ANNUAL PROGRESS REPORT

FISH RESEARCH PROJECT
OREGON

Willamette Valley Projects- Lookout Point- Oregon Chub (2006)

Contract Number: ACOE Task Order FW2006-02 (FY06)
ODFW Cost Code: 53400-534000-10

Project Period: 1 October 2005- 30 September 2006

Prepared by: Paul Scheerer and Steve Jacobs
Oregon Department of Fish and Wildlife
28655 Highway 34
Corvallis, Oregon

Mark Terwilliger
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon

This project was financed with funds administered by the U.S. Army Corps of Engineers.

CONTENTS

INTRODUCTION

The Oregon chub *Oregonichthys crameri,* endemic to the Willamette Valley of western Oregon, was listed as endangered in 1993 under the federal Endangered Species Act (Rhew 1993). This species was formerly distributed throughout the Willamette Valley (Markle et al. 1991) in off-channel habitats such as beaver ponds, oxbows, stable backwater sloughs, and flooded marshes. These habitats are characterized by little to no water flow, silty and organic substrate, and abundant aquatic vegetation and cover for hiding and spawning. In the past 100 years, these habitats have been drastically reduced because of changes in seasonal flows resulting from the construction of dams throughout the basin, channelization, revetments, diking, and drainage of wetlands. This loss of habitat, combined with the introduction of non-native species to the Willamette Valley such as largemouth bass *Micropterus salmoides* and bluegill *Lepomis macrochirus,* have been implicated in the decline and the restricted distribution of Oregon chub (U.S. Fish and Wildlife Service 1998).

Oregon Department of Fish and Wildlife (ODFW) monitored the effects of water storage and flow management operations at Lookout Point Reservoir from 2000-2005 and found that changes in reservoir elevation directly affected water levels, water temperatures, and the suitability and availability of Oregon chub spawning habitat in Hospital Pond (Scheerer and McDonald 2000; 2001; 2003; Scheerer and Terwilliger 2002; 2003; 2004; Scheerer et al. 2005). Seasonal changes in reservoir and pond elevations were found to affect Oregon chub spawning success and juvenile survival. We found that the filling of the reservoir and flooding of the pond terrace were necessary to increase pond temperatures (>15^{o}C) that allow for successful Oregon chub spawning in Hospital Pond (Scheerer and McDonald 2000).

In 2000, following the listing of Willamette spring chinook and winter steelhead under the federal Endangered Species Act (NOAA 1999), flow management in the Willamette River was modified. New minimum conservation flows at Albany and Salem were recommended during April through June of each year (Mamoyac et al. 2000). Management of tributary flows was also altered to balance the demand for water for recreation in the Willamette subbasins with flow levels at Albany and Salem. Because Lookout Point has some of the lowest recreational use and the highest storage volume of the Willamette reservoirs, the demand to draft this reservoir to provide spring flows increased. Under the new management regime, Lookout Point Reservoir was not projected to fill, or if it filled it was not projected to remain full through the chub spawning season (May through mid-July), in most years. In 2000, the Corps initiated a study to determine the feasibility of modifying Hospital Pond to provide managers the ability to independently regulate pond elevation. ODFW was contracted to collect life history and population data to assess the effects of these modifications on Oregon chub abundance and recruitment (Scheerer and McDonald 2001; Scheerer and Terwilliger 2002; 2003; 2004; Scheerer et al. 2005).

Hospital Pond is a long (~300 m), narrow (6-10 m), deep (2-5 m), spring-fed pond that was created during the construction of the North Shore Road near Lookout Point Reservoir (Figure 1). A culvert connects the pond to Lookout Point reservoir at reservoir elevations exceeding 916 ft (full pool elevation is 926 ft). Prior to 2001, the availability of suitable Oregon chub spawning habitat in Hospital Pond was dependent on the flooding of the vegetated terrace. Pond elevation was determined solely by Lookout Point Reservoir elevation. When the reservoir elevation exceeded 921 feet, the vegetated terrace was flooded. This occurred over a 9-10 week period from early-May to mid-July. Hatch date analyses showed that

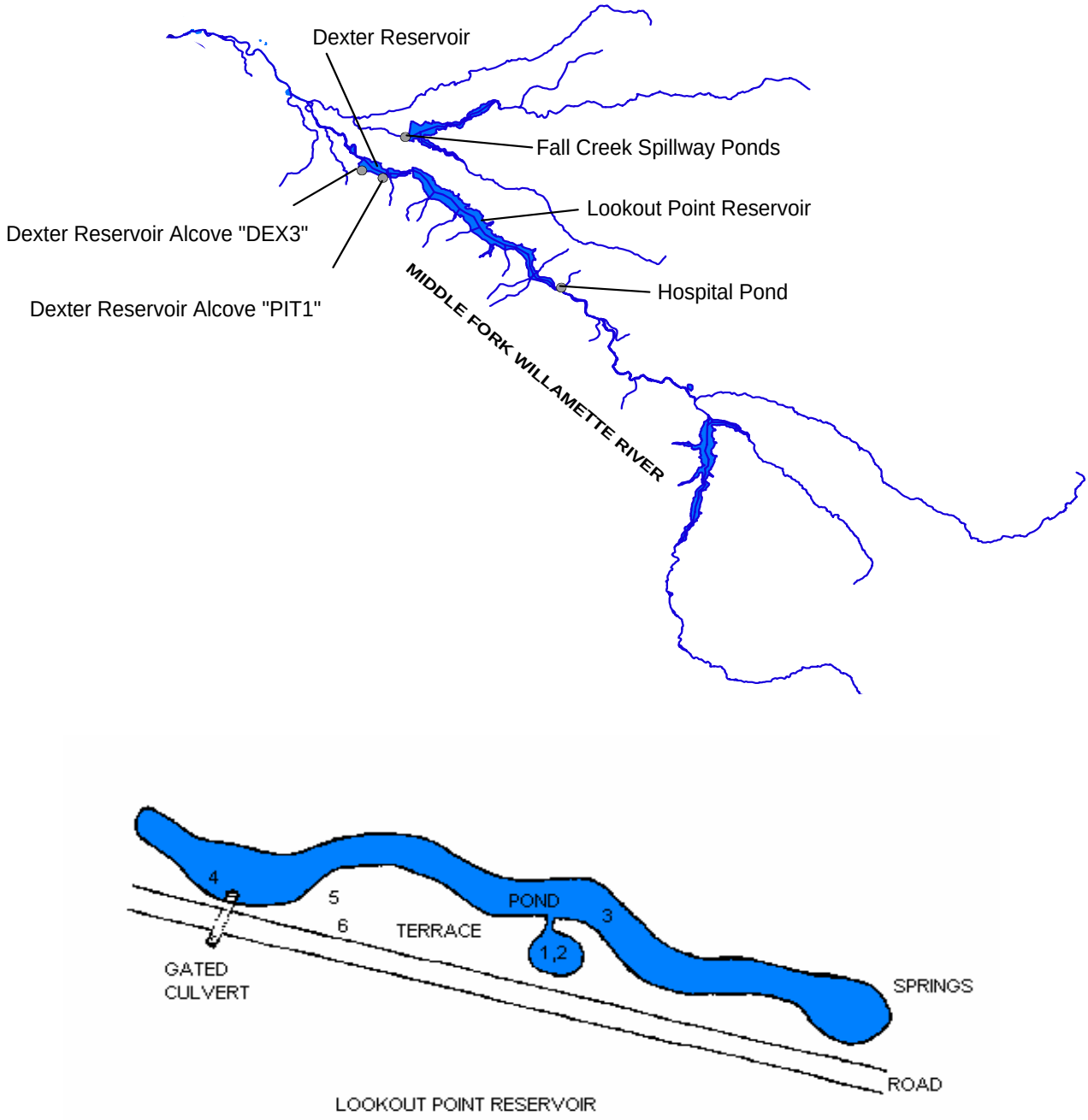


Figure 1. Map (top) showing the locations of Oregon chub sites located on Corps properties in the Middle Fork Willamette River drainage. Diagram of Hospital Pond (bottom) showing locations of temperature monitors placed in the alcove (1-surface, 2-substrate), the pond (3-surface, 4-substrate), the terrace (5-substrate), and in a tree located on the terrace (6-air temperature). The springs that feed the pond are located at the east end and the gated culvert is located at the west end. The terrace is located between the pond and the North Shore Road. Lookout Point Reservoir is located south of the road.

