TEXAS
PARKS &
WILDLIFE

Environmental Flows in Texas: The road to implementation?

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What are environmental flows?

Flows that remain in the stream (instream flows). Instream flows provide for aquatic and riparian habitat; water quality protection; recreation; navigation; and freshwater inflows to bays and estuaries.

Why are environmental flows important?

Water quality and assimilative capacity

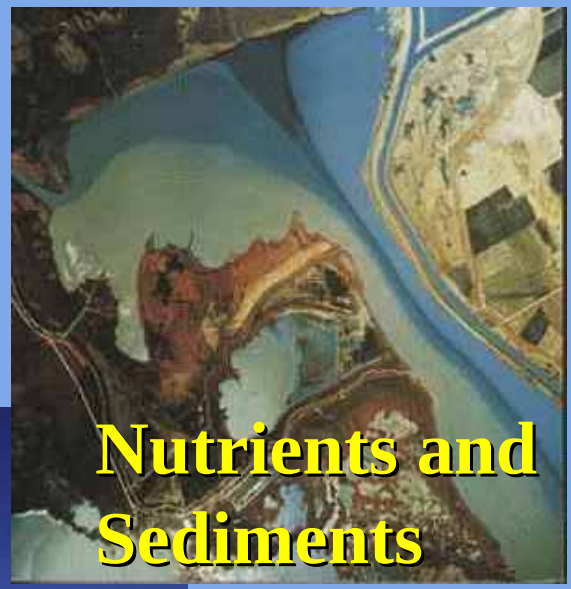
Maintenance of native and rare species, biodiversity, and habitat

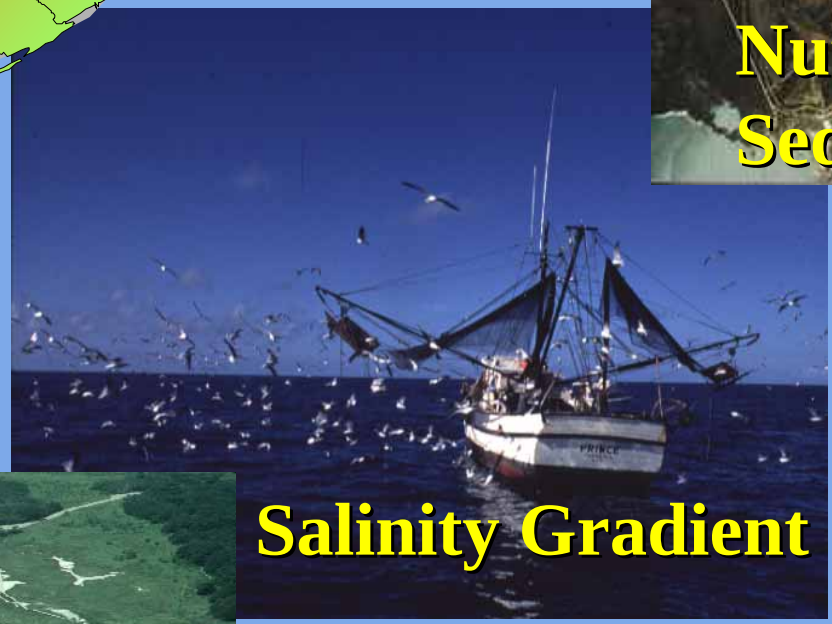
Channel maintenance

Recreation

Economics

Freshwater Inflows…





…By Definition Create and Sustain Estuaries

Sabine-Neches Estuary

(Tanyeri-Abur, et al. 1998)

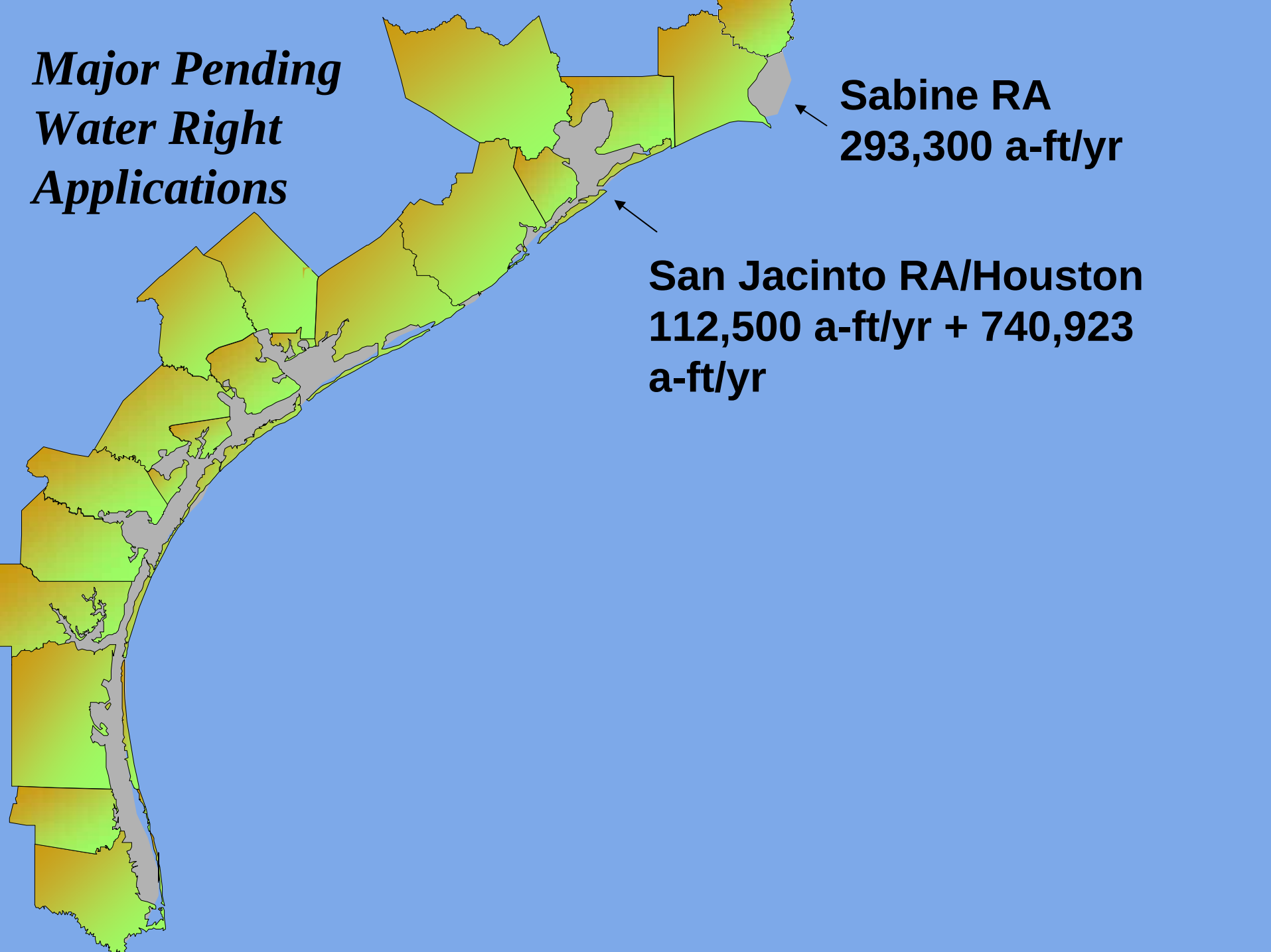
Photo by Earl Nottingham

- $34.4 million in direct regional impact from water-related recreation
- Direct regional impact from inshore commercial fishing $850,000
- Direct regional impact of total commercial fishing $1.24 million

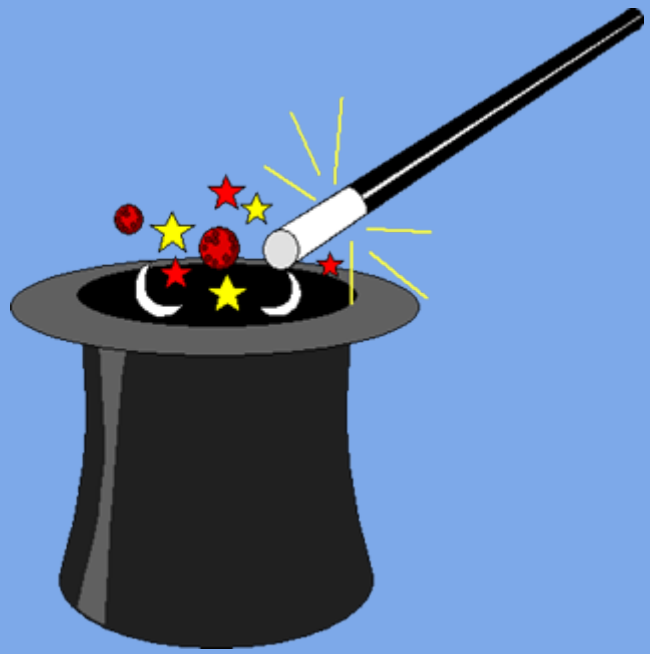
- Analyses indicate that each dollar of bay and estuary related tourist and recreationist expenditure resulted in about $1.81 in total value of output, $0.75 of personal income, and $1.15 of value added in the regional economy. In addition, an employment multiplier of about 37 jobs per million dollars of tourist and recreationist expenditures is indicated by the analysis. (Tanyeri-Abur, et al. 1998)

Why worry about environmental flows?

