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Review of Juvenile Sturgeon Setline Survey

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Introduction

Here we briefly summarize catch and effort information from a multi-year, long-concluded (2002) survey that was conducted to assess the year-class strength of white sturgeon (*Acipenser transmontanus*) in the San Francisco Estuary. The survey is one of very few sources of distribution and brood-year information on white sturgeon 2-8 years of age in California and provides some insight into green sturgeon status, trends, and research methodology. R. Schaffter provided several progress reports (Schaffter 1999a, 1999b, 2000) while the survey was underway but the results of surveys after 1999 have not been previously reported.

Materials and Methods

Baited setlines were used to target white sturgeon 40-116 centimeters total length (cm TL; Schaffter 1999a). Lines were set and collections were made by boat on 118 days from Carquinez Strait to the Sacramento-San Joaquin river confluence (Tables 1 and 2; Figure 1).

Up to 4 setlines baited with some combination of lamprey, squid, and shrimp were deployed by one boat each field day. Lines were set 343 times (Table 2). Typical lines were about 550 m (1,800-ft) long and fitted with about 80 gangions (Honey et al. 2004). Each gangion was fitted with one 2/0-, 4/0-, or 6/0-sized hook affixed by a 1-m (3-ft) leader (Honey et al. 2004). Lines were deployed and fished at 1-11 m depths, averaging about 4 m.

White sturgeon and green sturgeon were usually measured to the nearest cm TL, and sturgeon greater than approximately 125 cm TL were sometimes counted and released without being measured. Sturgeon were speciated and counted if lost at the boat before a measurement was made. By-catch was counted and in some cases measured (cm fork length). Condition and mortalities were not noted.

Sampling occurred primarily in June, July, and August (Table 3). Deployment dates were always recorded but deployment times, retrieval dates, and retrieval times were not recorded in 1991 and were sometimes not recorded thereafter. Count of hooks per set was recorded, but the number of hooks by size per line was not. Temperature (°C or °F), electrical conductivity (µmhos or mmhos), and water clarity (Secchi, cm) were recorded at most once for each set. GPS coordinates were recorded for most sets.

Table 1 Regions sampled by year; X = region sampled, blank = region not sampled.

Region	1991	1995	1996	1997	1998	1999	2000	2001	2002
Carquinez Strait	X	X			X	X	X	X	X
Grizzly Bay	X	X	X	X	X	X	X	X	X
Honker Bay	X	X	X	X	X	X	X	X	X
Napa River			X	X					
Sacramento River	X	X	X	X	X	X	X	X	X
San Joaquin River	X	X	X	X	X	X	X	X	X
San Pablo Bay	X	X	X	X	X	X	X		
Suisun Bay	X	X	X	X	X	X	X	X	X

Table 2 Number of lines set by region and year.

Region	Number of lines set									
	1991	1995	1996	1997	1998	1999	2000	2001	2002	Total lines set
Carquinez Strait	1	1			1	2	2	1	2	10
Grizzly Bay	1	2	5	4	4	6	6	2	4	34
Honker Bay	3	5	9	6	6	12	9	3	3	56
Napa River			2	1						3
Sacramento River	3	6	8	6	6	8	7	6	2	52
San Joaquin River	3	3	9	6	6	10	7	6	4	54
San Pablo Bay	2	3	8	3	6	6	3			31
Suisun Bay	5	8	18	11	10	18	15	6	12	103
Total	18	28	59	37	39	62	49	24	27	343

