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IEP Aquatic Ecology Section
Yolo Bypass Zooplankton Sampling Meta Data
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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 monitoring program 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 insect 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., 2004).

The collection of zooplankton is one element of the Aquatic Ecology Section's (AES), Yolo Bypass Fish Monitoring Program's (YBFMP) lower trophic monitoring that is conducted under the IEP umbrella. Zooplankton are an important component in the diet of larval, juvenile, and small adult fishes within the San Francisco Estuary, including Delta Smelt, juvenile Chinook Salmon, Striped Bass, and Sacramento Splittail. The goals of the zooplankton monitoring project are to compare the seasonal variation in species densities and trends within (1) the Sacramento River channel, and (2) the Yolo Bypass, the river's seasonal floodplain.

Key findings to date include: (1) Chinook Salmon sampled in the floodplain contained diets comprised of 90% dipterans and zooplankton, with zooplankton being the dominant prey item in all months (Sommer et al., 2001), (2) laboratory studies showed that the increased chlorophyll-a concentrations in the Yolo Bypass resulted in faster growth rates for the cladoceran *Daphnia magna* as compared to the Sacramento River (Mueller-Solger et al., 2002), and (3) due to high phytoplankton biomass in the spring, the floodplain is suggested to be important in the bottom-up energy transfer through the food web of the San Francisco Estuary (Sommer et al., 2001, Lehman et al., 2007).

