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Oregon Chub Investigations at Hospital Pond, 2000-2008

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Hospital Pond when Lookout Point Reservoir was at maximum conservation pool elevation in July 2008.

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ABSTRACT

Previous studies suggested relationships between Lookout Point Reservoir water elevations, Hospital Pond water levels and temperatures, and Oregon chub spawning and recruitment in the pond. Hospital Pond is fed by large cold springs and spawning only occurs when the reservoir is nearly full and floods the pond terrace. Changes in flow management in the Middle Fork Willamette River occurred in 2000, following the listing of Willamette spring chinook and winter steelhead, and resulted in changes in the frequency and magnitude of reservoir filling and the length of time the reservoir would remain full. The US Army Corps of Engineers modified the pond in an attempt to allow managers the ability to manage water levels and temperatures in Hospital Pond independently from reservoir levels. We found that these modifications were largely unsuccessful. We found that strong year-classes were infrequent and occurred in several, but not all of the years, when the reservoir filled. Our data also suggests that strong year-classes may limit the recruitment of the following year-class through density-dependent mechanisms, i.e. competition for food and space. If the reservoir continues to fill every few years, as it has for the last decade, we feel that that Oregon chub recruitment in Hospital Pond will be adequate to maintain a stable population into the future.

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. 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, has 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 on the Middle Fork Willamette River from 2000 through 2008 and found that changes in reservoir elevation directly affected water levels, water temperatures, and the availability and suitability of Oregon chub spawning habitat in Hospital Pond (Scheerer and McDonald 2000; 2001; 2003; Scheerer and Terwilliger 2002; 2003; 2004; Scheerer et al. 2005; 2006; 2007).

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 (river km 193) and Salem (river km 137) were recommended and management of tributary flows was altered to balance the demand for water for recreation in the Willamette subbasins with flows at Albany and Salem (Mamoyac et al. 2000). 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-July) in most years. In 2000, the U.S. Army Corps of Engineers (Corps) initiated a study to determine the feasibility of modifying Hospital Pond to provide managers the ability to independently regulate pond elevation and contracted with ODFW to collect life history and population data to assess the effects of these modifications on Oregon chub abundance and recruitment.

Pond modifications were made in 2001 through 2003. In the spring of 2001, the Corps installed a gate on the culvert exiting Hospital Pond. 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 2003, the Corps excavated a shallow alcove in the terrace to provide potential spawning habitat that was available for Oregon chub when pond elevations were less than 920 ft.

This report presents the results of investigations conducted from 2000 through 2008 at Hospital Pond, including results of monitoring adult Oregon chub population abundance, water temperature profiles, reservoir and pond level elevations, and the analysis of Oregon chub adult aging and juvenile hatch date data. Adult aging was conducted to assess age structure and year-class strength. Juvenile hatch date analyses were conducted to determine approximate spawning timing. Both were related to pond conditions. These data were collected to determine what factors influence successful Oregon chub recruitment in Hospital Pond and whether the pond modifications were successful in creating conditions that favor strong year-classes. We provide these data to the Corps for use in planning near-term and long-range water storage and flow management to protect Oregon chub and their habitat in Hospital Pond.

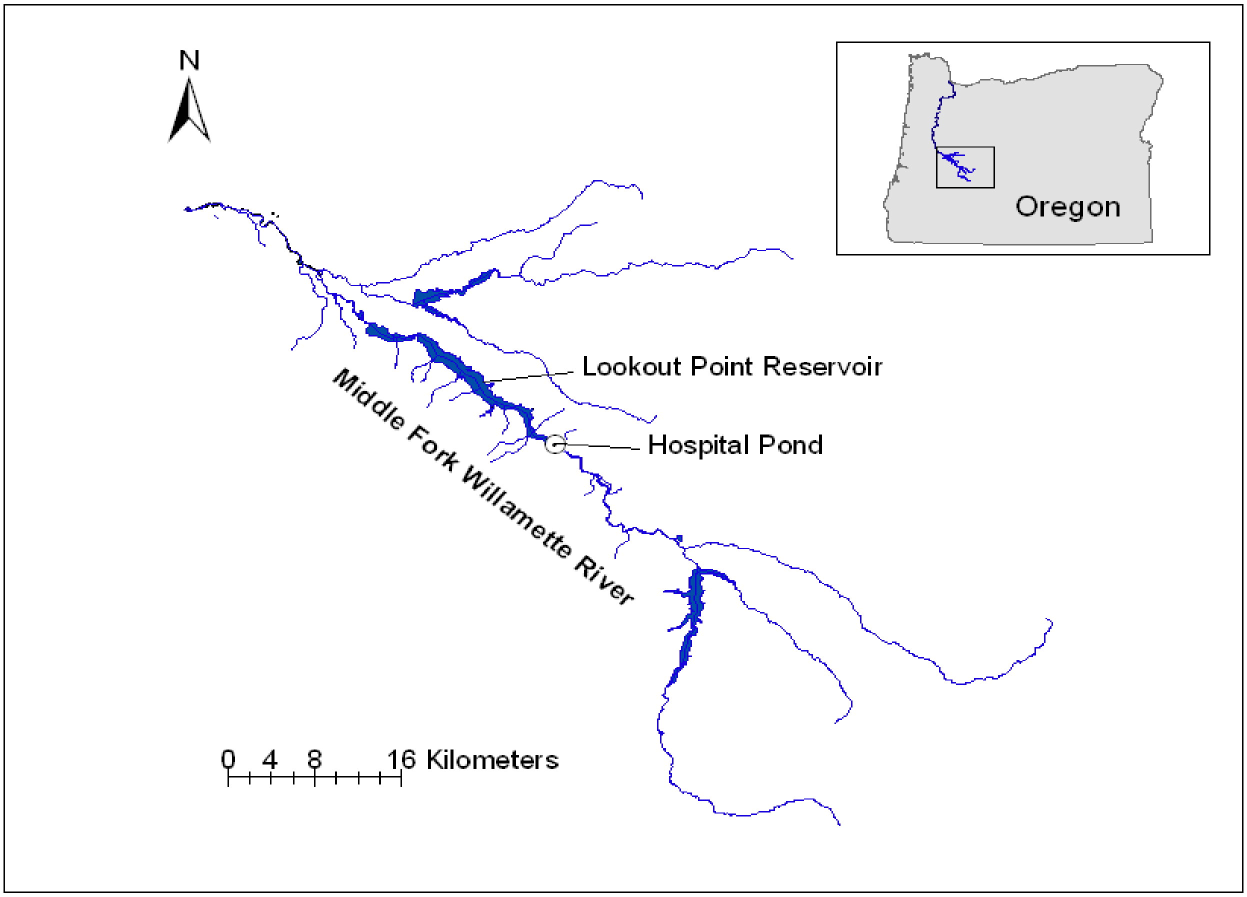
METHODS

Monitoring Reservoir and Pond Elevations

We uploaded Lookout Point Reservoir elevations from the Corps data query website: http://www.nwd-wc.usace.army.mil/perl/dataquery.pl. We installed staff gages on the gate structure on the pond side of the culvert at Hospital Pond. We recorded Hospital pond water elevations periodically from April through October of each year. For reference, the elevations of the lower lip of the pond culvert, the bottom of the pond alcove, the bottom of the pond terrace, and maximum conservation pool are approximately 916.0 ft, 916.6 ft, 921.0 ft, and 926 ft, respectively.