blanks = region not sampled

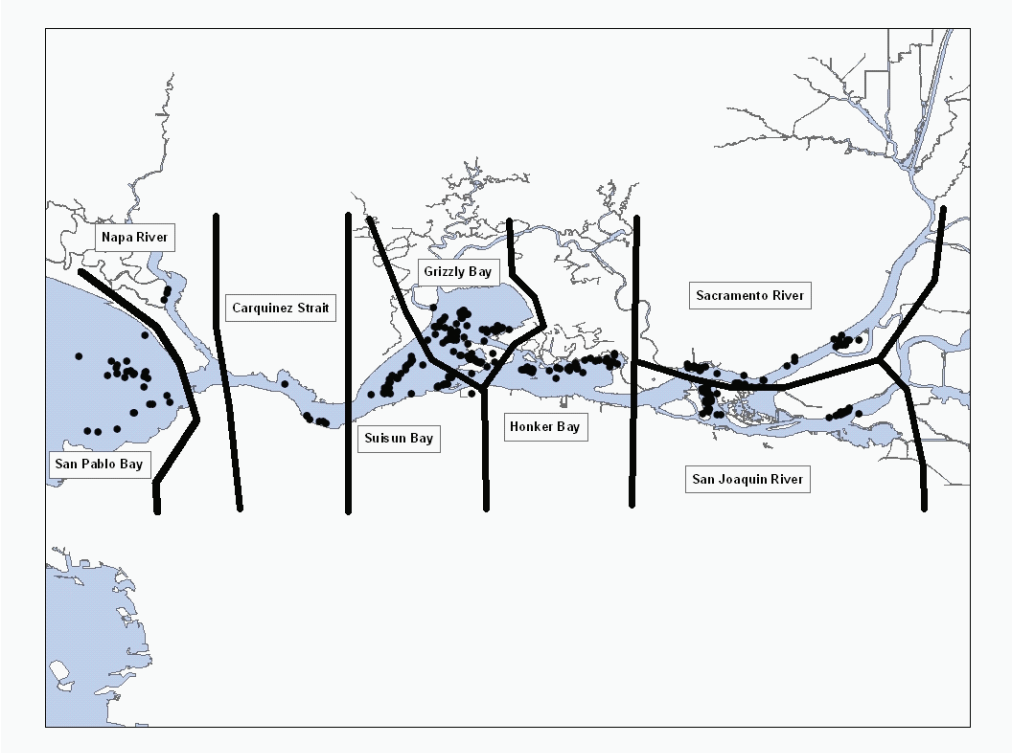

Figure 1 Region demarcations and sites where lines were set.

For collections when effort data were recorded, lines typically remained in the water for a day (N= 302, average = 22.54 h, range = 14.42-48.25 h). Annual hook-hours (Equation 1) by region were typically around 2,000 (Table 4). This data excludes 14 lines that were noted as being compromised by theft, vandalism, or bait loss.

$$\text{Hook - hours} = (\text{number of hooks on setline}) \times (\text{hours fished}) \quad (1)$$

Results

Lengths were recorded for 2,326 white sturgeon (average = 86 cm TL; Figure 2). The 2 green sturgeon collected were both 57 cm TL. Striped bass (N=196), white catfish (N=145), and leopard shark (N=82) were the most-common by-catch (Table 5).

Because catch per unit effort might be an index of juvenile white sturgeon abundance, we calculated catch per 100 hook-hours for each site ($CPUE_i$) using (1) all white sturgeon for which a measurement of ≤ 116 cm TL was recorded and (2) only sets where duration and number of hooks were recorded (i.e., sets for which hook-hours could be calculated; Equation 2). Average catch per 100 hook-hours ($\hat{R}_1$) (Equation 3; Table 6) differs by region and year, such that the differences might suggest trends in juvenile white sturgeon abundance.

$$CPUE_i = \left[\frac{c_i}{e_i}\right] \times 100 \quad (2)$$

where i = individual site
c = number of fish measured
e = hook-hours

$$\hat{R}_1 = \frac{\sum_{i=1}^{n} CPUE_i}{n} \quad (3)$$

where n = number of sites for which $CPUE_i$ was estimated

Table 3 Months sampled by sampling year; X = sampled, blank = not sampled.

Year	Months Sampled							
	March	June	July	August	September	October	November	December
1991		*X*	*X*					
1995				*X*			*X*	*X*
1996				*X*	*X*	*X*		
1997			*X*				*X*	
1998				*X*			*X*	
1999	*X*	*X*	*X*		*X*			
2000		*X*	*X*	*X*				
2001		*X*	*X*					
2002		*X*	*X*					

Table 4 Average, standard error (SE), minimum, and maximum hook-hours by region and sampling year; N = number of sites used for average and SE (all valid lines set included).

