ECOLOGY OF UPPER KLAMATH LAKE SHORTNOSE AND LOST RIVER SUCKERS

2. Larval Ecology of Shortnose and Lost River suckers in the lower Williamson River and Upper Klamath Lake

1999
ANNUAL REPORT (partial)

SUBMITTED TO
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February 25, 2000

INTRODUCTION

The larval life history stage of Klamath Basin suckers has received relatively little study. However, the early life history stages of endangered shortnose and Lost River suckers are targets for much of the restoration activity in the basin, including the restoration of the lower Williamson River delta at Tulana Farms.

This study is part of doctoral dissertation work begun in 1998. Primary questions being evaluated are: 1) whether significant early life history events take place in the Williamson River; 2) whether habitat selection changes with age or location; 3) whether feeding habits change with age or location; 4) whether community structure influences larval sucker survival; and 5) whether differences exist between Lost River and shortnose sucker early life histories. Sampling in 1998 was partly exploratory and was used to guide subsequent sampling in 1999. This report is based on the 1998 sampling but includes preliminary comments on aspects of the 1999 data.

STUDY AREA

The study area is the lower Williamson River and adjacent shorelines of Upper Klamath Lake (UKL) (Figure 1). The sampling was based on the recognition that the lake and the river were fundamentally different areas. Each area was divided into spatially segregated zones to ensure coverage of different habitat types.

The three lake zones were West Shore Tulana (WST), Goose Bay (GB), and other UKL lake sites (Figure 1). The WST zone was at the south-west tip of

Tulana Farms on the far side of the promontory of land west of the river mouth. The littoral zone soils were muck and peat with high organic content, and the lake shore was dominated by non-woody vegetation (i.e., *Scirpus* sp. and *Sparganum* sp.) interspaced with patches of rip-rap, willows, and flotsam (large woody debris, rafts of dead scirpus stems, human litter). The GB zone was the western portion of Goose Bay, a large, shallow, gently sloping, sandy bottomed portion of UKL approximately 1.5 mi east of the river mouth. Until recently, the western shoreline of Goose Bay was devoid of vegetation (L. Dunsmoor, personal communication), but this area has been recently planted with willows. In addition, there are sporadic patches of emergent macrophytes, mostly *Scirpus* and *Polygonum*. Other lake sites (100 m offshore of the Williamson R. mouth, Hagelstein Park and off-shore of Sucker Springs) were sampled with drift nets on an *ad hoc* basis when time permitted.

The four river zones were lower Williamson River (LWR), Big Bend (BB), Modoc Point Road (MPR), and Lonsome Duck (LD). The LWR zone was the lower half mile of river including the river mouth. The Nature Conservancy's Tulana Farms borders the river to the west and Goose Bay Farms borders the east bank. Extensive river widening, deepening, and straightening has occurred in this zone, and the river is isolated from its floodplain by an extensive levee system. The river edges are heavily vegetated with intermingled patches of woody and non-woody plants, and extensive beds of submergent macrophytes (i.e., *Potamageton* spp.) developed as the growing season progressed. The BB zone was approximately half-way between MPR and LWR and slightly upstream of the first Tulana Farms pump-house. It was not sampled in 1998. The river banks are a mixture of emergent macrophytes and willows with a moderate slack water zone 5-10 ft wide. The Nature Conservancy has developed a floodplain pond outside of the river levee in this area and plans to remove the levee and reconnect the river. The MPR zone was immediately downstream of Modoc Point Rd. bridge over the Williamson River. The bridge is approximately four mi from the mouth of the river and downstream from all known sucker spawning locations. The river channel in this area has been dredged and dyked. Both river banks are predominantly grass lined, but sporadic patches of mature willows and emergent macrophytes exist. Cattle grazing occurs along the eastern bank, which has been largely broken down in many places. The LD zone was the eastern bank of the river above the Highway 97 bridge, approximately 8 miles upstream of the mouth of the Williamson and four miles upstream of the MPR zone. It was not sampled in 1998. The river channel suffers from extensive bank degradation resulting from historic cattle grazing practices. A limited amount of small, isolated patches of willows and non-woody macrophytes exist along the river bank and create slack water areas. All other areas have current. The present owners of the property, managing their holdings as a fishing destination resort, are working on a restoration program emphasizing improved cattle grazing practices and addition of large woody debris to the channel.

MATERIALS AND METHODS

Four sampling gears were used: popnets, drift nets, dip nets and directional traps (the latter two in 1999 field season only).