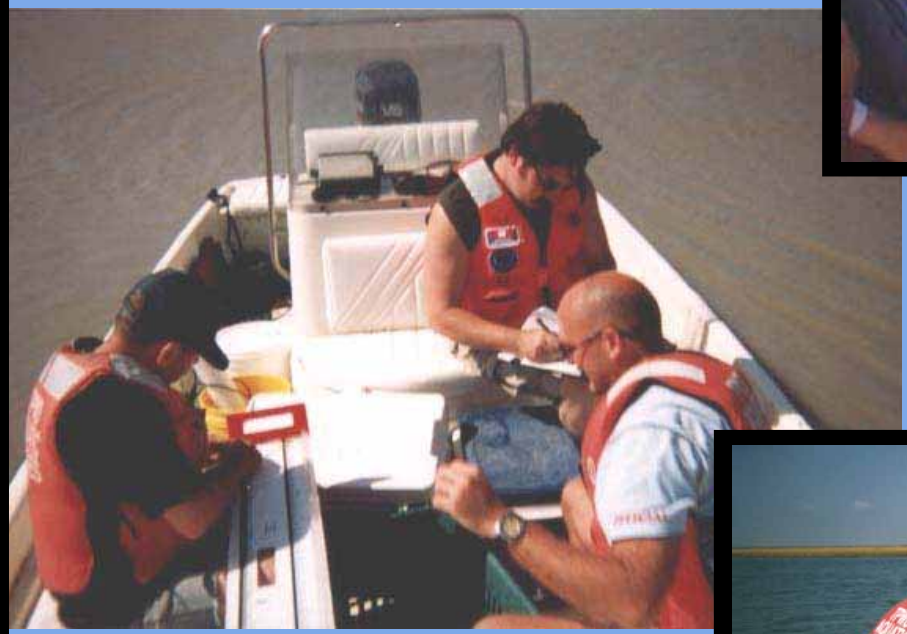
- Water rights are granted on a perpetual basis.
- Most water rights do not have provisions for environmental maintenance flows.
- Many streams in the state are over-appropriated: more water is permitted for use than typically occurs in the stream.
- Data indicates that some aquatic systems are currently degraded due to altered hydrology.


Major Pending Water Right Applications
Sabine RA
293,300 a-ft/yr
San Jacinto RA/Houston
112,500 a-ft/yr + 740,923 a-ft/yr

How are environmental flows determined?



TPWD
AQUATIC
STUDIES

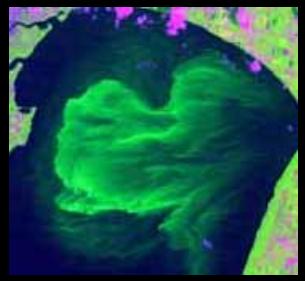


TPWD
AQUATIC
STUDIES

The Process of Developing FWI Recommendations

Objectives & Constraints

Fisheries Analysis
Fisheries Dependent Data



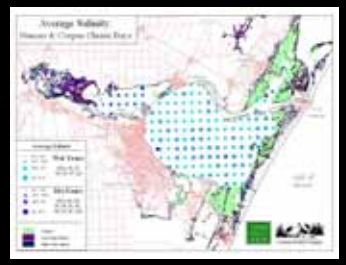
Nutrient Analysis

Sediment Analysis

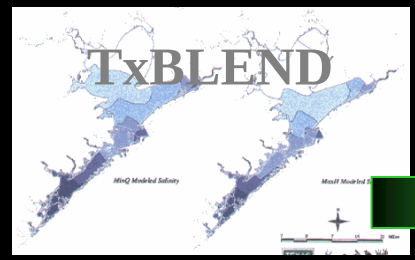
Hydrographic Survey

Verification

Fisheries Analysis
Fisheries Independent Data

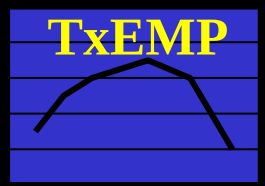


Hydrology



Hydrodynamic & Conservation
Transport Model

Wetlands



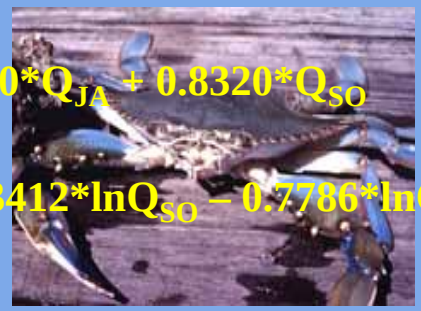
Optimization
Model

Recommendations

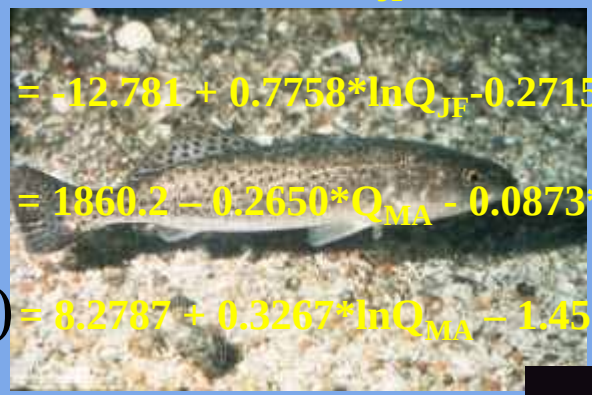
FWI recommendations are based on the biological needs of a group of target species expressed as a statistical relationship between harvest/catch and inflow

Target Species

Atlantic Croaker $= 194.41 - 0.5437*Q_{JF} + 0.8295*Q_{MA} - 0.2000*Q_{JA} + 0.8320*Q_{SO}$



Gulf Menhaden(ln) $= -12.781 + 0.7758*\ln Q_{JF} - 0.2715*\ln Q_{MJ} + 3.3412*\ln Q_{SO} - 0.7786*\ln Q_{ND}$



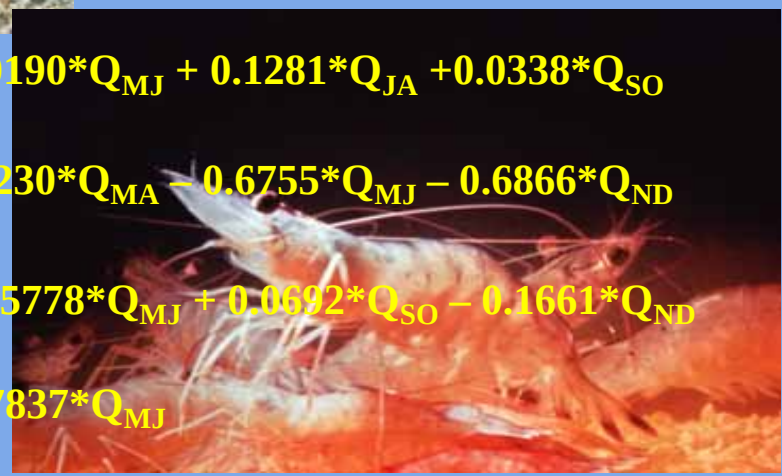
Spot $= 1860.2 - 0.2650*Q_{MA} - 0.0873*Q_{ND}$

Spotted Seatrout(*ln) $= 8.2787 + 0.3267*\ln Q_{MA} - 1.4519*\ln Q_{MJ} + 1.0125*\ln Q_{JA} - 0.4809*\ln Q_{SO}$

Red Drum * $= 17.606 - 0.0189*Q_{JF} - 0.0190*Q_{MJ} + 0.1281*Q_{JA} + 0.0338*Q_{SO}$

White Shrimp $= 10399 + 0.6125*Q_{JF} - 0.7230*Q_{MA} - 0.6755*Q_{MJ} - 0.6866*Q_{ND}$

Blue Crab $= 1146.6 - 0.0303*Q_{JF} - 0.05778*Q_{MJ} + 0.0692*Q_{SO} - 0.1661*Q_{ND}$



Brown Shrimp $= 11073 - 1.2238*Q_{MA} - 0.7837*Q_{MJ}$

Sabine
9.6*

Galveston
5.2

Matagorda
2.0

San Antonio
1.15

Aransas
0.82

Nueces
0.14

Laguna Madre
0.25

Legislatively Mandated Studies to Determine Freshwater Inflows Necessary to Conserve Health and Productivity Of Texas Major Estuaries Have Been Completed

*** Millions of Acre Feet Per Year**

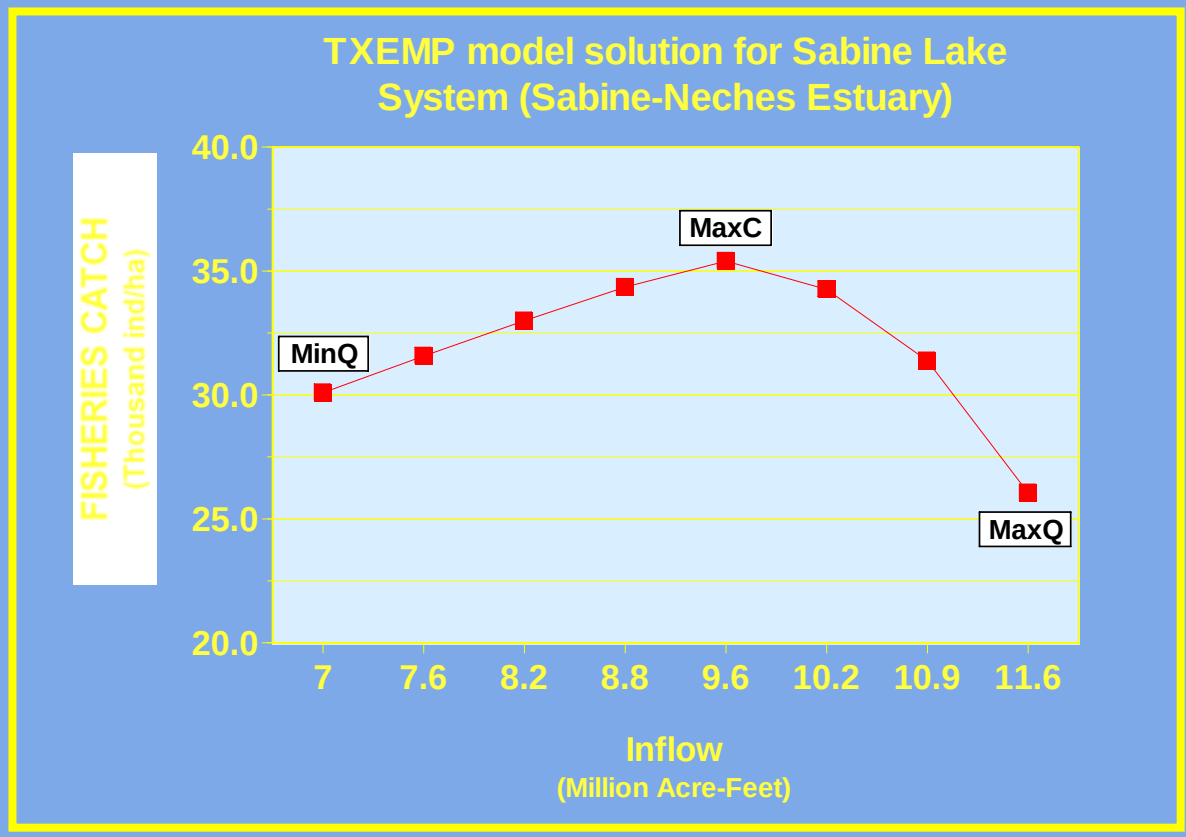
Freshwater Inflow Terminology

- **MaxH/C** – the maximum fisheries harvest achieved while meeting all model constraints
- **MinQ** – the minimum inflow achieved while meeting all model constraints
- **MinQSal** – the minimum inflow achieved while meeting only model salinity constraints