III. Study Area and Sample Sites

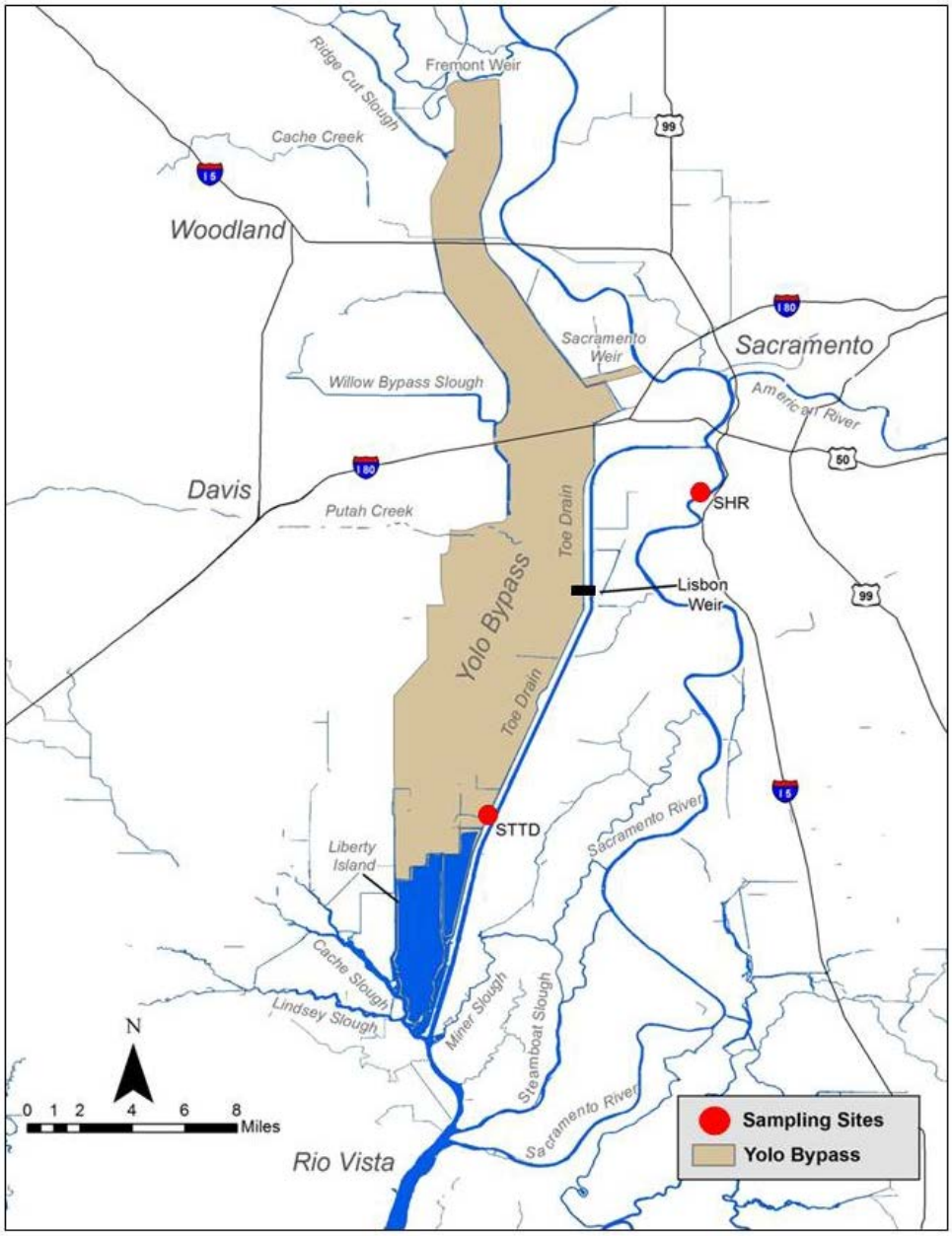
A. *General Information*

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

B. *Name and Location Information for Zooplankton Sampling Sites*

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 Sites



IV. Period of Record

Zooplankton monitoring began in 1999 and continues through the present. The zooplankton dataset includes the proper sorting, identification, and enumeration of (1) meso-zooplankton (calanoids, cyclopoids, harpacticoids, and cladocerans), (2) microzooplankton and nauplii (rotifers, barnacles, copepod nauplii, cladocera nauplii, and ostracods), and (3) macrozooplankton (mysids, clams, snails, etc.).

V. Sampling Frequency

Following initial pilot years 1999-2001, sampling was conducted at least once monthly during the months of January - June at two sites: One at the rotary screw trap in the Yolo Bypass Toe Drain, and the other at Sherwood Harbor in the Sacramento River. In some years, sampling was conducted weekly during the inundation and draining of the Yolo Bypass floodplain. Since 2011, sampling is conducted at least biweekly (every other week) year-round during non-flooding periods, and weekly during floodplain inundation and drainage events.

Sampling Frequency by Month and Year

Yolo Bypass Screw Trap at Toe Drain (STTD) (150 µm Net)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1999	0	0*	8*	5	0	0	0	0	0	0	0	0	**13**
2000	0	4*	3*	0	0	0	0	0	0	0	0	0	**7**
2001	1	2	2	2	1	1	0	0	0	0	0	0	**9**
2002	4*	2	3	2	3	2	0	0	0	0	0	0*	**16**
2003	6*	0	2	2	3*	2	0	0	0	0	0	0	**15**
2004	2*	2*	2*	2	1	1	0	0	0	0	0	0	**10**
2005	4	3	4	4	2*	2	0	0	0	0	0	0	**19**
2006	3*	3*	4*	1*	2*	1	0	0	0	0	0	0	**14**
2007	0	1	2	1	2	2	0	0	0	0	0	0	**8**
2008	1	1	2	2	2	2	0	0	0	0	0	0	**10**
2009	2	2	2	2	2	2	0	0	0	0	0	0	**12**
2010	4*	3	3	2	2	0	0	0	0	0	0	0*	**14**
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	4	4	3	3	2	2	2	2	2	3	1	2	**30**
2014	3	2	2	2	2	2	2	3	2	2	2	3	**27**
2015	4	4	7	4	3	6	4	4	2	3	2	2	**45**
Total	**42**	**37**	**53**	**40**	**32**	**30**	**12**	**13**	**11**	**13**	**10**	**11**	**303**