Popnets were one m^2 floating PVC frames attached to stainless steel frames with a remote releasing device, and constructed of 100 *u*m mesh Nitex netting. Popnets were used to sample near shore habitats lacking current, typically 20 - 120 cm deep. Near shore habitats were present in both river and lake environments and were classified into one of three categories based on vegetation; woody (willows), non-woody (either emergent or submergent macrophytes), or no vegetation. When applicable, all vegetation present at each sample site was identified to lowest taxonomic unit practical. For each sample collected, we recorded water depth, distance from shore measured from the net's center, climatic conditions, water temperature and pH. After popnets were set in vegetated habitats, weighted green bamboo rods were placed inside the popnet to recreate ambient natural stem densities. All popnets remained undisturbed for at least 30 min before triggering the device. Popnets were most often deployed during daylight habitat sampling in the different zones. Night-time popnets were used in LWR, two hours after sunset. In addition, they were also used to evaluate sucker preference for *Scirpus* versus *Sparganium* on the eastern edge of WST and to evaluate distribution patterns along a depth gradient in GB (linear array samples). Linear arrays were a four net sequence with one net placed as far from shore as could be reached by wading and three nets placed equi-distant apart in a straight line to the shore. All popnet data are area density estimates (numbers/m^2).

Dip nets were about 1000 *u*m mesh aquarium nets attached to 5' long handles and were also used in near shore habitats. Dip net samples were timed (five minute) active searches. Searches were terminated prior to five minutes if more than 50 larvae were collected. Active search introduces weather and investigator – related variation but increases the likelihood of detecting low larval densities compared to popnets. No dipnet data are presented herein..

Drift nets were one ft diameter constructed with 8 ft long, 800 *u*m mesh, and with a flow meter suspended in the mouth of each net. Drift nets were used to sample open water areas such as the river channel and off-shore areas of the lake. Three deployments of drift nets were made; standard, diel, and benthic (1999 only). Standard deployment occurred in various areas, either at night two hours after sunset, or during daylight. Preliminary data herein are presented as numbers per net, though future analyses will use volume density estimates (numbers/m^3). Diel deployment was for either 12 or 24 hr. Twenty four hr sampling occurred only at MPR in 1998 and involved paired samples, one near the water surface and one near the channel bottom, collected every two hours. Twelve hour sampling occurred only in 1999 at LD, MPR and LWR and involved simultaneous collecting of one surface thalwag sample every hour between sunset and sunrise in the three areas. Benthic drift samples were collected within one foot of the river bottom during daylight at LD, BB, and LWR.

Directional traps were 4 ft. tall rectangular boxes with uni-directional openings and constructed with 800 *u*m mesh netting and 5 ft wings opening outward from the mouth at 45^{o}. Directional traps were always set as back-to-back pairs with one facing upstream and one facing downstream.

Sampling in 1998 was based on a three-week rotation. Week 1 was standard drift sampling with two nights at MPR and two nights at LWR and other UKL (100 m from river mouth). Additional drift samples were collected during day light hours from other UKL sites not safely sampled at night (GB, Hagelstein Park and off-shore of sucker springs). Week 2 was popnet sampling in two river zones, MPR and LWR, and two lake zones, WST and GB. Effort was equally distributed among the three habitat categoreis present in each zone. Week 3 was process-oriented sampling to evaluate: 1) differences in sucker preference for *Scirpus-Sparganium*, 2) differences in sucker preference along a linear depth array, 3) night-time popnet sampling, and 4) 24 hr. drift sampling.

Sampling in 1999 was adjusted to a one week rotation with drift and popnet samples collected simultaneously where possible. Six zones, excluding other UKL, were visited once per week during daylight hours and LD, LWR, and WST were visited once per week at night. Benthic drift samples were collected within one foot of the river bottom during daylight at LD, BB, and LWR. All night collections began two hours after sunset. On four occasions, the schedule was supplemented with 12-hour sampling at LD, MPR, LWR.

All collections were immediately preserved in the field with 10% formalin and stained with Alazarin red-S. Within 72 hours of collection, all samples were sorted, fishes removed and transferred to 70% ethanol. In 1998, all popnet samples were saved, after removal of fishes, for food availability analysis. In 1999, a subset of popnet samples were retained. All other samples were discarded after removal of fishes.

All fishes were identified to lowest possible taxon under a stereo-microscope at 7-30X magnification and standard length (SL), developmental stage, and gut fullness recorded. We used the following developmental stages, modified from Snyder and Muth (1990) with all border-line cases placed in the more advanced stage. Protolarvae – larval stage between swim-up and initiation of flexion, characterized by a straight notochord. Early flexion mesolarvae – larval stage characterized by notochord flexion, sometimes with one or more caudal fin rays developed. Middle flexion mesolarvae – larval stage characterized by formation of caudal rays in the lower third to lower two thirds of the caudal fin. Late flexion mesolarvae – larval stage characterized by formation of caudal rays in the lower two-thirds of the caudal fin up to completion. Post-flexion mesolarvae – larval stage characterized by a full complement (16-20) of caudal fin rays with hypural plates at or near perpendicular to median line of fish. Metalarvae – larval stage characterized by completion of all median fin rays. Juvenile – stage characterized by completion of all median and paired fins and complete resorption of fin folds. Gut fullness was categorized as: empty - no material present in gut; low – up to 20% of gut cavity volume full; medium - 20-50% of gut cavity volume full; medium high – 50-95% of gut cavity volume full; and high – gut full to capacity with no free space.