	Avg	SE	N	Min	Max	Avg	SE	N	Min	Max
Region	**1995**					**1996**				
Carquinez Strait	1592.5	NA	1	1592.5	1592.5	not sampled				
Grizzly Bay	1763.3	3.3	2	1760.0	1766.7	1708.0	49.5	*5*	1590.0	1885.0
Honker Bay	1737.2	144.7	4	1425.0	2125.0	1801.8	72.1	*8*	1458.9	2107.0
Napa River	not sampled					1662.7	30.7	*2*	1632.0	1693.3
Sacramento River	1582.3	110.3	6	1100.7	1800.0	1725.2	84.7	*8*	1241.3	1987.5
San Joaquin River	1785.9	126.6	3	1532.7	1912.5	1527.8	106.6	*7*	924.0	1753.3
San Pablo Bay	1872.5	88.3	3	1697.5	1980.0	1766.5	91.4	*8*	1440.0	2237.7
Suisun Bay	1716.7	80.0	6	1487.5	1953.3	1601.4	67.4	*17*	1282.5	2215.7
Region	**1997**					**1998**				
Carquinez Strait	not sampled					1760.0	NA	*1*	1760.0	1760.0
Grizzly Bay	1375.1	397.3	3	582.5	1820.0	1566.9	172.4	*3*	1222.7	1756.3
Honker Bay	1657.6	86.0	6	1317.8	1879.2	1595.0	106.9	*5*	1245.4	1806.7
Napa River	1706.7	NA	1	1706.7	1706.7	not sampled				
Sacramento River	1869.9	139.9	6	1503.5	2401.0	1604.5	116.5	*6*	1306.7	2002.0
San Joaquin River	1681.4	97.2	5	1392.4	1920.0	1552.0	72.5	*6*	1230.0	1726.7
San Pablo Bay	1595.6	96.6	3	1420.0	1753.3	1869.8	71.2	*5*	1715.3	2096.7
Suisun Bay	1730.7	48.4	11	1481.7	1969.5	1721.5	110.8	*9*	1153.3	2217.1
Region	**1999**					**2000**				
Carquinez Strait	1692.0	250.2	2	1441.8	1942.2	1665.1	73.9	*2*	1591.3	1739.0
Grizzly Bay	1595.6	69.9	6	1290.0	1810.4	1813.6	175.5	*5*	1256.7	2340.0
Honker Bay	1763.6	22.2	12	1625.0	1886.7	1473.1	104.1	9	1037.0	1950.0
Napa River	not sampled					not sampled				
Sacramento River	2076.2	222.5	8	1668.8	3620.5	1469.6	128.2	7	931.7	1786.7
San Joaquin River	2101.9	174.1	10	1687.6	3240.0	1519.5	164.6	7	866.3	2239.8
San Pablo Bay	1577.7	53.2	6	1412.6	1786.0	1590.3	291.7	3	1120.8	2125.0
Suisun Bay	1699.8	60.2	17	1310.0	2269.3	1703.0	88.0	14	1032.0	2259.8
Region	**2001**					**2002**				
Carquinez Strait	1821.3	NA	1	1821.3	1821.3	1414.5	NA	1	1414.5	1414.5
Grizzly Bay	1713.3	14.8	2	1698.5	1728.0	1729.9	125.1	4	1377.0	1911.0
Honker Bay	1732.0	179.6	3	1528.1	2090.0	1547.1	NA	1	1547.1	1547.1
Napa River	not sampled					not sampled				
Sacramento River	1547.3	38.0	5	1414.4	1630.3	2908.5	951.5	2	1957.0	3860.0
San Joaquin River	1717.1	49.9	5	1560.0	1869.0	2848.3	504.2	4	1906.5	3746.7
San Pablo Bay	not sampled					not sampled				
Suisun Bay	1572.7	41.5	6	1446.3	1740.9	1808.7	39.7	10	1619.5	2000.0

Table 5 By-catch count during setline sampling(By-catch was not recorded in 1991)