Temperature Monitoring

Each spring, we placed temperature recorders (Hobo®) at multiple locations in Hospital Pond (Figures 1 and 2). We placed one recorder on the pond substrate near the culvert at the southwestern end of the pond, we attached a second recorder to a cable that was anchored to a post and was floated in the pond approximately 0.1 m below the water surface near the center of the pond, we placed a third recorder on the substrate of the alcove, we attached a fourth recorder to a cable that was anchored to a post and was floated in the pond approximately 0.1 m below the water surface in the alcove, and we placed a fifth recorder on the substrate of the shallow vegetated terrace on the south side of the pond. We monitored air temperature with a recorder placed on a branch of a tree, approximately 1.5 m above the ground, which was growing on the edge of the pond terrace. We covered this recorder with moss and it remained in the shade throughout the day. We set the recorders to record temperatures at five hour intervals. Each fall, we uploaded the data from the temperature recorders. We used the maximum temperature recorded each day to determine whether the threshold temperature of approximately 15^0C, necessary for Oregon chub to spawn, was exceeded (Scheerer and McDonald 2000).



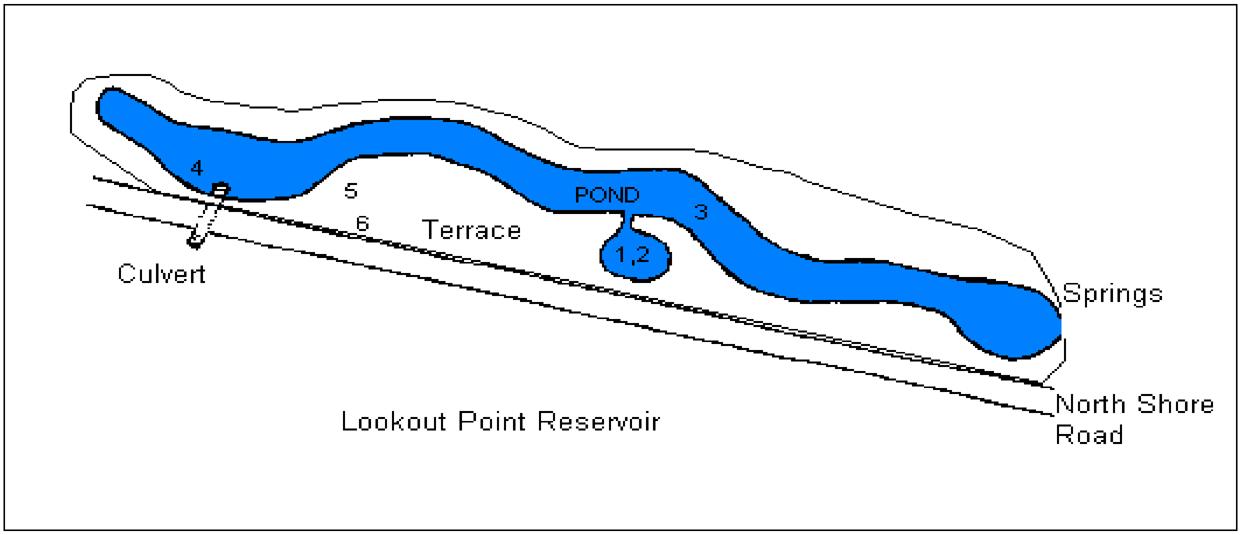


Figure 1. Map (top) showing the location of Hospital Pond in the Middle Fork Willamette River drainage. Diagram of Hospital Pond (bottom) showing locations of temperature monitors placed in the alcove (1-surface, 2-substrate), the pond (3-surface, 4-substrate), the terrace (5-substrate), and in a tree located on the terrace (6-air temperature). The springs that feed the pond are located at the east end and the culvert running under the road 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. The outer line represents the pond area when the reservoir is full.

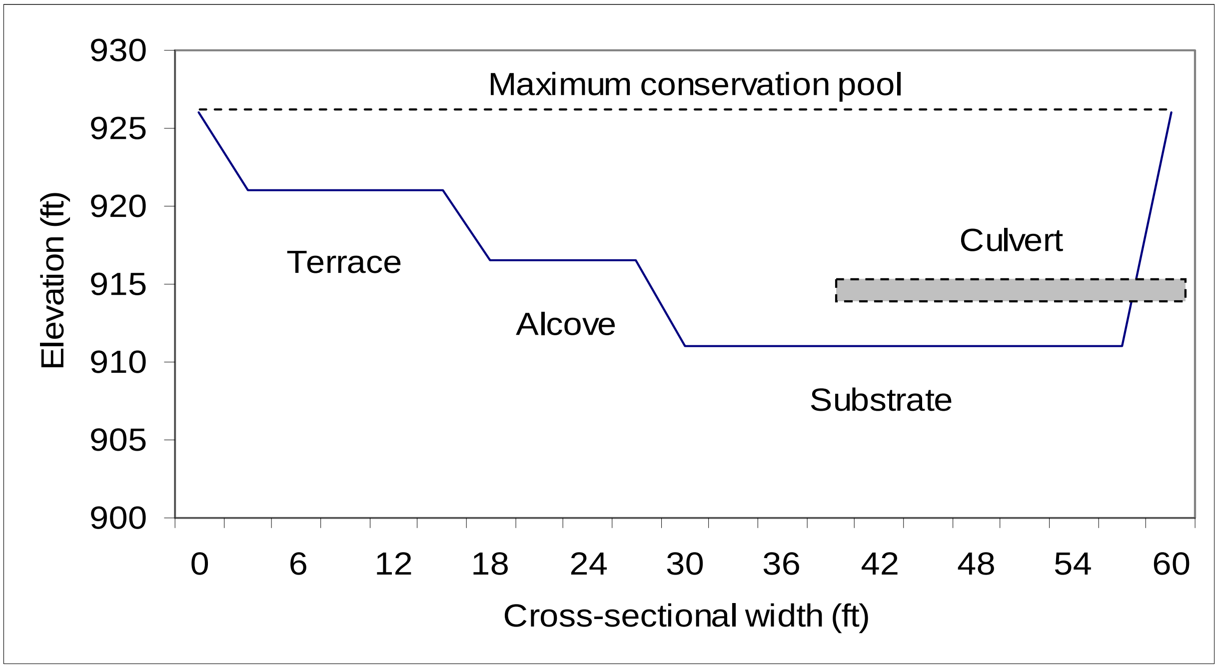


Figure 2. Schematic diagram illustrating the relative elevations of pond surfaces (terrace, alcove, and substrate) in Hospital Pond. Also included are the elevation of the culvert that connects the pond to Lookout Point Reservoir and the pond elevation when the reservoir is at maximum conservation pool. Note that this diagram is not to scale and in reality, the culvert is located on the terrace side of the pond.

