Development of Information Needed to Determine Freshwater Inflow Requirements for Galveston Bay

Trinity San Jacinto BBEST

Biological Indicators Workshop I

August 13, 2009

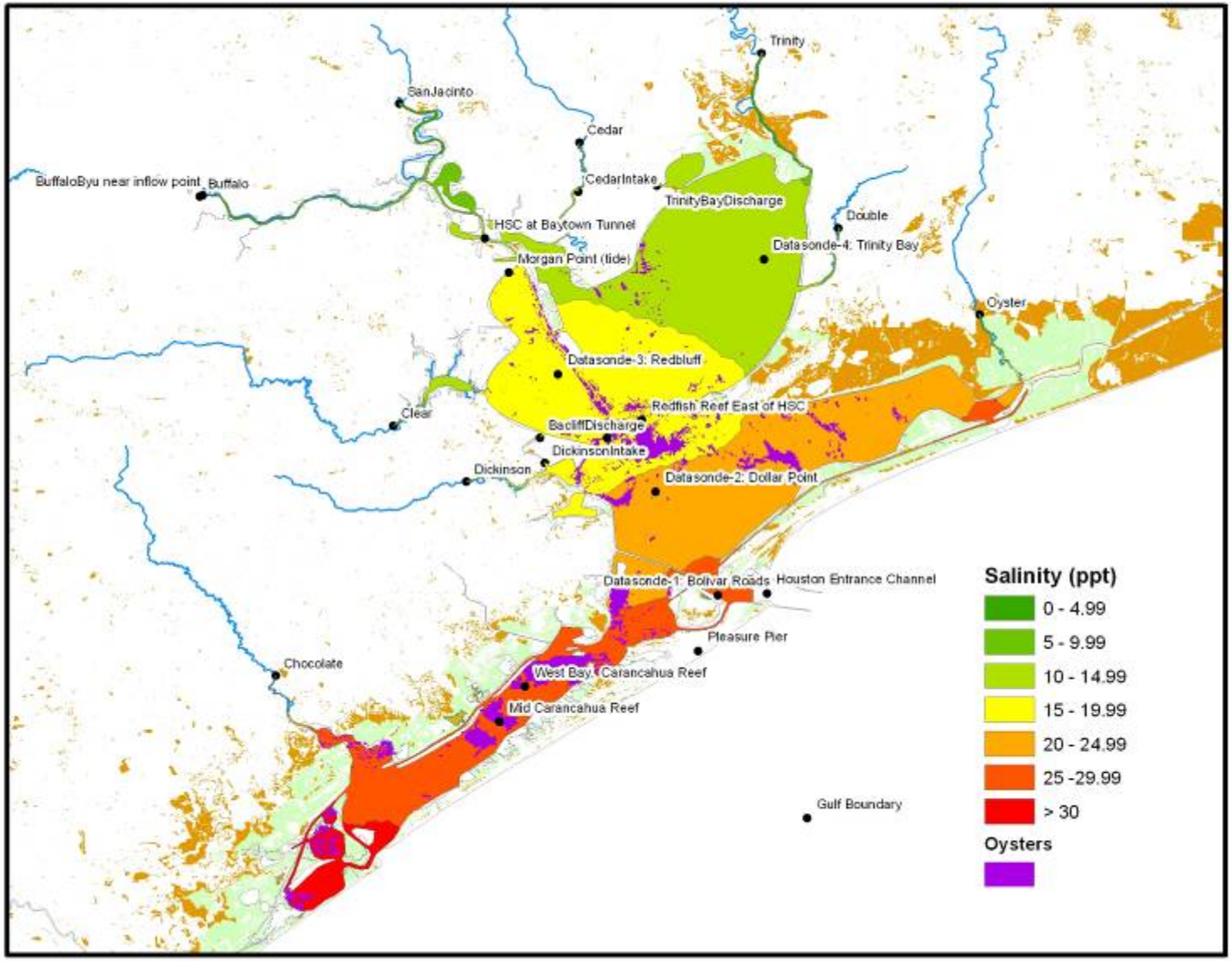
Tasks

1. Spatial and temporal characterization of salinity in Galveston Bay
2. Synthesis of Pre-reservoir Flow Pattern
3. Development of Salinity-Ecology Relationships
4. Determination of flows necessary to desired salinity conditions
5. Production of documentation and final report

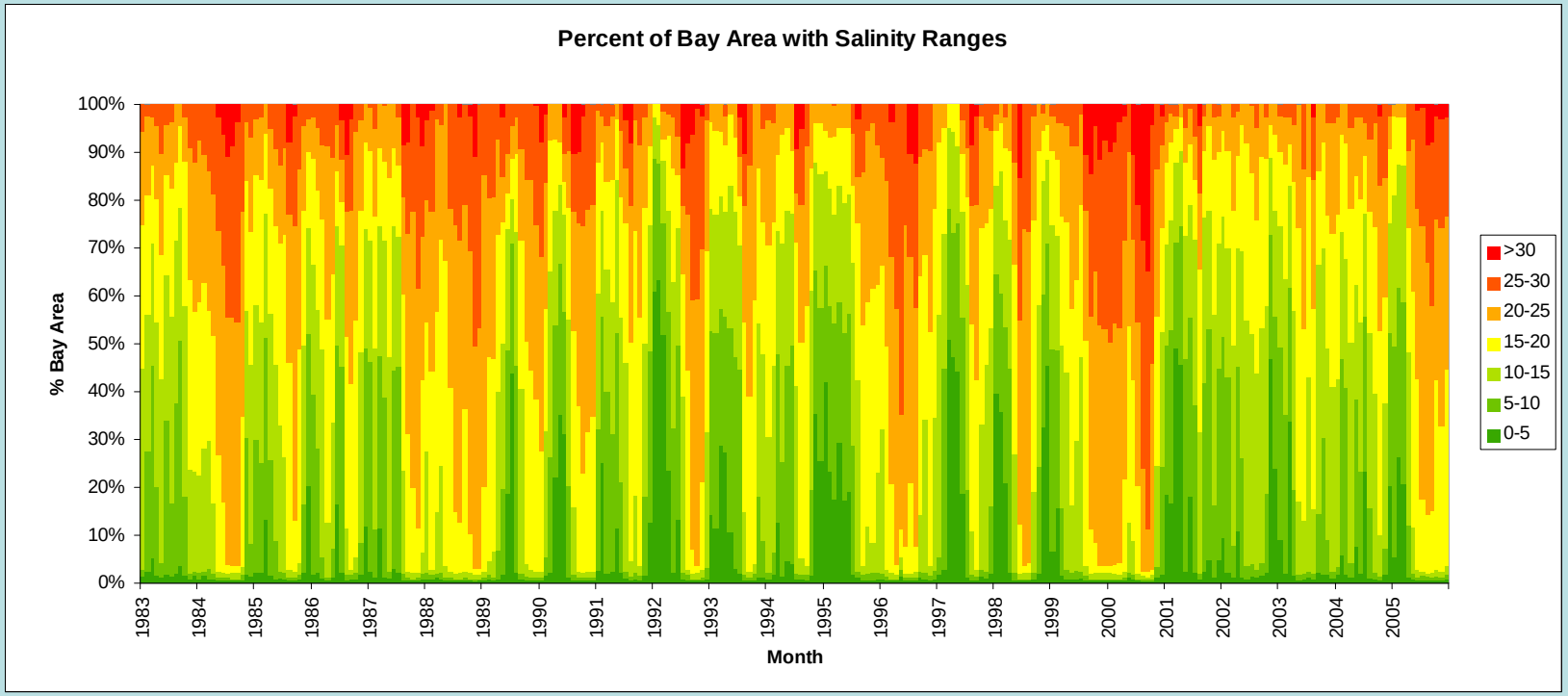
Task 1: Spatial and temporal characterization of salinity in Galveston Bay

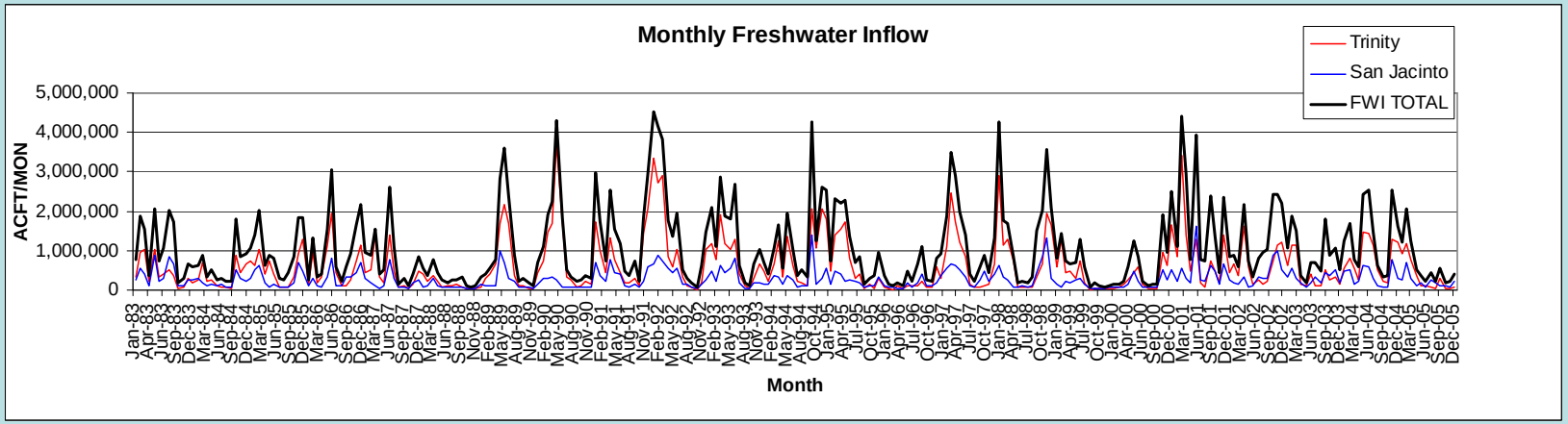
- Time series - Isohaline maps
- Bay area within salinity ranges and relationship to flow
- Compare empirical and mechanistic modeling