Year	Region	Brown Smoothhound	Channel Catfish	Leopard Shark	Sacramento Pikeminnow	Spiny Dogfish	Staghorn Sculpin	Striped Bass	Sevengill Shark	White Croaker	White Catfish	Other Species[a]
1995	Carquinez Strait						1	2				
1995	Grizzly Bay							7				
1995	Honker Bay				2		1	5				
1995	Sacramento River				2		2	9			4	1
1995	San Joaquin River		1					5			11	1
1995	San Pablo Bay			12		1	4	1	1	1		2
1995	Suisun Bay						3	27				
	Yearly Totals	0	1	12	4	1	11	56	1	1	15	4
1996	Grizzly Bay							9				
1996	Honker Bay				8			14			4	
1996	Napa River						1			1		
1996	Sacramento River				2			6			17	
1996	San Joaquin River		2		4			10			8	
1996	San Pablo Bay	15		53		3	2		11	8	1	
1996	Suisun Bay						6	20				2
	Yearly Totals	15	2	53	14	3	9	59	11	9	30	2
1997	Honker Bay				1			7			7	
1997	Sacramento River		3		6			9			12	
1997	San Joaquin River				2			4			9	
1997	San Pablo Bay	12		3				2		3		1
1997	Suisun Bay						1	8				
	Yearly Totals	12	3	3	9	0	1	30	0	3	28	1
1998	Grizzly Bay							1				
1998	Honker Bay				1			3			4	
1998	Sacramento River		5		2			1			2	
1998	San Joaquin River		5								1	
1998	San Pablo Bay			11		4		3		5		2
1998	Suisun Bay							2				
	Yearly Totals	0	10	11	3	4	0	10	0	5	7	2
1999	Carquinez Strait							1				
1999	Grizzly Bay							1				
1999	Honker Bay				2			5			5	
1999	Sacramento River				1			2			8	
1999	San Joaquin River				3						7	2
1999	San Pablo Bay	2		1		1		1				2
1999	Suisun Bay							6			1	1
	Yearly Totals	2	0	1	6	1	0	16	0	0	21	5
2000	Grizzly Bay				1			3				
2000	Honker Bay				3			7			5	
2000	Sacramento River				7			2			9	
2000	San Joaquin River				1			6			11	
2000	San Pablo Bay	8		2		12						5
2000	Suisun Bay							3			1	1
	Yearly Totals	8	0	2	12	12	0	21	0	0	26	6
2001	Grizzly Bay							1				
2001	Honker Bay							1			6	
2001	Sacramento River				1						9	
2001	San Joaquin River							1			2	
	Yearly Totals	0	0	0	1	0	0	3	0	0	17	0
2002	Sacramento River		1									
2002	Suisun Bay							1			1	
	Yearly Totals	0	1	0	0	0	0	1	0	0	1	0
	Survey Totals	37	17	82	49	21	21	196	12	18	145	20

[a]Other species included bat ray (2), cottid unid (4), croaker unid (3), green sturgeon (2), Sacramento blackfish (1), Sacramento splittail (3), starry flounder (3), and thresher shark unid (2)

Table 6 White sturgeon ≤ 116 cm TL average catch per 100 hook-hours with standard error (SE) and sample size (number of sets used in average, N) by region and sampling year.

Year	Carquinez Strait			Grizzly Bay			Honker Bay			Napa River		
	Avg Catch/ 100 hook-hours	SE	N	Avg Catch/ 100 hook-hours	SE	N	Avg Catch/ 100 hook-hours	SE	N	Avg Catch/ 100 hook-hours	SE	N
1995	0.06	NA	1	1.05	0.37	2	0.37	0.09	4	not sampled		
1996	not sampled			0.41	0.14	5	0.39	0.05	8	0.12	0.00	2
1997	not sampled			0.24	0.13	3	0.50	0.14	6	0.23	NA	1
1998	0.00	NA	1	0.13	0.07	3	0.24	0.13	5	not sampled		
1999	0.21	0.21	2	0.42	0.15	6	0.23	0.06	12	not sampled		
2000	0.06	0.06	2	0.62	0.30	5	0.60	0.18	9	not sampled		
2001	0.11	NA	1	0.21	0.09	2	0.64	0.30	3	not sampled		
2002	0.14	NA	1	0.77	0.09	4	0.58	NA	1	not sampled		