Hatch Date Distribution

In late-September or early-October of each year, we collected ~50 young-of-the-year Oregon chub from Hospital Pond to determine their hatch date distribution and to relate the onset and duration of spawning with pond temperatures. Juveniles were collected by dip netting the shallow shoreline areas and in the alcove. In those years when recruitment was low and juveniles were scarce, we did not achieve our target of 50 fish. 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.

Adult Aging

In April of 2000 through 2005, we collected 50 adult Oregon chub from Hospital Pond for aging using baited minnow traps. We collected these fish to determine the age structure of the population. Starting in 2006, we increased our sample size to 75 adult chub. We also measured a total of 200 fish during the marking phase of the mark-recapture estimate to determine the size distribution of chub in the pond to reduce the probability of collecting a biased sample for aging (which occurred in 2005). We measured the total lengths to the nearest millimeter and combined lengths into 5 mm categories. Then, based on this size distribution, we collected similar proportions from each 5 mm size category for the aging sample. We sacrificed the fish and placed them in 95% ethanol. We took these fish back to the lab to be processed. We removed the right lapillus from each fish using a fine tip probe under a dissecting scope. We soaked each otolith 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). We embedded the otoliths into molds (plugs) of Spurr® epoxide resin (Spurr 1969). We mounted the plugs on glass slides for thin sectioning using a low speed Isomet® diamond blade saw. We made two transverse cuts into the plug to produce a thin section (0.5 mm) that included the otolith core. We mounted thin sections on glass slides in Crystal Bond, ground using 1500 grit wet/dry sandpaper, and polished them using Buehler Gamma Micropolish alumina solution (0.05μ) and a Buehler Microcloth polishing cloth. We aged adult otoliths using transmitted light at 250X under a compound scope (Hoff et al. 1997). One reader read each adult otolith two times. If there was a discrepancy, we made a third reading. In these cases, we assigned the age that was determined for the majority of reads to the fish. We determined the precision of age determinations using an index of average percent error (Beamish and Fournier 1981).

Population Estimates

We obtained population estimates for adult Oregon chub at Hospital Pond annually in April. We used cylindrical minnow traps (23 cm x 46 cm with 64 mm mesh) 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). We calculated confidence intervals using a Poisson approximation (Ricker 1975). Because we do not routinely capture chub smaller than 40 mm in total length (TL) in the minnow traps; the abundance estimates only include fish larger than 40 mm TL.

RESULTS

Reservoir and Pond Elevations

Reservoir elevations and pond depths varied substantially year to year depending on the amount, type, and timing of precipitation that fell during the preceding winter and spring months (Table 1). The elevation of Lookout Point Reservoir exceeded 916 ft, the elevation of the Hospital Pond culvert, for varying periods of time in all years of the study except 2001, 2004, and 2007 (Figure 3). During 2000, 2002, 2003, 2005, 2006, and 2008, pond elevations exceeded 921 ft and flooded the pond terrace for a period of 6 to 75 days (Table 1). Since the culvert at Hospital Pond is located several feet above the substrate, the pond maintains an average depth of approximately 6 ft throughout the year. Prior to 2002, the water depth in Hospital Pond was determined solely by the water elevation of Lookout Point Reservoir. In 2002 the Corps installed a gate on the pond's culvert to allow managers to regulate the depth of the pond independently of the reservoir. Due to leakage around the gate and through the road fill, we were only able to raise the level of Hospital Pond ~1 foot above the elevation of the culvert in 2002. In 2003, the gate was modified and the pond bottom was sealed with bentonite

Table 1. Maximum elevations of Lookout Point Reservoir, maximum water depths and ranges of water depths of Hospital Pond, maximum water depths on the pond terrace and constructed alcove, and the number of days during the year when the depth of Hospital Pond flooded the pond terrace, 2000 through 2008. The water depths for Hospital Pond represent the depth of water above the lip of the culvert (elevation 916 ft). Pond depth at ≤916 ft reservoir elevation averages ~6 ft. The elevation of the pond terrace and alcove are ~921 ft and 916.6 ft, respectively. Maximum conservation pool elevation of Lookout Point Reservoir is 926 ft. Note that the alcove was constructed in 2003.

	Reservoir	Hospital Pond	Terrace		Alcove
Year	Maximum elevation (ft)	Maximum depth (ft)	Maximum depth (ft)	Number of days flooded	Maximum depth (ft)
2000	927.5	11.5	6.5	71	-
2001	876.2	1.0	0.0	0	-
2002	922.4	6.4	1.4	34	-
2003	920.6	5.5	0.5	6	4.9
2004	905.2	2.4	0.0	0	1.8
2005	922.5	7.5	2.5	30	6.9
2006	926.4	9.0	4.0	59	8.4
2007	913.4	2.8	0.0	0	2.2
2008	926.3	9.0	4.0	75	8.4