*****Months with overtopping at Fremont Weir.

Sacramento River at Sherwood Harbor (SHR) (150 µm Net)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1999	0	0*	8*	5	0	0	0	0	0	0	0	0	13
2000	0	3*	3*	0	0	0	0	0	0	0	0	0	6
2001	1	2	2	2	1	1	0	0	0	0	0	0	9
2002	4*	2	3	2	3	2	0	0	0	0	0	0*	16
2003	6*	1	2	2	3*	2	0	0	0	0	0	0	16
2004	2*	1*	1*	2	1	1	0	0	0	0	0	0	8
2005	4	3	4	4	2*	2	0	0	0	0	0	0*	19
2006	3*	2*	4*	2*	2*	2	0	0	0	0	0	0	15
2007	0	0	2	1	2	1	0	0	0	0	0	0	6
2008	1	2	2	1	2	2	0	0	0	0	0	0*	10
2009	2	2	2	2	2	2	0	0	0	0	0	0	12
2010	4*	4	3	2	2	0	0	0	0	0	0	0*	15
2011	2*	2	2*	3*	2	3	2	2	2	2	3	2	27
2012	2	2	2	2	3	2	2	2	2	3	2	2*	26
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	4	4	6	5	4	4	5	5	2	2	2	2	45
Total	43	36	51	40	33	28	13	14	10	12	10	11	**301**

*****Months with overtopping at Fremont Weir.

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	Total
STTD	13	7	9	16	15	10	19	15	8	10	12	16	27	26	30	27	45	301
SHR	13	6	9	16	16	9	19	15	6	10	12	16	27	26	31	26	45	302
Total	**26**	**13**	**18**	**32**	**31**	**19**	**38**	**30**	**14**	**20**	**24**	**32**	**54**	**52**	**61**	**53**	**90**	604

VI. Field Collection Methods

A simple plankton net is used to capture (1) Calanoids (adult and juvenile copepods), (2) Cyclopoids (adult and juvenile copepods of the genera Limnoithona, Oithona, and Acanthocyclops), (3) Cladocerans, (4) Harpacticoids and (5) Microzooplankton and Nauplii (copepod and cladocera nauplii, ostracods, and rotifers).

A. Simple conical plankton net

The plankton net is made of 150 micron mesh net, with a 0.50 m diameter outer mouth (with a General Oceanics Model 2030R flowmeter mounted inside) and 2 meters in length. It tapers to 0.076 m at the cod-end where a polyethylene jar screened with 150 micron mesh collects the organisms. When there is sufficient flow (typically from January – June), Toe Drain samples are collected during the ebb tide from the rotary screw trap anchored in the middle of the channel, and 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 approximately 2-3 mph upstream near the screw trap or dock. Net tow times have varied through the years, with shorter tows occurring with high flows and/or debris loads. Generally, tows have been 5 or 10 minutes long, and tow times are recorded with every sampling event.

All samples are preserved in in the field with 10% formalin with Rose Bengal dye to aid in separating organisms from detritus and algae.

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

Zooplankton samples are concentrated and retained in the laboratory by pouring them through a sieve screened with 106 micron mesh wire. Excess formalin is rinsed off using tap water, and sample is transferred to 70-80% ETOH before delivery to contractor for taxonomic identification and enumeration: BSA Environmental Services, Inc. (23400 Mercantile Road, Suite 8, Beachwood, Ohio 44122).