Year	Sacramento River			San Joaquin River			San Pablo Bay			Suisun Bay		
	Avg Catch/ 100 hook-hours	SE	N	Avg Catch/ 100 hook-hours	SE	N	Avg Catch/ 100 hook-hours	SE	N	Avg Catch/ 100 hook-hours	SE	N
1995	0.34	0.09	5	0.48	0.17	3	0.51	0.31	3	0.67	0.11	6
1996	0.13	0.03	8	0.23	0.11	6	0.25	0.07	8	0.41	0.06	17
1997	0.39	0.08	6	0.35	0.12	4	0.10	0.06	3	0.32	0.05	11
1998	0.08	0.04	6	0.05	0.02	5	0.26	0.10	5	0.45	0.13	9
1999	0.10	0.03	7	0.13	0.04	10	0.02	0.01	6	0.45	0.07	17
2000	0.23	0.05	7	0.13	0.07	7	0.07	0.04	3	0.55	0.09	14
2001	0.48	0.25	5	0.21	0.12	5	not sampled			0.32	0.11	6
2002	0.53	0.19	2	0.44	0.09	4	not sampled			0.85	0.12	10

Table 7 Age-length key for white sturgeon; number of fish in each length bin (from length frequency) assigned an age based on proportions in key (data for key in Kohlhorst et. al. 1980).

Length bin (cm TL)	*Age-0*	*Age-1*	*Age-2*	*Age-3*	*Age-4*	*Age-5*	*Age-6*	*Age-7*	*Age-8*	*Age-9*	*Age-10*	*Age-11*	*Age-12*	*Age-13*	*Age-14*	*Age-15*	*Age-16*	*Age-17*	*Age-18*	*Age-19*	*Age-20*	*Age-21*	*≥Age-22*
21-25	1.0000																						
26-30	1.0000																						
31-35	1.0000																						
36-40	0.7000	0.2000	0.1000																				
41-45		0.6667	0.3333																				
46-50		0.3542	0.5625	0.0833																			
51-55		0.1148	0.8033	0.0656	0.0164																		
56-60			0.6863	0.2157	0.0588	0.0196	0.0196																
61-65			0.2308	0.3846	0.2308	0.0769	0.0513	0.0256															
66-70			0.0625	0.2813	0.3125	0.2813	0.0313	0.0313															
71-75				0.0175	0.3333	0.4211	0.2105	0.0175															
76-80					0.1136	0.2273	0.4091	0.2500															
81-85					0.0313	0.1719	0.3125	0.2969	0.1094	0.0625	0.0156												
86-90						0.0317	0.1746	0.3968	0.2381	0.1270	0.0317												
91-95							0.0526	0.2500	0.3158	0.2763	0.0789	0.0263											
96-100							0.0541	0.2568	0.3108	0.2838	0.0811	0.0135											
101-105							0.0526	0.2281	0.1842	0.3070	0.1579	0.0702											
106-110							0.0286	0.0571	0.2143	0.3000	0.2429	0.1000	0.0286	0.0286									
111-115									0.1186	0.3051	0.4237	0.1017	0.0169	0.0339									
116-120									0.1136	0.1818	0.1818	0.1591	0.1591	0.0455	0.0909	0.0455	0.0227						
121-125										0.0833	0.1111	0.1944	0.1389	0.1389	0.1389	0.1667	0.0278						
126-130										0.0541	0.0811	0.2162	0.1351	0.0541	0.1622	0.0541	0.0811	0.0811	0.0270	0.0270	0.0270		
131-135											0.0882	0.1176	0.1471	0.1176	0.0294	0.1176	0.1471	0.1176	0.0294	0.0000	0.0882		
136-140													0.1154	0.0000	0.2308	0.1538	0.2308	0.1538	0.0385	0.0769	0.0000		
141-145													0.0286	0.0571	0.1429	0.1429	0.2286	0.1714	0.1143	0.0000	0.0857	0.0286	
146-150													0.0270	0.1081	0.1622	0.1622	0.1351	0.0541	0.1892	0.1622	0.0000	0.0000	
151-155														0.0435	0.1304	0.0870	0.0870	0.1304	0.3478	0.0000	0.0870	0.0870	
156-160															0.0769	0.0769	0.1538	0.0769	0.1538	0.0769	0.3077	0.0000	0.0769
161-165																	0.2500	0.1667	0.1667	0.0833	0.1667	0.1667	
166-170																	0.1250	0.0000	0.1250	0.5000	0.2500	0.0000	
171-175																	0.1250	0.2500	0.2500	0.3750	0.0000	0.0000	
176-180																			0.1667	0.1667	0.3333	0.1667	0.1667
181-185																			0.3333		0.3333		0.3333
>185																					0.7500		0.2500