A range of possible solutions lies between two points along an optimization curve: *MinQ* and *MaxQ*, with *MaxH/MaxC* at the peak

MaxH/MaxC* is FWI necessary to sustain historic fisheries harvest as evaluated against existing fisheries data to meet the Legislative definition of *Beneficial Inflows

***MinQ* is the minimum inflow that maintains 80% of mean historic harvest and all other physical constraints: salinity, nutrient, and sediment needs**



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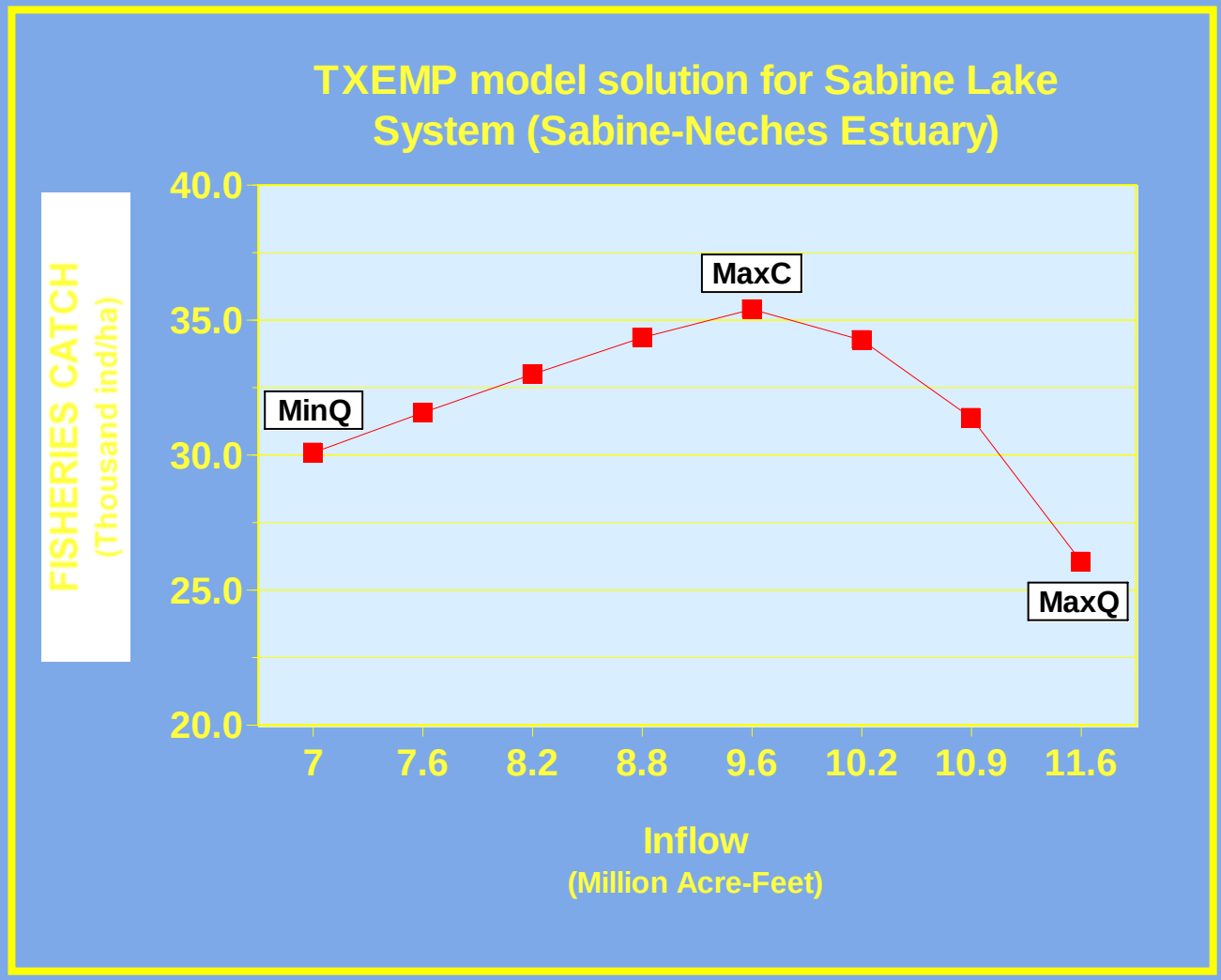
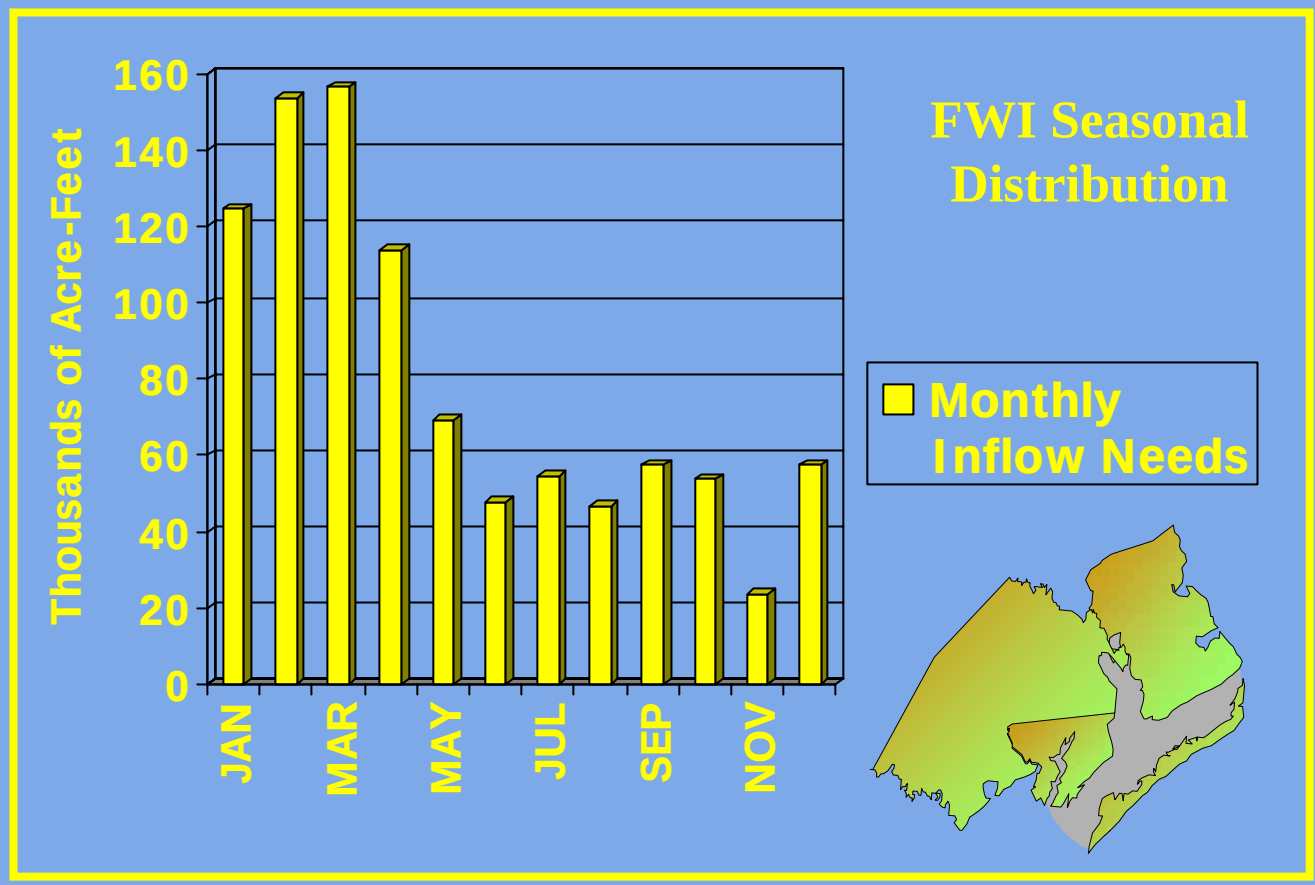


Delivery of Freshwater Inflows Must Incorporate Seasonality to Have Any Ecological Significance

The recommended FWI is often expressed as a single annualized number, but always infers the sum of monthly inflows