A. Sample Analysis Procedure (2015-Current)

1. Each sample is rinsed and filtered through a 153 micron sieve and a 43 micron sieve. The 153 micron sieve removes debris and large non-target organisms. Material on the 43 micron sieve is retained.
2. For mesozooplankton, water is added to the remaining sample to achieve a target of 40-50 organisms per mL, and subsample each 5 times to accumulate a total of 200-250 organisms per sample.
3. For microzooplankton, the sample total volume is readjusted to target 100 organisms per mL, and 3 subsamples are taken to accumulate 300 organisms total per sample.
4. This results in two total volumes and two subsample volumes for each sample; one for mesozooplankton and the other for microzooplankton.
5. The sample is stirred to distribute the organisms homogeneously, and the volume of water added with be recorded as the subsample volume.
6. A sub-sample is extracted with a Hensen Stempel pipette, dispensed into a Ward zooplankton counting wheel, and examined under a compound microscope at a minimum 100x magnification.
7. The sub-sample volume is recorded and zooplankton are enumerated to the lowest taxon possible
8. Mesozooplankton are enumerated by differentiating life stages and species. *Calanoid copepods, Acanthocyclops vernalis, Oithona* and *Limnoithona* will be identified to species level, and juveniles and adults are recorded separately. *Harpacticoids* are identified to order level, with juveniles and adults combined. *Cladocerans* are identified to the genus level, with juveniles and adults combined. Microzooplankton (i.e. rotifers, barnacles, copepod nauplii, cladocera nauplii, unid. nauplii, ostracods) will be enumerated.
9. If the sample has any suspended sediment, the sediment volume is recorded separately.
10. For selected samples, additional subsamples will be taken to obtain at least 20 adult females of the numerically dominant copepod species unless no copepod is very abundant in the sample. In addition, the analyst also counts egg masses that are clearly identified as coming from the abundant species. Either all of the egg masses, or a subsample of 20 egg masses, are teased apart and the eggs are counted.

B. Calculating Volume of Water Sampled

The number per cubic meter for each zooplankton taxon taken in the net was calculated using the following equation:

N = ((C/S)/V)

N = the number of a taxon per cubic meter of water sampled
C = the total number of a taxon counted for the sample
S = the total subsample volume
V = the volume of water sampled through the net (m^3)
Calculations 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.):

$$\frac{\text{(Flowmeter count start – Flowmeter count end) x Rotor Constant}}{999999} \times \frac{\text{Net mouth area}}{4}$$

The rotor constant depends upon which the flowmeter rotor was 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 Constat R6 = 57,560

Organisms Found in Zooplankton Samples

MICROZOOPLANKTON & NAUPLII	CLADOCERA
Rotifers	Bosmina
Barnacles	Ceriodaphnia
Copepod nauplii	Daphnia
Cladocera nauplii	Chydorus
Unid nauplii	Camptocercus
Ostracods	Scaphloberis
CYCLOPOIDS	Diaphanosoma
Cyclopoid adult	Juvenile Daphnia
Cyclopoid copepodid	Alona
Acanthocyclops vernalis copepodid	Ilyocryptus
Acanthocyclops vernalis adult	Macrothrix
Oithona spp.	**HARPACTICOIDS**
Oithona similis	
Oithona davisae	
Oithona copepodid	
Limnoithona spp.	
Limnoithona tetraspina	
Limnoithona sinensis	
Limnoithona copepodid	
CALANOIDS	
Acartia spp.	
Acartia copepodid	
Diaptomidae	
Diaptomidae copepodid	
Pseudodiaptomus forbesi adult	
Pseudodiaptomus forbesi copepodid	
Eurytemora affinis adult	
Eurytemora affinis copepodid	
Sinocalanus doerrii adult	
Sinocalanus doerrii copepodid	
Acartiella sinensis	
Acartiella copepodid	
Tortanus spp.	
Tortanus copepodid	
Osphranticum labronectum	
Osphranticum copepodid	

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 monthly 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.

Field Datasheet

LOWER TROPHIC SAMPLING – YOLO BYPASS STUDY
2015/2016

Location: _____ pH: DO: SpCnd: Cnd (EC):

Crew: Date: Time: Vial #:

Secchi Depth: m Water Temp: °C Weather: Turb: NTU

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

	Yes	No	Replicate		
Chlorophyll Sample :				Time:	Filtered: 500mL OR 250mL
Phytoplankton Sample :			60 mL Amber Bottle w/ Lugol Solution		

Entered by :_____ Date:_____ Checked by :_____ Date:_____

C. Taxonomic Data

Taxonomic results are received via email from the contractor and entered into the AES Access database by DWR personnel. Electronic copies of results for taxonomic 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 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 BSA contractor with the samples, and the contractor is notified of approximate date of delivery.