successful spawning of Oregon chub occurred only when the reservoir elevation exceeded 921 ft and the vegetated terrace was flooded (Scheerer et al. 1998, Scheerer and McDonald 2000). After the reservoir level dropped in mid-July, the water temperature in the pond dropped, and no successful spawning was documented. In 2001, the Willamette Basin experienced drought conditions and Lookout Point reservoir did not fill. These conditions negatively impacted the recruitment of Oregon chub in Hospital Pond. Successful spawning was limited in 2001, resulting in a weak 2001 year-class.

Pond modifications were conducted in 2001-2003. In the spring of 2001, the Corps installed a gate on the culvert exiting Hospital Pond. However, leakages around the culvert and through the road fill prevented managers from being able to increase pond elevations enough to flood the pond terrace. In the spring of 2002, the Corps sealed the western end of the pond with bentonite clay and reconstructed the gate on the culvert. In 2002, we were able to maintain the pond elevation above the elevation of the vegetated terrace (921 ft.), only when the reservoir elevation exceeded 917 ft. When the reservoir dropped below 917 ft, the pond elevation stabilized at 920 ft. In 2003, the Corps excavated a shallow alcove in the terrace to provide potential spawning habitat that was available for Oregon chub at the pond elevations less than 920 ft. In 2003-2005, the newly excavated alcove was flooded from May through October. However, we found that water temperatures in the alcove exceeded 15^{o}C only when the water depth in the alcove was relatively shallow (<1.5 feet).

This report contains the results of research conducted in 2006 at Hospital Pond, including monitoring of air and water temperature profiles, monitoring of reservoir and pond level elevations, and the collection and analysis of Oregon chub aging and hatch date data. These data will be useful to the Corps for planning near-term and long range water storage and flow management and to protect Oregon chub and their habitat in Hospital Pond. This report also contains results of monitoring naturally occurring and reintroduced Oregon chub populations on Corps properties in the Willamette Valley.

METHODS

Temperature Monitoring

Temperature recorders (Hobo®) were placed at six locations in Hospital Pond (Figure 1). One recorder was placed on the substrate near the culvert at the southwestern end of the pond, a second recorder was attached to a cable that was anchored to a post and was floated in the pond approximately 0.1 m below the surface near the center of the pond, a third recorder was placed on the substrate of the alcove, a fourth recorder was floated approximately 0.1 m below the surface in the alcove, and a fifth recorder was placed on the shallow vegetated terrace on the south side of the pond. Air temperature was monitored with a recorder placed on the branch of a tree (approximately 1.5 m above the ground) growing on the edge of the shallow vegetated terrace of the pond. This recorder was covered with moss and remained in the shade throughout the day. Recorders were set to record at five hour intervals. The maximum temperature recorded each day was used to determine whether the threshold temperature of approximately 15^{0}C, necessary for Oregon chub to spawn, was exceeded (Scheerer and McDonald 2000).

Monitoring Pond and Reservoir Elevations

Staff gages were installed on the gate structure of the culvert and in the alcove. The staff gage in the culvert was pushed 0.6 meters into the substrate to match the readings on the gage mounted on the gate structure. Water elevations were recorded from April through September. The elevations of culvert and the bottom of the alcove are approximately 916.0 feet and 916.6 feet, respectively.

Adult Aging

In April 2006, we collected a sample of 75 adult Oregon chub from Hospital Pond using baited minnow traps. The fish were collected to determine the age structure of the population. To reduce the probability of collecting a biased sample for aging, a total of 200 fish were measured during the marking phase of the mark-recapture estimate to determine the size distribution in the pond. Total lengths were measured to the nearest millimeter and were separated into 5 mm categories. Then, based on this size distribution, we collected similar proportions from each 5 mm category for the aging sample. The fish were sacrificed and placed in 95% ethanol. Samples were taken back to the lab to be processed. The right lapillus was removed from each fish using a fine tip probe under a dissecting scope. Each otolith was soaked in a 10% bleach solution for several minutes to remove tissue, rinsed twice with distilled water, rinsed a third time with 95% ethanol, and allowed to air dry (Secor et al. 1992). Otoliths were embedded into molds (plugs) of Spurr® epoxide resin (Spurr 1969). Plugs were mounted on glass slides for thin sectioning using a low speed Isomet® diamond blade saw. Two transverse cuts were made into the plug to produce a thin section (0.5 mm) that included the otolith core. Thin sections were mounted on glass slides in Crystal Bond, ground using 1500 grit wet/dry sandpaper, and polished using Buehler Gamma Micropolish alumina solution (0.05μ) and a Buehler Microcloth polishing cloth. Adult otoliths were aged using transmitted light at 250X under a compound scope (Hoff et al. 1997). Adult otoliths were read twice by one reader. If there was a discrepancy, a third reading was made. In these cases, the age determined in the majority of reads was assigned to the fish.

Hatch Date Distribution

In mid-October 2006, we collected 50 juvenile Oregon chub from Hospital Pond to determine their hatch date distribution and to relate the onset and duration of spawning with pond temperatures. Otoliths (right lapilli) were removed using a fine tip probe under a dissecting scope. Otoliths were mounted dorsoventrally in Crystal Bond® on glass slides and polished in the sagittal plane to the core. Otoliths were flipped and polished on both sides to improve resolution of growth increments. Otoliths from juvenile chub were ground and polished in the same manner as otoliths from adult chub. Otoliths were aged with transmitted light at 500X using a microcomputer equipped with Optimas® imaging software. Each translucent-opaque band represented a daily growth increment (DGI) (Campana and Neilson 1985). DGI were counted from the core out to and including the posterior edge of the otolith. Increments that disappeared when adjusting the fine focus were not counted as DGI. Hatch dates were estimated by subtracting the number of daily increments from the collection date. Otoliths from juvenile fish were read three times by one reader. A final age was assigned that was the median of the three counts. Hatch dates were combined into one-week (7-day) categories. Spawning dates were estimated to be seven days prior to the hatch date. Data for incubation time are not available for Oregon chub. We used available data, approximately seven days from spawning to hatching, for redside shiner *Richardsonius balteatus* (Weisel and Newman 1951).

Population Estimates

In 2006, we obtained population estimates for naturally occurring Oregon chub populations at Hospital Pond and the Dexter Reservoir alcoves and for introduced Oregon chub populations in the Fall Creek Spillway Ponds and Foster Pullout Pond. Minnow traps (23 cm x 46 cm with 64 mm mesh) were used to capture chub. We baited the traps with a third of a slice of bread and fished them for 3 to 4 hours. We marked fish with a partial caudal fin clip and returned them to the water. We estimated population abundance using single-sample mark-recapture procedures (Ricker 1975). Confidence intervals were calculated using a Poisson approximation (Ricker 1975). Fish smaller than 40 mm in length were not captured by the minnow traps and were not included in the estimates. Excluded from estimates were all age 0 and some age 1 fish (Scheerer and McDonald 2000).