TxBLEND Generated Isohaline maps



Bay area within salinity ranges

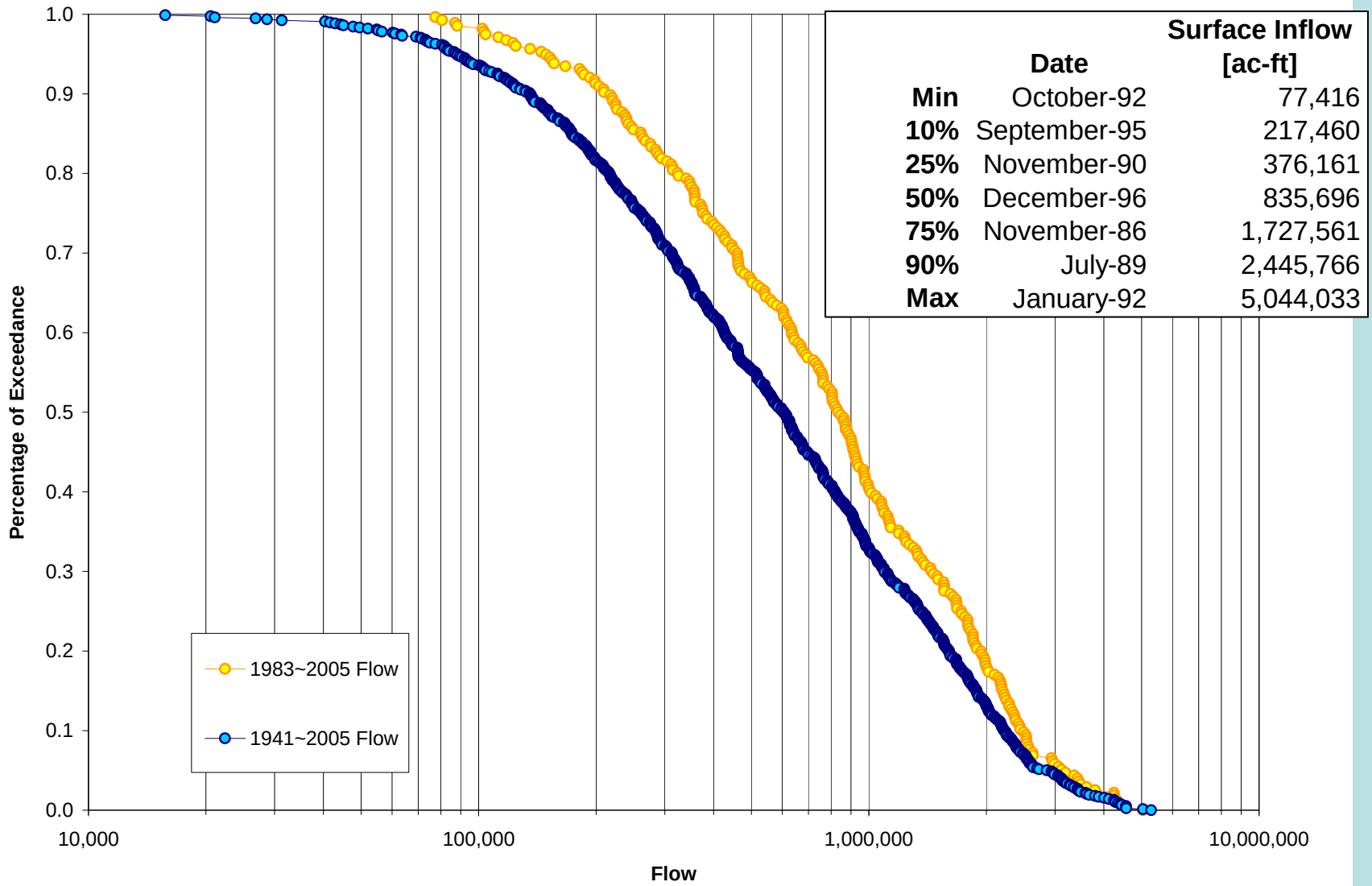




Ranking of Annual Inflows to Galveston Bay

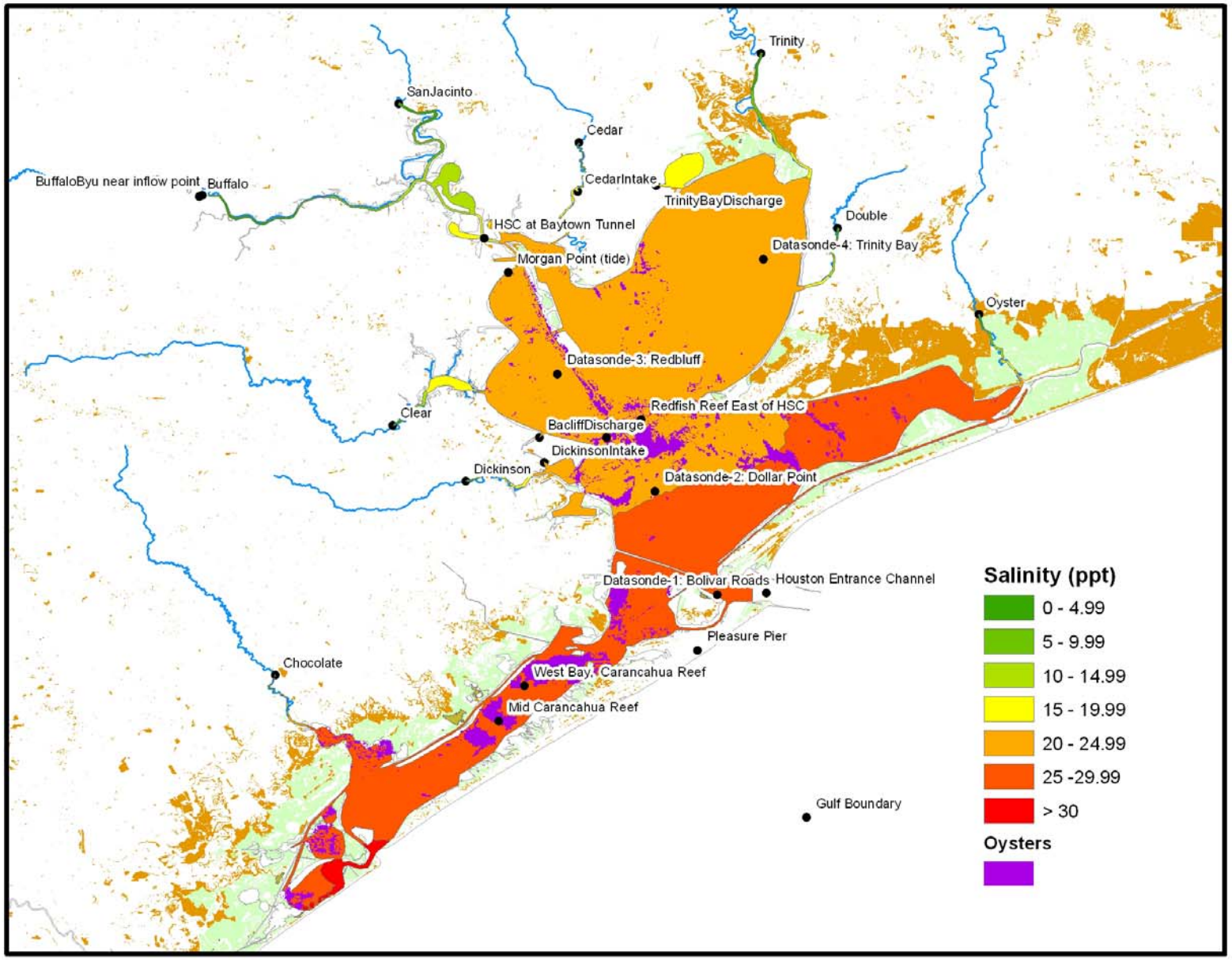
Year	Surf.In.	PerecentRan	Select
1977	8,522,177	41%	
1978	4,957,771	14%	
1979	18,671,349	88%	
1980	7,936,640	36%	
1981	11,989,336	58%	
1982	10,947,433	47%	
1983	13,248,081	64%	
1984	7,795,042	34%	
1985	12,491,535	59%	
1986	13,277,419	66%	
1987	9,988,234	44%	
1988	3,954,690	8%	D1
1989	12,530,243	61%	A3
1990	14,394,320	73%	W1
1991	22,598,609	97%	
1992	25,148,391	100%	
1993	19,951,721	91%	W3
1994	16,462,970	80%	W2
1995	15,484,064	77%	
1996	5,156,988	17%	D2
1997	16,811,926	83%	
1998	18,223,638	86%	
1999	7,112,886	28%	D3
2000	6,973,234	27%	
2001	24,324,853	98%	
2002	15,609,910	78%	
2003	11,666,127	56%	A2
2004	16,486,943	81%	
2005	8,058,561	38%	A1

Total Galveston Bay Watershed Monthly Inflows
1983 – 2005 POR
Compared to
1941 – 2005 POR

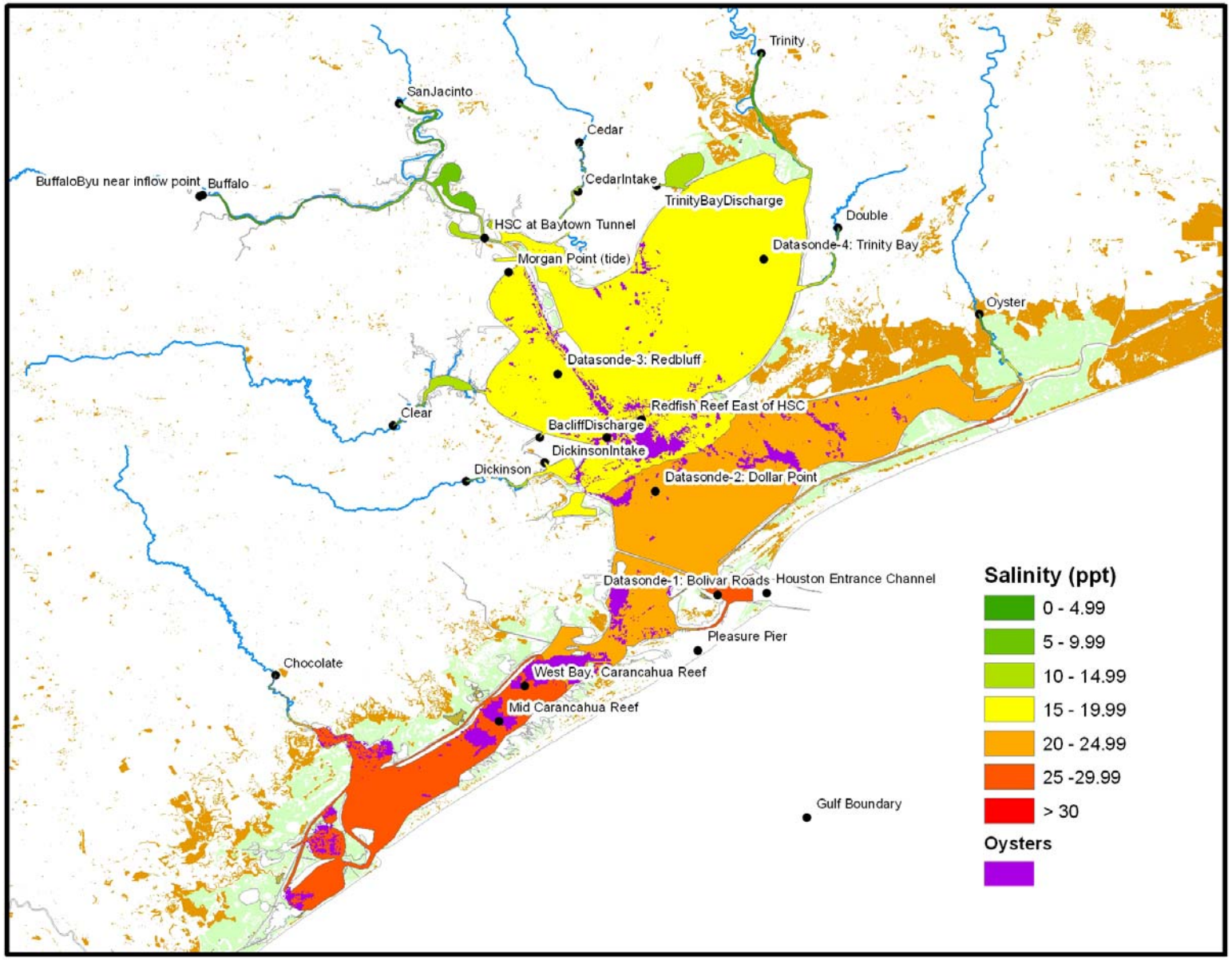


	Date	Surface Inflow [ac-ft]
Min	October-92	77,416
10%	September-95	217,460
25%	November-90	376,161
50%	December-96	835,696
75%	November-86	1,727,561
90%	July-89	2,445,766
Max	January-92	5,044,033