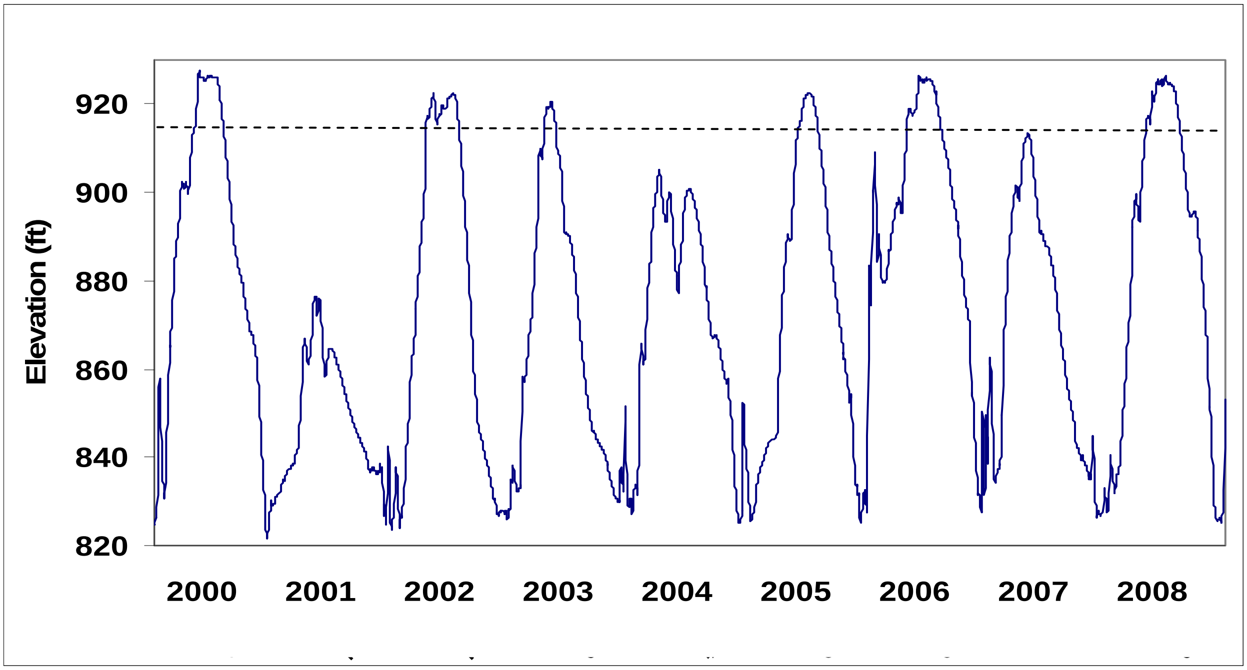


Figure 3. Annual fluctuations in Lookout Point Reservoir elevations, 2000-2008. The dotted line represents the elevation of the Hospital Pond culvert (916 ft). The reservoir maximum conservation pool elevation is 926 ft.

clay to reduce leakage of water from the pond. From 2003 through 2008, we closed the gate on the culvert in April and reopened it in October. When we closed the gate on the culvert, we could impound water in Hospital Pond and increase the depth by as much as an additional 6.2 ft (922.2 ft elevation). However, this level could only be maintained when the reservoir elevation exceeded 917 ft. At reservoir elevations below 917 ft, we were only able to maintain an elevation of ~920.5 ft (increased pond depth of ~4.5 ft). Plots of pond and reservoir elevations for April through September, 2000-2008 are shown in Figure 4.

Temperature Monitoring

Water temperatures in Hospital Pond showed substantial spatial variation within the pond (Table 2, Figure 5). Cold dense spring water enters the pond at the eastern end, flows westward approximately 300 meters through the pond, and exits the pond through the culvert near the southwestern end. Water temperatures recorded on the substrate of the pond, which represent a stratum that extends almost to the surface of the pond, are cold and remarkably constant, averaging 10.3^{o}C to 11.8^{o}C in May through August. During the spring and summer, a narrow band of warm water at the pond surface covers the cold stratum. However, this band only extends ~0.1 m down from the surface and because the pond banks are steep, little habitat is available for fish to use in this warmer stratum. Water temperatures measured near the surface of the pond were consistently higher than temperatures measured elsewhere in the pond and closely paralleled changes in air temperature (Figure 5). In years when the reservoir filled and the terrace was flooded, water temperatures on the terrace were relatively warm in May through August, averaging 15.9^{o}C to 18.3^{o}C. Alcove temperatures averaged 12.1^{o}C to

Table 2. Maximum daily temperatures measured from May through August on the substrate, terrace, and alcove in Hospital Pond, 2000-2008. The number of days when temperatures exceeded 15^{o}C includes temperatures recorded on the terrace, the alcove, or both. Lookout Point reservoir did not fill in 2001, 2003, 2004, or 2007. The pond alcove was constructed in 2003.

	Pond substrate		Pond terrace		Pond alcove		Number of days
Year	average	range	average	range	average	range	greater than 15^{o}C
2000	11.8	10.2 - 12.9	18.3	13.2 - 23.4	-	-	65
2001	10.9	10.0 - 12.6	-	-	-	-	0
2002	11.2	10.2 - 12.2	15.9	10.6 - 19.4	-	-	58
2003	11.4	9.8 - 12.1	-	-	12.4	10.9 - 18.1	3
2004	10.4	9.8 - 11.3	-	-	13.4	10.6 - 18.6	27
2005	10.3	9.8 - 11.3	17.8	15.4 - 21.9	12.1	10.2 - 16.5	64
2006	11.2	9.8 - 12.1	16.8	9.6 - 23.6	13.8	10.2 - 20.3	70
2007	10.8	10.2 - 11.3	-	-	15.0	10.8 - 17.0	25
2008	11.1	10.2 - 12.1	16.8	13.8 - 21.2	12.2	10.2 - 17.5	75

