Regional Trends in Fish Assemblage Stability and Diversity Based on Fall Seine and Trawl Sampling, 1995-2005 September – December.

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Background

As part of the Interagency Ecological Program, the Delta Juvenile Fish Monitoring Program at the Stockton Fish and Wildlife Office has used beach seines, Kodiak (KDTR) and mid-water (MWTR) trawls to monitor the relative abundance and distribution of juvenile Chinook salmon (*Oncorhynchus tshawytscha)* and other juvenile fish species in the Sacramento-San Joaquin River Delta and Bays. This article reports total fish catch for the sampling period during September 1 and December 31, 2005. In addition, as a follow up to Wichman and Hanni (2005) and Hanni (2005), this article examines fish assemblage stability and diversity during September-December across an eleven-year period (1995-2005).

Methods

All sampling locations previously have been described in Wichman and Hanni (2005). STFWO divides the Sacramento-San Joaquin River Delta and Bays into six different regions (Figure 1): (1) Lower Sacramento River, (2) North Delta, (3) Central Delta, (4) South Delta, (5) San Joaquin River, and (6) San Francisco and San Pablo Bays. Trawling locations are located at Sherwood Harbor on the Sacramento River (Region 2), Chipps Island in Suisun Bay (Region 3), and Mossdale on the San Joaquin River (Region 5). Juvenile fish were collected during September-December of each year over the eleven year period with few exceptions. Beach seine sampling in Regions 5 and 6 was not conducted throughout the year until 1999 and 1998, respectively. Trawl volume was not recorded at all trawl locations until 1997. Included in this report are trawls where only volume was recorded. Mossdale KDTRs were not conducted during September-December until 1998. In 2000, no trawls were conducted at Mossdale. In addition, MWTRs at Sherwood Harbor were only conducted during the first month of the reporting period (September) and KDTRs were conducted for the remaining three months (October-December). Unmarked salmon (those without a clipped adipose fin) were assigned a race according to Fisher (1992). All salmon catch data were converted to CPUE to compare among samples, where effort is the volume of water sampled.

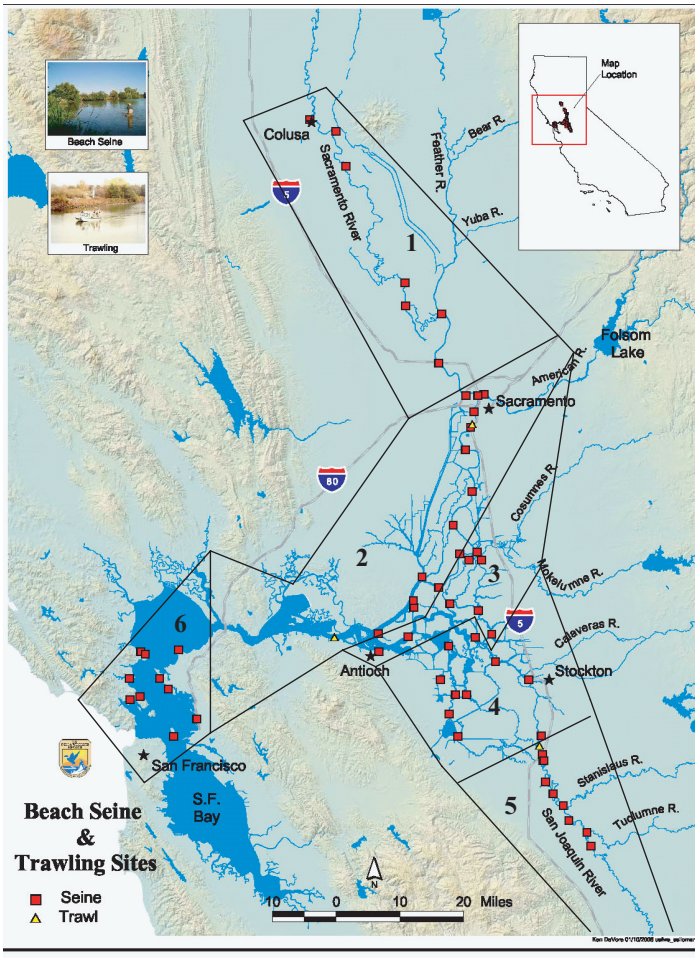

Figure 1 2005 Stockton Fish and Wildlife Sampling Regions and Locations

Kendall's coefficient of concordance with tied ranks, W_c (Zar 1984 was used to investigate fish assemblage stability through time at each trawl location and beach seine region. To calculate W_c, species were ranked by CPUE within a region for each year. Ties were handled by giving each tied species the average rank. Next, W_c was calculated (Wichman & Hanni 2005). Values of this coefficient range between 0 (no consistency in species ranks among years) and 1 (complete consistency in species ranks among years).