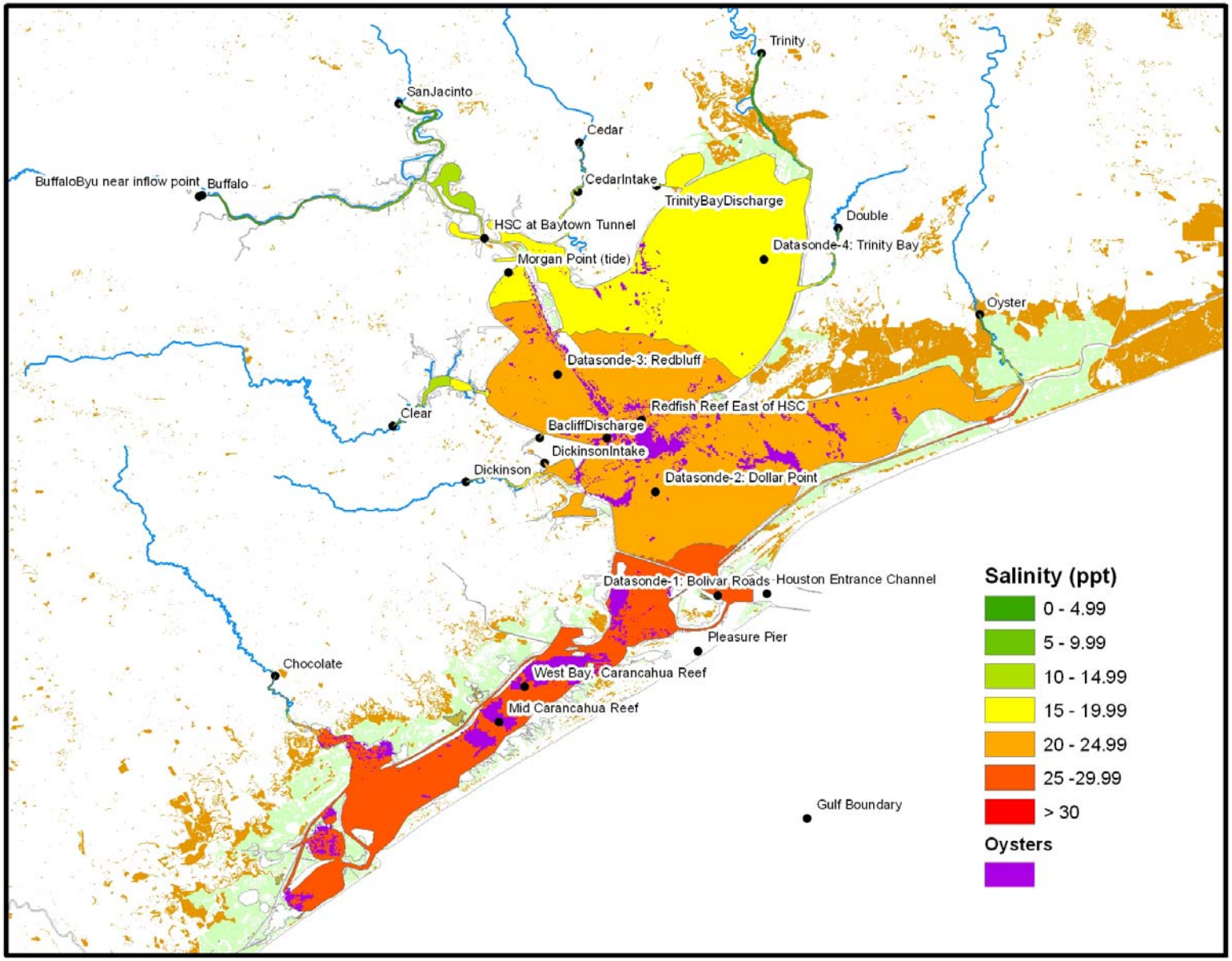
Historical Minimum Month - October 1992



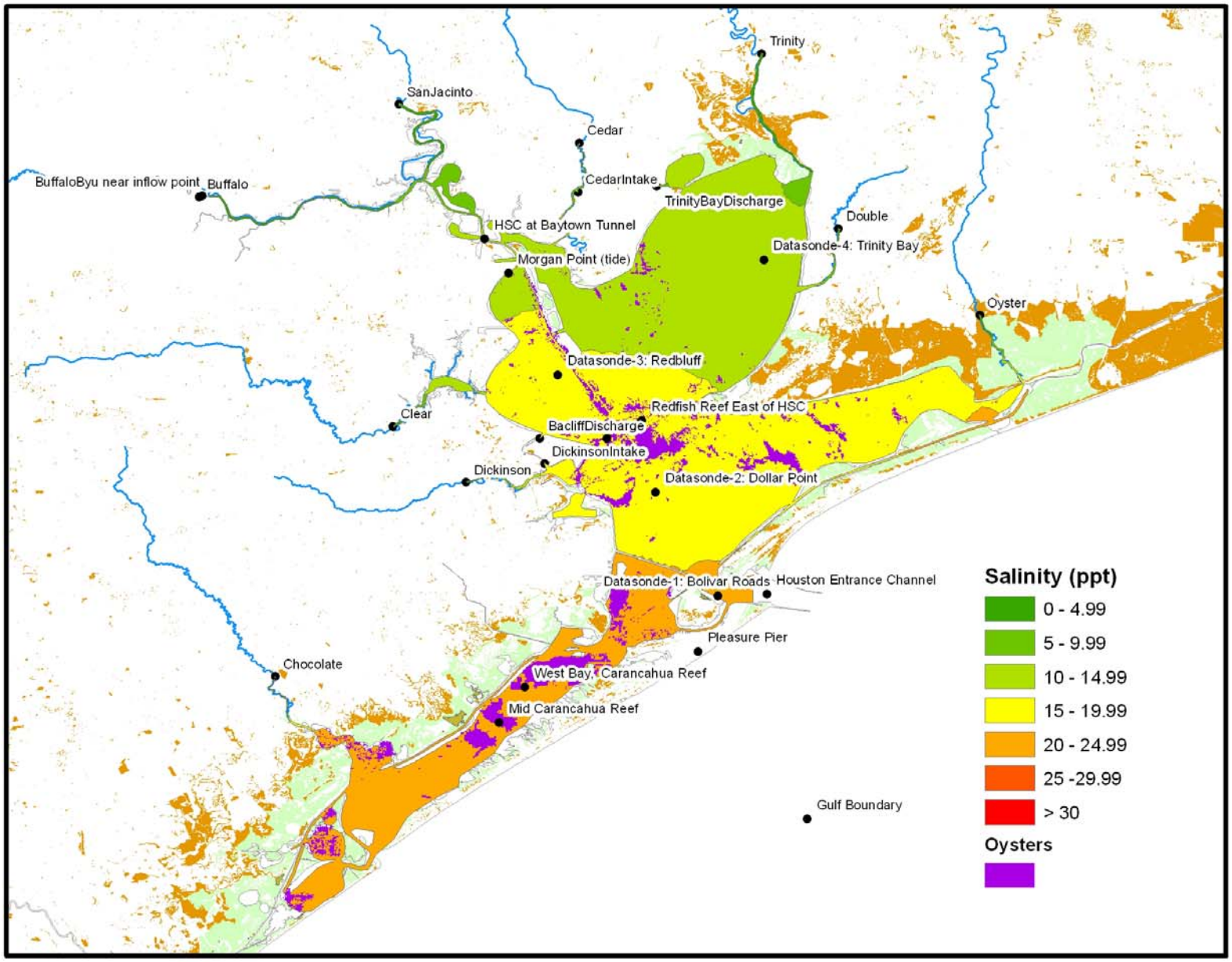
10th %-ile Month - September 1995



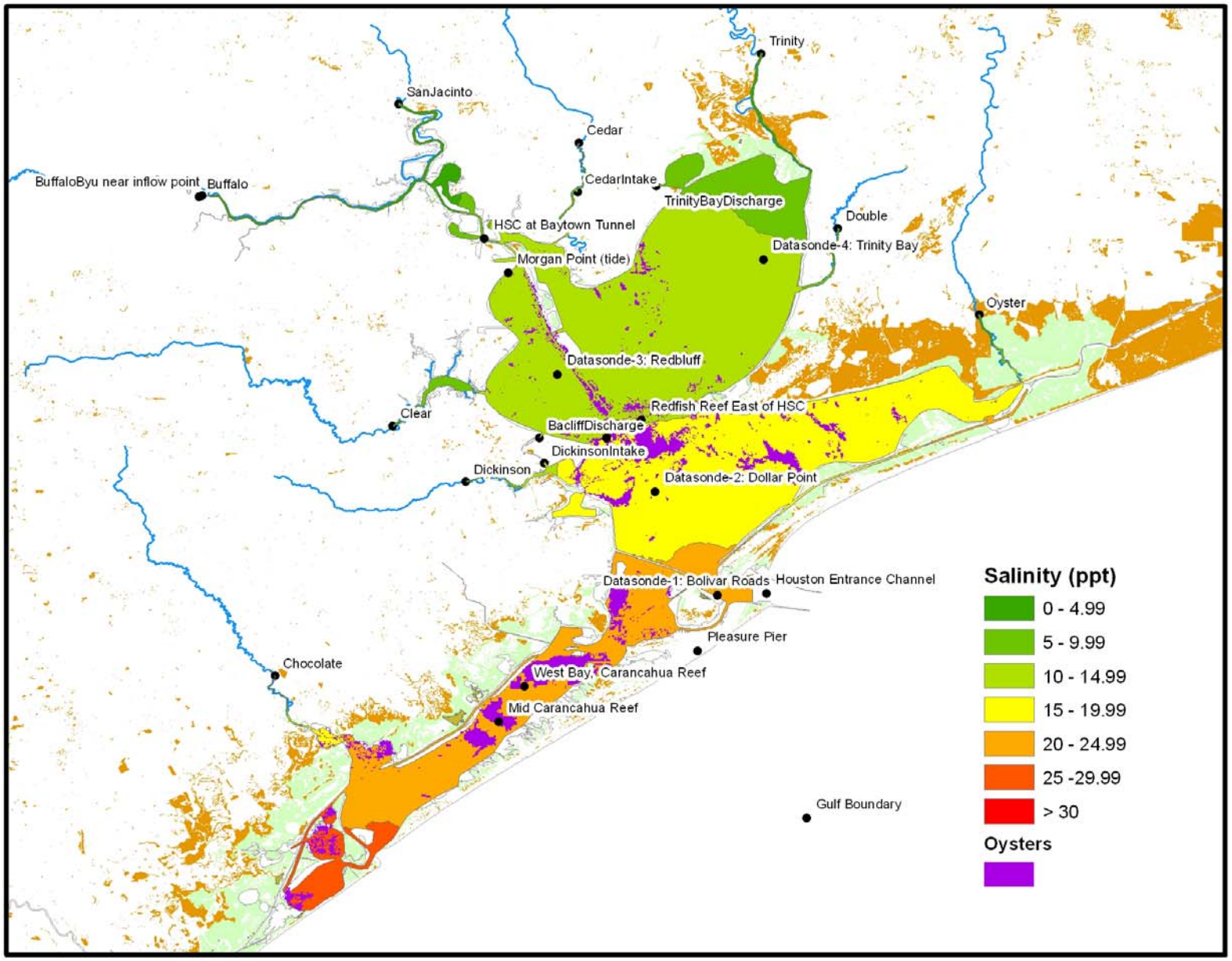
25th %-ile Month - November 1990



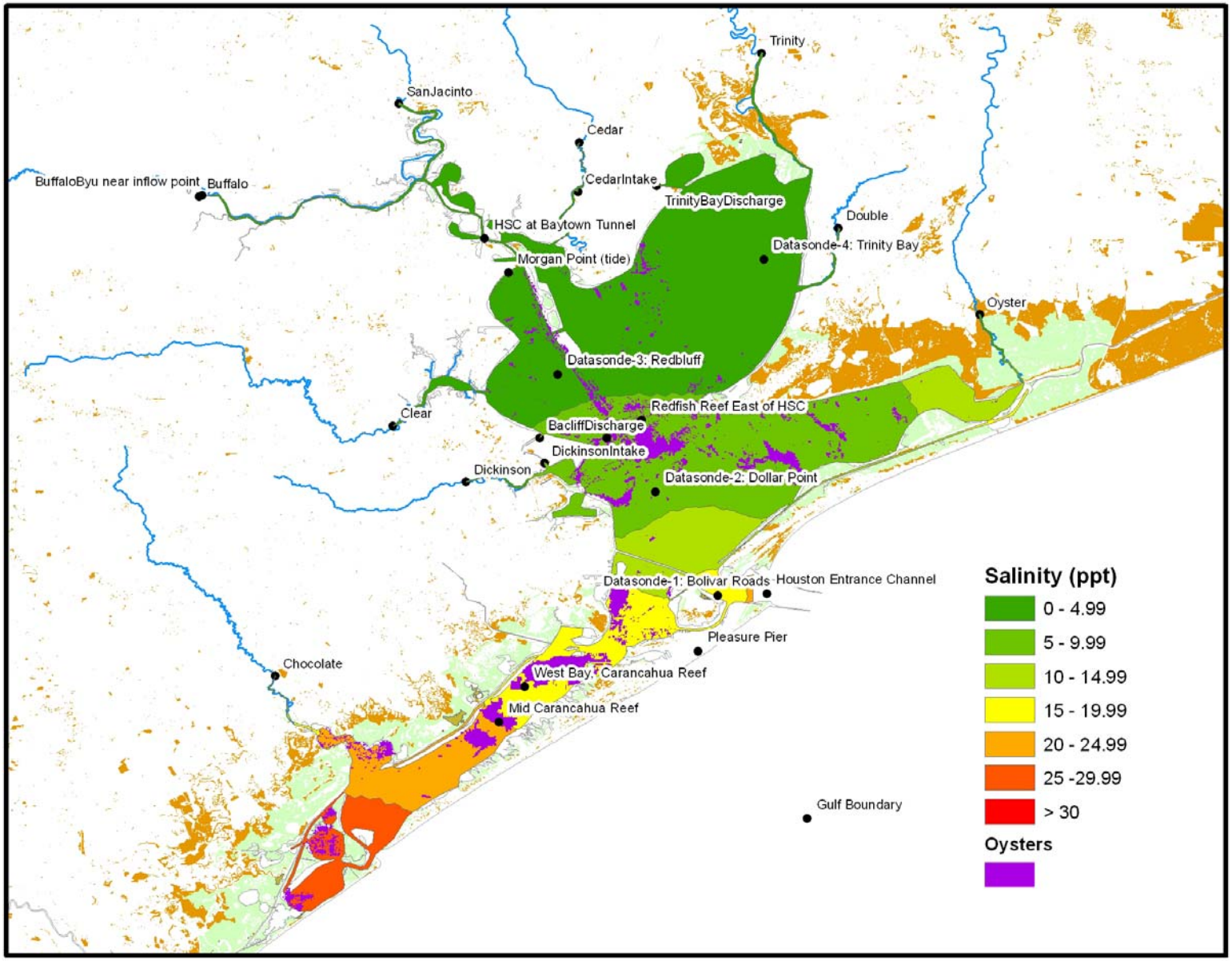
Median Month – December 1996



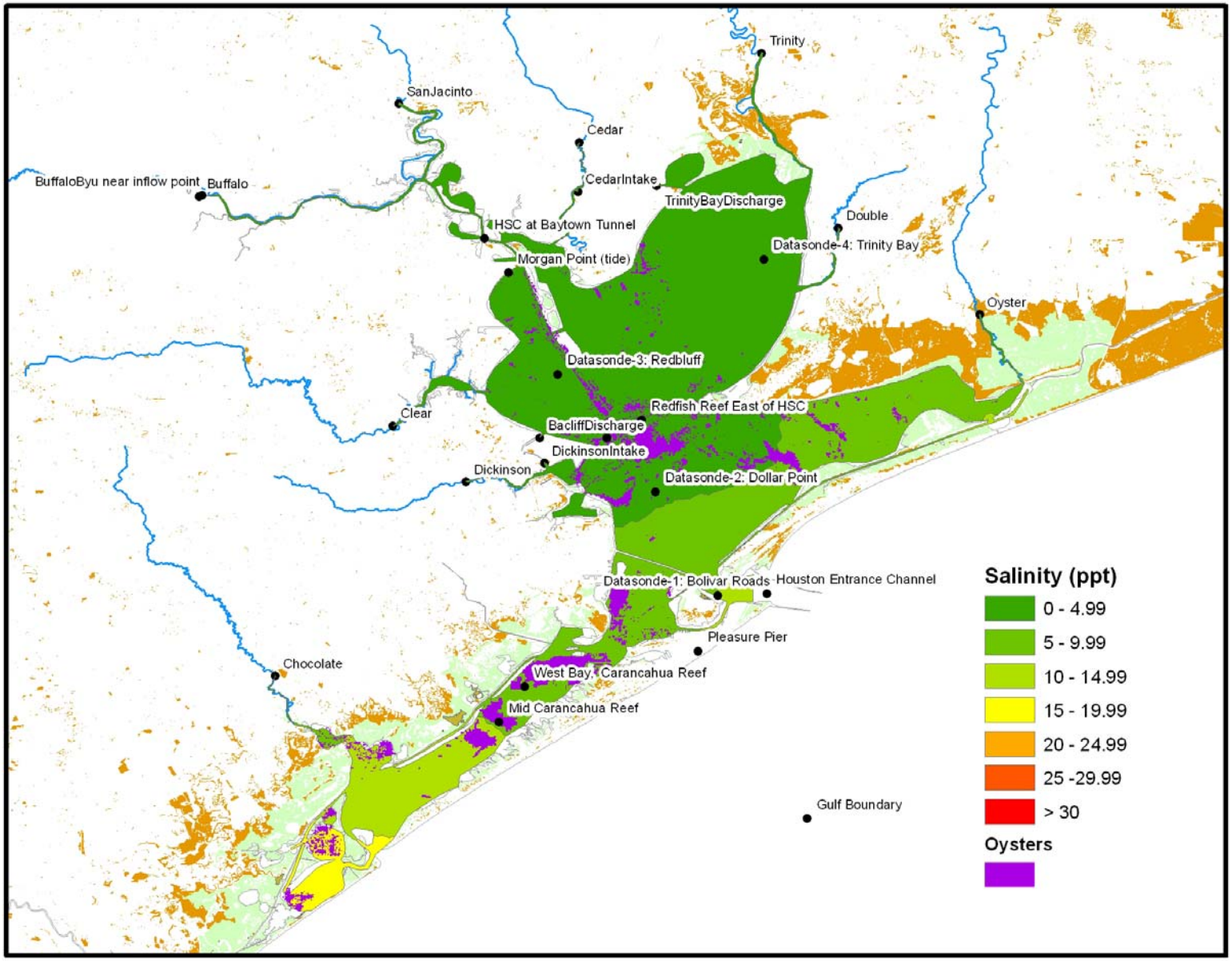
75th %-ile Month – November 1986



90th %-ile Month – July 1989



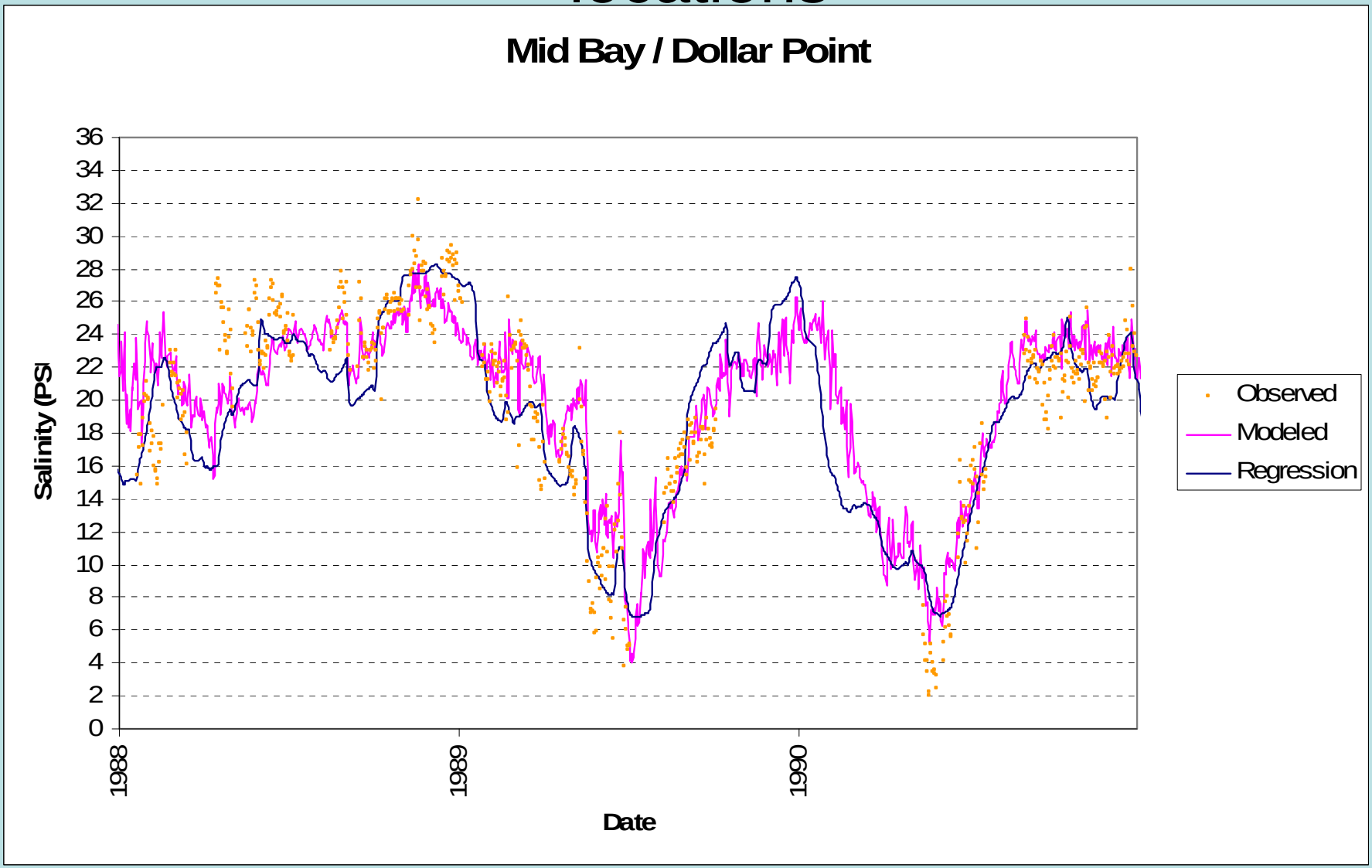
Historical Maximum Month – January 1992