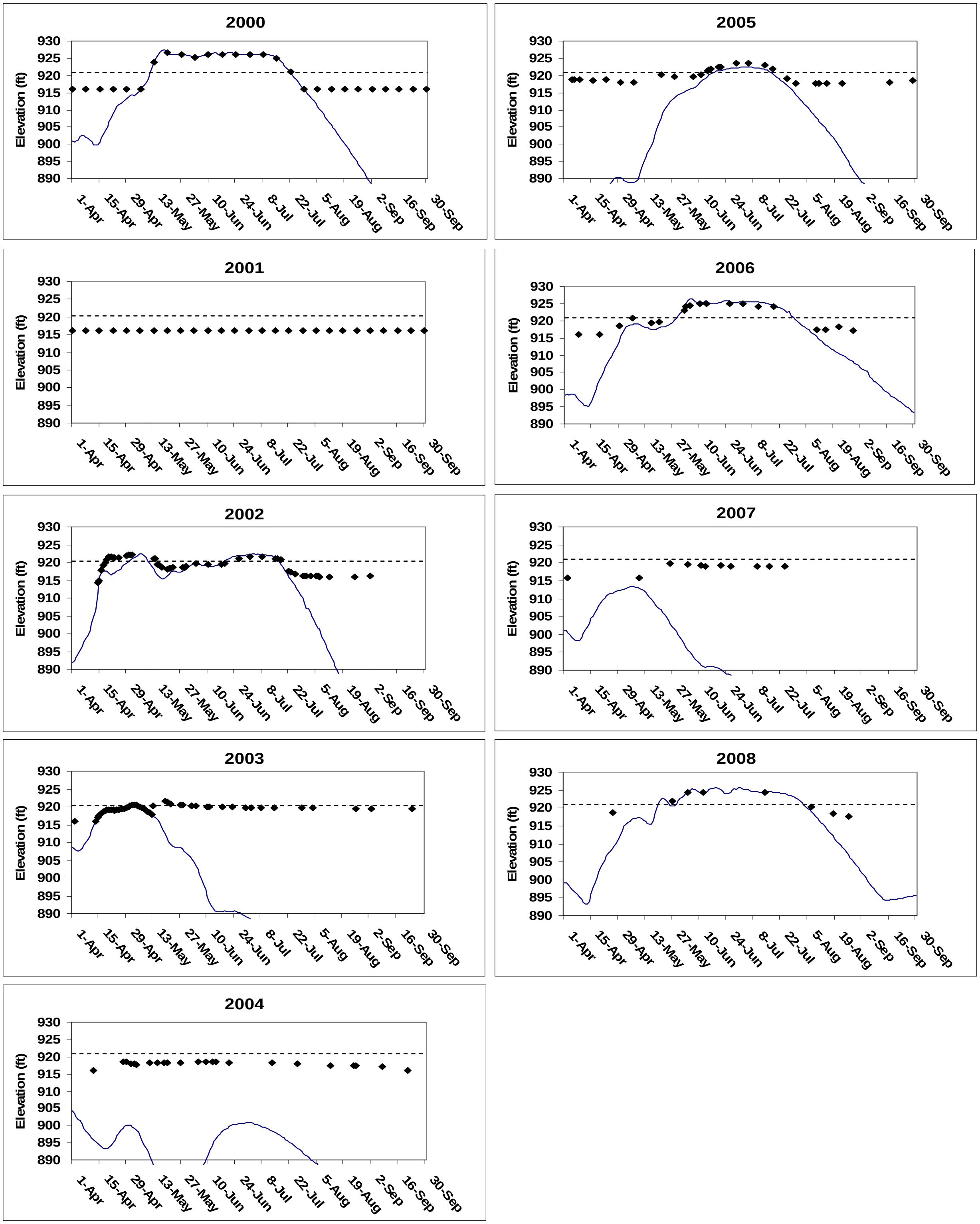


Figure 4. Elevations of Hospital Pond and Lookout Point Reservoir from 1 April through 30 September, 2000-2008. Reservoir elevations are represented by solid lines and pond elevations are represented by diamonds. The elevation of the pond terrace (921 ft) is represented by a dotted line. The maximum conservation pool elevation for Lookout Point Reservoir is 926 ft. Note that the maximum reservoir elevation in 2001 was only 876 ft.

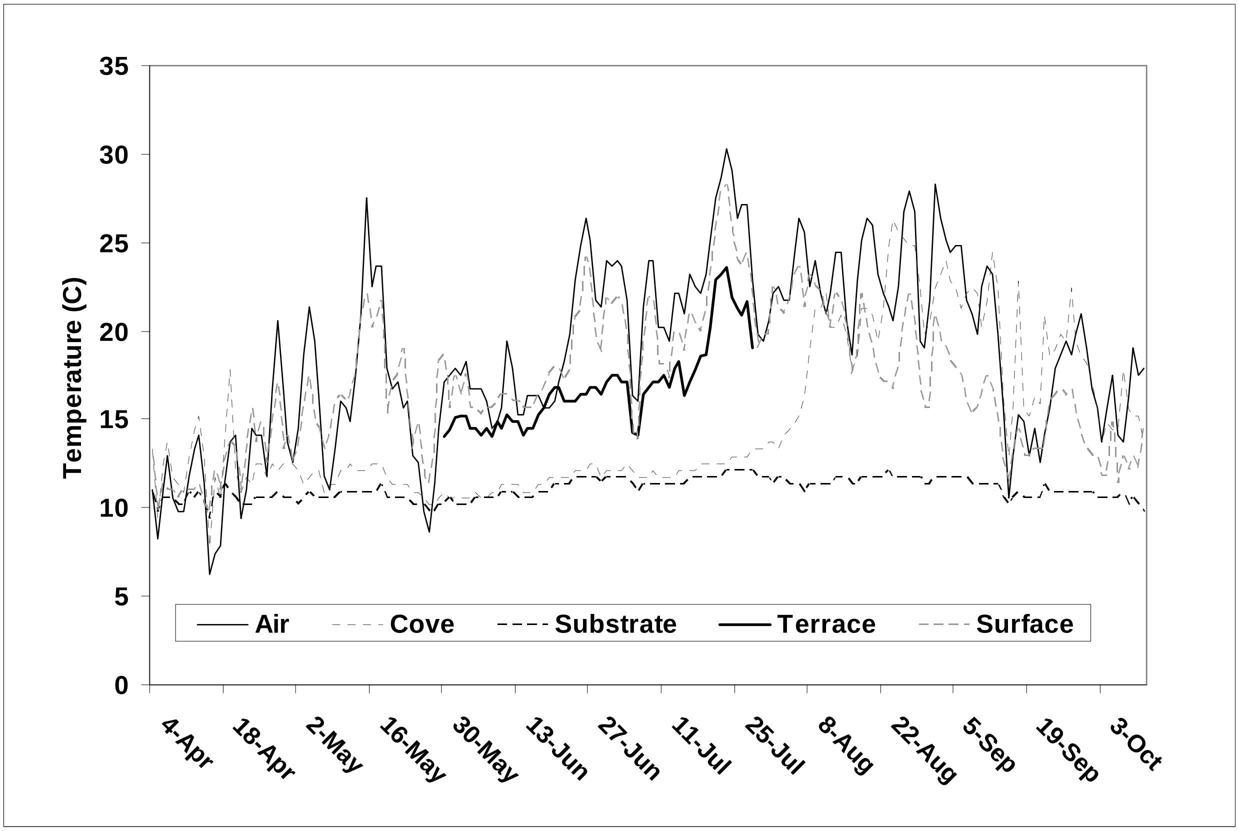


Figure 5. An example of the maximum daily water and air temperatures recorded at Hospital Pond, 2006. Note that the alcove temperatures increased in August and September when the pond elevations dropped below 918.6 ft (alcove depths less than 2.0 ft).

15.0°C and paralleled pond substrate temperatures, except for short periods when the alcove depth was less than ~1.5 ft. The only year when alcove depths were <1.5 ft for an extended period was 2007, which was the year when the average alcove temperature was the highest (15.0°C). We only measured surface temperatures in the alcove in 2003, as we found them to be nearly identical to surface temperatures in the pond.

Hatch Date Distributions

We found that Oregon chub hatch date distributions varied among years (Figure 6). In years when the reservoir filled and the terrace was flooded (2000, 2002, 2005, 2006, 2008), the hatch date distributions peaked between mid-June and mid-July and hatching coincided with the periods when the terrace was flooded and temperatures exceeded 15°C. In 2001, 2003, 2004, and 2007, the reservoir did not fill. In 2001 and 2007, juvenile chub were rare when we dip netted in the shallow margins of the pond. In 2003 and 2004, hatch date distributions were broad (~3 months versus ~2 months) and hatching typically coincided with periods when the pond elevations were less than 918.1 ft (alcove water depths were less than 1.5 ft) and alcove water temperatures exceeded 15°C. It is unclear why there were some early hatch dates in April in 2001 and 2003, years when the reservoir did not fill, that were not apparent in other years.