RESULTS

The 1998 sampling began 25 April and ended 29 July. We collected 401 samples and 1,745 larval or juvenile suckers (Table 1). By comparison, the 1999 sampling began 26 April, ended 16 July and we collected approximately 12,000 larval and juvenile suckers. Overall, samples from the river area contained >93% of preflexion larvae and samples from the lake contained >94% of post-flexion larvae and juveniles (Table 2). Flexion larvae were about equally abundant in both areas. Overall, larvae from the river were smaller and the range of variation in length smaller than for lake samples (Figure 2).

Standard drift samples

One hundred ninety seven drift samples were collected in the MPR and LWR and 46 drift samples were collected from other UKL sites in 1998. Sucker larvae caught at other UKL sites were larger and had a larger size range than suckers caught at either river location (Figure 3). Sampling bias would be expected to be towards smaller fish at other UKL sites sampled during daylight than river sites sampled at night. Within the river, larvae were less abundant but larger in the upstream MPR zone than in the downstream LWR zone (Figure 3). Larvae captured in MPR were significantly larger than those in LWR (Kolmpogov-Smirnov test of ranks, $p<0.0001$). Although we caught an order of magnitude more larvae at LWR, very few were greater than 12.5 mm which was about the modal size of larvae upstream at MPR. As would be expected, however, most larvae at MPR were preflexion while those at LWR were about equally prelexion and flexion larvae (Table 3). Most sucker larvae caught in the river had empty guts (Table 4). In mid-June a larger proportion of larvae from LWR had non-empty guts than those from MPR (Table 4).

Diel drift samples

Four 24-hr drift sampling events were conducted in MPR in 1998 (21-22 May, 9-10 June, 30 June – 1 July, and 21-22 July). Total numbers of sucker larvae caught per event were 27, 92, 10, 0,respectively. Catch of larval suckers was highly restricted to 2100-0500 hrs with peak density at 0300 hr (Figure 4). We saw no obvious differences in stage of development and time of day. All specimens had empty guts.

Daylight habitat sampling with popnets

Four daylight habitat sampling events were conducted with popnets in MPR, LWR, WST, and GB in 1998 (12-15 May, 1-5 June, 22-26 June, and 14-17 July (Table 5). Most sucker larvae were caught during late June. Of 498 sucker larvae captured, 448 were in non-woody habitats, 20 in woody, and 30 in un-vegetated areas (Table 5). Collections in 1999 also show preference for non-woody vegetation.

The GB samples were the only ones with 10 or more larvae collected in each habitat type (Table 5). In GB, the number of suckers in non-woody habitats was significantly greater than the number in woody or un-vegetated habitats (one way ANOVA, p=0.015). However, standard lengths of suckers in woody habitats were significantly larger than suckers in the other habitats (one way ANOVA, p=0.0002). A non-parametric Kruskal-Wallace comparison of ranked lengths yielded similar results.

Developmental stage of larvae caught was dependent on the area sampled. In late June, pre-flexion larvae dominated collections from the two river zones while older larvae and juveniles dominated collections from the two lake zones (Table 6). An exception to this pattern was the collection of five post-flexion suckers at LWR in a single popnet on 17 July.

The guts of most larvae caught in the two river zones were empty while >42% of larvae from lake zones had a gut fullness index of medium or greater (Table 7). Within the lake, 68% of GB (N=88) and 42% of WST (N=288) had medium or greater gut fullness (Table 7). Older, more developed larvae had greater gut fullness (Table 8). However, when comparing across zones within a single developmental stage, it is clear that food in the gut is mostly dependent on zone of capture (Table 8). Flexion larvae, which were present at all sample locations, appeared more likely to have medium or greater gut fullness in lake zones than river zones (Table 8).

Scirpus-Sparganium habitat sampling with popnets

Scirpus-Sparganium comparisons were made on five days from side by side habitat patches near the eastern edge of WST (Table 9). Larvae were present only during the first two sampling dates. There was no significant difference in number of suckers caught in each habitat (two-way two-sample T-test; p=0.510). There is no obvious difference in gut fullness between the two habitats. However, standard lengths of suckers captured in each habitat were significantly different (two-way, two-sample T-test; p=0.0015) and there were more post-flexion larvae in *Sparganium* in both June samples. Water temperatures were similar between habitats but the *Sparganium* patch had lower pH values (equipment failure limited water quality collections to three days and prohibits further analysis).