RESULTS

Temperature Monitoring

Water temperatures in Hospital Pond varied substantially depending on the location of the temperature monitor (Figure 2). From April 4 through October 11, changes in water temperature measured near the surface of the pond (mean 17.0^{o}C; range 12.9-26.3^{o}C), near the surface of the alcove (mean 14.7^{o}C; range 7.8-27.2^{o}C), and on the substrate in the alcove (mean 14.7^{o}C; range 7.8-26.3^{o}C) closely paralleled changes in air temperature (mean 18.7^{o}C; range 6.2-30.3^{o}C). Water temperatures were substantially cooler and remarkably constant on the bottom of the pond during this period (mean 11.0^{o}C; range 9.4-12.1^{o}C). Cold dense spring water enters the pond at the eastern end, flows through the pond, and exits the pond through the culvert at the southwestern end. A warmer surface stratum covers the cold stratum and extends ~0.1 m down from the surface. In 2006, when reservoir levels exceeded 921 ft from May 30 through July 28, water temperatures on the terrace averaged 16.8^{o}C (range 14.0-23.6^{o}C). As the reservoir and pond levels dropped in August, water temperatures in the alcove exceeded 15^{o}C (alcove water depth ranged from 0.6-1.6 feet). Cove temperatures from August through September averaged 20.0^{o}C (range 12.9-26.3^{o}C).

Pond and Reservoir Elevations

We closed the gate on the pond's outflow culvert on April 4. The pond depth fluctuated between 2.6 and 3.7 feet (918.6 and 919.6 feet elevation) through mid-May, increased in June to a maximum of 9.0 feet (925.0 feet pond elevation; 926.4 feet reservoir elevation), remained high (7.0 to 9.0 feet) through mid-July (reservoir elevation > 924.0 feet), then fluctuated between 1.2 and 2.2 feet from mid-August through October as reservoir elevation dropped steadily from 924.0 to 877.7 feet in elevation (Figure 3). The pond terrace was flooded from May 30 through June 28. Water depth on the terrace averaged 3.4 feet (range 2.0-4.0 feet) during this period. The cove depth was 2.0 to 4.2 feet through mid-May, was completely flooded (as was the terrace) through mid-July (6.4 to 8.4 feet), and then fluctuated between 0.6 and 1.2 feet from mid-August through October. We opened the gate on the culvert on October 23.

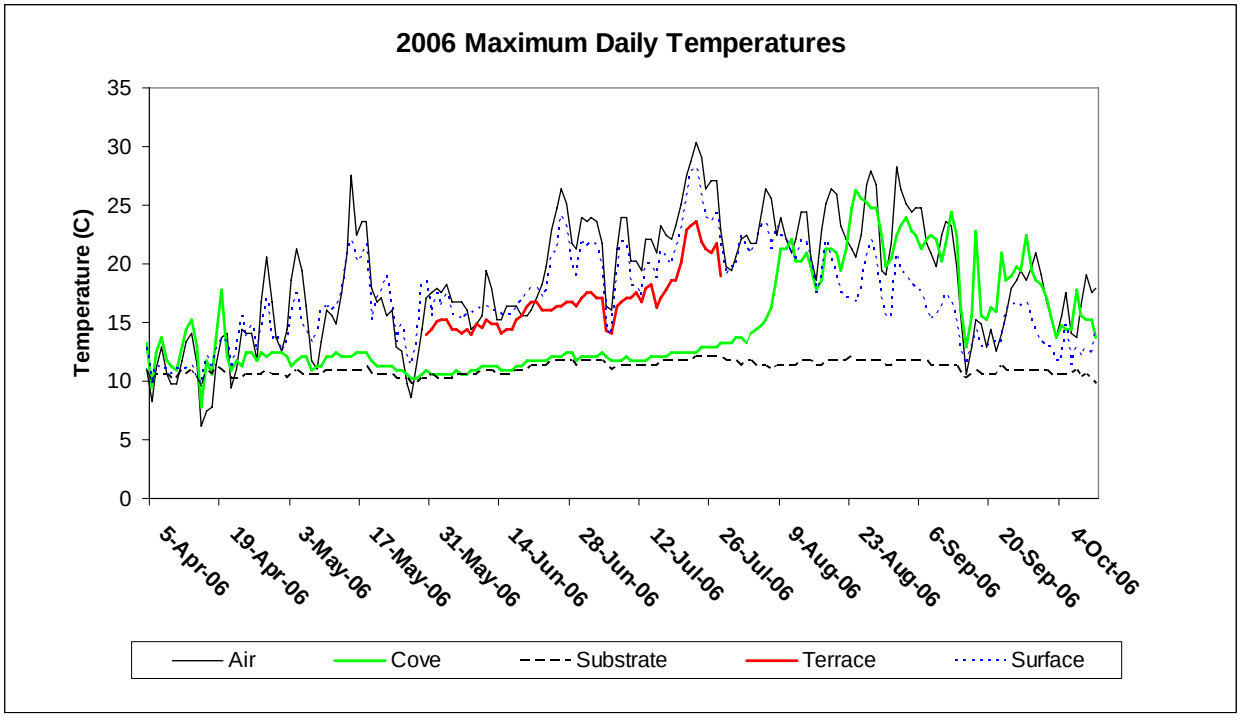


Figure 2. Maximum daily water and air temperatures recorded at Hospital Pond in 2006.