Example Chain of Custody Form

BSA Environmental Services, Inc.
Chain of Custody

Page 1 of 2

Samples sent from:	West Sacramento	Samples sent to:	Beachwood, Ohio
Samples sent by:	DWR, Jared Frantzich	Contract #: 4600D 11015	
Date:	8/16/2016	Date:	
Transported By:	UPS	Samples received by:	Dr. John R. Beaver
Signature:	Jared Frantzich 8/15/16	Signature:	
Requested Analysis:	Zooplankton		

	Station	Date	ZoopNetType	Time	# of Jars	Comments
1	SHR	3/30/2016	50	8:28	1	
2	SHR	3/30/2016	150	8:28	1	
3	SHR	4/7/2016	50	10:05	1	
4	SHR	4/7/2016	150	10:05	1	
5	SHR	4/18/2016	50	10:55	1	
6	SHR	4/18/2016	150	10:55	1	
7	SHR	5/5/2016	50	8:38	1	
8	SHR	5/5/2016	150	8:38	1	
9	SHR	5/20/2016	50	9:37	1	
10	SHR	5/20/2016	150	9:37	1	
11	SHR	5/31/2016	50	9:15	1	
12	SHR	5/31/2016	150	9:15	1	
13	SHR	6/13/2015	50	9:17	1	
14	SHR	6/13/2015	150	9:17	1	
15	SHR	6/29/2016	50	9:00	1	
16	SHR	6/29/2016	150	9:00	1	
17	SHR	7/6/2016	150	8:57	1	
18	STTD	3/30/2016	50	10:51	1	
19	STTD	3/30/2016	150	10:51	2	
20	STTD	4/8/2016	50	9:58	1	
21	STTD	4/8/2016	150	9:58	1	
22	STTD	4/19/2016	50	9:19	1	
23	STTD	4/19/2016	150	9:19	1	
24	STTD	5/4/2016	50	10:59	1	
25	STTD	5/4/2016	150	10:59	1	
26	STTD	5/19/2016	50	10:08	1	
27	STTD	5/19/2016	150	10:08	1	
28	STTD	6/1/2016	50	10:04	1	
29	STTD	6/1/2016	150	10:04	1	
30	STTD	6/14/2016	50	9:40	1	
31	STTD	6/14/2016	150	9:40	3	
32	STTD	6/30/2016	50	10:40	1	
33	STTD	6/30/2016	150	10:40	1	
34	BL5	6/30/2016	150	11:30	2	
35	LIB	6/30/2016	150	12:15	1	

Example Chain of Custody Form (Continued)

BSA Environmental Services, Inc.
Chain of Custody

N=51 zoop samples (57 Jars)

Samples sent from:	**West Sacramento**	**Samples sent to:**	**Beachwood, Ohio**
Samples sent by:	**DWR, Jared Frantzich**	**Contract #: 4600011015**	
Date:	**8/16/2016**	**Date:**	
Transported By:	**UPS**	**Samples received by:**	**Dr. John R. Beaver**
Signature:		**Signature:**	J. Beaver 8.18.16 3:30
Requested Analysis:	**Zooplankton**		

	Station	Date	ZooNetType	Time	# of Jars	Comments
36	RYI	6/30/2016	150	12:40	1	
37	SRV	6/30/2016	150	13:10	1	
38	LIB	7/7/2016	150	12:58	2	
39	SRV	7/7/2016	150	13:53	1	
40	RCS	7/8/2016	150	9:30	1	
41	RD22	7/8/2016	150	10:22	1	
42	I80	7/8/2016	150	11:49	1	
43	LIS	7/8/2016	150	12:40	1	
44	LIS	7/19/2016	150	10:18	1	
45	STTD	7/19/2016	150	10:40	1	
46	BL5	7/19/2016	150	11:38	1	Lrg Jar/Due To Algae
47	LIB	7/19/2016	150	12:20	2	
48	LIS	8/2/2016	150	9:39	1	
49	STTD	8/2/2016	150	10:02	1	
50	BL5	8/2/2016	150	10:43	1	Lrg Jar/Due To Algae
51	LIB	8/2/2016	150	11:17	1	Lrg Jar/Due To Algae

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