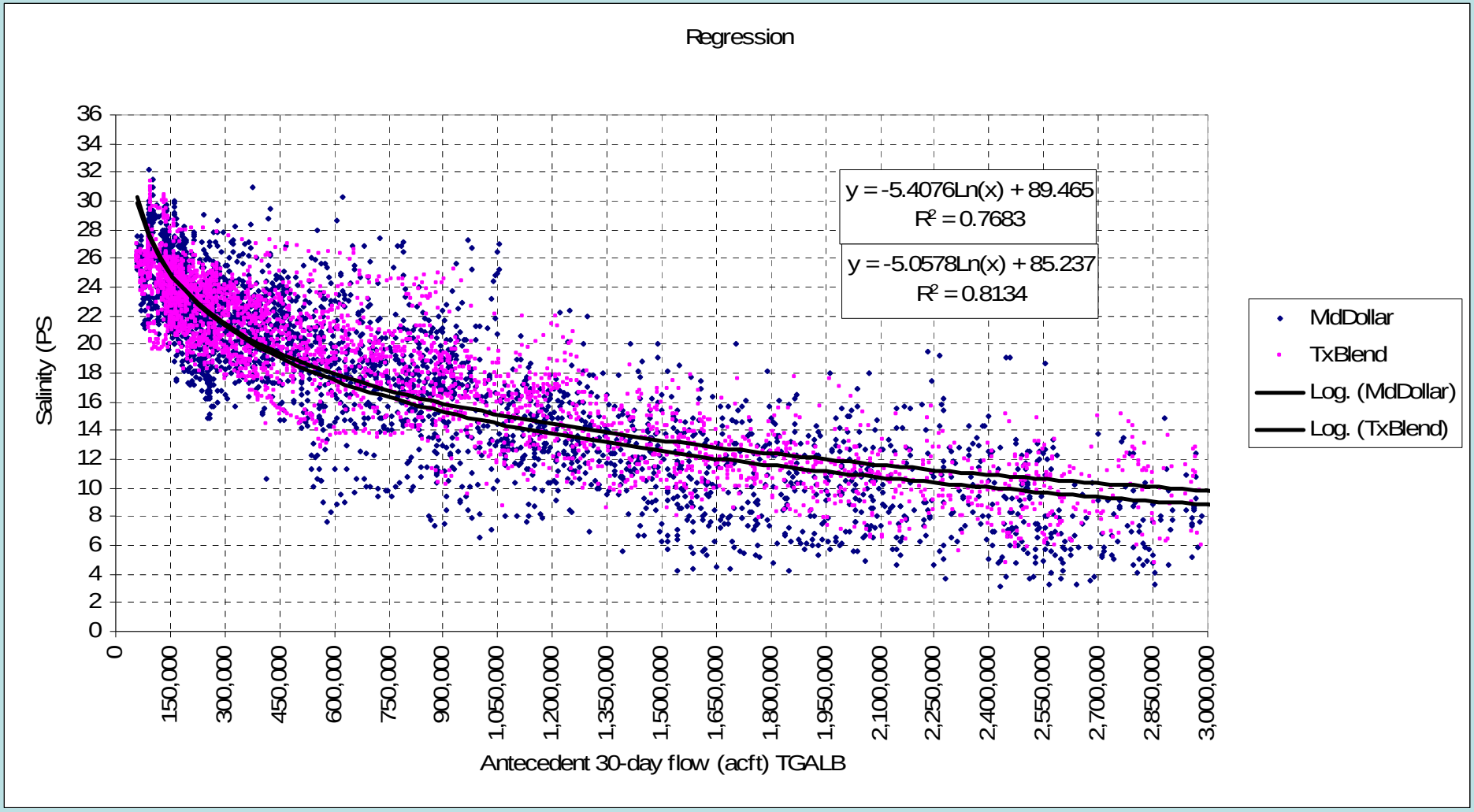
TxBLEND and Regression Comparison

- Time series comparison and statistical test between observed and modeled (mechanistic and empirical) salinities at datasonde locations. e.g. Nash-sutcliffe
- Compare regressions (flow and observed salinity) vs (flow and modeled salinity) e.g. test slope and intercept
- Decision – direct TxBLEND output or regression -> TxBLEND isohaline interpolation & utilization of TxBLEND for verification