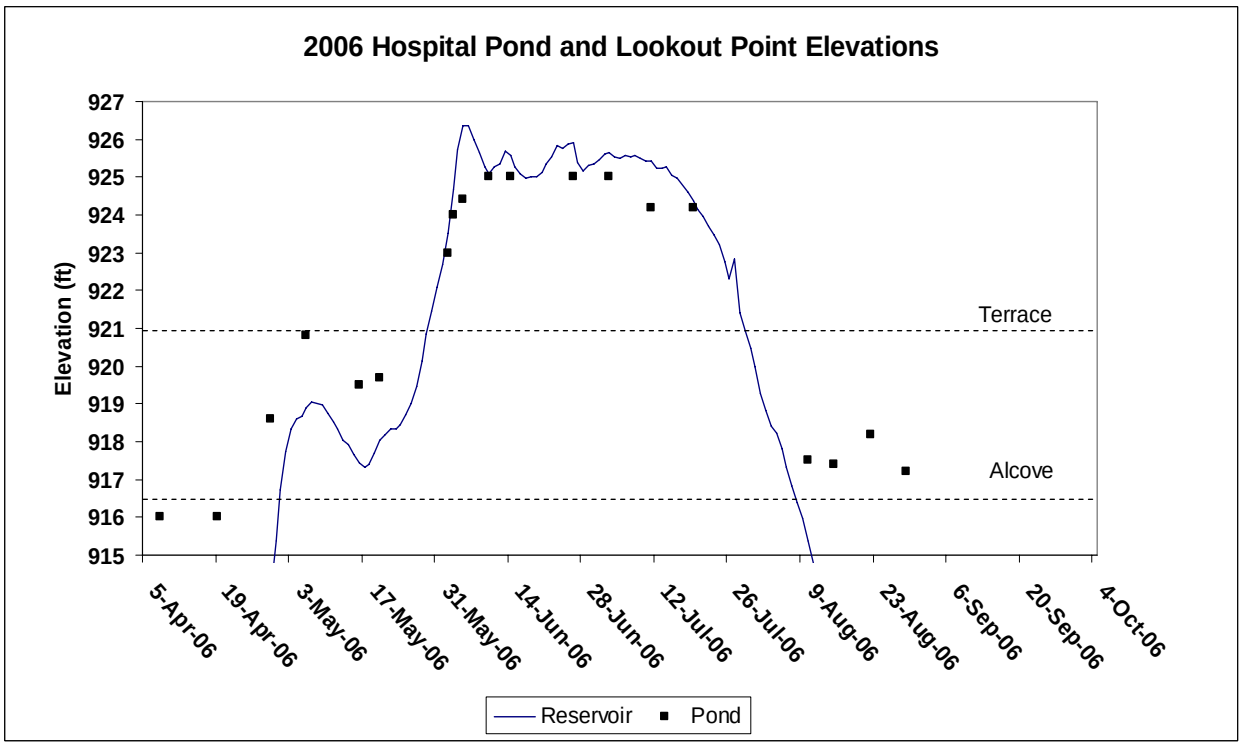


Figure 3. Water elevations recorded in Hospital Pond and Lookout Point Reservoir in 2006. The elevation of the alcove and the pond's terrace are represented by dotted horizontal lines. The elevation of the pond's culvert is 916 feet.

Adult Age and Growth

In 2006, ages of adult Oregon chub ranged from 2 to 7 years and the sample was dominated by the 2002 year-class (age 4) (Figure 4). The fish collected for aging ranged in size from 47 to 80 mm (TL). There was substantial overlap in the ranges of total lengths across the age categories (Table 1). There was no evidence of substantial recruitment since 2002. The weak 2001, 2003, and 2004 Oregon chub year-classes occurred during years when the pond terrace was not flooded. The weak 2005 year-class was unexpected, since the reservoir levels exceeded 921 feet in elevation and the pond terrace was flooded from June 6 and July 27, 2005. It is possible that due to the later hatch dates these fish grew slowly and were too small to be vulnerable to our sampling gear.

There is an apparent discrepancy in the 2002 age structure. The 2000 year-class comprises 26% of the 2001 age composition (age 1), 4% of the 2002 age composition (age 2), and 21% of the 2003 age composition (age 3). We would have expected the proportion of age 2 fish in the 2002 aging sample to be larger. Comparison of the length frequency distributions for fish that we measured in 2002 while conducting the population estimate with fish sacrificed for aging shows that smaller (younger) fish were under represented in the aging sample (Figure 5). In 2002, fish smaller than 65 mm accounted for 36% of the sample we measured, but only 6% of the fish aged. To reduce the probability of collecting a biased sample for aging in 2006, a total of 200 fish were measured during the marking phase of the mark-recapture estimate to determine the size distribution in the pond. Total lengths were measured to the nearest millimeter and were separated into 5 mm categories. Then, based on this size distribution, we collected similar proportions from each 5 mm category for the aging sample.

Hatch Date Distribution

Approximate hatch dates, determined for 50 juvenile chub (18-31 mm) collected in 2006, extended from June 28 through July 26, and peaked in early-July (Figure 6). The 2006 hatch date distribution was narrow, began several weeks earlier than in 2005, and was most similar to the 2002 distribution, the year when the last strong year class was produced at Hospital Pond (Figure 7). The range of hatch dates corresponds with periods when the pond terrace was flooded and maximum daily temperatures recorded on the pond terrace exceeded 15^0C. In late-September, juvenile chub were observed to be abundant and concentrated in the alcove and in shallow areas on the west end of the pond.

Population Estimates

In 2006, there were five populations of Oregon chub located at sites on U.S. Army Corps of Engineers properties. Naturally occurring populations were found at Hospital Pond and in two Dexter Reservoir alcoves, located in the Middle Fork Willamette River drainage. Introduced populations were found in the Fall Creek Spillway Ponds in the Middle Fork Willamette drainage and in Foster Pullout Pond in the Santiam drainage. Population abundance estimates for these locations are presented in Table 2.

The 2006 population estimate for Hospital Pond was 2,040 adult chub (95% CI: 1,440-2,890), down substantially from the 2004 estimate of 5,040 fish, but within the range of estimates obtained prior to 2004. The abundant 2002 year-class was responsible for the large chub abundance estimates obtained in 2004 and 2005 and dominated the 2006 catch.

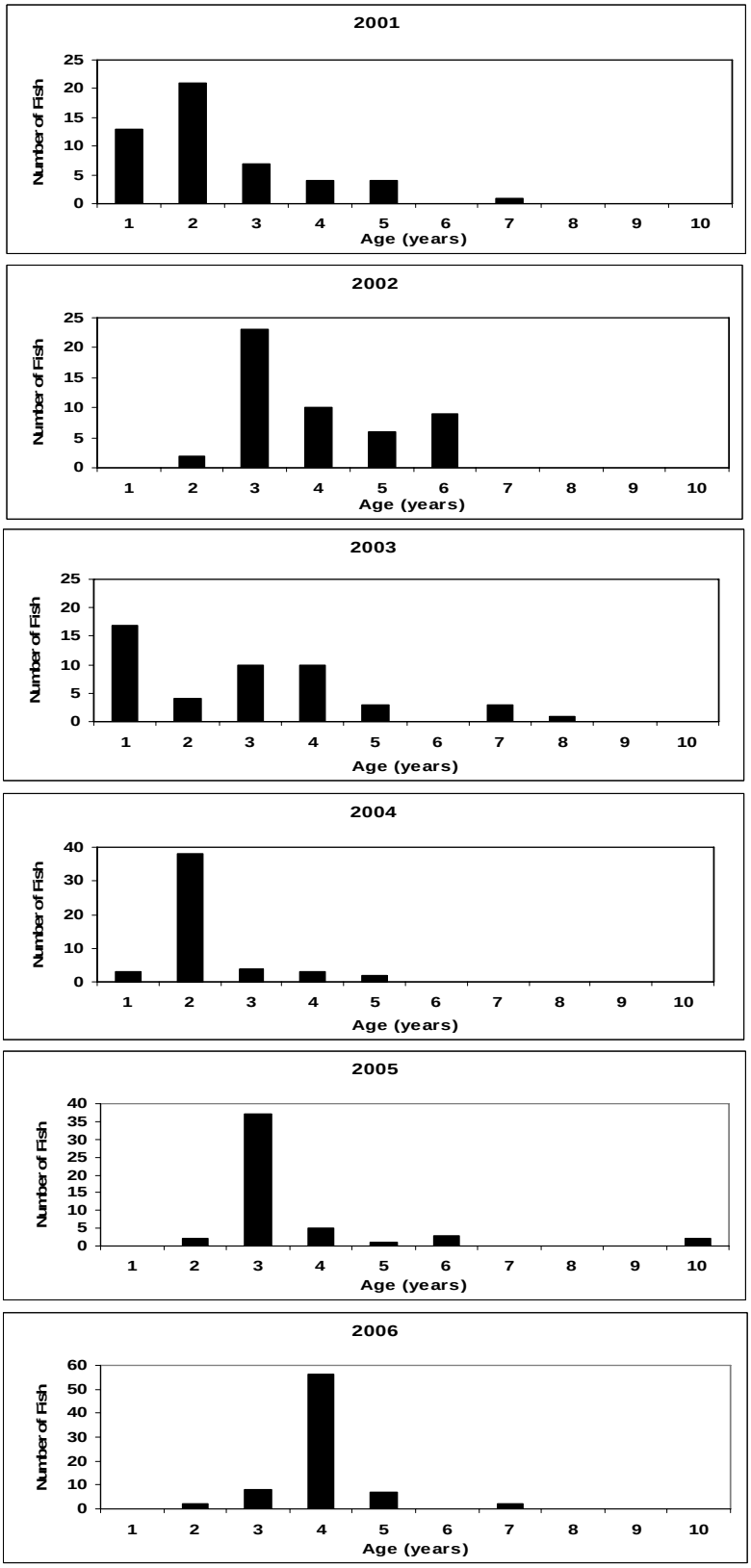


Figure 4. Age structure of the Oregon chub population in Hospital Pond from 2001-2006.