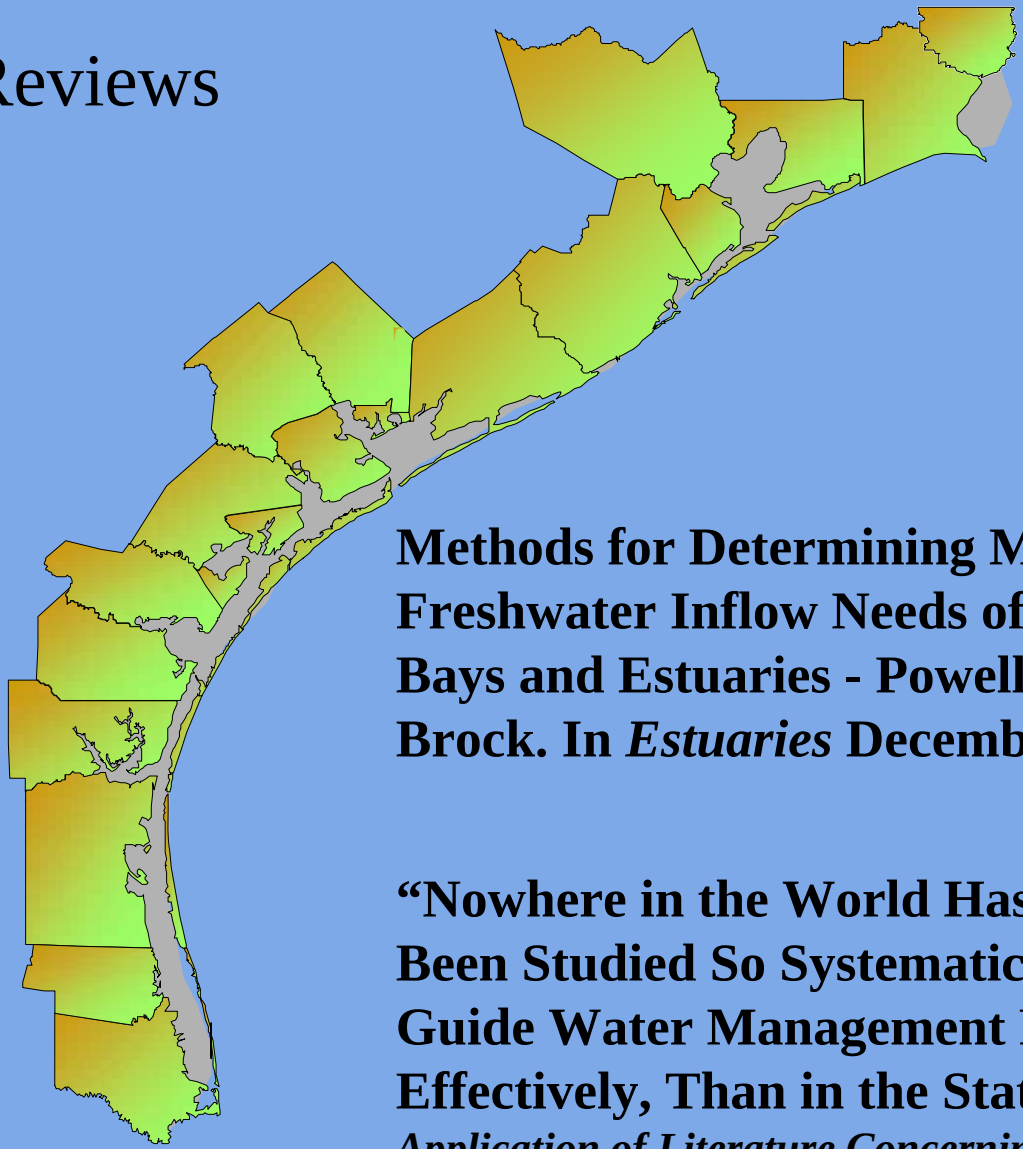


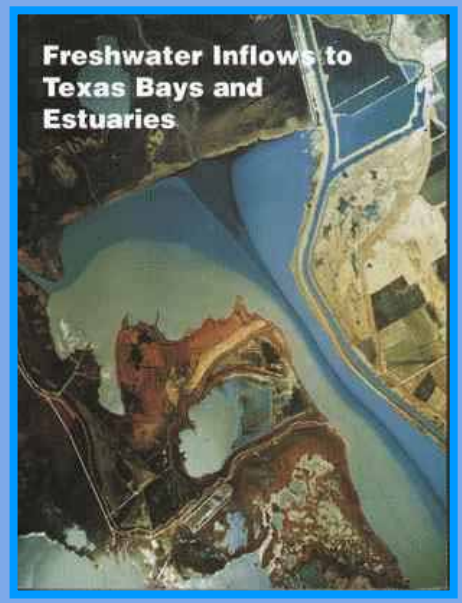
IMPLEMENTATION OF ENVIRONMENTAL FLOW NEEDS IN REGIONAL WATER PLANNING AND FUTURE STATE WATER PERMITTING

Target Amount	Historical Frequency (Exceedence)	Target Frequency** (Exceedence)
Above Normal Conditions [MaxH = 5.2 M Ac-Ft/Yr]*	~66%	>50%
Below Normal Conditions [MinQ = 4.2 M Ac-Ft/Yr]*	~70%	>60%
Dry Conditions [MinQ-Sal = 2.5 M Ac-Ft/Yr]*	~82%	>75%
Drought-of-Record [Min Historic = 1.8 M Ac-Ft/Yr]*	~98%	>90%

*Flows from Texas Water Development Board and Texas Parks & Wildlife;
**Target Frequencies from Galveston Bay Freshwater Inflow Group (Region H)

Reviews

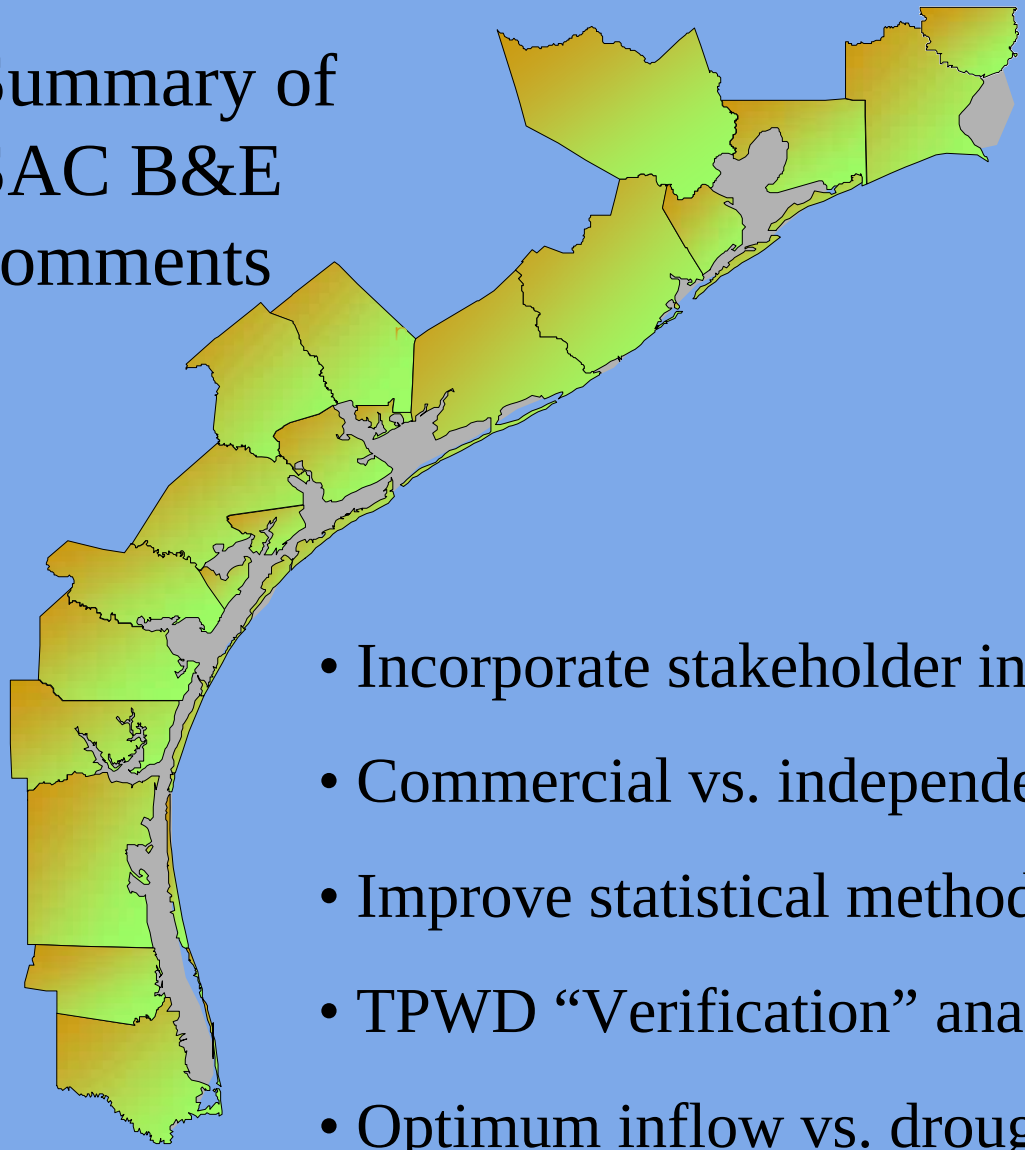


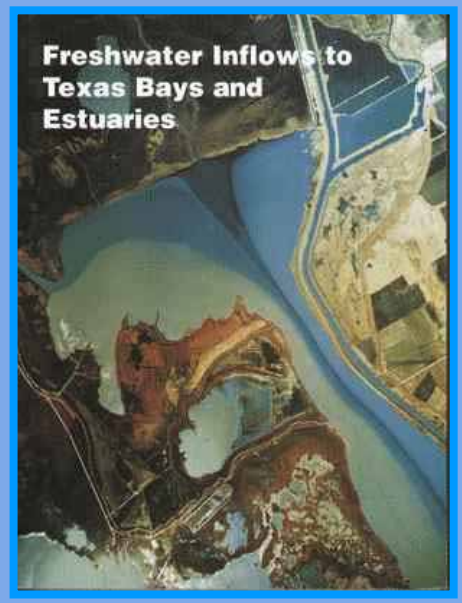


Methods for Determining Minimum Freshwater Inflow Needs of Texas Bays and Estuaries - Powell, Matsmuto, Brock. In *Estuaries* December 2002.

"Nowhere in the World Has the Issue of Freshwater Inflow Been Studied So Systematically, or The Results Used to Guide Water Management Policies and Practices So Effectively, Than in the State of Texas." – *A Review and Application of Literature Concerning Freshwater Flow Management in Riverine Estuaries* (2000), by Dr. E. Estevez, Director, Center for Coastal and Tropical Ecology, Mote Marine Laboratory, Sarasota, Florida.