Linear-array depth sampling with popnets

Six linear-array samples were conducted in GB in 1998. Distance from shore ranged from 2.0 to 23.9 m. Four of 24 popnets captured larval suckers. All positive collections were between 7.1 and 8.7 m off-shore but three other samples at similar distances (between 6.9 and 8.8 m off shore) did not capture suckers. There were no obvious patterns in environmental parameters that correlate with this pattern.

Night – Day Popnet Comparisons

We collected 6 night time popnet samples in LWR in 1998. Unfortunately, the night time popnet samples were not collected during the narrow time window when sucker larvae were abundant in LWR. Only three suckers were collected. In 1999, more night popnet samples were collected from more zones.

Comparison of contemporaneous drift and popnet samples

Drift and popnet samples were collected at similar times and locations within LWR on three occassions in 1998 (Table 10). Developmental stage (Table 10) and length were not significantly different between the two sample types. However, 21 % of June suckers from popnets had gut fullness of medium or better compared to <1% for suckers from drift nets (Table 11). In 1999, more contemporaneous drift and popnet sampling was conducted.

DISCUSSION

Preflexion larvae were primarily found in the Williamson River (MPR and LWR zones) in both popnets and drift nets and were largely absent from the lake (Tables 2 & 6). In this area of Upper Klamath Lake there was little evidence of in-lake production of sucker larvae and our samples are presumed to come from Williamson/ Sprague River spawners. Agency Lake subbasin or in-lake larval production is therefore presumed a minor component of these samples.

Flexion larvae are primarily found in LWR in drift samples (Table 3) but are much more abundant in lake zones, especially WST, in daylight popnet samples (Table 6). These data suggest that flexion occurs quickly in LWR and these larvae quickly leave the river and are unavailable to popnets in the river but are available to popnets in the lake. One likely explanation for the quick departure from the river is lack of food. Larvae from drift samples (Table 4) and popnet samples (Table 7) in the river zones, MPR and LWR, seldom have food in the gut. More significantly, the comparison of a single developmental stage, flexion larvae, across river and lake zones shows a dramatic difference in gut fullness with the lake-caught larvae much more likely to have food in the gut (Table 8).

The timing and process by which larvae traverse the distance from the spawning grounds to the lake would therefore appear to be important. Passive drift in the river is clearly temporally restricted to about a four hr period after midnight (Figure 4). Within LWR there is no difference in developmental stage between contemporaneous drift and popnet samples (Table 10) though guts are more likely to have food in popnet samples. Clearly the distance passively drifted will depend on river flow and, for this event, would seem to favor larvae born early in the season. Active daylight movement along the shoreline and deepwater channel drift are additional potential dispersal mechanisms. Data collected in 1999 were designed to address questions about alternative dispersal mechanisms and whether larvae could accomplish the dispersal task in one night.

All post-flexion larvae and juveniles were found in the lake (Tables 2, 3 and 6), primarily in popnet samples. Larvae in popnet samples appear to prefer non-woody vegetation (emergent and submergent macrophytes) (Table 5), though there is preliminary evidence that larger individuals might prefer woody vegetation. Preliminary data also suggest a trend for larvae to prefer *Sparganium* to *Scirpus* (Table 9), though sample sizes were very small.

These data strongly suggest that growth and development of larval suckers is better in Upper Klamath Lake than in the Williamson River. If early growth minimizes starvation and minimizes the probability of predation, increased larval sucker survivorship would be maximized by facilitating transport of larvae through the Williamson River and into Upper Klamath Lake. In the lake, larval suckers use non-woody vegetated habitats to a much greater extent than nearby unvegetated areas.

Table 1. Summary of drift net and popnet sampling effort and sucker catch in 1998.

	No. drift samples	No. suckers in drift	No. popnet samples	No. suckers in popnets	Total no. suckers
River	197	920	59	95	1015
Lake	46	114	99	616	730
Totals		1034		711	1745

Table 2. Summary of sucker developmental stages in river and lake sampling areas, 1998. N represents number of specimens and % represents the percent of that stage caught in that area.

Developmental stage	River		Lake		Total
	N	%	N	%	N
Preflexion, yolk	54	96	2	4	56
Preflexion	542	93	39	7	581
Flexion, yolk	17	85	3	15	20
Flexion	383	43	508	57	891
Post-flexion mesolarvae	1	1	104	99	105
Metalarvae	3	6	44	94	47
Juvenile	1		22		23
Damaged / undetermined	15		7		22
Total					1745

Table 3. Developmental stages of sucker larvae collected in standard drift samples at MPR, LWR and other UKL sites, 1998. N represents number of specimens and % represents the percent of that stage caught in that area.

Developmental stage	MPR		LWR		UKL	
	N	%	N	%	N	%
Preflexion, yolk	10	25	28	70	2	5
Preflexion	56	15	310	81	18	4
Flexion, yolk	1	6	16	89	1	6
Flexion	12	3	339	83	58	14
Post-flexion mesolarvae	-		-		18	100
Metalarvae	-		-		4	100
Juvenile	-		-		7	100
Damaged	3		4		6	100
Total	82		697		114	

Table 4. Summary of gut fullness indices for sucker larvae from standard drift samples, 1998.