Table 1. Mean lengths at capture and ranges of lengths for Oregon chub from Hospital Pond in 2001 through 2006.

	Age (years)							
	1	2	3	4	5	6	7	8
2001								
Mean total length (mm)	55	63	65	72	72	-	85	-
Range of values	(52-59)	(56-68)	(60-69)	(71-74)	(65-78)	-	(85-85)	-
Number of fish	13	21	7	4	4	0	1	0
Percentage of sample	26	42	14	8	8	0	2	0
2002								
Mean total length (mm)	-	57	67	69	73	77	-	-
Range of values	-	(55-59)	(57-74)	(65-75)	(65-82)	(71-82)	-	-
Number of fish	0	2	23	10	6	9	0	0
Percentage of sample	0	4	46	20	12	18	0	0
2003								
Mean total length (mm)	43	48	62	69	73	-	74	79
Range of values	(39-48)	(42-52)	(58-66)	(64-72)	(69-78)	-	(70-79)	(79-79)
Number of fish	17	4	10	10	3	0	3	1
Percentage of sample	35	8	21	21	6	0	6	2
2004								
Mean total length (mm)	46	53	62	70	78	-	-	-
Range of values	(44-48)	(44-59)	(55-68)	(68-72)	(77-78)	-	-	-
Number of fish	3	39	4	3	2	0	0	0
Percentage of sample	6	78	8	6	4	0	0	0

Table 1 (continued).

	Age (years)							
	1	2	3	4	5	6	7	10
2005								
Mean total length (mm)	-	47	57	56	75	76		85
Range of values	-	(46-48)	(46-70)	(52-53)	(75-75)	(74-77)		(83-86)
Number of fish	0	2	37	5	1	3		2
Percentage of sample	0	4	74	10	2	6		4
2006								
Mean total length (mm)	-	49	61	63	65		76	
Range of values	-	(47-51)	(53-70)	(55-71)	(58-72)		(71-80)	
Number of fish	0	2	8	56	7		2	
Percentage of sample	0	3	11	75	9		3	

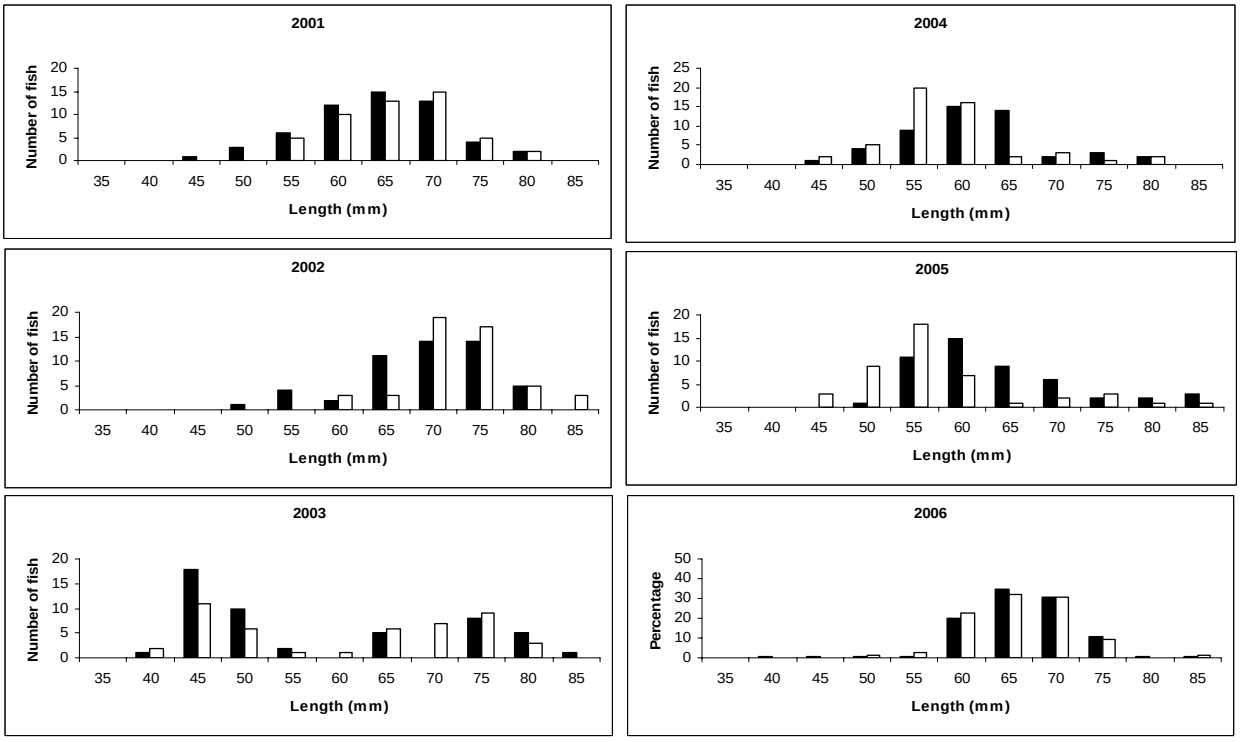


Figure 5. Length frequency histograms for Oregon chub collected in Hospital Pond from 2001-2006. Solid bars represent fish measured during population estimates. Open bars represent fish sacrificed for aging. Aging samples were collected in April of each year, less than one week after fish were measured while obtaining population estimates.

The 2006 estimate for the Dexter Reservoir alcove "The Pit" was 650 adult chub (95% CI: 460-900). This population has fluctuated substantially since 1992. The 2006 estimate for the western alcove of Dexter Reservoir near the RV park was 3,310 adult chub (95% CI: 2,180-4,990), a substantial increase in abundance compared to the 2005 estimate. Nonnative fish have access to the Dexter Reservoir alcoves from Dexter Reservoir and were noted in both alcoves in 2006.

In 1996, Oregon chub were introduced into the Fall Creek Spillway Ponds, beaver ponds located in the spillway overflow channel below Fall Creek Dam. A total of 500 Oregon chub were transferred from Shady Dell Pond (n=150) and East Fork Minnow Creek Pond (n=350) to these ponds. The population abundance increased rapidly. In 2006, the chub population totaled 3,250 adults (95% CI: 2,810-3,740), down substantially from estimates obtained in 1999-2005 (Scheerer et al. 2006). This decline in abundance can be attributed to desiccation of the lower pond during the summer 2006.

Foster Pullout Pond is a spring-fed beaver pond located on the north shore of Foster Reservoir in the South Santiam River drainage. Between 1999 and 2004, 500 Oregon chub were introduced into this pond from Geren Island in the North Santiam drainage. In 2006, the chub population estimate was 470 fish (95% CI: 380-570), up substantially from the 2005 estimate of 200 fish.