Simpson's Indices of Diversity were calculated for each year to determine diversity trends for each trawl location and beach seine region through time (Krebs 1989). These indices account for richness and evenness of fish species within the assemblage and denotes the probability that randomly sampled individuals will belong to different species. Variance calculations for Simpson's Index of Diversity were computed from Grundmann et al. (2001). To determine whether there were linear changes in diversity through time, separate regression analyses on diversity through time for each beach seine region or trawl location were performed. For further descriptions on these techniques, see Wichman and Hanni (2005) and Hanni (2005).

Results

Beach Seines

Chinook Salmon September 1 – December 31, 2005

We captured 2,003 unmarked Chinook salmon in beach seines during the four month reporting period. The majority of salmon captured were fall-run size (n = 1,179) from Regions 1, 2, and 3 (Table 1). Only two fall-run were captured in Region 5 and no salmon were captured in Regions 4 and 6. All eight of the marked salmon during the sampling period were recovered in Regions 1, 2, and 3. Only one adult salmon was captured in Region 1. Based on size criteria, a total of 10 late-fall, 328 spring-run, and 485 winter-run salmon were captured in Regions 1,2 and 3 combined.

Trawls

Chinook Salmon September 1 – December 31, 2005

A total of 204 unmarked Chinook salmon were captured in trawls during the reporting period (Table 2). The majority were winter- (n = 68) and fall-run size (n = 67) at Sherwood Harbor KDTR. We caught 117 marked Chinook salmon in trawls, 97% of which were captured at Chipps Island MWTR in December (n = 113). The marked salmon originated from various releases made by the Coleman National Fish Hatchery in December 2005.

Table 1 Regional catch and CPUE of unmarked and marked Chinook salmon captured from beach seining activities conducted from September 1 - December 31, 2005. All unmarked fish were classified into races based on size.

Region # and Name	*Total volume (m^3)*	*Adult*	*CPUE*	*Fall*	*CPUE*	*Late Fall*	*CPUE*	*Spring*	*CPUE*	*Winter*	*CPUE*	*Marked*	*CPUE*
1. Lower Sacramento R.	6405.5	1	0.00016	481	0.07509	7	0.00109	183	0.02857	246	0.03840	1	0.00016
2. North Delta	13092.40005	0	0	545	0.04163	2	0.00015	141	0.01077	226	0.01726	6	0.00046
3. Central Delta	7111.9	0	0	151	0.02123	1	0.00014	4	0.00056	13	0.00183	1	0.00014
4. South Delta	7886.1	0	0	0	0	0	0	0	0	0	0	0	0
5. San Joaquin R.	1781.2	0	0	2	0.00112	0	0	0	0	0	0	0	0
6. San Francisco & San Pablo Bays	5679	0	0	0	0	0	0	0	0	0	0	0	0
Total		1		1,179		10		328		485		8	

Table 2 Catch and CPUE of unmarked and marked Chinook salmon captured at each trawling location from September 1 through December 31, 2005. Unmarked fish were classified into races based on size.

Location	*Volume (m3)*	*Adult*	*CPUE*	*Fall*	*CPUE*	*Late Fall*	*CPUE*	*Spring*	*CPUE*	*Winter*	*CPUE*	*Marked*	*CPUE*
Chipps Island mid-water trawl	13318808	8	6.007 x 10-7	2	1.502 x 10-7	25	1.877 x 10-6	0	0	4	3.003 x 10-7	113	8.484 x 10-6
Mossdale Kodiak trawl	3495136.919	0	0	1	2.861 x 10-7	0	0	0	0	0	0	1	2.861 x 10-7
Sherwood Harbor mid-water trawl	646057.9357	0	0	0	0	0	0	0	0	0	0	0	0
Sherwood Harbor Kodiak trawl	3052792.638	1	3.276 x 10-7	67	204537106.7	1	4.889 x 10-9	27	5522501881	68	1.231 x 10-8	3	243639788.9
Totals		9		70		26		27		72		117	

Fish Assemblage Summary - Beach Seine Samples

We conducted 959 beach seine samples (volume = 41,956 m^3) for the reporting period, yielding 76,823 fish from 45 species (Table 3). The most abundant fish species captured in beach seine samples were inland silverside (*Menidia beryllina*, n = 51,394) and red shiner (*Cyprinella lutrensis*, n = 8,946), both non-natives. Species of concern captured from beach seine sampling included winter-run size Chinook salmon (n = 485), Sacramento splittail (*Pogonichthys macrolepidotus*, n = 8), and delta smelt (*Hypomesus transpacificus*, n = 1). The dominant fish fauna (defined as all species comprising 75% or more of the relative abundance) in each beach seine region or trawl location was comprised of one to four species (Table 3).

Regions 1 and 5 exhibited the strongest fish assemblage stability through time (W_c = 0.80 and 0.79 respectively). Moderate assemblage stability was observed for Regions 2, 3, and 4 (W_c = 0.75, 0.68, and 0.70, respectively), while the lowest assemblage stability was observed in Region 6 (W_c = 0.62).

Statistically significant linear declines in fish diversity from 1995-2005 were observed in Regions 2 (r^2 = 0.53, p = 0.012) and 3 (r^2 = 0.52, p = 0.012, Figure 2). Region 6 had a marginal decline in diversity (r^2 = 0.41, p = 0.085). A non-significant increase in diversity was observed in Region 4 (r^2 = 0.22, p = 0.145). Diversity did not change through time in Regions 1 and 5.

Fish Assemblage Summary - Trawl Samples

During the four-month reporting period (September-December) in 2005, we conducted 1,617 trawls (est. vol. 20,512,795 m^3) yielding 54,025 fish from 34 different species. Chipps Island MWTR yielded 52,282 fish from 23 species. Mossdale KDTR captured 1,254 individuals from 21 species. Sherwood Harbor MWTR yielded 75 individuals from eight species, while KDTR captured 415 individuals from 20 species. American shad was the most dominant species captured (n = 48,104), 89% of which were caught at Chipps Island. Species of concern included delta smelt (n = 83) and Sacramento splittail (n = 66), both of which were captured exclusively at Chipps Island. There were also 72 winter-run size salmon captured by trawling; 68 were caught in the Sherwood Harbor KDTR and four in the Chipps Island MWTR. The dominant fish fauna (species comprising 75% or more of the relative abundance) was comprised of one to six species within a region (Table 3).

Mossdale and Chipps Island trawls exhibited the strongest assemblage stability (W_c = 0.74 and 0.73, respectively). Sherwood Harbor KDTR had moderate assemblage stability (W_c=0.57), while Sherwood Harbor MWTR showed the lowest stability with in the fish assemblage (W_c=0.28).

Diversity declined through time at Chipps Island (R^2 = 0.67, p = 0.007), but did not change at any other trawl locations (Figure 2).

Table 3 Species that comprise greater than 75% of the fishes captured within each beach seine region and trawl sample area from September 1 - December 31, 2005.

	Species	*(n)*	*% of total fish captured*	*Total # Fish Captured*	*Total # Species*
Beach Seine Region					
1. Lower Sacramento River (n = 7 sites)	Inland Silverside	5,616	55%		
	Golden Shiner	1,347	13%		
	Chinook Salmon (fall)	481	5%		
	Fathead Minnow	447	4%		
	TOTAL	7,891	78%	10,176	33
2. North Delta (n = 10 sites)	Inland Silverside	18,113	89%		
	TOTAL	18,113	89%	20,459	32
3. Central Delta (n = 9 sites)	Inland Silverside	8,185	83%		
	TOTAL	8,185	83%	9,831	28
4. South Delta (n = 8 sites)	Inland Silverside	15,033	69%		
	Threadfin Shad	3,614	17%		
	TOTAL	18,647	85%	21,813	18
5. San Joaquin River (n = 10 sites)	Red Shiner	6,164	54%		
	Inland Silverside	4,435	39%		
	TOTAL	10,599	94%	11,321	17
6. San Francisco and San Pablo Bays (n = 9 sites)	Topsmelt	3,154	98%		
	TOTAL	3,154	98%	3,223	12
Trawl Location					
Chipps Island	American Shad	4,800	53%		
	Threadfin Shad	2,433	27%		
	TOTAL	7,233	80%	9,082	23
Mossdale	Threadfin Shad	676	54%		
	Inland Silverside	287	23%		
	TOTAL	963	77%	1,254	21
Sherwood Harbor (mid-water)	American Shad	66	88%		
	TOTAL	66	88%	75	8
Sherwood Harbor (kodiak)	Chinook Salmon (winter)	68	16%		
	Chinook Salmon (fall)	67	16%		
	Theadfin Shad	67	16%		
	Inland Silverside	66	16%		
	American Shad	30	7%		
	Chinook Salmon (spring)	27	7%		
	TOTAL	325	78%	415	20