Gut fullness	25-29 May		15-19 June		7-16 July	
	MPR	LWR	MPR	LWR	MPR	LWR
Empty	25	69	55	515	-	3
Low	-	2	2	93	1	1
Medium	-	-	-	5	-	-
Medium high	-	-	-	1	-	1
High	-	-	-	0	-	-
No data	4	3	1	4	-	-

Table 5. Summary of mean number of sucker larvae (bold) caught during daylight habitat sampling with popnets, 1998. N= sample size, ND = no samples taken, NW = Non-woody habitat, W = woody habitat, No= habitat without vegetation.

Date	12-15 May			1-5 June			22-26 June			14-17 July		
	NW	W	No	NW	W	No	NW	W	No	NW	W	No
MPR	**0**		**0**	**0**	**0**	**0.5**	**13**	**0**	**0**	**0**	**0**	**0**
N	2	ND	2	2	1	2	3	2	3	3	1	3
LWR	**0**	**0**	**0**	**1.3**	**1.3**	**1.0**	**11**	**0.7**	**1.7**	**1.7**	**0**	**0**
N	2	2	2	4	3	3	3	3	3	3	2	3
WST	**0**			**0.6**	**1.0**	**0.3**	**94**		**2**	**0.3**	**0**	**0.6**
N	4	ND	ND	3	1	3	3	**ND**	3	3	2	3
GB	**0**	**0**	**0**	**2.3**	**0.3**	**0.3**	**25**	**4**	**3.7**	**0**	**0**	**0**
N	2	2	1	3	3	3	3	3	3	3	3	3

Table 6. Comparison of number of sucker larvae in each developmental stage and each sampling zone for daylight popnet sampling 22-26 June, 1998.

Stage	MPR	LWR	WST	GB
Preflexion, yolk	-	-	-	-
Preflexion	31	27	3	1
Flexion, yolk	-	-	2	-
Flexion	9	12	232	59
Post-flexion mesolarvae	-	-	26	23
Metalarvae	-	-	20	10
Juvenile	-	-	5	5

Table 7. Summary of gut fullness indices for sucker larvae in each sampling zone for daylight popnet sampling 22-26 June, 1998.

Gut fullness	MPR	LWR	WST	GB
Empty	38	11	65	8
Low	2	20	103	20
Medium	-	-	23	4
Medium High	-	8	35	33
High	-	-	26	18
Not Visible	-	-	36	15

Table 8. Summary of gut fullness indices for each developmental stage of sucker larvae in each sampling zone for daylight popnet sampling 22-26 June, 1998.

	Empty	Low	Medium	Med. High	High	NV
MPR						
Preflexion w/Yolk	-	-	-	-	-	-
Preflexion	31	-	-	-	-	-
Flexion w/Yolk	-	-	-	-	-	-
Flexion	7	2	-	-	-	-
Post-Flexion	-	-	-	-	-	-
Mesolarvae						
Metalarvae	-	-	-	-	-	-
Juvenile	-	-	-	-	-	-
LWR						
Preflexion w/Yolk	-	-	-	-	-	-
Preflexion	8	15	-	4	-	-
Flexion w/Yolk	-	-	-	-	-	-
Flexion	3	5	-	4	-	-
Post-Flexion	-	-	-	-	-	-
Mesolarvae						
Metalarvae	-	-	-	-	-	-
Juvenile	-	-	-	-	-	-
WST						
Preflexion w/Yolk	-	-	-	-	-	-
Preflexion	1	1	-	1	-	-
Flexion w/Yolk	1	1	-	-	-	-
Flexion	61	100	21	31	15	4
Post-Flexion	2	1	2	3	10	8
Mesolarvae						
Metalarvae	-	-	-	-	1	19
Juvenile	-	-	-	-	-	5
GB						
Preflexion w/Yolk	-	-	-	-	-	-
Preflexion	1	-	-	-	-	-
Flexion w/Yolk	-	-	-	-	-	-
Flexion	2	14	4	23	13	3
Post-Flexion	4	6	-	8	5	-
Mesolarvae						
Metalarvae	1	-	-	2	-	7
Juvenile	-	-	-	-	-	5

Table 9. Mean number of larval suckers caught during *Scirpus / Sparganium* popnet sampling, 1998. N= sample size.

	Scirpus		*Sparganium*	
Date	N	suckers	N	suckers
11 June	2	9	2	15
16 June	2	31.5	2	43
6 July	2	0	2	0
8 July	1	0	1	0
23 July	2	0	2	0

Table 10. Comparison of developmental stages of larval suckers from contemporaneous drift and popnet samples in LWR, 1998.