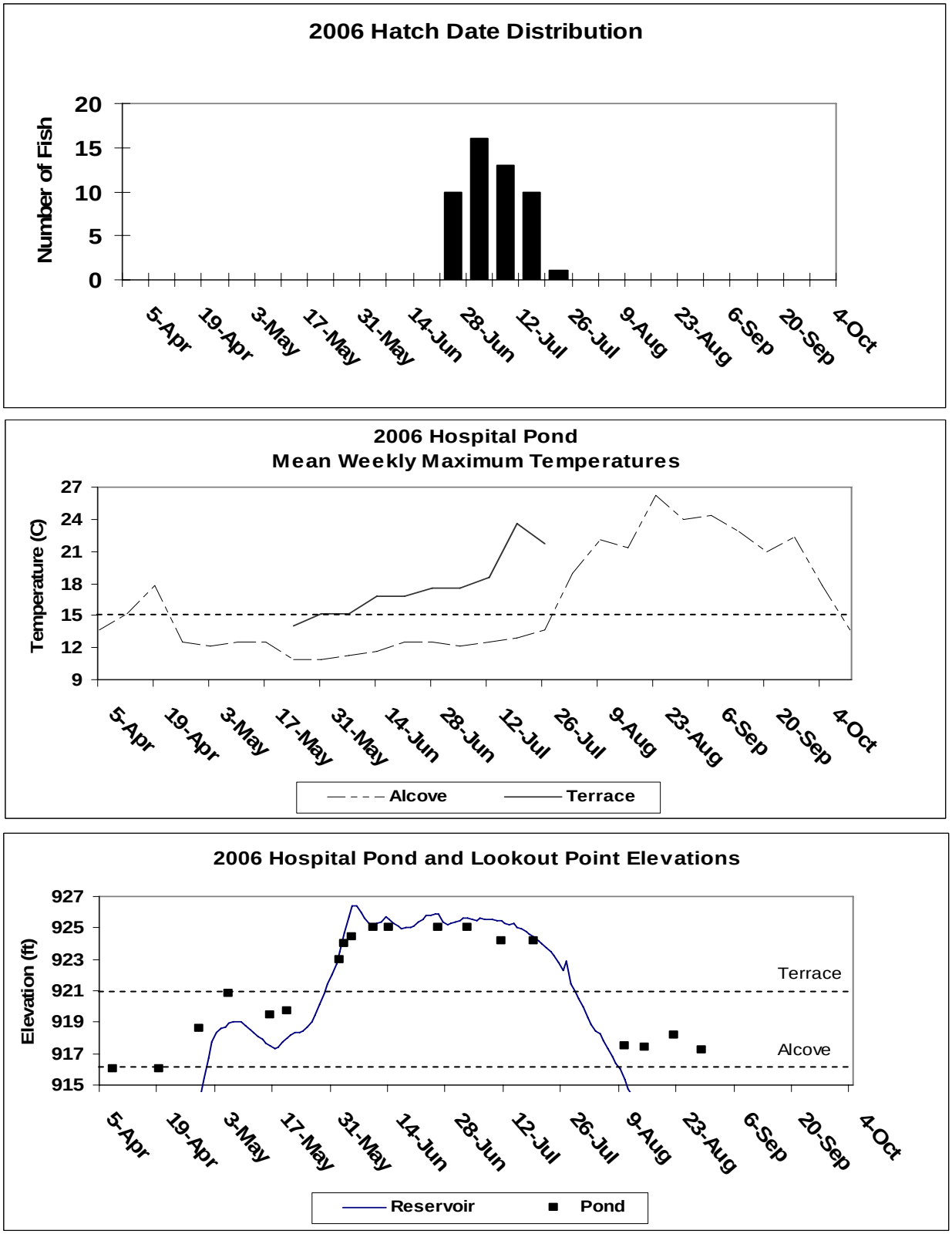


Figure 6. Oregon chub hatch date distribution, maximum daily temperatures, and water elevations in Hospital Pond in 2006. The approximate Oregon chub spawning temperature threshold is 15°C (middle figure). The elevations of the pond culvert and pond terrace are 916 feet and 921 feet, respectively (lower figure).

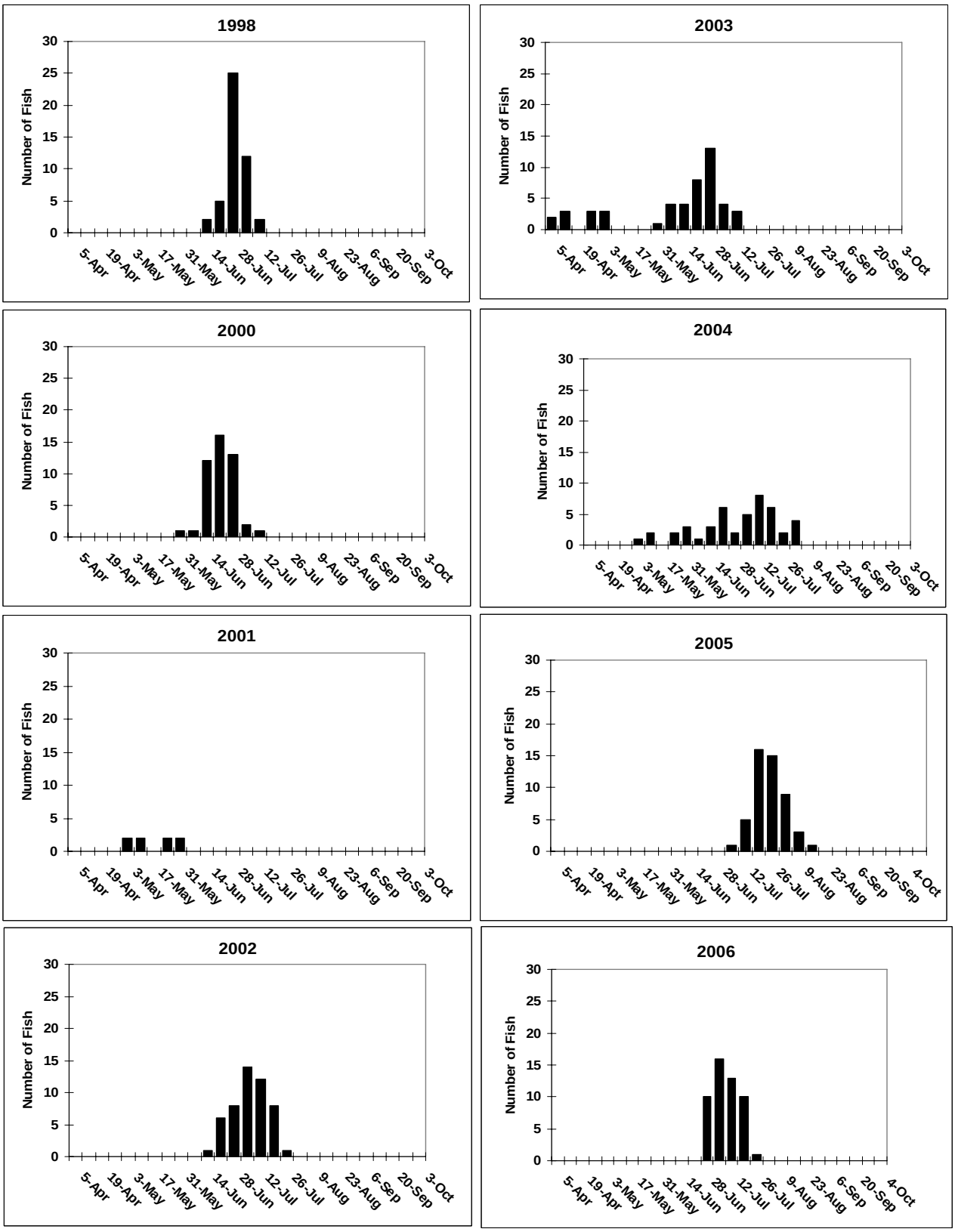


Figure 7. Oregon chub hatch date distributions at Hospital Pond in 1998 and 2000 to 2006.