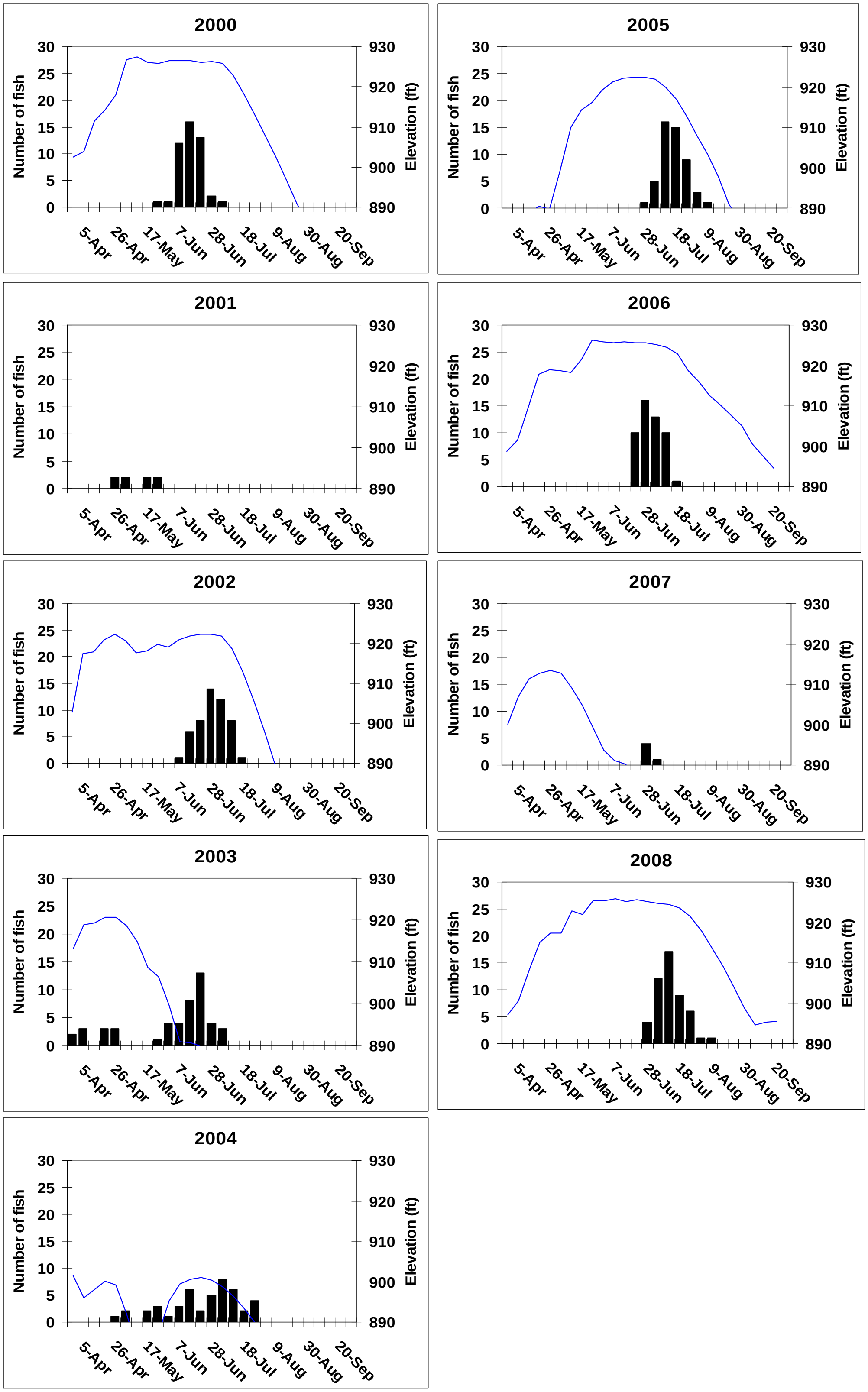


Figure 6. Oregon chub hatch date distributions (dark bars) at Hospital Pond, 2000-2008. The lines represent maximum weekly Lookout Point Reservoir elevations. Note that the maximum reservoir elevation in 2001 was only 876 ft.

Adult Age and Growth

Ages of adult Oregon chub in our samples ranged from 1 to 10 years; the majority of the fish (72-96%) were less than age 5 (Figure 7). Several strong year-classes are apparent in our data, including the 1999, 2002, and 2005 year-classes (Table 3). These year-classes were spawned during years when the reservoir filled. The mean length-at-age for fish (ages 2-4) has decreased steadily since 2001 (Figure 8; **APPENDIX A**). It is uncertain why this has occurred, but it is possible that the infrequent filling of the reservoir since 2001, which resulted in cooler pond temperatures and/or reduced influx of nutrients during the spring and summer months, has caused reduced growth rates of Oregon chub in Hospital Pond. Because small fish are not completely vulnerable to our sampling gear, age classes may be incompletely represented in the sample until the fish are 2 to 3 years old. Starting in 2006, we increased our sample size of fish collected for aging and partitioned our sample based on the size distribution of measured fish (see Methods). This was done after we discovered that the size distribution of the 2005 sample that was collected for aging was substantially different from the size distribution of the fish measured when obtaining our population estimate (**APPENDIX B**).

Population Estimates

We monitored the population abundance of Oregon chub at Hospital Pond in 1993, 1995 and 1997 through 2008 (Figure 9). Abundance estimates fluctuated widely and ranged from a low of 690 fish (95% CI; 470-1,320) in 1993 to a high of 5,040 (95% CI: 4,050-6,270) in 2005. Abundance was lowest in 1993 and 1995, increased significantly in 1997 and remained relatively constant through 2003 (no significant differences), increased significantly in 2004 to 2005, declined significantly in 2006 and 2007, and increased significantly again in 2008. The precision of our estimates improved, specifically the magnitude of upper 95% confidence limit relative to the estimate was reduced, starting in 2002 when we increased our sampling effort (increased the number of traps from 24 to 48). Increases in Oregon chub abundance at Hospital Pond were driven by strong year-classes that occurred in 1999, 2002, and 2005, years when the pond terrace was flooded (Tables 2 and 3). Weak year-classes typically occurred during those years when the reservoir did not fill and the terrace was not flooded (ex. - 2001, 2003, and 2004).