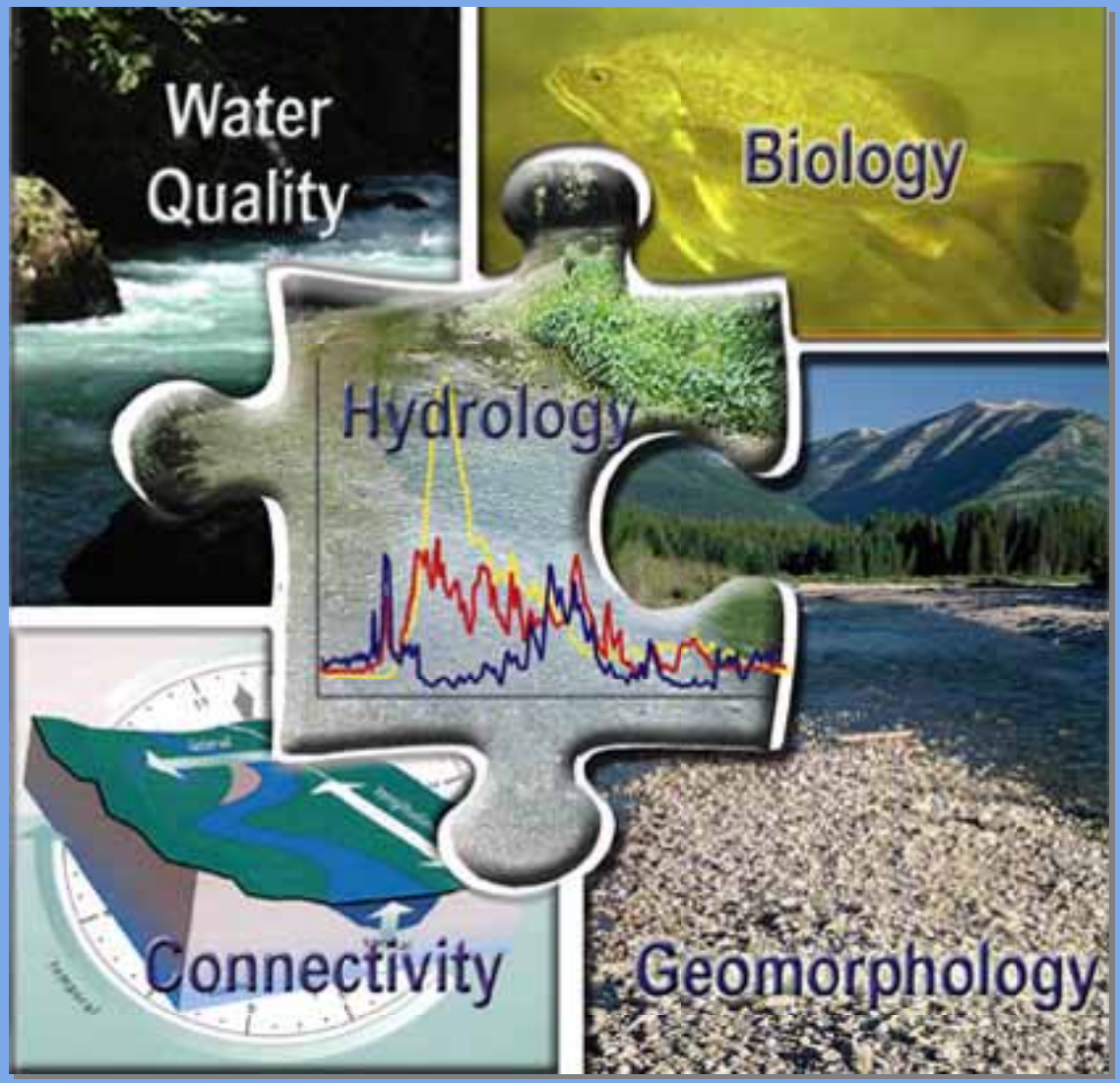
Summary of SAC B&E comments



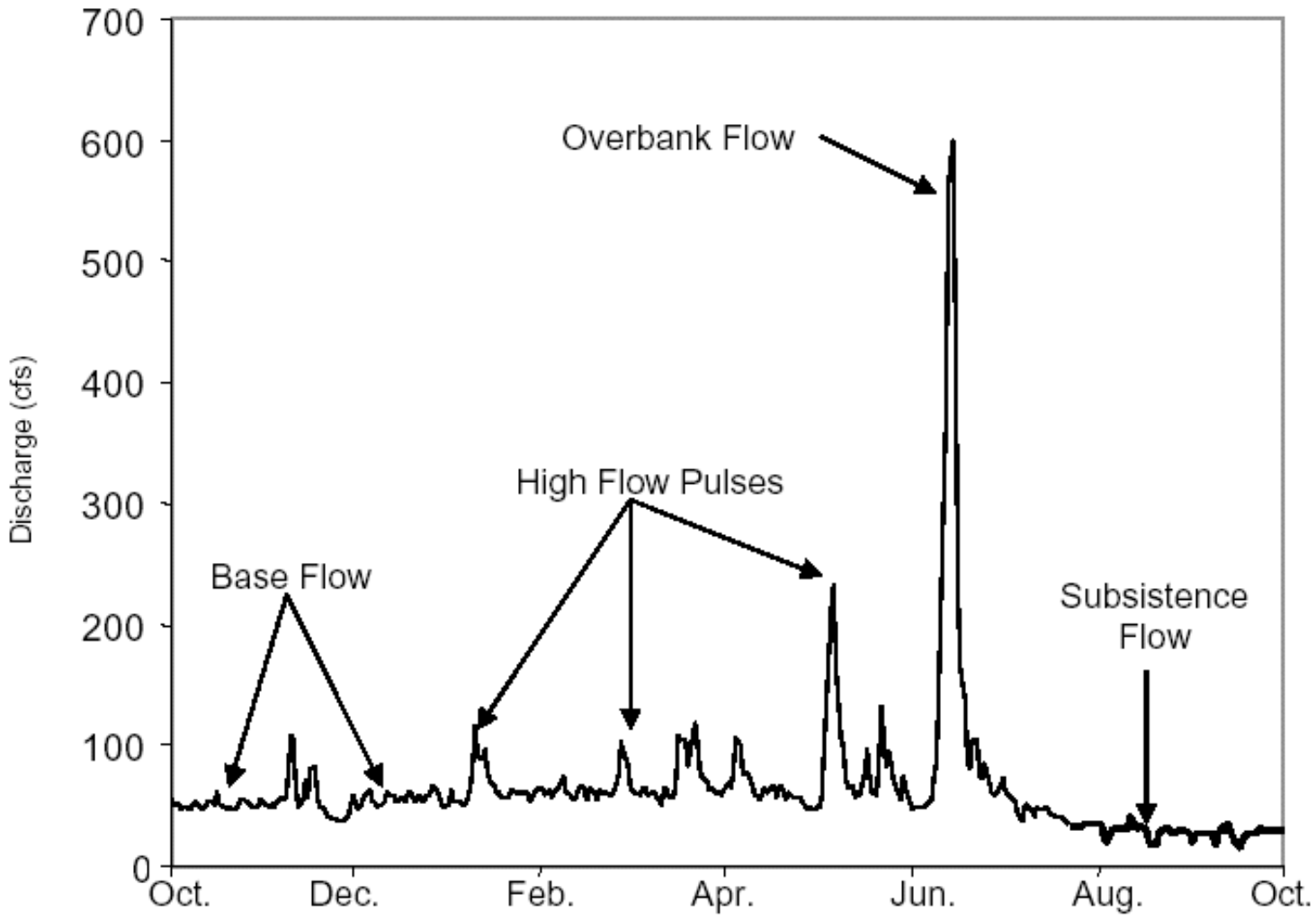


- Incorporate stakeholder input/peer review
- Commercial vs. independent fisheries data
- Improve statistical methods
- TPWD “Verification” analysis
- Optimum inflow vs. drought conditions
- Adaptive management and precautionary principle methods

Studies to Address Five Riverine Components



Environmental Flow Regime



Flow Regime Functions

Component	Hydrology	Geomorphology	Biology	Water Quality
Subsistence Flows	Infrequent, low flows	Increased deposition of fine & organic particles	•Restricted aquatic habitat •Limited connectivity	•Elevated temp •Reduced levels of DO
Base Flows	Normal flow conditions with variability	•Maintain soil moisture & groundwater table •Maintain diversity of habitats	•Suitable aquatic habitat •Connectivity along channel corridor	Suitable in-channel water quality
High Flow Pulses	In-channel, short duration, high flows	•Maintain channel & substrate characteristics •Prevent encroachment of riparian vegetation	•Recruitment events for organisms •Connectivity to near-channel water bodies	Restore in-channel water quality after prolonged low-flow
Overbank Flows	Infrequent, high flows that exceed normal channel	•Floodplain maintenance •Lateral channel movement •New habitat construction •Flush organic material into channel •Deposit nutrients in floodplain	•Life phase cues for organisms •Riparian recruitment & maintenance •Connectivity with floodplain	Restore water quality in floodplain water bodies

Instream Flow Building Blocks

Big Cypress Creek/ Caddo Lake

Floods

6,000-10,000 cfs for 2-3 days
Every 3-5 years
*Maintain aquatic habitat in floodplain
* Riparian seed dispersal
* Inhibition of upland vegetation for both creek & lake
*Seed dispersal
* Vegetation removal

20,000 cfs for 2-3 days
Every 10 years
*For channel migration

High Flow Pulses

6,000 cfs for 2-3 days
Every 2 years
* For channel maintenance

1,500 cfs for 2-3 days
3-5X a year every year
* 1 occurring in March for Paddlefish
* Sediment transport, oxbow connectivity
•Waterfowl habitat flushing
(Includes December)