Time series comparison between observed and modeled salinities at datasounde locations



Comparison between regressions (flow and observed salinity) and (flow and modeled salinity)



- Appears to do well at Dollar/Mid location
- Concerns exist over methodologies for comparisons at other locations
- Layout methodologies to solicit feedback from interested BBEST and SAC members
- Comparative analyses academic at this point due to issue regarding flows

Flow Discrepancy

- In prosecution of comparative analysis of TxBLEND & datasonde salinity data, discovered significant issue
- Discrepancy in Inflow Data
  - TxBLEND Flow Input Data for Total Galveston Bay watershed does not match with reported TWDB amounts (website) for Total Galveston system

    (Surface Inflows = Gage + Ungage – Div + RF)
- As long as this flow input issue remains unresolved, we may have a model that is calibrated to flow inputs that we are not sure have actually occurred.

% Difference between TxBLEND flow inputs & TWDB Total Galveston Bay Inflows

Over entire period of record (1977-2005)

- 21% of months exhibit a difference greater than -10%
- 1% of months exhibit a difference of greater than +10%

Excluding the 1991 – 1994 Time Period

- 12% of months exhibit a difference greater than -10%
- 2% of months exhibit a difference of greater than +10%

Pre-1991

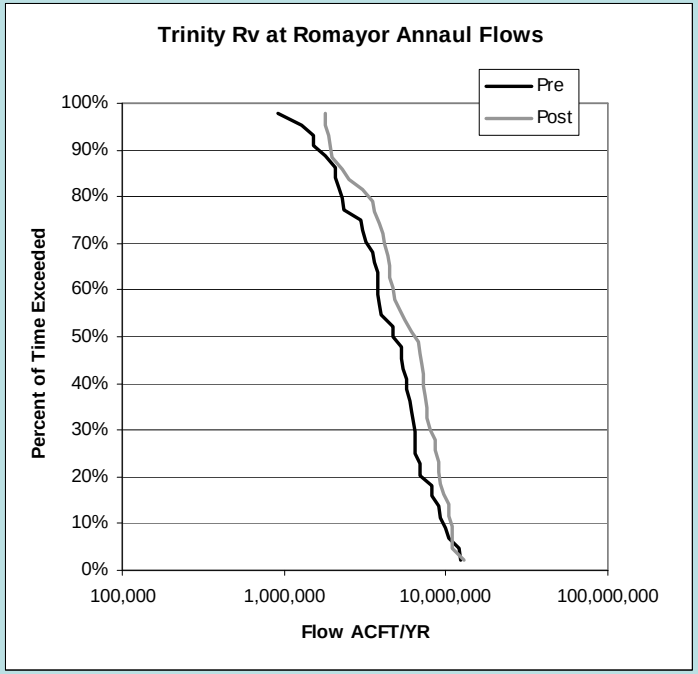
- 6% > -10%
- 2% > +10%

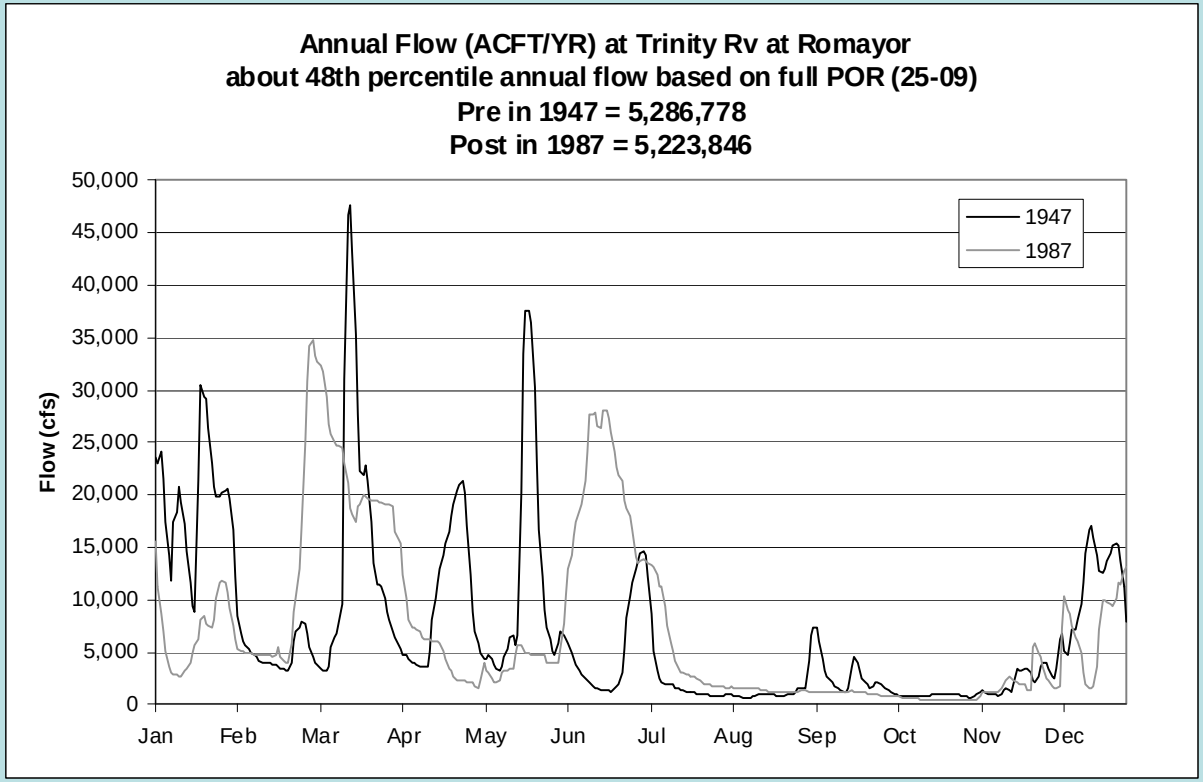
Post-1994

- 19% > -10%
- 2% > +10%

Task 2: Synthesis of Pre-reservoir Flow Pattern

- Comparison of flow statistics pre- and post- major reservoir construction
- Decision – Model naturalized flow regime to determine natural salinity patterns or conclude the salinity patterns pre/post not significantly different

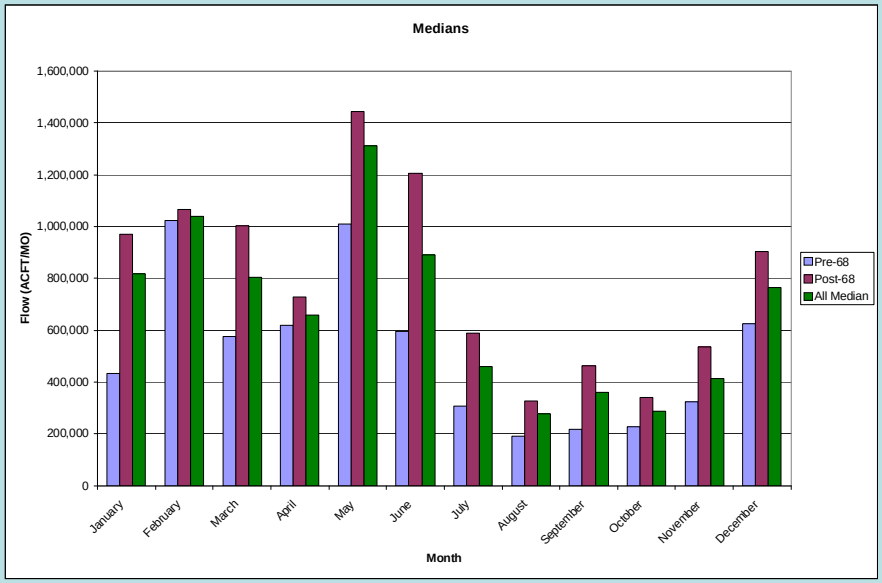


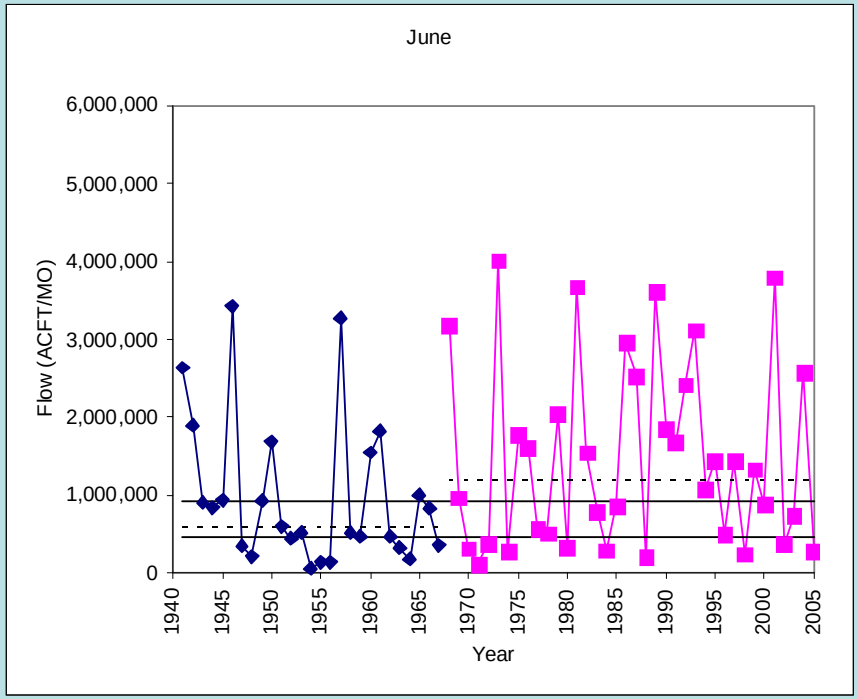


Comparison of flow statistics pre- and post- major reservoir construction

- Statistics of seasonal/monthly flow volumes and or freshets pre/post including measure of variability

Pre	27	9								
Post	38	12.7								
	0.5		0.33	0.66	12.7					
	Medians		RVA Boundaries		Hydrologic Alteration			Count Post		
	Pre Median	Post Median	RVA Low	RVA High	Low	Middle	High	Low	Middle	High
January	433,100	971,592	338,084	1,163,540	-53%	42%	11%	6	18	14
February	1,024,300	1,067,245	464,178	1,271,344	-29%	3%	26%	9	13	16
March	574,200	1,002,230	362,728	825,612	-53%	-21%	74%	6	10	22
April	619,800	729,619	427,832	863,976	-21%	3%	18%	10	13	15
May	1,010,400	1,442,854	469,910	1,485,492	-37%	-13%	50%	8	11	19
June	597,300	1,204,739	458,296	928,432	-21%	-45%	66%	10	7	21
July	306,300	588,024	204,144	485,072	-76%	11%	66%	3	14	21
August	191,180	328,428	124,316	287,113	-84%	18%	66%	2	15	21
September	216,320	462,930	165,939	422,768	-100%	42%	58%	0	18	20
October	228,640	339,811	112,977	277,832	-61%	-29%	89%	5	9	24
November	323,900	534,996	212,853	384,840	-53%	-45%	97%	6	7	25
December	625,300	902,913	289,007	922,552	-45%	3%	42%	7	13	18