Date	5/26 - 6/5		6/16 - 24		7/7 - 17	
Developmental Stage	Drift	Popnet	Drift	Popnet	Drift	Popnet
Preflexion, yolk	7	-	21	-	-	-
Preflexion	58	8	249	27	3	-
Flexion, yolk	1	-	15	-	-	-
Flexion	6	1	331	12	2	-
Post-flexion mesolarvae	-	-	-	-	-	1
Metalarvae	-	-	-	-	-	3
Juvenile	-	-	-	-	-	1
Damaged	2	2	2	-	-	-
Total	74	11	618	39	0	0

Table 11. Comparison of gut fullness of larval suckers from contemporaneous drift and popnet samples in LWR, 1998. ND = not determined.

Date	5/26-6/5		6/16-24		7/7-17	
Gut fullness	Drift	Popnet	Drift	Popnet	Drift	Popnet
Empty	69	7	515	11	3	-
Low	2	1	93	20	1	-
Medium	-	-	5	-	-	-
Medium high	-	-	1	8	1	-
High	-	-	-	-	-	3
ND	3	3	4	-	-	2

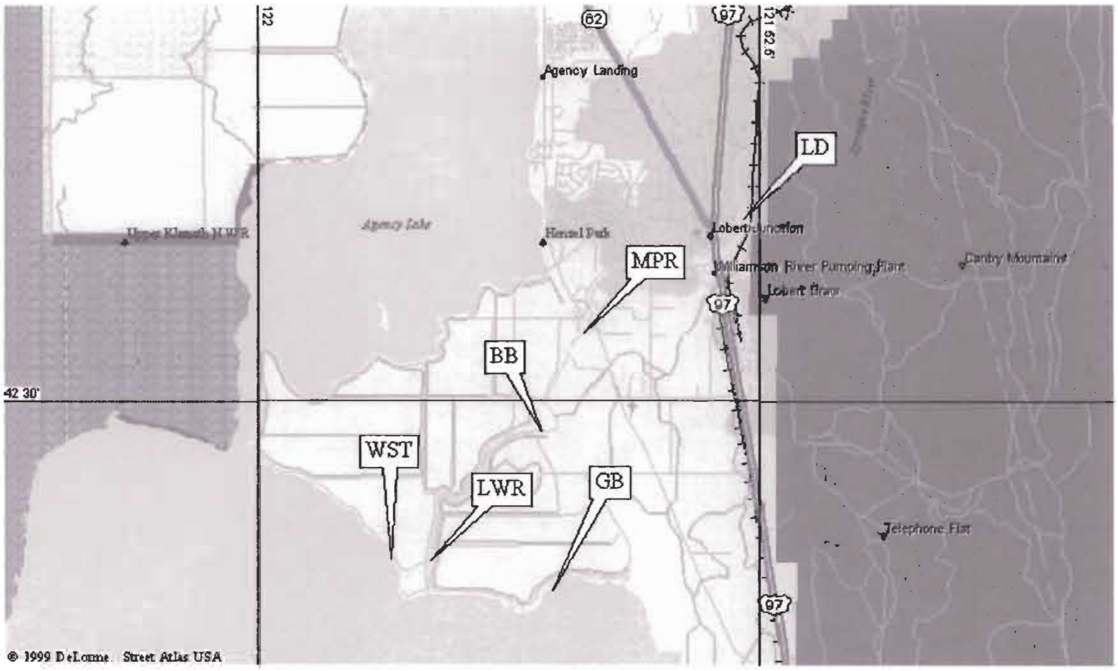

Figure 1. Map of lower Williamson River and Upper Klamath Lake showing sampling zones; LD –Lonesome Duck, MPR – Modoc Point Road; BB – Big Bend; LWR – lower Williamson River; WST- west shore Tulana; and GB – Goose Bay. Other UKL sites not shown.