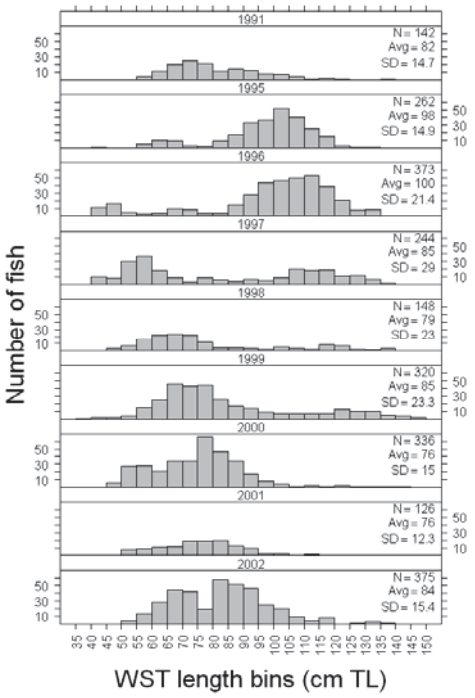

Figure 2 Annual length frequency distribution of white sturgeon.

Discussion

Due largely to errors in estimated effort, any time-trends in white sturgeon abundance (e.g., abundance by brood year) that might be suggested by setline catch per unit effort are not likely to be reliable. Much of the error in effort was thought to be attributable to removal of bait by Chinese mitten crabs, *Eriocheir sinensis*, (Schaffter 1999a; Hieb 2009; K. Hieb pers. comm.), but non-sturgeon by catch and bait preference are likely also confounding.

The length frequency distributions of white sturgeon showed within-year structure and changes over time that demonstrate varying recruitment and growth. When using an age-length key (Table 7) to assign brood years, trends in annual year-class strength are evident (Figure 3). The trends are generally consistent with the year-class strength index reported by Fish (2010), but differences warrant further investigation because they may speak to white sturgeon ecology, the merits of various indices of white sturgeon abundance, and limits on white sturgeon age-length key utility.

Since their implementation by the California Fish and Game Commission in 2007, Sturgeon Fishing Report Cards have also provided white sturgeon length frequency distributions that show within-year structure (e.g., DuBois et al. 2010) and changes over time that demonstrate varying recruitment and growth. We have begun to explore the degree to which these trends are consistent with the year-class strength index reported by Fish (2010), because — should they be generally consistent — Sturgeon Fishing Report Card data may be a very low cost ongoing alternative or complement to any new setline survey.

Green sturgeon were not particularly susceptible to the setlines or were not abundant (or both). Catch of green sturgeon in trammel nets from 1990-2002 does not alone help distinguish between the two possibilities, because the setlines were selected for relatively small fish and the trammel nets were not (Schaffter and Kohlhorst 1999). However, trammel-net catch of small green sturgeon in 2009 was relatively high (DuBois and Mayfield 2009) while angler catch of small green sturgeon has been consistently low for several years (DuBois et al. 2010; DuBois et al. 2009; Gleason et al. 2008), it is at least plausible and is probably likely that green sturgeon catch by setline was low largely because they were not particularly susceptible to baited hooks.

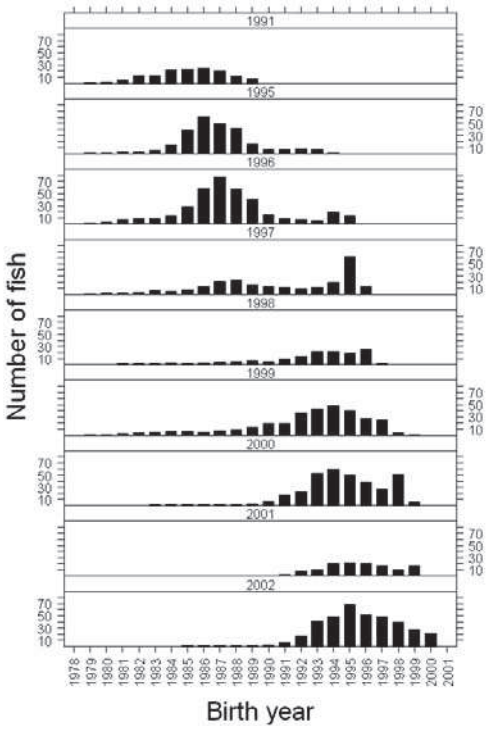

Figure 3 Annual birth-year (BY) frequency distribution of white sturgeon (BY cutoff at 1978 for simplicity - sampling-year 1991: 1 fish BY=1977; 1996: 1 fish BY=1976; 1997: 1 fish BY=1977).