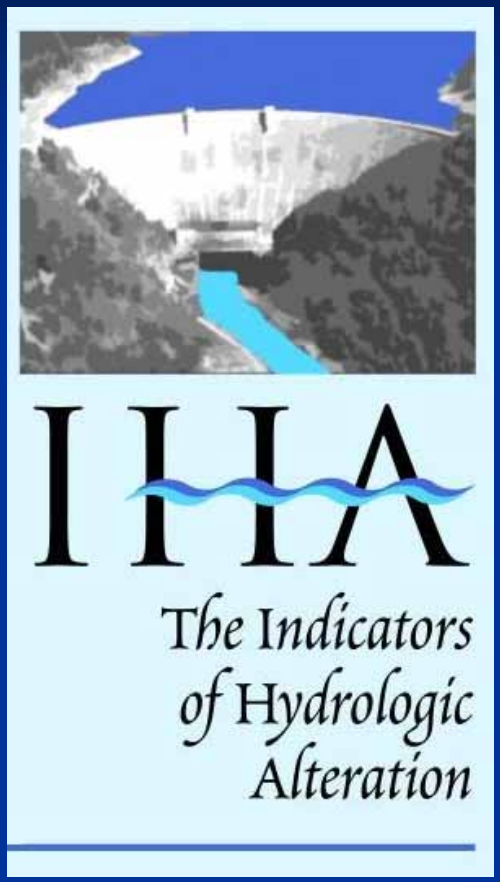
Low Flows

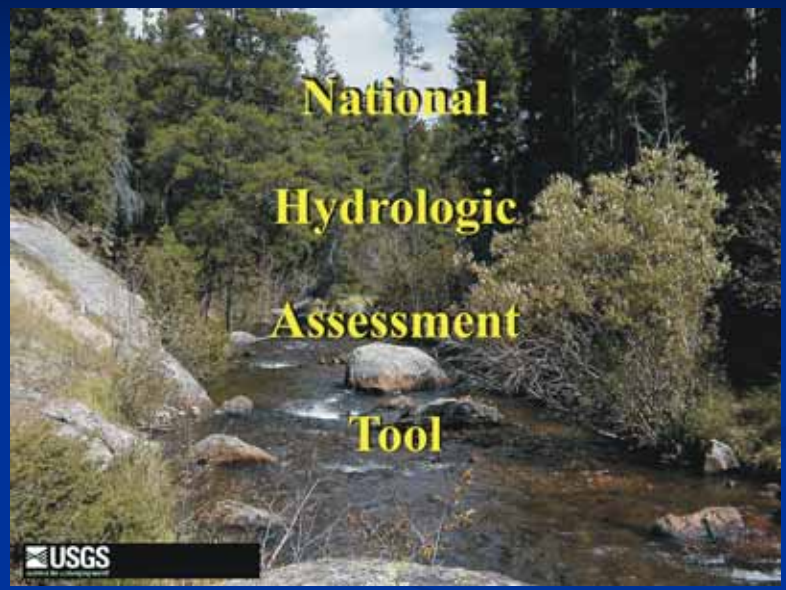
40 – 536 cfs
Maintain biodiversity and connectivity (backwater & oxbows)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
268-347 cfs Pre-dam median		390 - 79 cfs Benthic drift & dispersal, fish spawning				35 - 40 cfs Fish habitat			40 - 117 cfs Pre-dam median		
90 cfs Fish habitat		218 – 49 cfs Spawning habitat				13 - 6 cfs Maintain aquatic diversity			40 - 90 cfs Fish habitat		

Key

- Wet Year
- Avg Year
- Dry Year





USGS

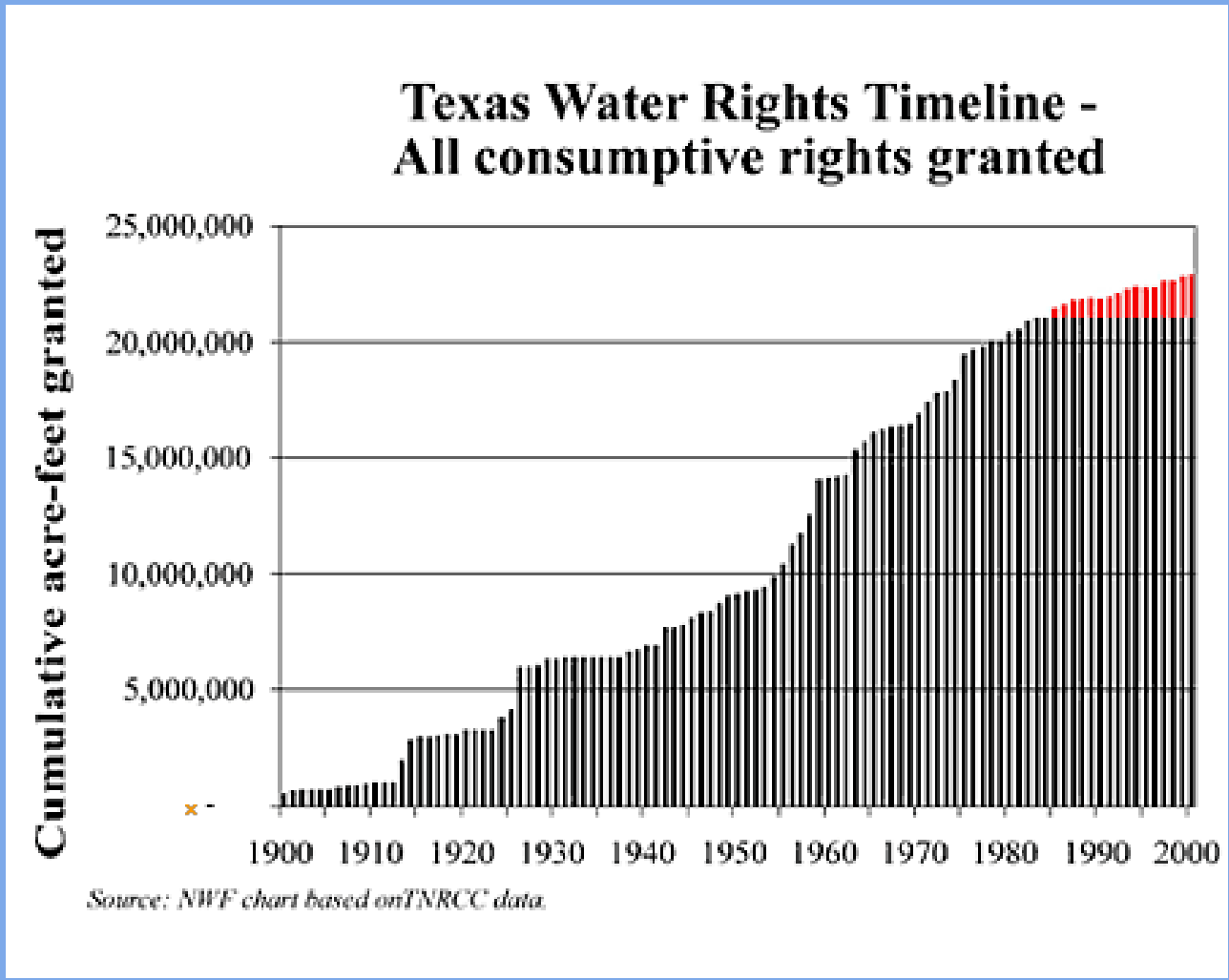
The Nature Conservancy

The Indicators of Hydrologic Alteration (IHA)

- Richter et al., 1996 & 1997
- 33 Annual Statistics
- Parametric (mean) or non-parametric (median)
- One or two period analysis
- Range of Variability Approach (RVA) to quantify hydrologic alteration
- 34 Environmental Flow Components (EFCs) from NAS review (Mallard et al. 2005)

Hydrologic Assessment Tool (HAT)

- National HAT: USGS Fort Collins Science Center and Colorado State Univ.
- 171 indices from 13 papers (in Olden and Poff 2003), including the 33 IHA
- Input: daily and peak (optional) flow data
- Six stream classifications
  - from Poff 1996
  - 420 U.S. rivers


Texas Water Rights Timeline -
All consumptive rights granted
Cumulative acre-feet granted
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
-
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Source: NWF chart based on TNRCC data.

Overall Texas Aquatic Ecosystems Are Maintaining Their Ecological Health, Productivity and Diversity*

Signs of Decline

Endangered Species
Extinctions
Assemblage Changes
Harmful Algal Blooms
Invasive Species
Fragmentation

Foundations Are Threatened:

50% Springs Gone
50% Coastal Wetlands Lost
63% Riparian Lost

**** With Obvious Exceptions***

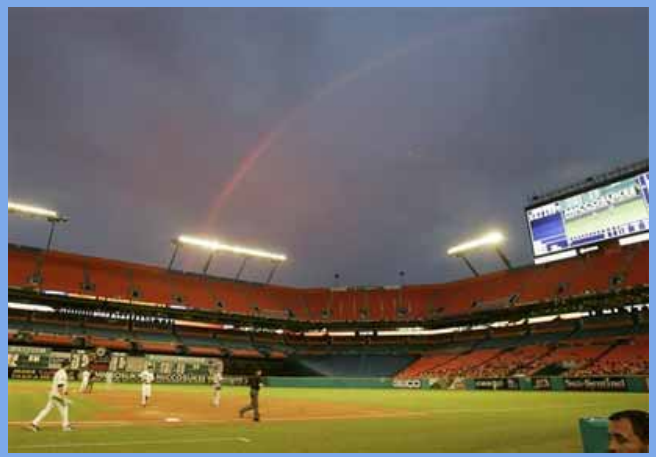
Existing Science

- Bay and estuary studies
- Results from TIFP
- Alternate desktop methods
- TNC collaborative approach (Cypress example)