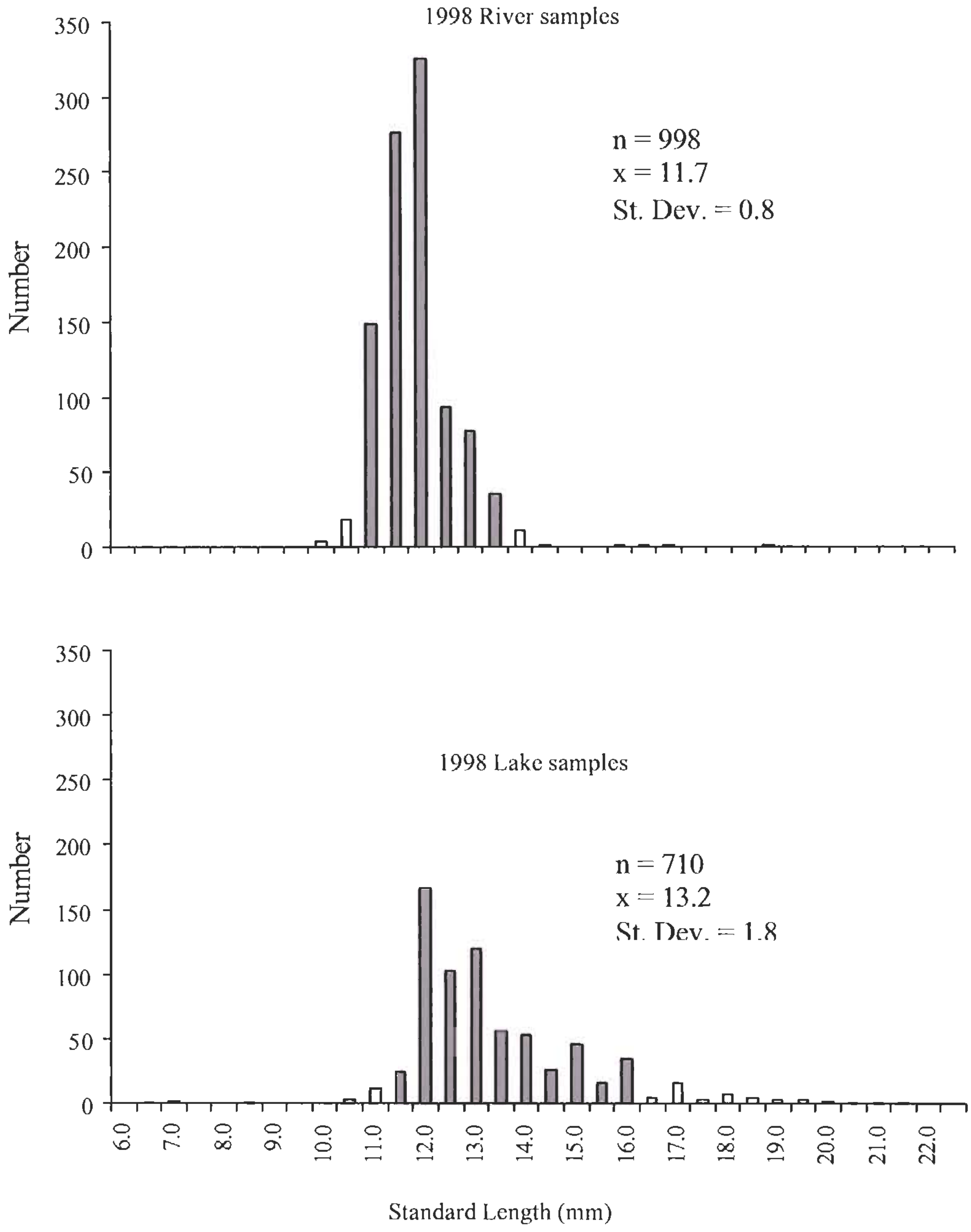

Figure 2. Size distribution of suckers collected in the Williamson River and Upper Klamath Lake, 1998.