References

DuBois J, Mayfield R (California Department of Fish and Game). 2009. 2009 field season summary for adult sturgeon population study. Stockton, California.

DuBois J, Matt T, Beckett B (California Department of Fish and Game). 2010. 2009 sturgeon fishing report card: preliminary data report. Stockton, California.

DuBois J, Gingras M, Mayfield R (California Department of Fish and Game). 2009. 2008 sturgeon fishing report card: preliminary data report. Stockton, California.

Fish MA. 2010. A white sturgeon year-class index for the San Francisco Estuary and its relation to delta outflow. Interagency Ecological Program for the San Francisco Estuary Newsletter 23(2).

Gleason E, Gingras M, DuBois J (California Department of Fish and Game). 2008. 2007 sturgeon fishing report card: preliminary data report. Stockton, California.

Hieb K. 2009. 2008 Status and Trends Report Common Crabs of the San Francisco Estuary. Interagency Ecological Program for the San Francisco Estuary Newsletter 22(3):14-15.

Honey K, Baxter R, Hymanson Z, Sommer T, Gingras M, Cadrett P. 2004. IEP Long- Term Fish Monitoring Program Element Review. Interagency Ecological Program for the San Francisco Bay/Delta Estuary:12.

Kohlhorst DW, Miller LW, Orsi JJ. 1980. Age and growth of white sturgeon collected in the Sacramento-San Joaquin Estuary, California: 1965-1970 and 1973-1976. California Fish and Game 66(2):83-95.

Malvestuto SP. 1996. Sampling the Recreational Creel. *in* Fisheries Techniques, Murphy BR, Willis DW, editors. 2nd ed. Bethesda, Maryland:American Fisheries Society. 732 p.

Schaffter R. 2000. Juvenile White Sturgeon. Interagency Ecological Program for the San Francisco Estuary Newsletter 13(2):30-31.

Schaffter RG, Kohlhorst DW. 1999. Status of white sturgeon in the Sacramento-San Joaquin Estuary. California Fish and Game 85:37-41.

Schaffter R. 1999a. Juvenile White Sturgeon. Interagency Ecological Program for the San Francisco Estuary Newsletter 12(1):2-3.

Schaffter R. 1999b. Juvenile White Sturgeon. Interagency Ecological Program for the San Francisco Estuary Newsletter 12(3):10.

Notes

Kathryn Hieb (California Department of Fish and Game), e-mail, 25-Aug-2010

Production Schedule: IEP Newsletter

Calendar Year 2011

The IEP Newsletter is produced quarterly. The sequence of the four issues in a volume (one year) is winter, spring, summer, fall. Below are the appropriate article deadlines for each issue.

Posted on the IEP website is the IEP Newsletter Guide to Authors. In it you will find instructions for submitting an article. Please follow the instructions; if you have any questions you may contact Patricia Cornelius at pcorn@water.ca.gov or 916-651-9606.

Winter Issue

Article Deadline: Friday January 28, 2011

Spring Issue

Article Deadline: Friday April 29, 2011

Summer Issue

Article Deadline: Friday July 29, 2011

Fall Issue

Article Deadline: Friday October 28, 2011

■ Interagency Ecological Program for the San Francisco Estuary ■

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For information about the Interagency Ecological Program, log on to our website at http://www.iep.water.ca.gov. Readers are encouraged to submit brief articles or ideas for articles. Correspondence—including submissions for publication, requests for copies, and mailing list changes—should be addressed to Patricia Cornelius, California Department of Water Resources, P.O. Box 942836, Sacramento, CA, 94236-0001. Questions and submissions can also be sent by e-mail to:pcorn@water.ca.gov.

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IEP NEWSLETTER

The Interagency Ecological Program for the San Francisco Estuary
is a cooperative effort of the following agencies:

California Department of Water Resources
State Water Resources Control Board
U.S. Bureau of Reclamation
U.S. Army Corps of Engineers
California Department of Fish and Game
U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Environmental Protection Agency
National Marine Fisheries Service