Task 3: Development of Salinity-Ecology Relationships

- What does this group need from flows - salinity analysis
- What outputs might be expected from as a desired ecological conditions that can be related to flows

Task 4: Determination of flows necessary to desired salinity conditions

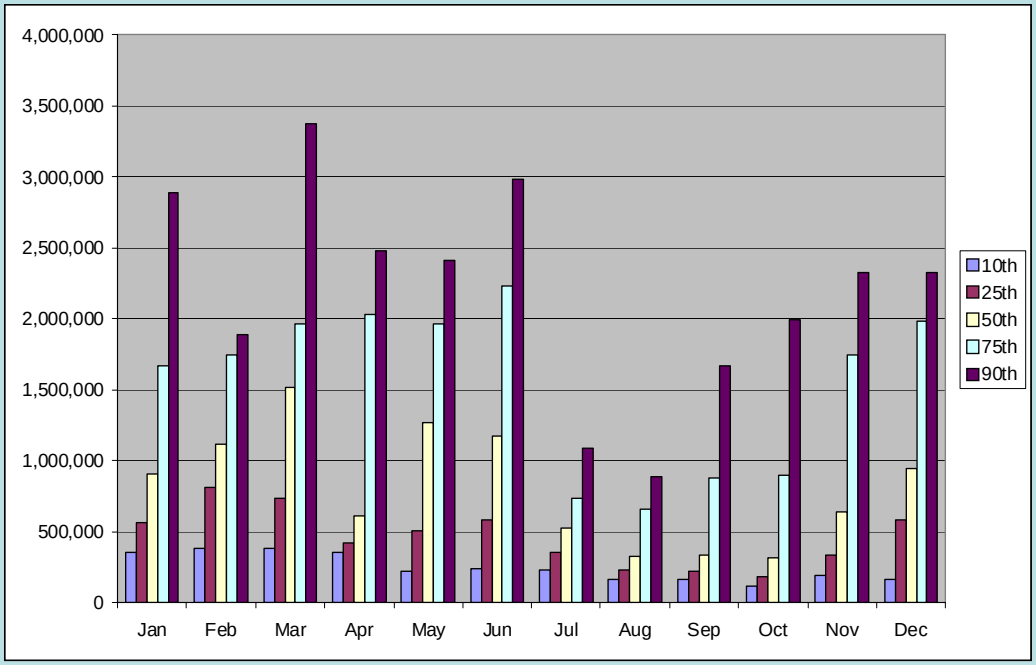
- Use regression relationships to determine starting point for flow estimates that would provide desired ecological conditions
  - Identify Salinity Zones (Task 3)
  - Incorporate refined TxBLEND isohalines into geographic depiction of Flow/Salinity Area
  - Calculate estimated historical areas utilizing regressions
  - Develop Flow-Area relations
  - Develop historical Salinity Area ogives according to Flow
- Simulated flows in TxBlend to determine if they produce desire conditions.

Task 5: Production of documentation and final report

Spare Slides

Flows

Month	0.1	0.25	0.5	0.75	0.9
Jan	349,080	562,689	903,548	1,664,535	2,887,426
Feb	378,446	807,387	1,117,918	1,743,038	1,884,596
Mar	375,584	728,575	1,518,450	1,967,912	3,372,451
Apr	354,543	415,909	613,131	2,027,177	2,475,120
May	213,258	508,123	1,265,540	1,963,177	2,408,985
Jun	242,507	581,481	1,172,993	2,232,888	2,988,680
Jul	227,750	347,412	526,003	736,504	1,088,036
Aug	160,998	226,822	323,653	656,624	883,461
Sep	165,424	215,877	332,051	875,438	1,666,873
Oct	111,786	184,033	310,175	892,863	1,993,828
Nov	188,163	335,644	638,737	1,742,461	2,321,515
Dec	164,400	577,273	943,355	1,980,847	2,325,498
All	189,307	336,754	748,459	1,652,425	2,424,060

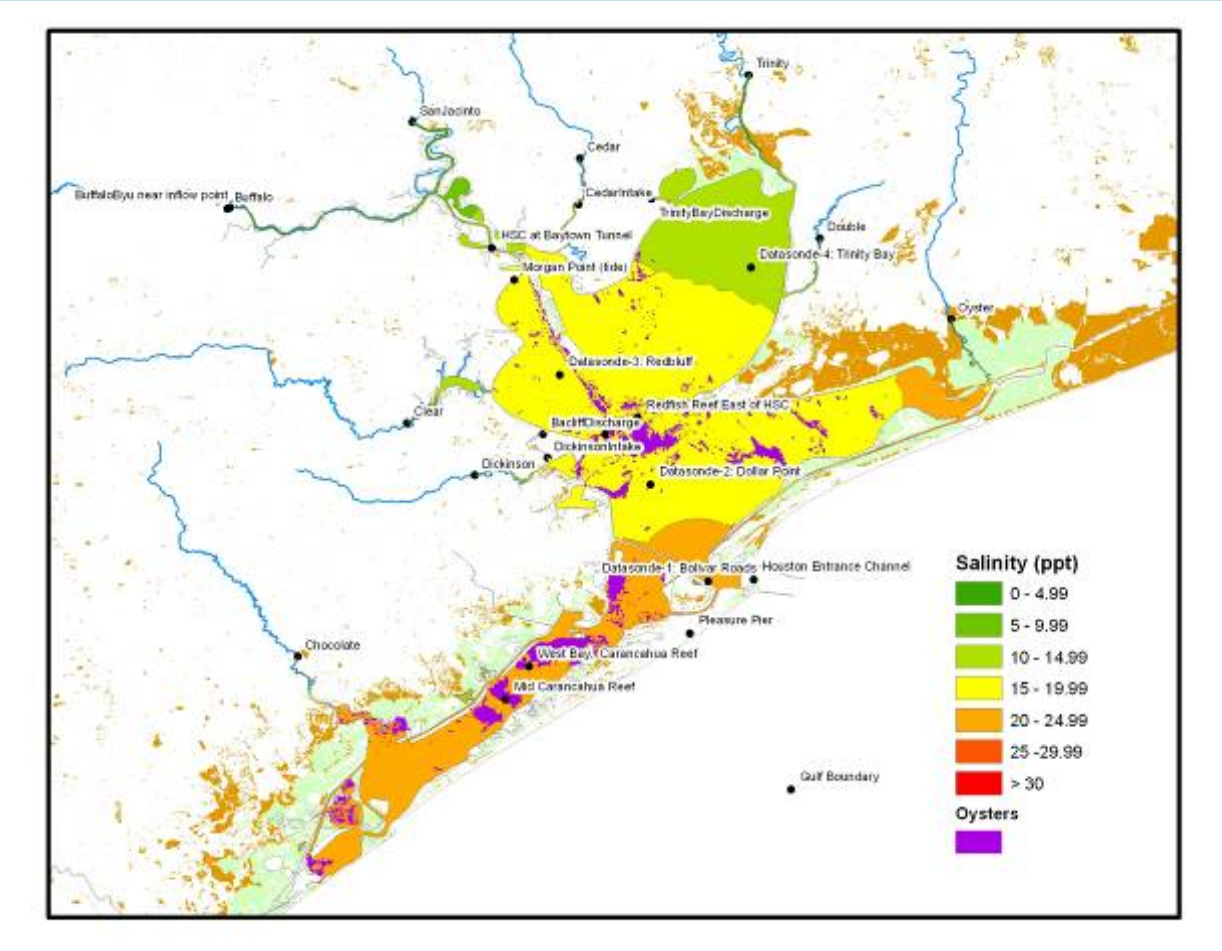


PreferenceZones.xls

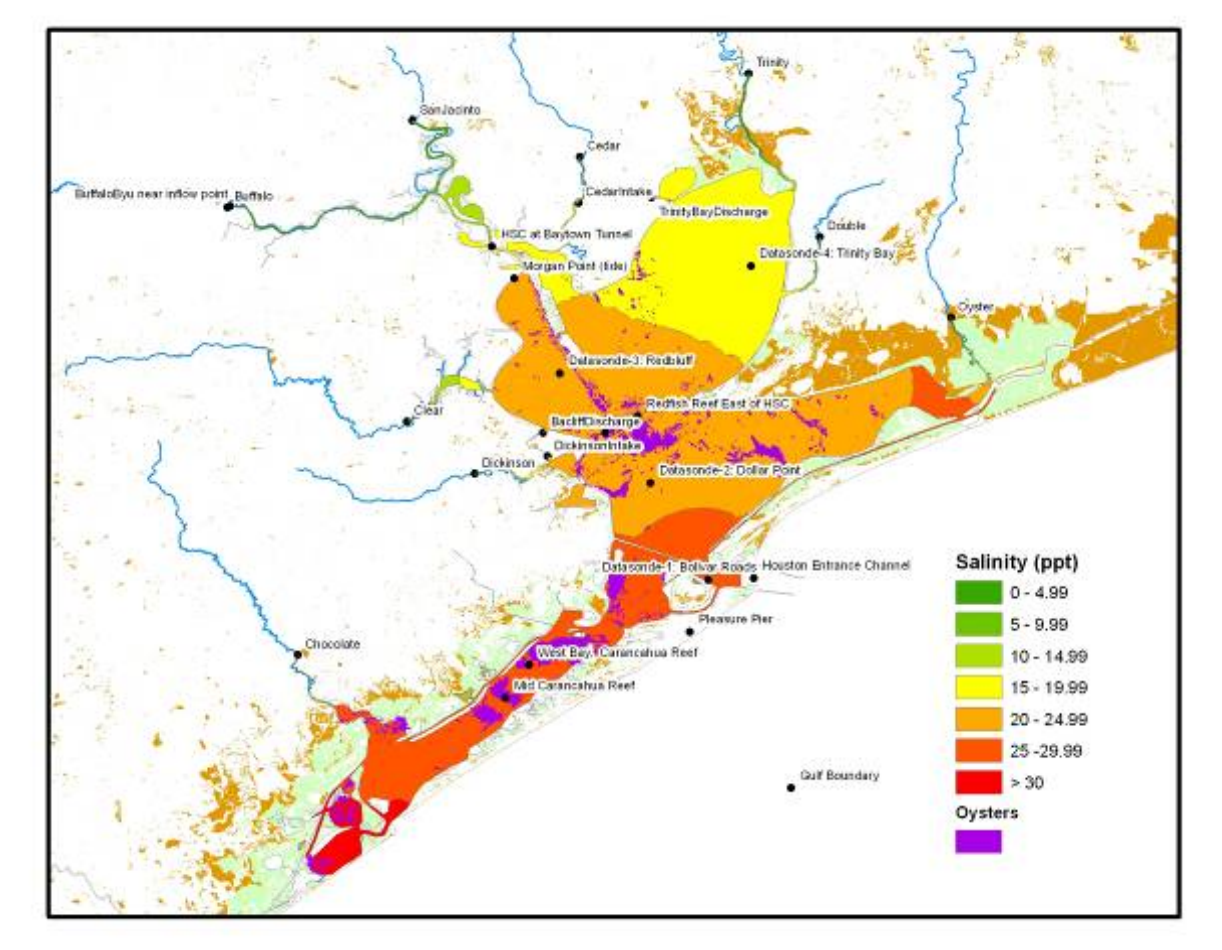
Month	0.1	0.25	0.5	0.75	0.9
Jan	349,080	562,689	903,548	1,664,535	2,887,426
Feb	378,446	807,387	1,117,918	1,743,038	1,884,596
Mar	375,584	728,575	1,518,450	1,967,912	3,372,451
Apr	354,543	415,909	613,131	2,027,177	2,475,120
May	213,258	508,123	1,265,540	1,963,177	2,408,985
Jun	242,507	581,481	1,172,993	2,232,888	2,988,680
Jul	227,750	347,412	526,003	736,504	1,088,036
Aug	160,998	226,822	323,653	656,624	883,461
Sep	165,424	215,877	332,051	875,438	1,666,873
Oct	111,786	184,033	310,175	892,863	1,993,828
Nov	188,163	335,644	638,737	1,742,461	2,321,515
Dec	164,400	577,273	943,355	1,980,847	2,325,498
All	189,307	336,754	748,459	1,652,425	2,424,060