Environmental Flow Regime

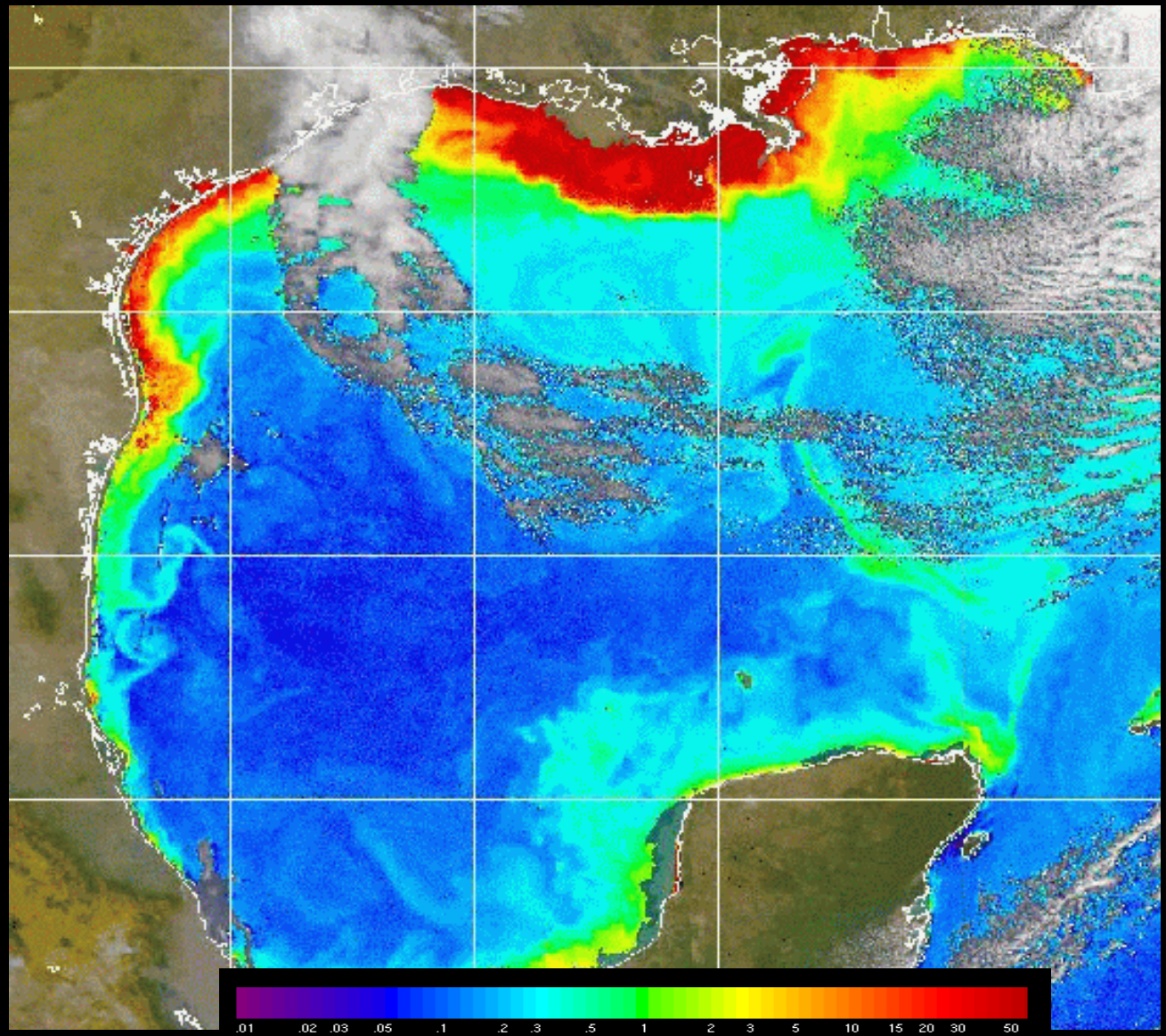
- Subsistence – maintain water quality MinQsal
- Base Q – maintain habitat (lotic) MinQ
- HFP/small floods – channel maintenance sediments and nutrients to bays MaxH/MaxC
- Overbanking Q – riparian health geomorphology floodplain dependent species

And then there's the Chicago Cubs…



- More threatening is the combustible mix of historic laws, traditions, wasteful practices, a statewide and regional mandate for communities to secure sufficient water supplies through 2050, and a rapidly growing number of users and uses for the river whose collective demand already outstrips the existing supply.

Joe Nick Patoski



Chlorophyll a Concentration
mg/m3

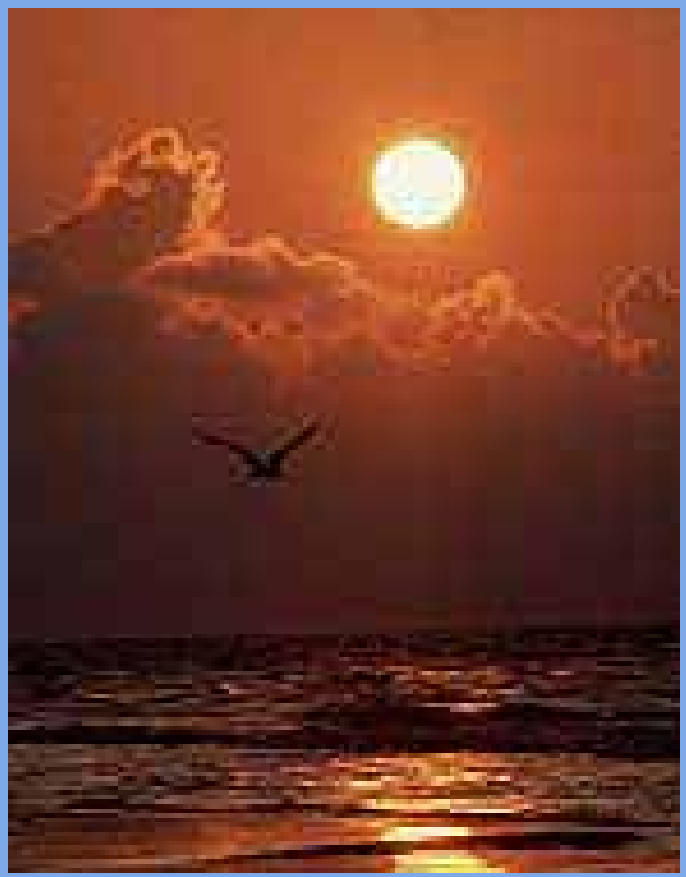
Galveston Bay

(Linda Shead)

- In 1993, quarter million people used the bay for boating and fishing
- Recreational boating - $364 million/year
- Commercial fishing - $200 million/year
- Provided 2/3 ’s of Texas’ oyster harvest

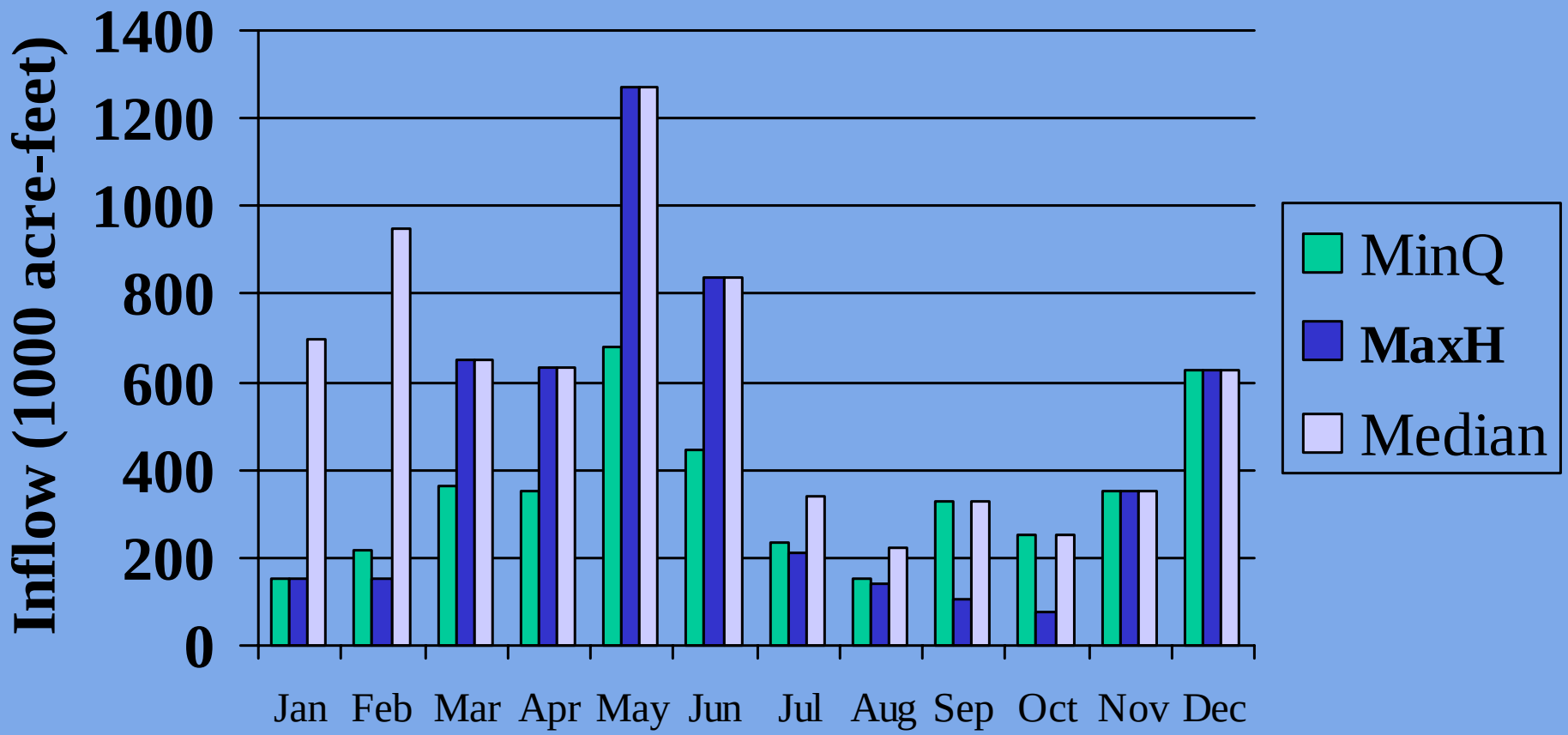
Trinity-San Jacinto Estuary

(Tanyeri-Abur, et al. 1998)