Table 3. Cohort reconstruction for Oregon chub in Hospital Pond from 1999-2005. Total abundance of each brood year is summed for ages 2 to 3. Age 1 fish were excluded from the analysis because we do not typically collect them in our sampling gear. Abundances of ages 4 and older were not available beyond 2004, thus were excluded from this table. Note that no aging data was available prior to 1999.

Brood year	Abundance
1999	2,114
2000	419
2001	529
2002	7,484
2003	419
2004	486
2005	1,896

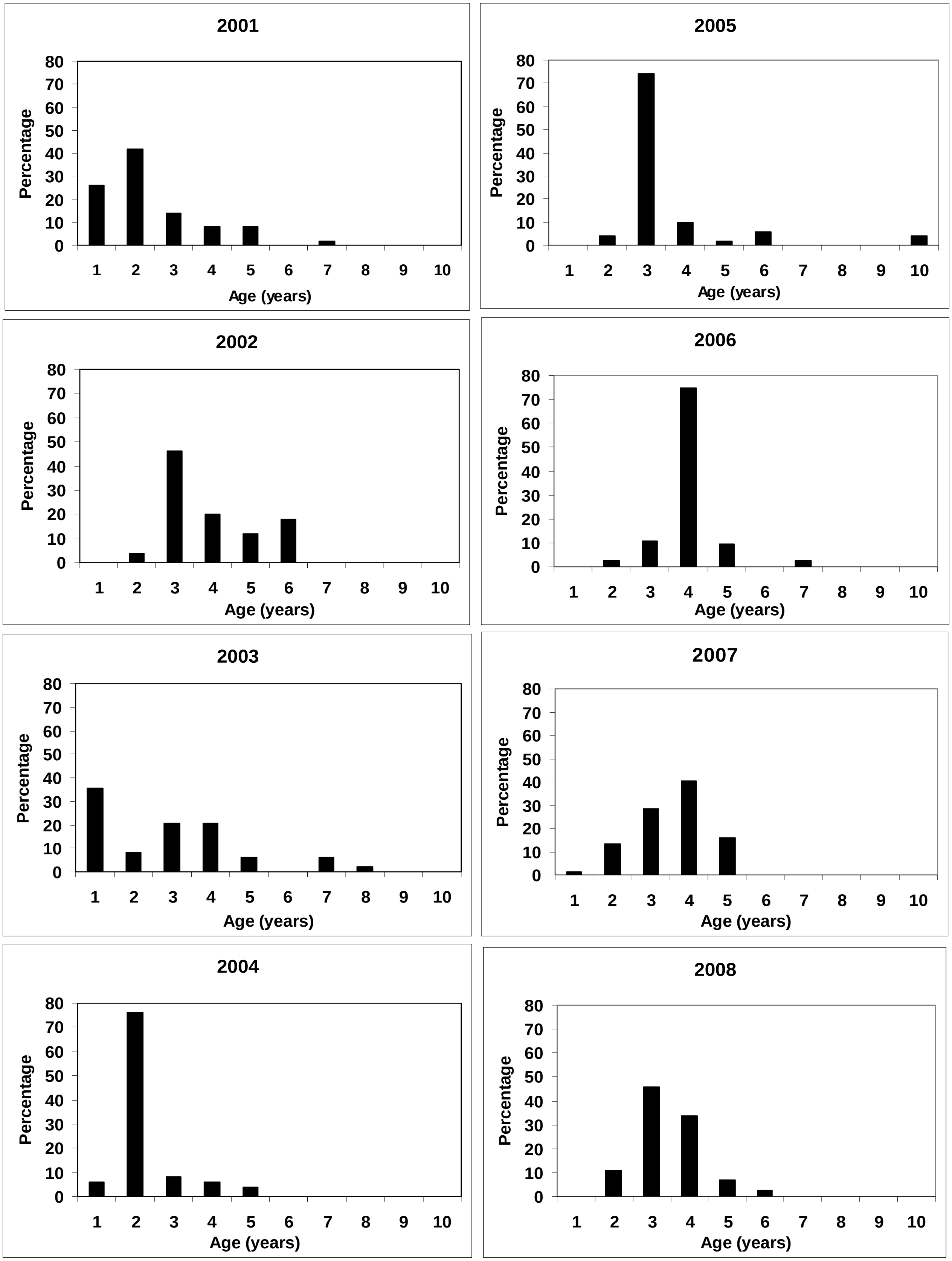


Figure 7. Age structure of the Oregon chub populations in Hospital Pond, 2001-2008.

