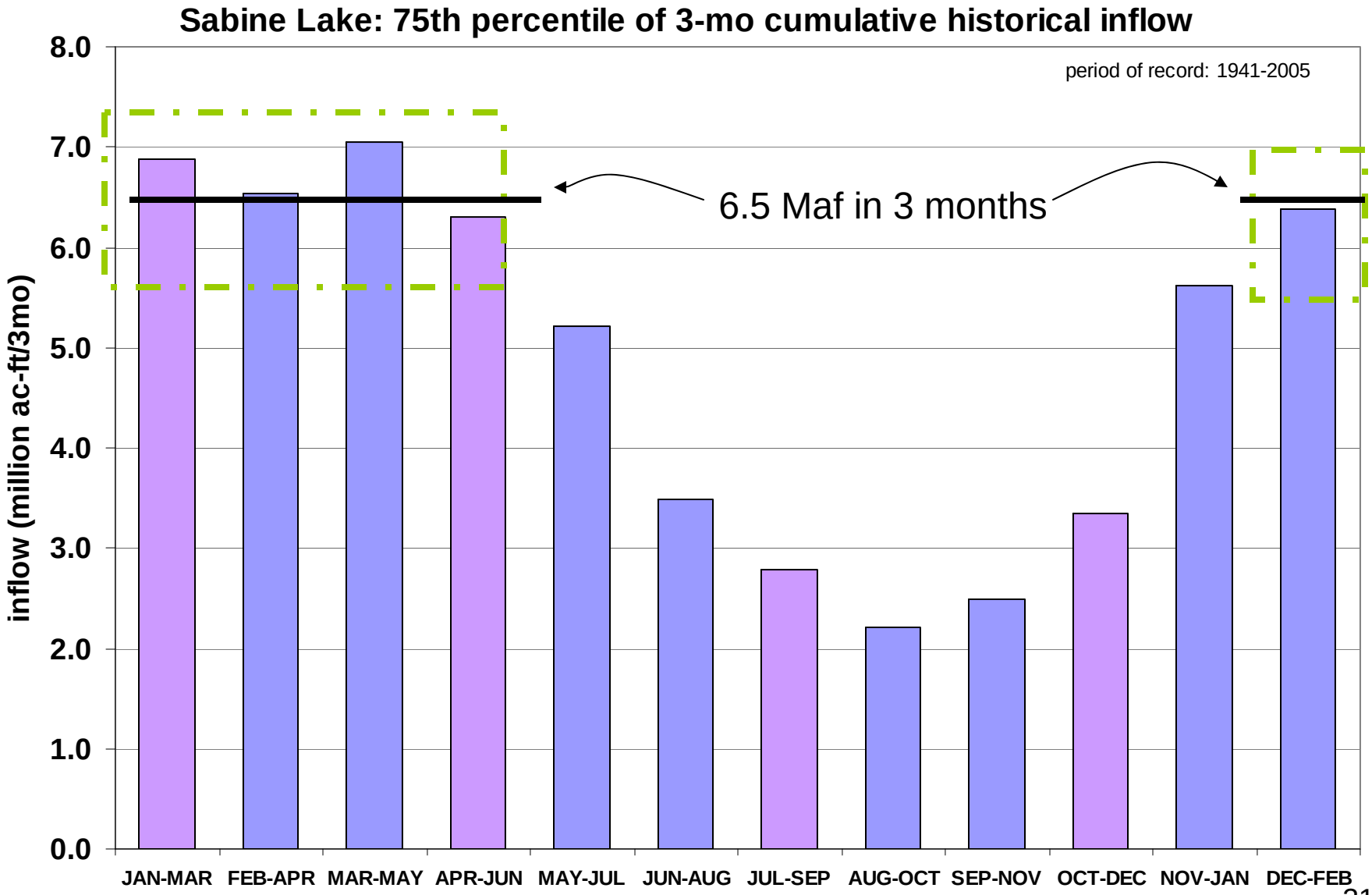
JUL-1998
JAN-1999
JUL-1999

# Sabine Lake - Freshwater Inflow Patterns



# Potential High Winter / Spring Pulse



# Possible Winter/Spring High-inflow criteria combinations. 75th percentile 3-mo pulse & 65th percentile in other months

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | Annual | P'tile |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN-MAR | 6.5 | | | 1.76 | 1.80 | 1.37 | 0.94 | 0.58 | 0.62 | 0.51 | 0.63 | 1.42 | 16.1 | 60 th |
| FEB-APR | 1.98 | 6.5 | | | 1.80 | 1.37 | 0.94 | 0.58 | 0.62 | 0.51 | 0.63 | 1.42 | 16.4 | 62 th |
| MAR-MAY | 1.98 | 2.00 | 6.5 | | | 1.37 | 0.94 | 0.58 | 0.62 | 0.51 | 0.63 | 1.42 | 16.5 | 63 th |
| APR-JUN | 1.98 | 2.00 | 2.35 | 6.5 | | | 0.94 | 0.58 | 0.62 | 0.51 | 0.63 | 1.42 | 17.5 | 68 th |
| DEC-FEB | | | 2.35 | 1.76 | 1.80 | 1.37 | 0.94 | 0.58 | 0.62 | 0.51 | 0.63 | 6.5 | 17.1 | 65 th |

# for discussion- possible estuary inflows framework: Sabine Lake

DRAFT

| | % time applicable | |
|---|---|---|
| Med.-High Pulse Inflows | ~25% | inflows totalling 6.5 million ac-ft in 3-mo period within Dec-Jun window; other months inflow @ 65th percentile. Total annual inflow of 16.1-17.5 million ac-ft [approx. 60-68th percentile of annual inflows]. |

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC