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Yolo Bypass Fish Egg and Larval Sampling Metadata
Aquatic Ecology Section, DWR
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I. Contact Information

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II. Study Element and Objectives

Largely supported by the Interagency Ecological Program (IEP), DWR has operated a fisheries and invertebrate monitoring program in the Yolo Bypass since 1998. The project has provided a wealth of information regarding the significance of seasonal floodplain habitat to native fishes. Basic objectives of the project are to collect baseline data on lower trophic levels (phytoplankton, zooplankton and invertebrate drift), juvenile and adult fish, hydrology and physical conditions. As the Yolo Bypass has been identified as a high restoration priority by the US Fish and Wildlife Service and National Marine Fisheries Service biological opinions for Delta Smelt (*Hypomesus transpacificus)* and winter and spring-run Chinook Salmon (*Oncorhynchus tshawytscha*), and by California EcoRestore, these baseline data are critical for evaluating success of future restoration projects. In addition, the data have already served to increase our understanding of the role of the Yolo Bypass in the life history of native fishes, and its ecological function in the San Francisco Estuary. Key findings include: (1) Yolo Bypass is a major factor regulating year class strength of splittail, *Pogonichthys macrolepidotus* (Sommer et al., 1997; Feyrer et al., 2006; Sommer et al., 2007a); (2) Yolo Bypass is a key migration corridor for adult fish of several listed and sport fish (Harrell and Sommer 2003); (3) it is one of the most important regional rearing areas for juvenile Chinook Salmon (Sommer et al., 2001a; 2005); and (4) Yolo Bypass is a source of phytoplankton to the food web of the San Francisco Estuary (Jassby and Cloern 2000; Schemel et al., 2004; Sommer et al., 2004a).

The collection of larval fish and eggs is one of multiple elements of the Aquatic Ecology Section's (AES) Yolo Bypass Fish Monitoring Program (YBFMP) lower trophic monitoring that is conducted under the IEP umbrella. The monitoring of fish larvae and eggs was initiated to compare the seasonal variations in densities and species trends within (1) the Sacramento River channel, and (2) the Yolo Bypass, the river's seasonal floodplain (Sommer et al. 2003). The collection of fish egg and larval samples is an important element in determining the annual presence, timing, and recruitment success of fishes utilizing the Yolo Bypass.

Key findings to date: (1) 26 species of fish larvae were observed in the Yolo Bypass during the 15-years of monitoring (Mollie Ogaz and J. Frantzich, DWR, unpublished data), including Delta Smelt, *Hypomesus transpacificus* (Sommer et al 2004b); (2) The native Prickly Sculpin and non-native Threadfin Shad dominated samples, compromising over 60% of the total larval catch (Mollie Ogaz and J. Frantzich, DWR, unpublished data); (3) Native species compromised a higher percent of total catch in the Yolo Bypass (22.43%) in comparison to the Sacramento River (10.2%), and appeared earlier in the year than many non-natives (Mollie Ogaz and J. Frantzich, DWR, unpublished data); (4) Similar to other seasonal floodplains in the San Francisco Estuary, alien fishes comprised a large portion of the assemblage of early life stages in the Yolo Bypass (Sommer et al 2004b); (5) Water temperature and stage are the best explanatory environmental variables for larval fish abundance in the Yolo Bypass (p=0.001). Flow was not statistically significant (Mollie Ogaz and J. Frantzich, DWR, unpublished data); (6) Species richness and diversity are higher in the Yolo bypass in comparison to the Sacramento River (Sommer et al. 2004b).

III. Study Area and Sample Sites

A. General Information

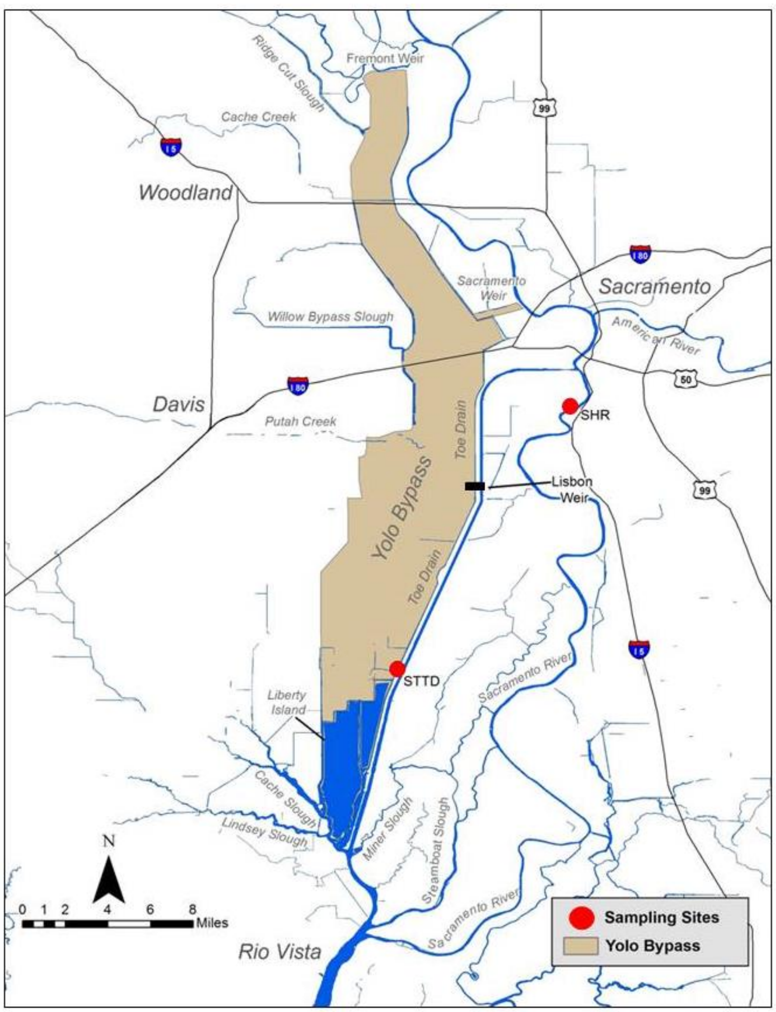
There are two fixed sampling sites for this element: (1) The Toe Drain of Yolo Bypass at our rotary screw trap (STTD), and (2) The Sacramento River at Sherwood Harbor (SHR). These sites are sampled at least twice monthly on an ebb tide on the same day or within one day of one another.

B. Name and Location Information of Egg and Larval Sampling Sites

Currently Sampled Stations

Station	Location	latitude			longitude			Start Year
		degrees	minutes	seconds	degrees	minutes	seconds	
STTD	Yolo Bypass - Screw Trap at Toe Drain	38	21	12.46	121	38	34.71	1999
SHR	Sacramento River at Sherwood Harbor	38	31	56.77	121	31	41.1	1999

Map of Currently Sampled Stations



IV. Period of Record

Fish egg and larval monitoring began in 1999 and includes the proper sorting, identification, measuring, and enumeration of all ichthyoplankton samples to the species level.

V. Sampling Frequency

From 1999-2010, sampling was typically conducted at least once monthly from March-June. During some years, sampling was started in January and/or conducted weekly during the inundation and draining of the Yolo Bypass. From 2011-2014, sampling was conducted at least biweekly (every other week) year-round and weekly during floodplain inundation and drainage events. Since 2015, sampling has been conducted at least biweekly from January-June, and weekly during inundation and drainage events.

Sampling Frequency by Month and Year

Yolo Bypass Screw Trap at Toe Drain (STTD)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1999	0	0*	2*	6	7	2	0	0	0	0	0	0	**17**
2000	0	0*	2*	0	1	1	0	0	0	0	0	0	**4**
2001	1	1	2	2	1	1	0	0	0	0	0	0	**8**
2002	0*	0	2	2	5	3	0	0	0	0	0	0*	**12**
2003	0*	0	2	1	3*	2	0	0	0	0	0	0	**8**
2004	1*	2*	2*	2	1	1	0	0	0	0	0	0	**9**
2005	1	2	3	3	2*	2	0	0	0	0	0	0	**13**
2006	3*	2*	4*	2*	2	2	0	0	0	0	0	0	**15**
2007	0	0	2	1	2	0	0	0	0	0	0	0	**5**
2008	1	2	2	2	2	2	0	0	0	0	0	0	**11**
2009	2	2	2	2	2	2	0	0	0	0	0	0	**12**
2010	4*	2	3	2	1	1	0	0	0	0	0	0*	**13**
2011	2*	2	2*	3*	2	3	2	2	2	2	3	2	**27**
2012	2	2	2	2	3	2	2	2	3	3	2	2*	**27**
2013	5	4	3	3	2	2	2	2	2	3	1	2	**31**
2014	3	2	2	2	2	2	2	3	2	2	2	3	**27**
2015	3	5	7	7	3	6	4	3	0	0	0	0	**38**
2016	1	2	2	4	0	0	1	0	0	0	0	0	**10**
2017	3*	4*	4*	8*	7*	3	3	0	0	0	0	0	**33**
Total	**32**	**34**	**50**	**54**	**48**	**37**	**16**	**12**	**9**	**10**	**8**	**9**	**320**

*****Months with overtopping at Fremont Weir

Sacramento River at Sherwood Harbor (SHR)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1999	0	1*	1*	2	1	1	0	0	0	0	0	0	**6**
2000	0	0*	1*	0	0	0	0	0	0	0	0	0	**1**
2001	1	2	2	2	1	1	0	0	0	0	0	0	**9**
2002	0*	0	2	2	5	3	0	0	0	0	0	0*	**12**
2003	3*	0	1	2	3*	2	0	0	0	0	0	0	**11**
2004	1*	2*	2*	2	1	1	0	0	0	0	0	0	**9**
2005	1	2	3	3	2*	2	0	0	0	0	0	0	**13**
2006	1*	1*	2*	2*	2	2	0	0	0	0	0	0	**10**
2007	0	1	2	2	2	0	0	0	0	0	0	0	**7**
2008	2	2	2	2	2	2	0	0	0	0	0	0	**12**
2009	2	2	2	2	2	2	0	0	0	0	0	0	**12**
2010	4*	3	3	1	2	1	0	0	0	0	0	0*	**14**
2011	2*	2	2*	3*	2	3	2	2	2	2	3	2	**27**
2012	1	2	2	2	3	2	2	2	2	3	2	2*	**25**
2013	5	4	3	3	2	2	2	2	2	3	1	2	**31**
2014	3	2	2	2	2	2	2	3	2	2	2	3	**27**
2015	3	4	6	5	4	4	3	2	0	0	0	0	**31**
2016	1	2	3	2	2	2	0	0	0	0	0	0	**12**
2017	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Total	**30**	**32**	**41**	**39**	**38**	**32**	**11**	**11**	**8**	**10**	**8**	**9**	**269**

Number of Sampling Events by Station and by Year

Station	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
STTD	17	4	8	12	8	9	13	15	5	11	12	13	27	27	31	27	38	10	33	**320**
SHR	6	1	9	12	11	9	13	10	7	12	12	14	27	25	31	27	31	12	0	**269**
Total	**23**	**5**	**17**	**24**	**19**	**18**	**26**	**25**	**12**	**23**	**24**	**27**	**54**	**52**	**62**	**54**	**69**	**22**	**33**	**589**

VI. Field Collection Methods

A. Conical plankton net

The fish egg and larval samples are collected with a conical plankton net made of 500 micron mesh, measuring 0.75 m diameter at the mouth and 0.91 m long, harnessed to a stainless steel frame (Sommer et al. 2003). It tapers to 0.076 m at the cod-end where a polyethylene jar screened with 500 micron mesh collects the egg and larval samples. When there is sufficient flow (typically from January – June) in the Toe Drain (STTD), samples are collected during the ebb tide from the rotary screw trap anchored in the middle of the channel, and the Sacramento River/Sherwood Harbor samples are taken dockside. In the absence of sufficient downstream flow, typically from July-Nov, Sacramento River and Yolo Bypass samples are taken from a boat moving upstream approximately 2-3 mph near the screw trap or dock. Flow is measured with a General Oceanics Model 2030R flow meter mounted in the mouth of the net. Generally, tows have been 10 minutes long but have been shorter or longer depending on flows and debris load. Tow times are recorded with every sampling event.

Samples are preserved in the field with 10% formalin with Rose Bengal dye to aid in separating fish eggs and larvae from detritus and algae. Samples are transferred to 70-80% ETOH within three weeks of collection, and before samples are sent to EcoAnalyst contractor for analysis.

Water quality parameters are recorded when the sample is collected. Temperature (C), electrical conductivity (uS/cm), dissolved oxygen (mg/L), and pH are measured using a YSI 556 Multiprobe System. Turbidity is measured from a water sample collected in a glass vial and later analyzed at the office using a Hach 2100Q Portable Turbidimeter. Secchi depth (cm) is also measured. Other factors including tide stage, weather, and trap condition code are also recorded.

VII. Lab Processing Methods

Current Procedure (1998-Current): All fish egg and larval samples are rinsed and passed through a 0.5 mm sieve. All the material remaining within the sieve is processed by removing all organisms from the sample for identification. All the fish larvae are counted and identified to the species level. Up to 30 individuals for a given larval species are measured in millimeters and recorded in total length and fork length. All fish eggs are counted and identified to family level (species level when possible). All current sorting, identification, measuring, and enumeration of fish egg and larval samples are carried out by the contractor: EcoAnalysts, Inc. (1420 South Blaine Street, Suite 14, Moscow, Idaho 83843).

The count per cubic meter for each fish egg and larval sample taken in the plankton net was calculated using the following equation:

N = C/V

Where:

N = the number of a taxon per cubic meter of water sampled
C = the cumulative number of a taxon counted for the sample
V = the volume of water sampled through the net (m^3)

A calculation for volume of water sampled through the net is specific to the General Oceanics Flowmeter model 2030R, and is calculated as follows (General Oceanics Inc.):

$$\frac{(\text{Flowmeter count start} - \text{Flowmeter count end}) \times \text{Rotor Constant}}{999999} \times \frac{\text{Net mouth area}}{4} = \text{Volume Sampled } (m^3)$$

The rotor constant depends upon which the flowmeter rotors were used during each sampling event and is identified in the sampling database. Rotor constants are specified in the General Oceanics Flowmeter 2030R manual as:

Standard Speed Rotor Constant = 26,873
Low Speed Rotor Constant R6 = 57,560

B*. Master List of Potential Egg and Larval Fish Species*

Code	Common Name	Scientific Name
AMS	American Shad	*Alosa sapidissima*
ASE	American Shad Eggs	*Alosa sapidissima*
AMM	Ammocoete Lamprey	*Petromyzontidae*
BPF	Bay Pipefish	*Syngnathus leptorhyncus*
BKB	Black Bullhead	*Ameiurus melas*
BKS	Black Crappie	*Pomoxis nigromaculatus*
BGS	Bluegill	*Lepomis macrochirus*
BKT	Brook Trout	*Salvelinus fontinalis*
BRB	Brown Bullhead	*Ameiurus nebulosus*
BT	Brown Trout	*Salmo trutta*
CAR	California Roach	*Lavinia symmetricus*
C	Carp	*Cyprinus carpio*
CHG	Chameleon Goby	*Tridentiger trigonocephalus*
CHC	Channel Catfish	*Ictalurus punctatus*

CHN	Chinook Salmon, Unknown Race	*Oncorhynchus tshawytscha*

B*. Master List of Potential Egg and Larval Fish Species (Continued)*

Code	Common Name	Scientific Name
CO	Clupeidae Eggs	
DSM	Delta Smelt	*Hypomesus transpacificus*
FHM	Fathead Minnow	*Pimephales promelas*
GF	Gold Fish	*Carassius auratus*
GSN	Golden Shiner	*Notemigonus crysoleucas*
GST	Green Sturgeon	*Acipenser medirostris*
GSF	Green Sunfish	*Lepomis cyanellus*
HH	Hardhead	*Mylopharodon conocephalus*
HCH	Hitch	*Lavinia exilicauda*
MSS	Inland Silverside	*Menidia beryllina*
JSM	Jacksmelt	*Atherinopsis californiensis*
LAM	Lamprey, Unidentified Adult	*Petromyzontidae*
LMB	Largemouth Bass	*Micropterus salmoides*
LP	Logperch	*Percina macrolepida*
LFS	Longfin Smelt	*Spirinchus thaleichthys*
MQF	Mosquito Fish	*Gambusia affinis*
NAN	Northern Anchovy	*Engraulis mordax*
BL	Pacific Brook Lamprey	*Lampetra pacifica*
PAH	Pacific Herring	*Clupea harengeus pallasii*
PL	Pacific Lamprey	*Lampetra tridentata*
PSS	Pacific Staghorn Sclupin	*Leptocottus armatus*
PE	Percichthyidae eggs	
PMP	Plainfin Midshipman	*Porichthys notatus*
PRS	Prickly Sculpin	*Cottus asper*
SF	Pumpkinseed	*Lepomis gibbosus*
RBT	Rainbow Trout (Steel Head)	*Oncorhynchus mykiss*
RBTT	Rainbow Trout, Tagged	*Oncorhynchus mykiss*
RSN	Red Shiner	*Cyprinella lutrensis*
RES	Redear Sunfish	*Lepomis microlophus*
REB	Redeye Bass	*Micropterus coosae*
RFS	Riffle Sculpin	*Cottus gulosus*
RL	River Lamprey	*Lampetra ayersi*
SCB	Sacramento Blackfish	*Orthodon microlepidotus*
SASQ	Sacramento Pikeminnow	*Ptychocheilus grandis*
SPLT	Sacramento Splittail	*Pogonichthys macrolepidotus*
SASU	Sacramento Sucker	*Catostomus occidentalis*
SHM	Shimofuri Goby	*Tridentiger bifasciatus*
SMB	Smallmouth Bass	*Micropterus dolomieu*
SPD	Speckled Dace	*Rhinichthys osculus*

STF	Starry Flounder	*Platichthys stellatus*
STB	Striped Bass	*Morone saxatilis*
SBE	Striped Bass Eggs	*Morone saxitalis*

B*. Master List of Potential Egg and Larval Fish Species (Continued)*

Code	Common Name	Scientific Name
SSM	Surf Smelt	*Hypomesus pretiosus*
TFS	Threadfin Shad	*Dorosoma petenense*
TSE	Threadfin Shad Eggs	*Dorosoma petenense*
TSS	Threespine Stickleback	*Gasterosteus aculeatus*
TSM	Top Smelt	*Atherinops affinis*
TP	Tule Perch	*Hysterocarpus traski*
POM	Unid Crappie	*Pomoxis spp*
CAT	Unid Ictalurid (catfish or bullhead)	*Ictaluridae*
BAS	Unid Juvenile Bass	*Micropterus spp*
MIN	Unid Juvenile Minnow	*Cyprinidae*
SNF	Unid Juvenile non-Micropterus Sunfish	*Centrarchidae*
SCP	Unid Juvenile Sculpin	*Cottus spp.*
STG	Unid Juvenile Sturgeon	*Acipenser spp.*
LEP	Unid Sunfish	*Lepomis spp*
TRD	Unid Tridentiger	*Tridentiger spp.*
WAG	Wakasagi	*Hypomesus nipponensis*
W	Warmouth	*Lepomis gulosus*
WHC	White Catfish	*Ameiurus catus*
WHS	White Crappie	*Pomoxis annularis*
WCK	White Croaker	*Genyonemus lineatus*
WST	White Sturgeon	*Acipenser transmontanus*
YEB	Yellow Bullhead	*Ameiurus natalis*
YFG	Yellowfin Goby	*Acanthogobius flavimanus*

VIII. Data Management and Quality Assurance/Quality Control

A. Field Data

Field data are collected and recorded onto datasheets by DWR personnel. These data are then entered monthly by DWR personnel into an Access database. Field data are reviewed by a separate staff person for accuracy and completeness. Annually, after all samples are processed for the year, lab data are reviewed for accuracy and completeness.

B. Field Datasheet

Paper datasheets are digitized and archived in binders that are stored at the West Sacramento, Industrial Blvd. DWR office.

Datasheet

LOWER TROPHIC SAMPLING – YOLO BYPASS STUDY
2015/2016

Location: ____________________ pH:

Crew: Date: Time: DO:

Vial #: SpCnd:

Secchi Depth: m Water Temp: °C Weather: Turb: NTU Cnd (EC):

Light Attenuation:

LI-COR Calibration
-143.27 (in air)
-232.10 (in water)

Surface Irradiance (in **air** avg): µmol

0.75 = µmol
0.50 = µmol
0.25 = µmol
0.01 = µmol

Subsurface Irradiance (in **water** avg)(~75%, ~50%, ~25%, ~1%):

Depth: m Depth: m
1 µmol 3 µmol
Depth: m Depth: m
2 µmol 4 µmol

Drift Sample : **Condition Code:**

Start Time: Stop Time: Set Time: **min**

Flow Meter:
Regular or Low Speed
*For low speed, record initial meter reading in "end meter" box

Flow : Start Meter: End Meter:

Comments:

Egg & Larval Fish Sample : **Condition Code:**

1st Start Time: 1st Stop Time: 2nd Start Time: 2nd Stop Time: Set Time: **min**

Flow Meter:
Regular or Low Speed
*For low speed, record initial meter reading in "end meter" box

Flow : **(Mid-West)** Start Meter: End Meter:
(Near-West) Start Meter: End Meter:
(Mid-East) Start Meter: End Meter:
(Near-East) Start Meter: End Meter:

Comments:

Zooplankton Sample : **Condition Code:**

Start Time: 150 Stop Time: 50 Stop Time: 150 Set Time: **min** 50 Set Time: **min**

Flow Meter:
Regular or Low Speed
*For low speed, record initial meter reading in "end meter" box

Flow :
150µm: Start Meter: End Meter:
50µm: Start Meter: End Meter:

Comments:

Chlorophyll Sample : **Yes** **No** **Replicate** Time: Filtered: 500mL OR 250mL

Phytoplankton Sample : 60 mL Amber Bottle w/ Lugol Solution

Entered by :__________ Date:__________ Checked by :__________ Date:__________

C. Taxonomic Data

Organism identification, measurement, and enumeration data are received from the EcoAnalyst contractor electronically via email. Electronic copies of results for laboratory analyses are archived on DWR/AES Network drives. Hard copies are printed and stored in binders at the West Sacramento, Industrial Blvd. DWR office.

Catch-per-unit effort data, in number per cubic meter of water sampled, for each species in a valid sample are available in Excel with the associated field data by contacting the DWR project lead Jared Frantzich (see contact information at beginning of document).

IX. Chain of Custody and Sample Handling

Samples are securely packaged to prevent leakage or breakage. All bottles are inspected and verified, and a chain of custody form is filled out with the sample collection time and date, study, site, and number of jars per sample. Signatures are required of both the person responsible for sending the sample package, and the person receiving it. The chain of custody form is signed and sent to the Eco Analyst contractor with the samples, and the contractor is notified of approximate date of delivery.

Chain of Custody Form

EcoAnalyst Inc.
Chain of Custody

Page 1 of 1

Samples sent from:	**West Sacramento**	**Samples sent to:**	**Moscow, Idaho**
Samples sent by:	**DWR, Jared Frantzich**	**Contract #: 4600009721**	
Date:		**Date:**	
Transported By:	**UPS**	**Samples received by:**	
Signature: _____________________		**Signature:_____________________**	
Requested Analysis:			

	Collection Date	Study	Time	Station	# of Jars	Add Notes
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2						
3						
4						
5						
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XI. Reference

A. *General Taxonomic References*

Wang, J.C.S., and R.C. Reyes. 2007. A Key to Early Life Stages and Early Life Histories of Cyprinids in the Sacramento-San Joaquin Delta, California: with Emphasis on Splittail, Pogonichthys macrolepidotus, Spawning in the Suisun Bay and Delta. Tracy Fish Collection Facility Studies. Volume 32. U.S. Bureau of Reclamation, Mid-Pacific Region. 150 pp

Wang, J.C.S. 2007. Spawning, Early Life Stages, and Early Life Histories of the Osmerids Found in the Sacramento-San Joaquin Delta of California. Tracy Fish Collection Facility Studies. Volume 38. U.S. Bureau of Reclamation, Mid-Pacific Region and Denver Technical Service Center. 110 pp.

Wang, J.C.S., and R.C. Reyes. 2008. Early Life Stages and Life Histories of Centrarchids in the Sacramento-San Joaquin River Delta System, California. Tracy Fish Collection Facility Studies. Volume 42. U.S. Bureau of Reclamation, Mid-Pacific Region and Denver Technical Service Center. 112pp.

Wang, J.C.S. 2011. Fishes of the Sacramento-San Joaquin River Delta and Adjacent Waters, California: A Guide to Early Life Histories. Tracy Fish Collection Facility Studies. Volume 44. U.S. Bureau of Reclamation, Mid-Pacific Region and Denver Technical Service Center. 441 pp.

B. *Program Reports, Publications, and Other Pertinent Literature*

Cranston, P.S., G.M. Benigno, and M.C. Domingeuz. 2007. *Hydrobaenus saetheri* Cranston, new species, an aestivating, winter-emerging chironomid (*Diptera: Chironomidae*) from California. Pages 73-79 in Contributions to the Systematics and Ecology of Aquatic Diptera-A tribute to Ole A. Saether. T. Andersen, editor. The Caddis Press

Feyrer, F, T. Sommer, and W. Harrell. 2006. Managing floodplain inundation for native fish: production dynamics of age-0 splittail in California's Yolo Bypass. Hydrobiology 573:213-226.

General Oceanics Inc. General Oceanics Digital Flowmeter Mechanical and Electronic Operators Manual. Miami FL. 15 pp.

Harrell, W.C. and T.R. Sommer. 2003. Patterns of Adult Fish Use on California's Yolo Bypass Floodplain. Pages 88-93 in P.M. Faber, editor. California riparian systems: Processes and floodplain management, ecology, and restoration. 2001 Riparian Habitat and Floodplains Conference Proceedings, Riparian Habitat Joint Venture, Sacramento, California.

Jassby A.D. and J.E. Cloern 2000. Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). Aquatic Conservation: Marine and Freshwater Ecosystems 10:323-352.

Kurth, R., and M. Nobriga. 2001 Food Habits of larval splittail. Interagency Ecological Program Newsletter 14 (2):40-42

Lehman, P. W., T. Sommer and L. Rivard. 2008. Phytoplankton primary productivity, respiration, chlorophyll a and species composition in the Yolo Bypass floodplain, California. Aquatic Ecology 42:363-378.

Moyle, P. R. D. Baxter, T. Sommer, T. C. Foin, and S. C. Matern. 2004. Biology and Population Dynamics of Sacramento Splittail (*Pogonichthys macrolepidotus*) in the San Francisco Estuary: a review. San Francisco Estuary and Watershed Science [online serial]. Vol. 2, Issue 2 (May 2004), Article 3.

Mueller-Solger, A. B., A. D. Jassby and D. C. Mueller-Navarra. 2002. Nutritional quality for zooplankton (Daphnia) in a tidal freshwater system (Sacramento-San Joaquin River Delta, USA). Limnology and Oceanography 47(5):1468-1476.

Schemel, L.E., T.R. Sommer, A.B. Muller-Solger, and W.C. Harrell. 2004. Hydrologic variability, water chemistry, and phytoplankton biomass in a large floodplain of the Sacramento River, CA, USA. Hydrobiologia 513:129-139.

Sommer, T., R. Baxter, and B. Herbold. 1997. The resilience of splittail in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society 126:961-976.

Sommer, T.R., W.C. Harrell, A. Mueller-Solger, B. Tom, and W. Kimmerer. 2004a. Effects of flow variation on channel and floodplain biota and habitats of the Sacramento River, California, USA. Aquatic Conservation: Marine and Freshwater Ecosystems 14:247-261.

Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batham, and W. J. Kimmerer. 2001. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58(2):325-333.

Sommer, T.R., W.C. Harrell, R. Kurth, F. Feyrer, S.C. Zeug, and G. O'Leary. 2004b. Ecological patterns of early life stages of fishes in a river-floodplain of the San Francisco Estuary. Pages 111-123 in F. Feyrer, L.R. Brown, R.L. Brown, and J.J. Orsi, editors. Early Life History of Fishes in the San Francisco Estuary and Watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Sommer, T, W. Harrell, and M. Nobriga. 2005. Habitat use and stranding risk of juvenile Chinook salmon on a seasonal floodplain. North American Journal of Fisheries Management 25:1493-1504.

Sommer, T., R. Baxter, and F. Feyrer. 2007. Splittail revisited: how recent population trends and restoration activities led to the "delisting" of this native minnow. Pages 25-38 in M.J. Brouder and J.A. Scheuer, editors. Status, distribution, and conservation of freshwater fishes of western North America. American Fisheries Society Symposium 53. Bethesda, Maryland.