	0-5	PPT 0-5	5-10	PPT 5-10	10-15	PPT 10-15	15-20	PPT 15-20	20-25	PPT 20-25	25-30	PPT 25-30	>30	PPT >30	FWI TOTAL	Rank FWI TOTAL
May-90	48,230	6%	43,521	22%	22,741	62%	12,169	86%	10,789	77%	0	100%	0	100%	4,286,378	1%
May-89	2,404	40%	24,770	39%	41,529	26%	35,067	47%	12,910	69%	16,989	31%	3,759	18%	2,844,490	6%
May-04	10,340	21%	42,389	23%	32,895	50%	31,255	52%	17,000	60%	3,577	67%	0	100%	2,438,858	10%
May-95	23,879	15%	48,150	17%	37,130	35%	21,819	68%	6,473	91%	0	100%	0	100%	2,289,491	12%
May-83	1,486	52%	4,251	50%	53,021	12%	35,400	46%	29,025	43%	14,251	35%	0	100%	2,041,111	15%
May-97	60,708	3%	42,655	23%	21,919	63%	12,160	87%	0	100%	0	100%	0	100%	1,994,628	17%
May-94	6,045	23%	56,232	7%	44,799	21%	23,914	63%	6,466	91%	0	100%	0	100%	1,931,726	18%
May-93	14,582	20%	58,584	4%	40,755	27%	20,684	73%	2,837	98%	0	100%	0	100%	1,800,803	22%
May-91	15,622	19%	56,555	7%	43,734	22%	17,226	78%	4,302	96%	0	100%	0	100%	1,555,892	26%
May-86	1,543	49%	8,541	47%	35,998	39%	42,550	32%	33,259	39%	15,558	33%	0	100%	1,549,057	27%
May-92	2,760	32%	41,927	24%	42,120	24%	32,145	51%	14,646	64%	3,832	63%	0	100%	1,350,637	31%
May-00	1,489	52%	1,448	72%	14,543	68%	56,438	13%	49,897	20%	13,622	36%	0	100%	1,265,540	32%
May-85	1,262	62%	10,658	45%	50,875	15%	39,737	37%	21,802	54%	13,112	38%	0	100%	874,792	43%
May-01	3,395	27%	61,142	1%	35,280	42%	20,920	72%	10,228	80%	6,484	52%	0	100%	757,373	50%
May-02	1,512	51%	34,498	33%	59,433	5%	36,286	44%	5,692	94%	0	100%	0	100%	737,367	51%
May-99	1,242	63%	1,610	67%	19,619	65%	56,429	13%	46,355	24%	12,164	41%	0	100%	687,023	54%
May-84	941	78%	660	90%	1,645	85%	33,304	50%	64,839	11%	32,121	14%	3,924	17%	509,895	63%
May-87	1,249	62%	2,128	55%	61,650	3%	51,080	19%	21,334	54%	0	100%	0	100%	506,350	64%
May-05	1,081	70%	1,661	66%	13,447	69%	67,362	4%	43,824	28%	10,062	45%	0	100%	384,323	71%
May-88	905	80%	803	80%	3,382	74%	87,194	0%	45,172	27%	0	100%	0	100%	271,029	81%
May-03	1,016	73%	1,537	70%	20,596	64%	78,870	0%	35,425	36%	0	100%	0	100%	198,815	89%
May-98	976	76%	1,756	60%	34,379	45%	54,688	16%	28,901	43%	16,720	31%	0	100%	168,756	92%
May-96	652	98%	557	99%	1,178	98%	2,592	95%	10,824	77%	29,022	18%	0	100%	122,924	96%

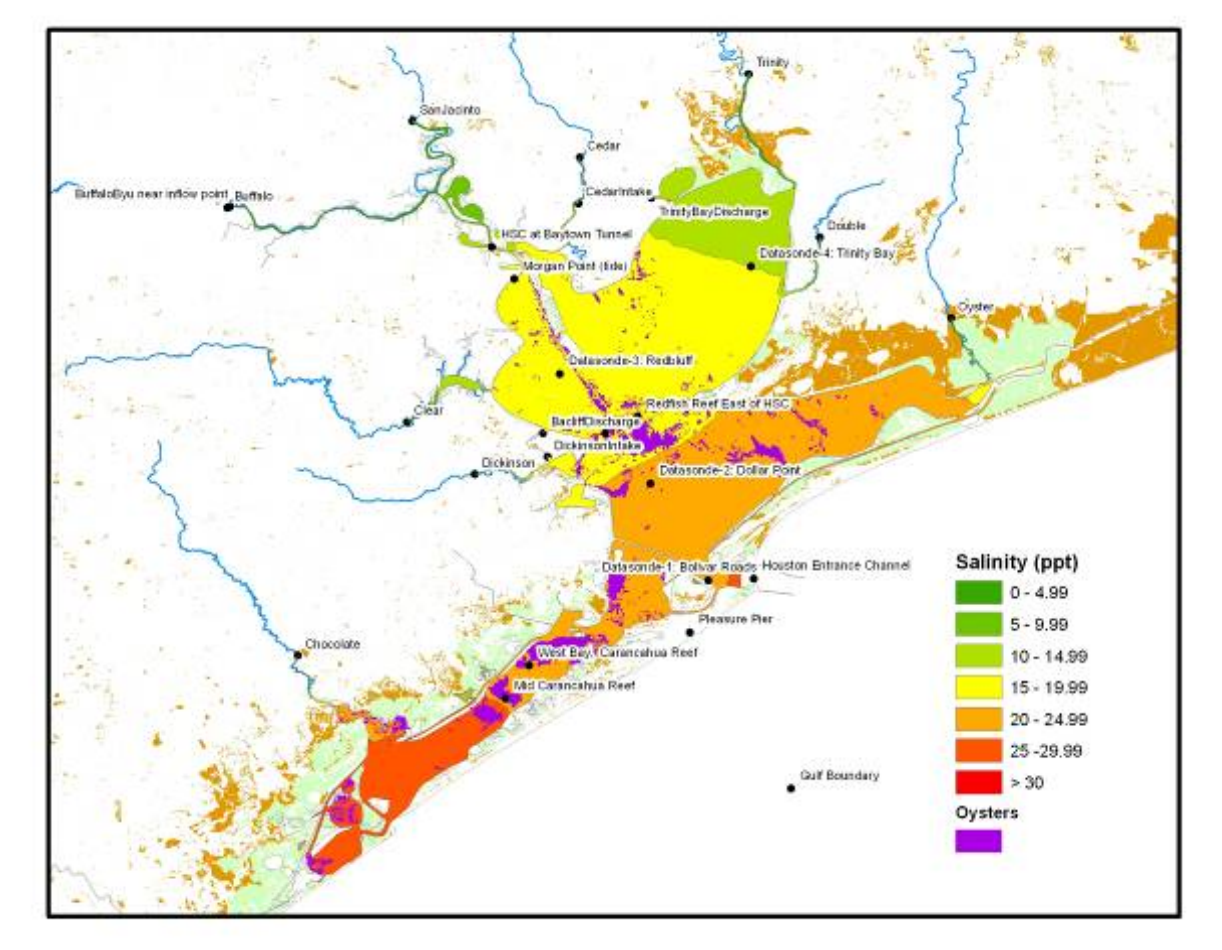
May 2003 (10th)



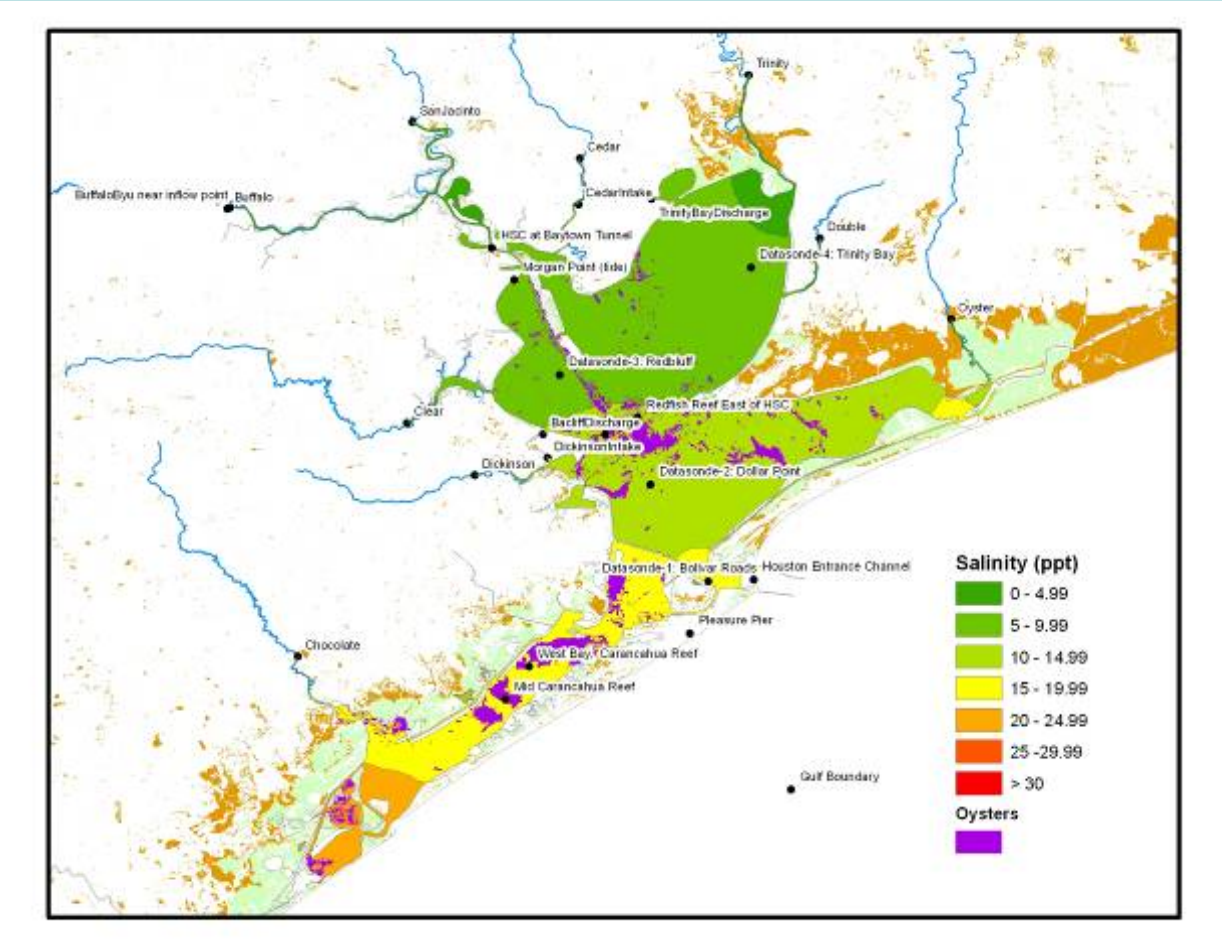
May 1984 (25th)