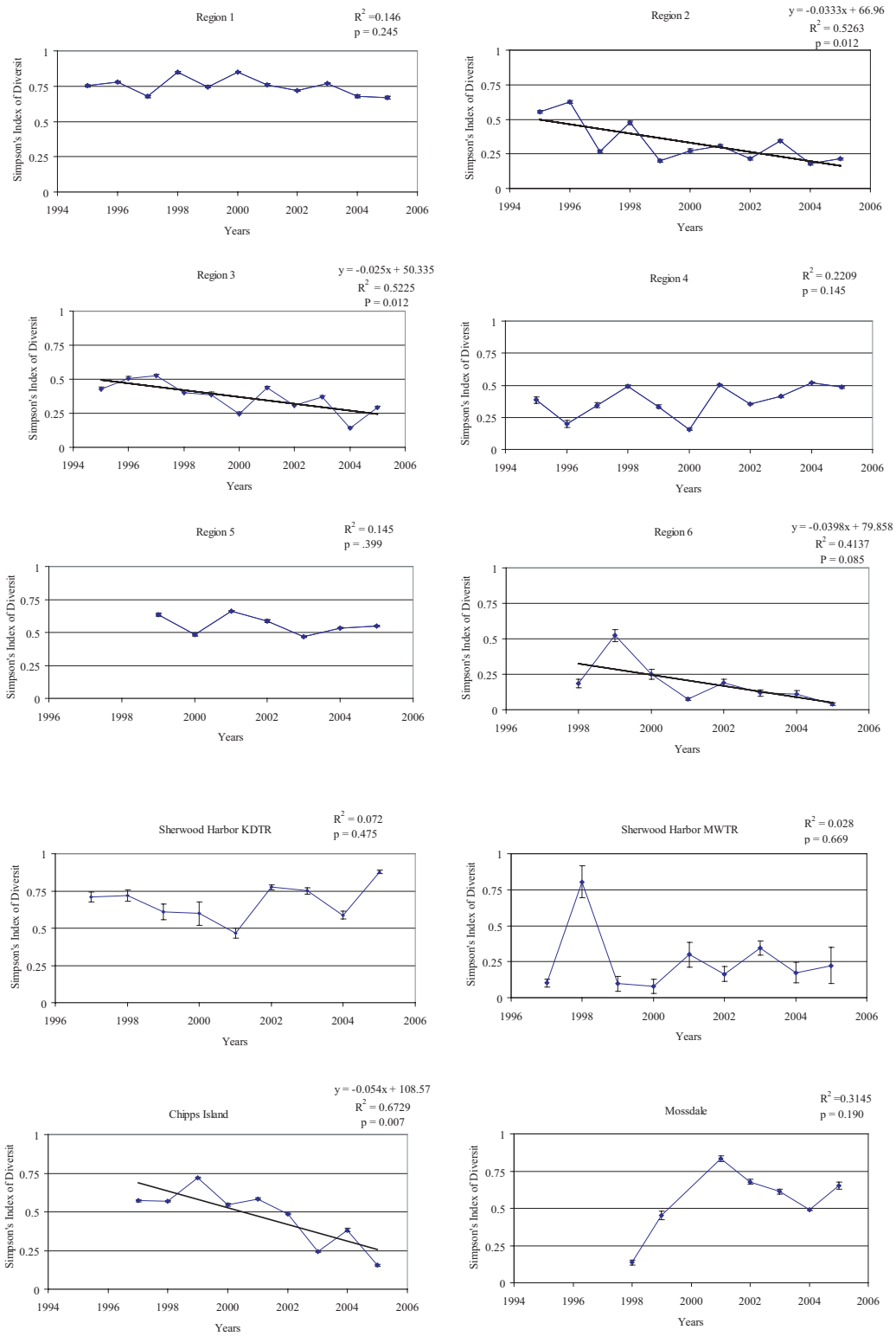

Figure 2 Graphs of Simpson's Index of Diversity over the previous 8 to 11 years for each beach seine and trawl location during the reporting period of September 1 through December 31, 2005.

Discussion

Fish assemblages in most regions and trawl locations remained fairly stable through time during fall months, as indicated by the relatively high values of Kendall's W_c. As discussed previously (Wichman and Hanni 2005), these values show that ranks in CPUE among species are consistent among years. Although the W_c values for fall (September-December) differ slightly from summer (May-August) and winter (January-April) values, the seasonal fish assemblages appear to be stable, at least during the study period. (Wichman and Hanni 2005*,* Hanni 2005). One exception is Sherwood Harbor MWTR, where the low W_c value indicates a relative lack of stability in the fish community assemblage through time. This lack of stability is related to the abundance ranks of individual species fluctuating drastically through time. There were 21 different species captured over the 9 years examined. Although American shad consistently received the highest abundance rank (21) among species each year, the abundance ranks assigned to other species captured fluctuated greatly. For example, in 2002, the abundance of threadfin shad was ranked eighth, yet in the following year, their abundance was ranked 20th.

In the current study, a significant decline in diversity, measured as species evenness, was observed in Regions 2 and 3, and a marginally significant decline in diversity was observed in Region 6 (Figure 2). The decrease in diversity through time in these regions may be attributed to changes in the number of dominant species through time (Table 3). In each of these regions, the number of dominant species decreased from multiple species in the early years of sampling to just one dominant species in 2005.

Hanni (2005) found a decrease in diversity through time in Regions 5 and 6 during the summer months of sampling. However, the reasons for this change in diversity through time appear to be more complicated than in the current study (Hanni, 2005).

Species diversity did not significantly change through time in three of the four trawl locations in fall months. There was a clear decline in diversity at Chipps Island (Figure 2). This decline is likely related to the shift in the number of dominant species through time from many to one, American shad (Table 3).

Hanni (2005*)* found no significant change in diversity through time at any trawl location during summer sampling. Differences in diversity trends between fall and spring may be due to the presence of different dominant species. For example, fall-run Chinook salmon, which composed up to 74% of all individuals caught in summer months, are extremely rare in fall months.

Further investigations into native and non-native dynamics between years may provide better insight into long term species diversity and assemblage stability. A common consequence of successful invasions by non-native species is the local extinction of native species competing for common resources (Moyle 2002).

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Delta Smelt Broodfish Collection, Fall 2005

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Sub-adult delta smelt were collected by lampara net in the lower Sacramento River in the fall of 2005, under state and federal permits for production of cultured animals in 2006. This year, the smelt appeared to be concentrated near the confluence of the Sacramento and San Joaquin Rivers with highest densities on the western Sacramento River bank across from Sherman Lake (near Channel marker 11). The sub-adults appeared to occupy a more restricted area in 2005 compared to the last several years of collecting with our gear. Delta smelt were collected efficiently after finding their location, and by-catch was mainly threadfin shad and American shad (Tables 1 and 2). The collected smelt were collected as part of a contract with the Department of Water Resources to provide several thousand juvenile and adult cultured smelt for the Capture, Handling, Transportation, and Release (CHTR) study conducted by the Department of Fish and Game.

Table 1 Collection and survival of delta smelt broodfish

			% Survival after capture and transport						
Collection date	*Number of Sets*	*Total collected*	*24 hours*	*48 hours*	*72 hours*	*Total fish after 72 hours*	*sample size n=*	*Average Length*	*Weight*
11/21/05	14	46	80.4	80.4	80.4	37	9	52	1.18
11/22/05	20	124	99.2	98.4	98.4	122	1	58	1.54
11/23/06	17	578	58.1	55.5	55.2	319	26	54	1.37
12/7/05	20	1033	95.5	94.6	94.5	962	67	53	1.33
12/9/05	9	516	92.8	91.7	91.5	472	27	53	1.22
Total take	2297								
Total remaining after 72 hrs						1912			
Average % survival after 72 hrs					83.2				

Table 2 Incidental take caught in the lampara net while collecting delta smelt

Species	*Collection Dates*					
	11/21/05	11/22/05	11/23/05	12/7/05	12/9/05	Totals
Alosa sapidissima,American shad	41	117	266	47	4	475
Dorosoma petenense,Threadfin shad	2	1	26	416	108	553
Hypomesus nipponensis,Wakasagi smelt	0	2	0	0	0	2
Menidia beryllina,Inland Silverside	2	3	16	21	10	52
Morone saxatilis,Striped bass	0	0	0	3	1	4
Pogonichthys macrolepidotus,Splittail	0	0	0	2	1	3
Spirinchus thaleichthys,Longfin smelt	1	0	10	6	4	21