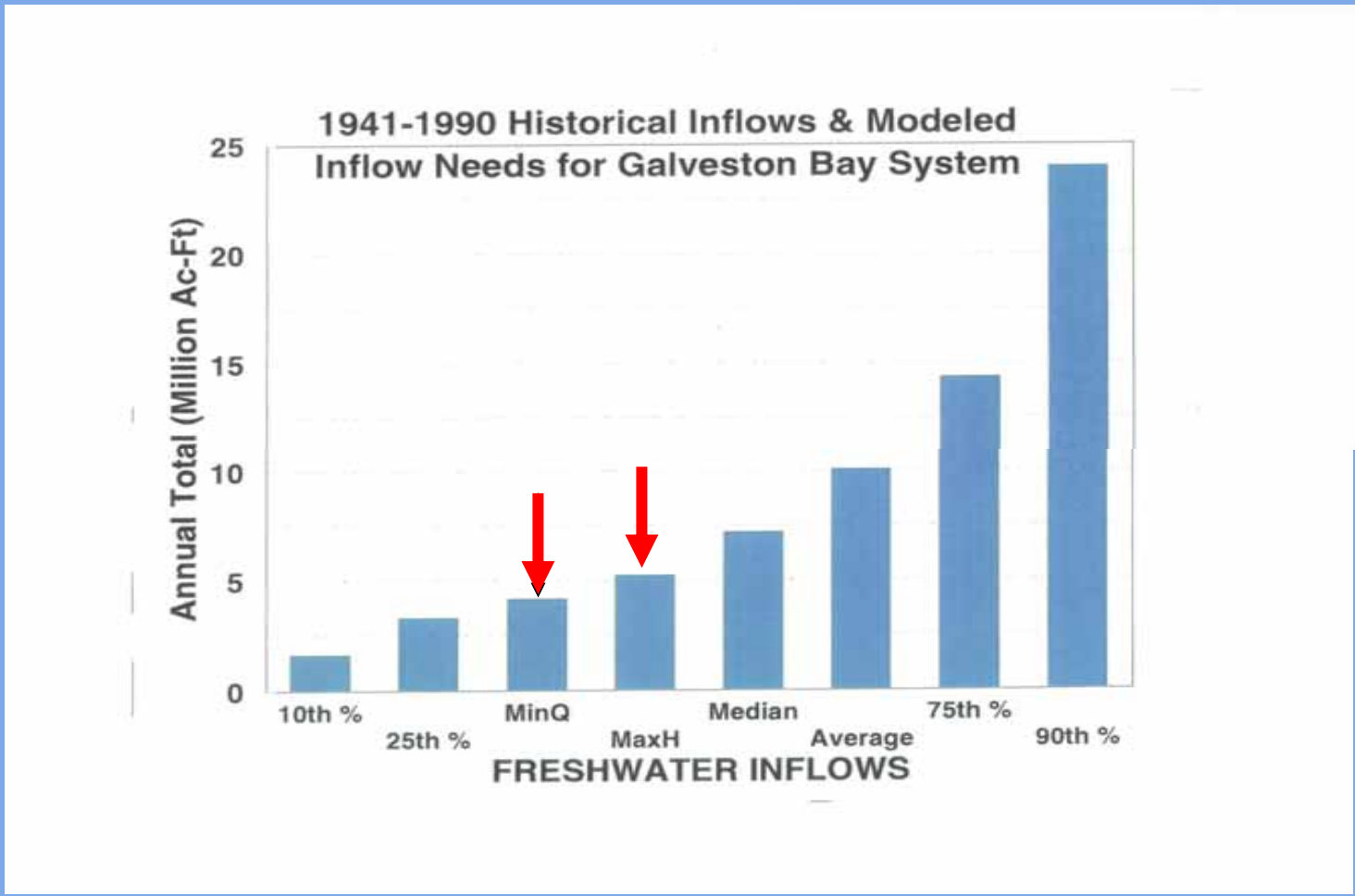


- $757.69 million in direct regional impact from water-related recreation
- Direct regional impact from inshore commercial fishing $23.39 million
- Direct regional impact of total commercial fishing $92.08 million

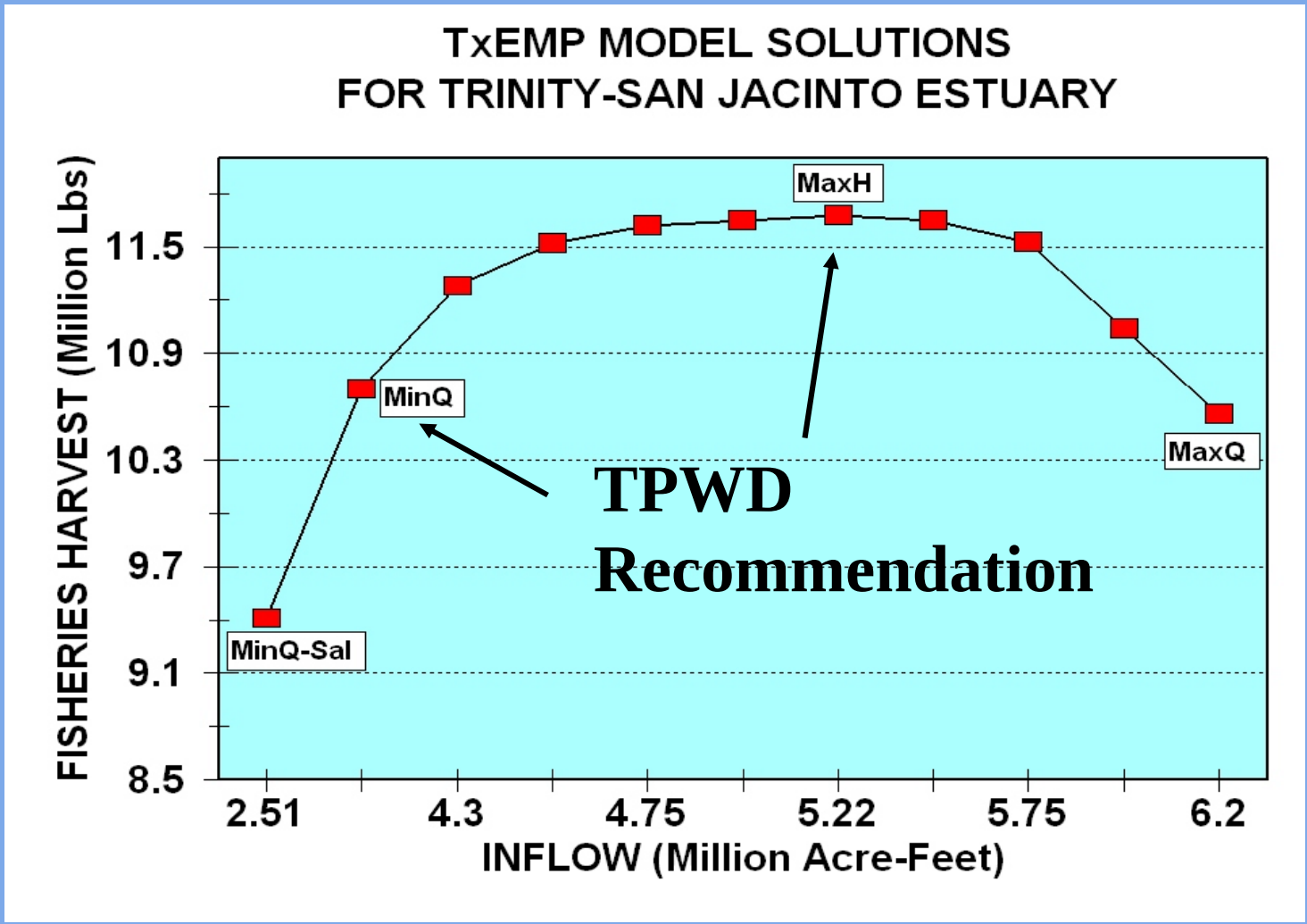
Trinity-San Jacinto Estuary Monthly Freshwater Inflow Targets



Comparison of Model Solutions to Historical Inflows



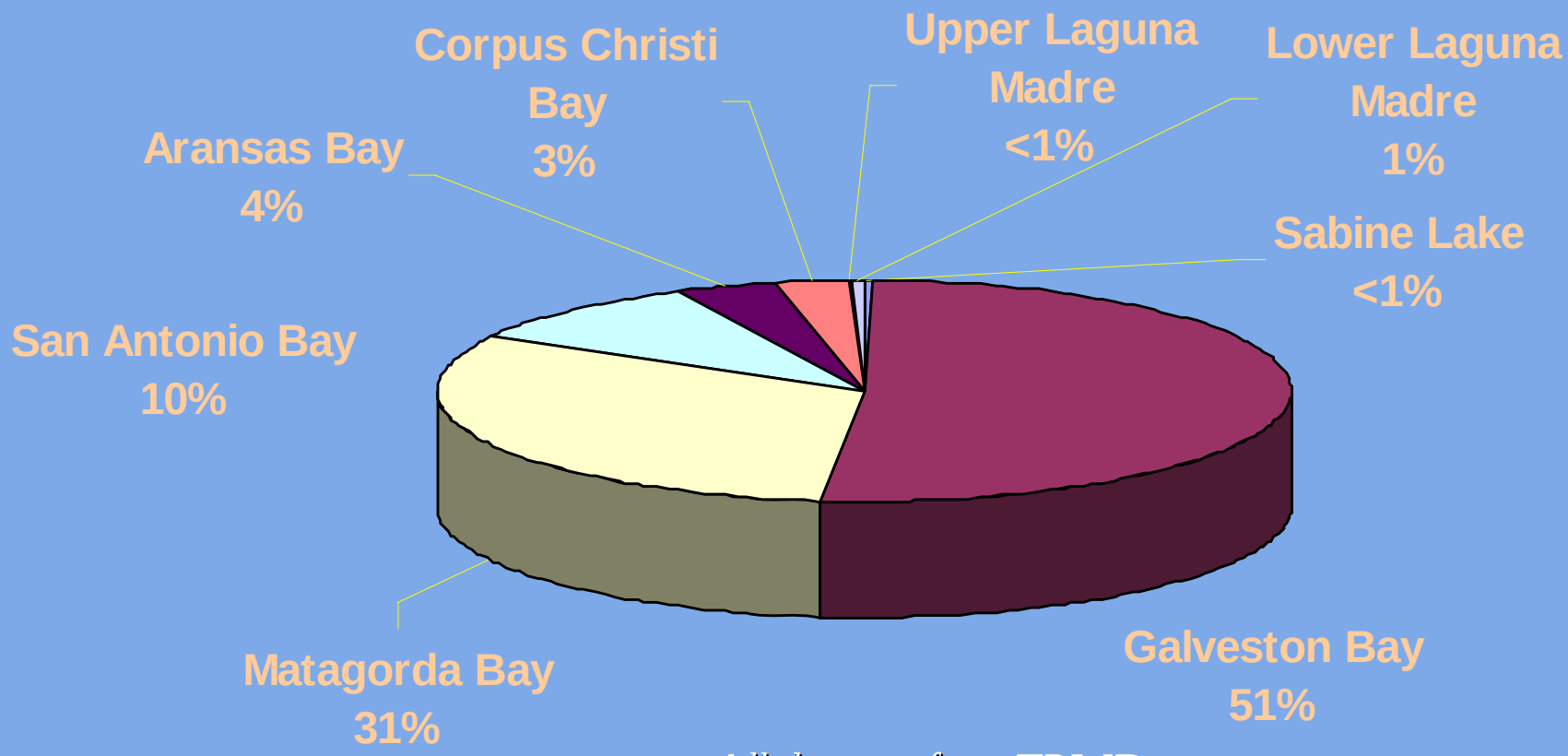
TxEMP MinQ and MaxH Solutions



Natural Reef Area

Percentage Of Oyster Reef Area By Bay System –

Lease Acres Are Not Included



- *All data are from TPWD*