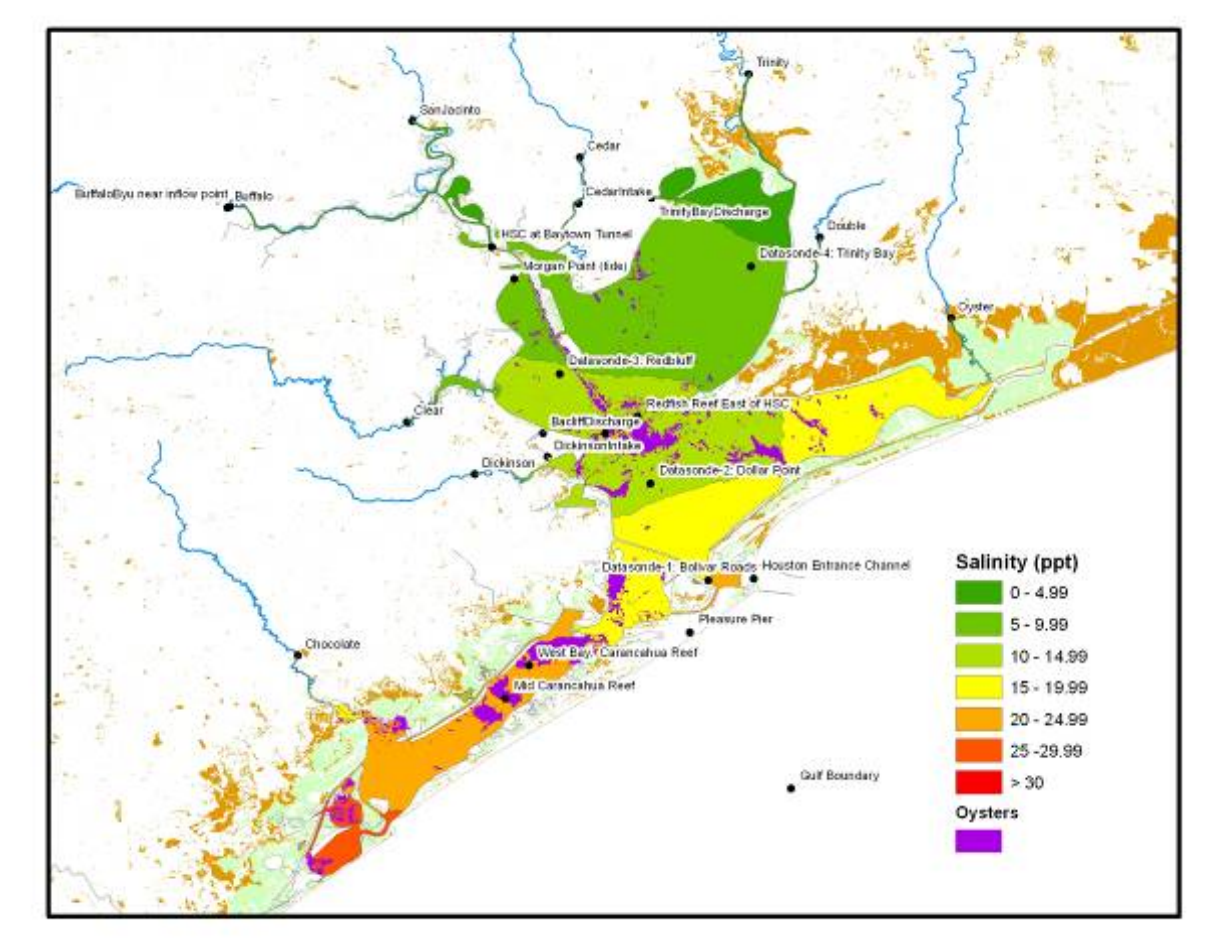
May 2000 (50th)



May 1994 (75th)



May 2004 (90th)



Difference between TxBLEND flow inputs & Reported TWDB Total Galveston Bay Inflows (ac-ft)

	January	February	March	April	May	June	July	August	September	October	November	December
1977	-52,254	-15,714	-45,218	54,704	-42,698	-36,740	-4,052	-7,351	-17,685	-2,929	-29,346	-21,933
1978	-40,057	646	-39,675	869	1,658	14,679	-1,115	-228	-11,686	-1,517	-24,303	-40,196
1979	41,468	55,707	-36,286	385,371	-16,486	57,491	-117,825	-54,824	61,667	-32,114	-39,199	-35,847
1980	-56,751	-4,512	-29,827	-39,622	-10,958	-25,927	-13,533	-2,884	-39,666	-21,209	-5,340	-9,290
1981	-8,557	-5,325	-13,840	-10,178	13,988	-25,233	-36,926	-18,793	-33,389	-60,060	-40,850	-44,170
1982	-53,165	-52,947	-42,768	25,051	123,692	-18,904	-4,530	-6,329	-402	-3,765	-10,852	-71,781
1983	-49,479	7,052	21,044	-31,751	309,287	-65,215	-58,184	44,826	-83,349	-45,585	-44,707	-16,126
1984	-45,405	-10,079	-41,404	-24,591	-18,376	-30,566	-26,315	-1,987	-6,885	20,961	-42,534	-37,498
1985	-26,651	19,942	13,154	-45,903	-27,589	-49,589	-39,992	-10,124	-29,219	-48,093	86,061	27,798
1986	-48,487	-1,670	-37,852	352	-12,273	108,943	-31,545	-1,840	-26,493	-76,162	-62,778	15,326
1987	-32,575	-25,609	-5,385	1,465	-34,184	92,181	-32,236	-388	-19,284	-9,660	14,209	-54,799
1988	-36,724	-45,618	-33,293	-36,024	-19,226	-3,548	-7,268	-6,536	-26,928	-961	-988	-1,741
1989	-12,655	-34,324	-11,885	-32,772	309,966	-28,533	-67,725	-40,085	-3,760	-17,420	-10,128	-1,935
1990	-20,534	-18,531	-42,622	-44,660	-69,239	-23,400	-14,344	-2,460	-10,946	-12,192	-8,717	-13,672
1991	-483,387	-469,488	-494,776	-460,884	-545,074	-509,888	-487,791	-337,052	-471,552	-234,606	-388,781	-500,303
1992	-528,175	-418,657	-429,196	-493,744	-497,698	-481,356	-469,545	-386,833	-87,325	-3,887	-224,762	-433,908
1993	-538,785	-441,655	-479,090	-481,279	-489,553	-440,066	-475,867	-304,406	-365,639	-42,182	-50,737	-64,278
1994	-49,365	17,083	-25,724	-61,042	-66,213	-62,247	-44,317	-65,313	-58,268	-11,684	-29,305	-33,296
1995	11,487	-54,313	-32,254	-14,540	-81,166	-72,864	-79,263	-115,927	-54,922	-47,056	-79,190	-58,224
1996	-84,043	-52,120	-22,481	-15,075	-25,931	-26,004	-42,832	-75,019	-81,650	-43,055	-10,767	-28,584
1997	-41,548	34,412	5,981	-21,093	-33,310	-40,931	-50,546	-21,422	-34,142	-55,083	-47,134	-31,616
1998	17,891	-25,370	35,529	-635	-17,827	-10,844	1,401	-23,466	-126,757	155,122	494,209	-42,145
1999	-52,215	-48,546	-46,209	-26,847	-58,377	-55,977	-37,414	1,609	-7,667	-4,700	146	-7,549
2000	-5,106	-533	-2,274	-50,124	-58,837	-32,818	426	3,221	-5,640	-2,318	-14,242	-35,683
2001	-14,007	-20,995	-41,684	-257,477	-57,391	127,447	-111,814	-82,801	-180,704	-24,635	-10,964	35,572
2002	-43,606	-30,683	-46,582	-19,228	-26,456	-30,895	-58,917	-80,900	-88,572	47,170	239,852	-24,639
2003	-11,850	58,043	-36,980	-51,850	-40,434	-55,020	-94,015	-71,512	-183,611	-46,103	34,680	-65,798
2004	-2,255	-225	-51,998	-46,188	-489	-50,770	-8,965	-39,348	-36,115	-21,145	34,541	-52,959
2005	-36,064	64,287	-56,527	-45,070	-51,031	-38,723	-38,736	-47,924	-55,016	-35,639	-48,899	-39,888

% Difference between TxBLEND flow inputs & TWDB Total Galveston Bay Inflows

	January	February	March	April	May	June	July	August	September	October	November	December
1977	-7.8%	-1.2%	-6.2%	2.2%	-5.2%	-6.5%	-2.1%	-3.4%	-5.0%	-2.5%	-5.1%	-4.9%
1978	-3.5%	0.1%	-9.0%	0.5%	1.0%	2.9%	-0.5%	-0.1%	-3.5%	-1.8%	-5.3%	-14.3%
1979	2.9%	3.8%	-2.2%	12.3%	-0.9%	2.8%	-4.9%	-8.5%	2.5%	-10.2%	-6.2%	-5.7%
1980	-3.9%	-0.4%	-3.1%	-5.1%	-0.6%	-8.1%	-5.5%	-2.1%	-6.8%	-5.0%	-3.9%	-5.6%
1981	-4.5%	-3.7%	-8.6%	-4.3%	1.5%	-0.7%	-2.8%	-5.4%	-3.2%	-4.7%	-2.3%	-4.9%
1982	-7.3%	-8.1%	-6.8%	2.6%	6.2%	-1.2%	-0.5%	-1.1%	-0.2%	-2.6%	-1.4%	-4.0%
1983	-6.1%	0.4%	1.4%	-8.3%	17.9%	-8.2%	-5.1%	2.3%	-4.6%	-20.3%	-12.8%	-2.4%
1984	-7.3%	-1.6%	-4.5%	-6.9%	-3.5%	-10.4%	-8.4%	-0.9%	-3.0%	1.2%	-4.7%	-3.9%
1985	-2.4%	1.4%	0.7%	-7.0%	-3.1%	-5.7%	-11.4%	-3.7%	-6.3%	-5.3%	4.9%	1.5%
1986	-15.6%	-0.1%	-10.2%	0.1%	-0.8%	3.7%	-5.2%	-0.8%	-4.3%	-7.8%	-3.6%	0.7%
1987	-3.3%	-2.8%	-0.3%	0.4%	-6.3%	3.6%	-2.9%	-0.3%	-5.9%	-7.9%	3.5%	-6.0%
1988	-6.3%	-11.0%	-4.1%	-7.7%	-6.6%	-1.7%	-2.8%	-2.4%	-7.5%	-0.9%	-1.1%	-1.7%
1989	-3.5%	-7.7%	-2.1%	-4.0%	12.2%	-0.8%	-2.8%	-4.3%	-1.8%	-5.5%	-5.2%	-1.9%
1990	-2.8%	-1.6%	-2.2%	-1.9%	-1.6%	-1.3%	-2.8%	-0.7%	-4.5%	-4.3%	-2.3%	-4.2%
1991	-14.0%	-21.5%	-40.1%	-15.4%	-25.9%	-30.3%	-50.2%	-48.8%	-39.5%	-51.7%	-17.6%	-14.6%
1992	-10.5%	-9.2%	-10.1%	-21.9%	-26.9%	-19.9%	-47.2%	-56.9%	-33.0%	-5.0%	-26.0%	-22.9%
1993	-20.5%	-28.3%	-14.3%	-20.4%	-21.4%	-14.1%	-43.4%	-61.6%	-76.2%	-5.8%	-4.7%	-8.4%
1994	-10.5%	1.6%	-1.5%	-10.1%	-3.3%	-5.8%	-10.4%	-10.9%	-15.1%	-0.3%	-2.3%	-1.3%
1995	0.5%	-6.9%	-1.4%	-0.7%	-3.4%	-5.0%	-10.4%	-11.9%	-25.3%	-13.2%	-17.1%	-5.8%
1996	-18.8%	-28.7%	-19.1%	-7.6%	-17.4%	-5.2%	-17.2%	-9.9%	-6.8%	-14.2%	-4.9%	-3.4%
1997	-4.4%	1.9%	0.2%	-0.7%	-1.6%	-2.8%	-11.0%	-8.9%	-5.5%	-5.9%	-9.4%	-2.3%
1998	0.4%	-1.4%	2.2%	-0.1%	-9.6%	-4.4%	0.8%	-6.8%	-7.8%	8.2%	16.1%	-2.0%
1999	-6.0%	-3.3%	-6.0%	-3.9%	-7.8%	-4.2%	-5.9%	2.0%	-3.9%	-4.6%	0.2%	-5.6%
2000	-3.5%	-0.4%	-1.0%	-7.8%	-4.4%	-3.7%	0.2%	2.6%	-3.4%	-1.5%	-0.7%	-3.6%
2001	-0.6%	-1.9%	-0.9%	-8.1%	-7.0%	3.4%	-12.8%	-10.3%	-7.0%	-1.8%	-2.4%	1.5%
2002	-5.0%	-3.3%	-7.4%	-0.9%	-3.5%	-8.3%	-6.7%	-7.7%	-7.9%	2.0%	11.0%	-1.1%
2003	-1.1%	3.2%	-2.4%	-12.3%	-16.9%	-7.4%	-11.7%	-13.2%	-9.3%	-5.0%	3.4%	-11.6%
2004	-0.2%	0.0%	-6.3%	-7.2%	0.0%	-2.0%	-0.6%	-5.8%	-10.1%	-5.6%	1.4%	-3.2%
2005	-2.9%	3.2%	-4.3%	-8.3%	-11.7%	-14.0%	-8.4%	-16.9%	-9.1%	-15.9%	-18.8%	-9.3%