Table 2. Estimates of the population abundance of Oregon chub at locations on U.S. Army Corps of Engineers properties in the Willamette Valley, Oregon from 1992 to 2006.

Location	Year	Estimate	95% Confidence Limits	
			lower	upper
Hospital Pond	1993	690	470	1,300
	1995	780	510	1,390
	1997	3,160	2,480	4,370
	1998	3,030	2,050	5,780
	1999	3,020	2,330	4,290
	2000	2,980	2,050	5,410
	2001	2,700	1,830	5,140
	2002	2,130	1,680	2,910
	2003	1,600	1,060	3,240
	2004	4,940	4,230	5,950
	2005	5,040	4,050	6,270
	2006	2,040	1,440	2,890
Dexter Reservoir Alcove (The Pit)	1992	780	560	1,100
	1995	140	80	400
	1996	40	20	200
	1997	920	760	1,170
	1998	450	380	540
	1999	1,130	910	1,480
	2000	1,440	1,030	2,440
	2001	800	600	1,200
	2002	460	280	1,330
	2003	390	290	590
	2004	70	30	120
	2005	600	430	830
	2006	650	460	900

Table 2. (continued).

Location	Year	Estimate	95% Confidence Limits lower	upper
Dexter Reservoir Alcove (RV Park)	1997	1,330	990	2,060
	1998	830	590	1,410
	1999	50	20	100
	2000	880	580	1,770
	2001	1,950	1,690	2,310
	2002	2,270	1,840	2,980
	2003	870	520	2,500
	2004	790	460	1,330
	2005	1,850	1,350	2,520
	2006	3,310	2,180	4,990
Fall Creek Spillway Ponds[a]	1997	480	400	590
	1998	1,400	960	2,660
	1999	6,300	5,460	7,450
	2000	5,030	4,060	6,620
	2001	7,770	6,480	9,690
	2002	6,370	5,320	7,930
	2003	5,620	4,380	7, 480
	2004	5,850	4,770	7,170
	2005	6,250	5,190	7,520
	2006	3,250	2,810	3,740

Table 2. (continued).

Location	Year	Estimate	95% Confidence Limits lower	upper
Foster Pullout Pond[a]	2000	80	40	320
	2001	210	130	700
	2002	320	200	780
	2003	640	370	1,480
	2004	570	370	1,240
	2005	200	130	320
	2006	470	380	570

[a] Introduced populations of Oregon chub.

Hospital Impoundment Pond is a habitat enhancement project which is located in Lookout Point Reservoir adjacent to Hospital Pond. It was constructed by the U.S. Forest Service and the U.S. Army Corps of Engineers in 1994. The fish community in this pond varies each year, depending on which species enter the pond from Lookout Point Reservoir or Hospital Pond. Non-native fish, which originate from the reservoir, were collected in 1995 and 1997 through 2006. Only a few Oregon chub were collected in 1995 (n=6), 1997 (n=1), and 1999 (n=1) (Scheerer et al. 2006). The pond appears to provide few benefits for Oregon chub.

DISCUSSION & RECOMMENDATIONS

Previous investigations at Hospital Pond established links between water elevations of Lookout Point Reservoir, water levels and water temperatures in Hospital Pond, and Oregon chub spawning and recruitment (Scheerer and McDonald 2001, Scheerer and Terwilliger 2002; 2003; 2004; Scheerer et al. 2005). In 2001-2003, ODFW and the Corps initiated projects designed to provide managers the ability to regulate pond elevations independently of Lookout Point Reservoir elevations. A gate was installed on the culvert, the pond was sealed with bentonite clay, and a shallow alcove was excavated on the pond terrace.

In 2003 and 2004, neither the reservoir nor the pond elevations exceeded 921 ft and the pond terrace did not flood. However, by closing the gate on the culvert we were able to back up water into the recently excavated alcove during the spring and summer months. In 2003, pond elevations initially increased to 921.5 feet (alcove depth 4.9 feet) and stabilized between 919.6 and 920.2 feet (alcove depth 3.0-3.6 feet). However, water temperatures in the alcove rarely exceeded 15^{o}C, and only for brief periods when the pond elevation was less than 918 feet (alcove depth <1.4 feet). The 2003 year-class was not abundant. Poor recruitment may have resulted from our inability to maintain warm temperatures in the alcove in 2003; however density dependent mechanisms, i.e. competition with the abundant 2002 year-class, may also have been a factor. Simply flooding the alcove was not sufficient to create conditions where water temperatures were

suitable for chub spawning to occur, but rather water levels in the alcove needed to be maintained below 1.4 feet to ensure adequate warming of the water.

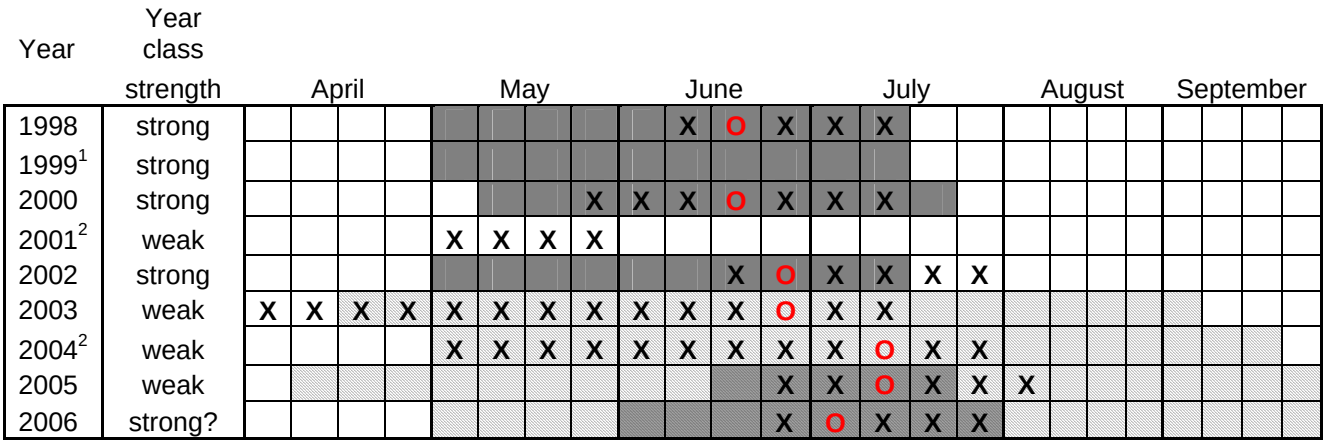
In 2004, for unknown reasons, when the gate on the culvert was closed the maximum pond elevation reached only 918.4 feet (alcove depth 1.8 feet) and ranged from 917.9 to 918.4 feet through July (alcove depth 1.3-1.8 feet). These water levels averaged almost 2.0 feet lower than the levels observed in 2003. Water temperatures exceeding 15^{o}C were more common in the alcove in the summer of 2004. The shallower water depth in the alcove, combined with the blanket of *Azolla mexicana* covering the alcove during most of the spring and summer, both contributed to warmer alcove water temperatures, however the 2004 year-class was not abundant.