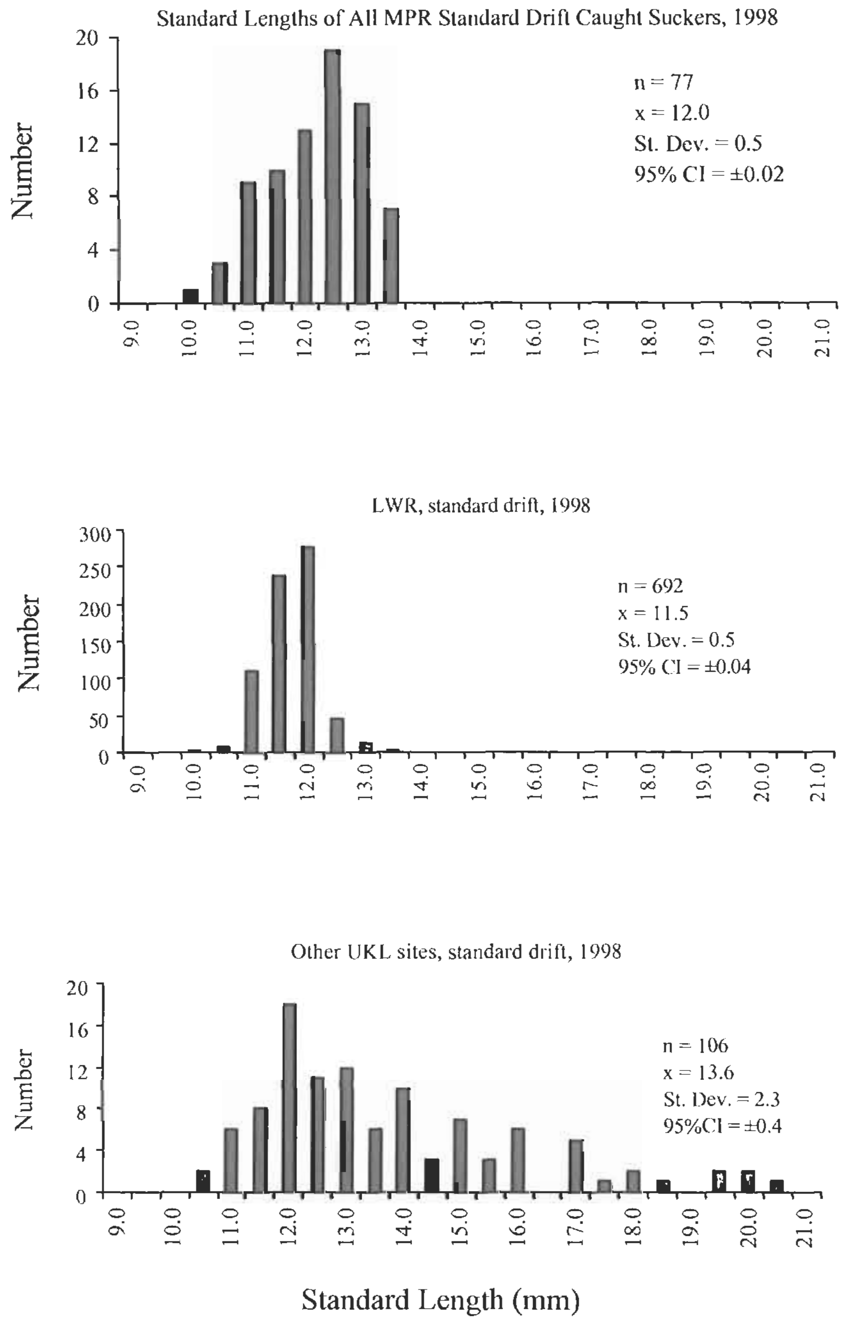

Figure 3. Size frequency distributions for standard drift samples in 1998 at MPR, LWR and other UKL sites.

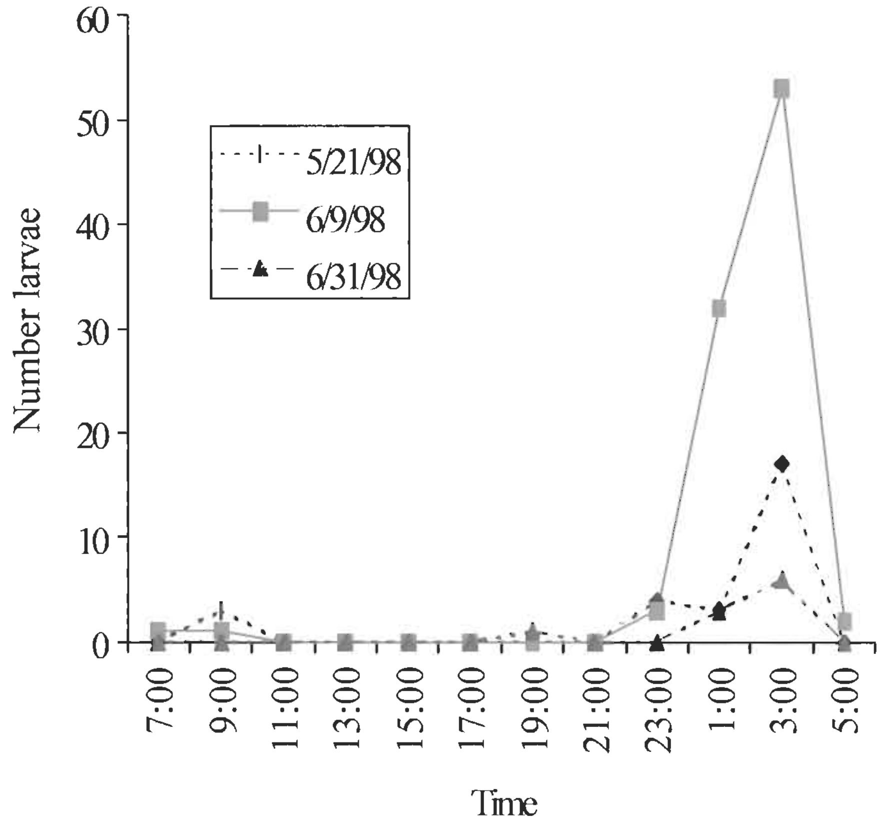

Figure 4. Relationship between total number of sucker larvae captured in surface and bottom nets and time of day for three 24-hr drift sampling events at MPR, 1998.

Literature Cited

Snyder, D.E. and R.T. Muth, 1990. Descriptions and identification of razorback, flannelmouth, white, Utah, bluehead, and mountain sucker larvae and early juveniles. Tech. Pub. No. 38, Colorado Division of Wildlife, 152 p.