In 2005, the Lookout Point Reservoir came within 2.5 feet of filling and flooded the terrace; however the timing was much later than during earlier years of our study, due to the drought-like conditions in the winter and early spring of 2005. The pond terrace was flooded for approximately five weeks from mid-June through July 2005 and water temperatures on the terrace exceeded 15^{o}C during this entire period. In addition, as the reservoir and pond water levels dropped, temperatures in the alcove warmed above 15^{o}C. The water depth in the alcove was 1.2 feet during this period. Successful spawning in 2005 began in mid-June, when the terrace was flooded, and continued into August, when water temperatures in the alcove exceeded 15^{o}C. Prior to pond modifications (ex. 1998 and 2000), no successful spawning occurred after the pond levels and pond temperatures dropped. In 2005, additional spawning occurred after the pond levels dropped, perhaps because suitable conditions existed in the alcove.

The Oregon chub population abundance in Hospital Pond peaked in 2004 and 2005 and has been dominated by the 2002 year-class for the past 3 years. Density dependent mechanisms, specifically competition for food and cover with the abundant 2002 year-class, may have limited recruitment in recent years. It is also possible that Oregon chub in Hospital Pond require warm temperatures early in the spring for rapid egg maturation and/or high egg-to-fry survival. Warmer temperatures in May might promote early and abundant planktonic food resources needed by the emerging fry. Strong year-classes may occur only when the timing of hatching coincides with the availability of abundant prey. In addition, when water temperatures are colder juvenile growth is slower, which may result in reduced overwinter survival.

Flooding of the pond terrace in May through July appears to be a prerequisite for successful Oregon chub spawning and recruitment to occur. In 1998, 1999, 2000, and 2002, the reservoir filled, the terrace was flooded for ~10 weeks, and strong year-classes were produced (Figure 8). These conditions have not occurred since 2002.

We recommend the continuation of monitoring efforts at Hospital Pond. It is uncertain whether the current flow management, pond modifications, and pond water level management are sufficient to maintain a stable or increasing trend in population abundance. It does not appear that the spawning alcove is providing much benefit to Oregon chub, because temperatures in the alcove are only suitable for spawning when the water depth is less than ~1.4 feet. Installation of a self-regulating mechanism on the culvert gate may allow managers to maintain shallow water depths in the alcove throughout the summer. Because the alcove is small in size, increasing the area of the alcove and/or creating additional alcoves or low terraces that are flooded at varying pond elevations may create conditions that promote successful chub spawning in years when Lookout Point Reservoir does not fill (flood the terrace) and remain full during the summer. If these modifications do not result in increased chub recruitment, then we recommend that at least every third year, Lookout Point Reservoir is allowed to fill and remain full during the months of May, June, and July.



[1] No hatch date analysis was conducted in 1999.

[2] The reservoir did not fill in 2001 or 2004; there was no peak hatch date in 2001.

Figure 8. Relationships between year-class strength, time periods when reservoir levels exceeded 921 feet (gray boxes), time periods when the pond alcove was flooded (hatched boxes), hatch date distributions (X's), and peak hatch dates (O's) at Hospital Pond, 1998-2006.

ACKNOWLEDGEMENTS

We acknowledge the assistance of Greg Taylor and Greg Gauthier of the U.S. Army Corps of Engineers and Peggy Kavanagh and Brian Bangs of Oregon Department of Fish and Wildlife.

REFERENCES

Campana, S. E., and J. D. Neilson. 1985. Microstructure of fish otoliths. Canadian Journal of Fisheries and Aquatic Sciences 42:1014-1032.

Hoff, G.R., D.J. Logan, and D.F. Markle. 1997. Otolith morphology and increment validation in young Lost River and shortnose suckers. Transactions of the American Fisheries Society 126:488-494.

Mamoyac, S., M. Buckman, and E. Tinus. 2000. Biological and technical justification for the Willamette River flow proposal of the Oregon Department of Fish and Wildlife. ODFW, Portland. 20 p.

Markle, D. F., T. N. Pearsons, and D. T. Bills. 1991. Natural history of *Oregonichthys* (Pisces: Cyprinidae), with a description of a new species from the Umpqua River of Oregon. Copeia 1991(2):277-293.

NOAA (National Oceanic and Atmospheric Administration). 1999. Endangered and threatened species: threatened status for two ESU's of steelhead in Oregon and Washington. Federal Register 64:14517-14528.

Rhew, R. 1993. Endangered and threatened wildlife and plants: determination of endangered status for the Oregon chub. Federal Register 58: 53800-53804.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada, Bulletin 191, Ottawa, Ontario.

Scheerer, P. D., G. D. Apke, and P. J. McDonald. 1998. 1998 Oregon chub research: Middle Fork Willamette and Santiam River drainages, Fish Research Project E96970022, Annual Progress Report, Corvallis. 53 p.

Scheerer, P. D., and P. J. McDonald. 2000. Oregon chub research (2000): Santiam and Middle Fork Willamette River drainages, Fish Research Project W66QKZ93345985, Annual Progress Report, Corvallis. 85 p.

Scheerer, P. D., and P. J. McDonald. 2001. Monitoring of Hospital Pond: Willamette Basin Oregon Chub Investigations, Monitoring, and Management, Fish Research Project W66QKZ93345985, Annual Progress Report, Corvallis. 9 p.

Scheerer, P. D., and M. Terwilliger. 2002. Monitoring of Hospital Pond (2001): Willamette Basin Oregon Chub Investigations, Monitoring, and Management, Fish Research Project W66QKZ10230433, Annual Progress Report, Corvallis. 20 p.

Scheerer, P. D., and M. Terwilliger. 2003. Monitoring of Hospital Pond (2002): Willamette Basin Oregon Chub Investigations, Monitoring, and Management, Fish Research Project W66QKZ13186771, Annual Progress Report, Corvallis. 19 p.

Scheerer, P. D., and M. Terwilliger. 2004. Monitoring of Hospital Pond (2004): Willamette Basin Oregon Chub Investigations, Monitoring, and Management, Fish Research Project W66QKZ13304328, Annual Progress Report, Corvallis. 19 p.

Scheerer, P. D., M. Terwilliger, and S. E. Jacobs. 2005. Monitoring of Hospital Pond (2005): Willamette Basin Oregon Chub Investigations, Monitoring, and Management, Fish Research Project W66QKZ13304328, Annual Progress Report, Corvallis. 20 p.

Scheerer, P. D., and P. J. McDonald. 2003. Age, growth, and timing of spawning of an endangered minnow, the Oregon chub (*Oregonichthys crameri*), in the Willamette basin, Oregon. Northwestern Naturalist 84:68-79.

Scheerer, P. D., P. S. Kavanagh, B. L. Bangs, and S. E. Jacobs. 2006. 2006 Oregon chub investigations. Oregon Department of Fish and Wildlife, Fish Research Project EF-06, Annual Progress Report, Salem. 23+ p.

Secor, D. H., J. M. Dean, and E. H. Laban. 1992. Otolith removal and preparation for microstructural examination. *In* Otolith microstructure examination and analysis. Stevenson, D. K., S. E. Campana, editors. Canadian Special Publication of Fisheries and Aquatic Sciences 117: 19-57.

Spurr, A. R. 1969. A low-viscosity epoxy resin embedding medium for electron microscopy. Journal of Ultrastructural Research 26:31-43.

U.S. Fish and Wildlife Service. (Brown, C., R. Rhew, A. Bentivoglio, and P. D. Scheerer). 1998. Oregon Chub (*Oregonichthys crameri*) Recovery Plan. Portland, Oregon. 69+ p.

Weisel G. F., and H. W. Newman. 1951. Breeding habits, development and early life history of *Richardsonius balteatus*, a northwestern minnow. Copeia 3: 187-194.