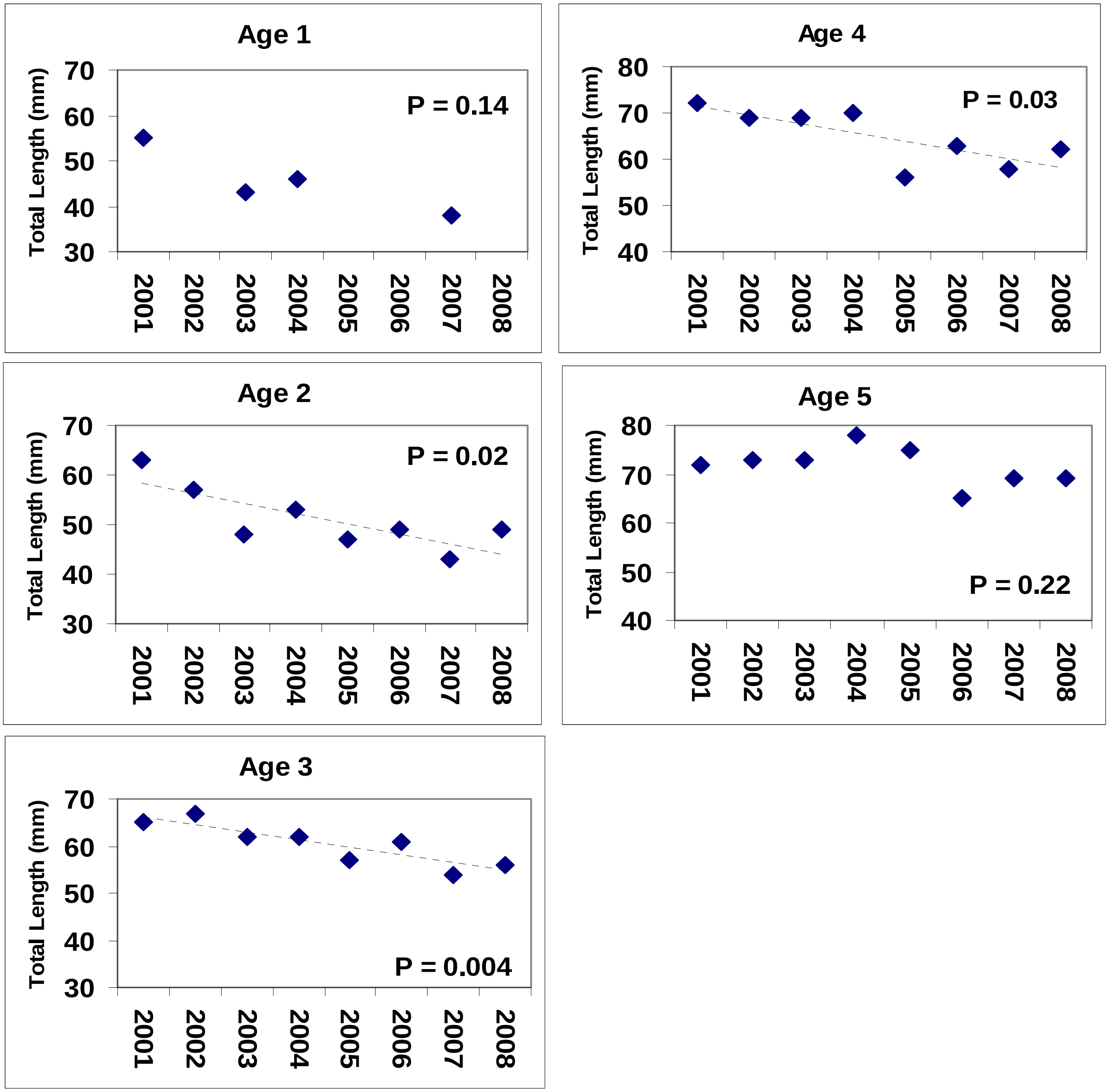


Figure 8. Changes in mean length-at-age for Oregon chub collected from Hospital Pond, 2001 through 2008. Fitted regression lines (dotted lines) are shown where significant slopes occur.

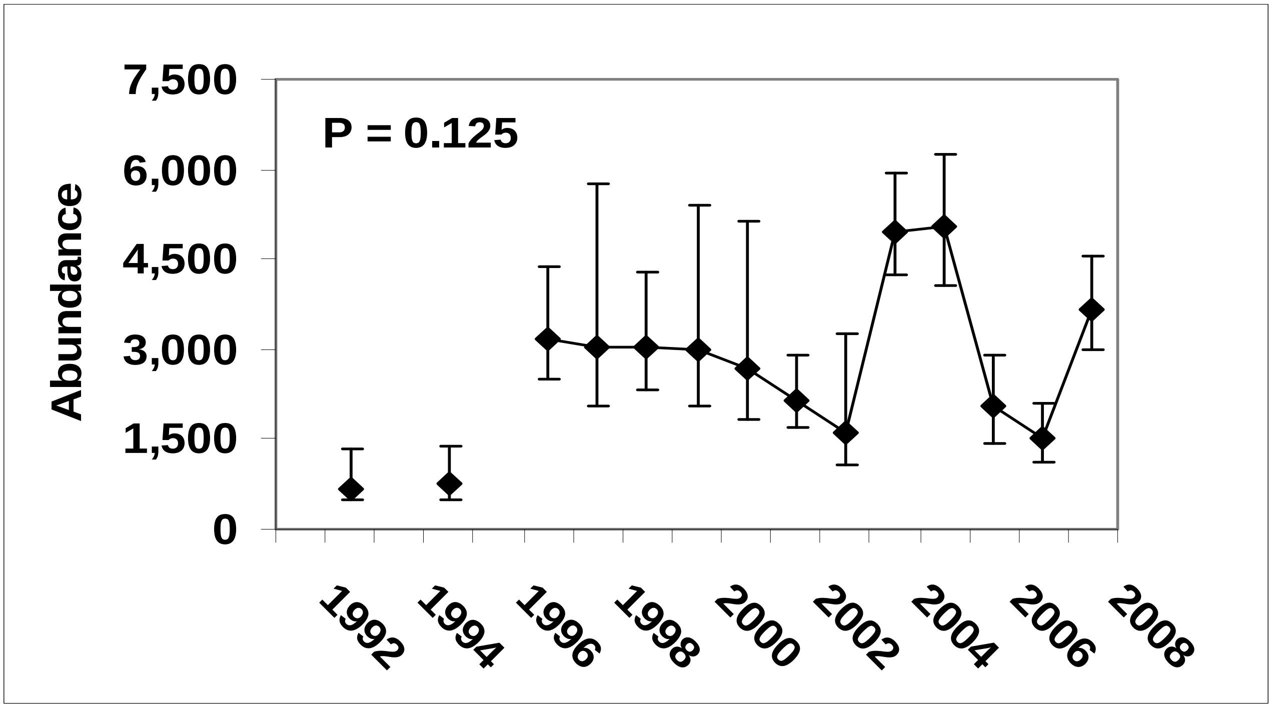


Figure 9. Oregon chub population abundance estimates at Hospital Pond, 1993-2008. Horizontal bars represent 95% confidence intervals for each estimate. The slope of regression line fitted to these points was not significant (P>0.10).

DISCUSSION

Previous investigations suggested links between water elevations of Lookout Point Reservoir, water levels and water temperatures in Hospital Pond, and Oregon chub spawning and recruitment (Scheerer et al. 1998; Scheerer et al. 2000). In 2001 through 2003, the Corps completed habitat enhancement projects designed to provide managers the ability to regulate pond elevations independently of Lookout Point Reservoir elevations.

We found that Hospital Pond was fed by a high discharge, cold water spring (10-12^{o}C) and that few areas of the pond warmed substantially during the Oregon chub spawning period, which begins as early as April and can extend through early-August. We also found that when the pond levels exceeded an elevation of 921 ft, then the pond terrace was flooded and water temperatures on the terrace exceeded the temperature threshold ($\underset{\sim}{}$15^{o}C) for chub spawning to occur. We documented successful recruitment by analyzing the Oregon chub age structures and found strong year-classes were produced only in years when the terrace was flooded for at least 30 days (1999, 2002, and 2005), but not all years when the terrace was flooded (2000 and 2006). It is possible that recruitment in 2000 and 2006 was limited by density-dependant mechanisms, i.e. competition for food and space with the strong 1999 and 2005 year-classes.

We documented through hatch date analyses that successful spawning typically coincided with periods when pond temperatures exceeded 15^{o}C and that pond temperatures adequate for spawning occurred when the terrace was flooded and when the water depth in the constructed alcove was less than 1.5 ft (Figure 10). However, the pond modifications that were designed to allow us to regulate pond elevations to create conditions suitable for Oregon chub spawning were largely unsuccessful. We found that only when reservoir elevations exceeded 917 ft were we able to raise water levels in Hospital Pond enough to flood the terrace (921 ft). We were able to flood the constructed alcove in 2003 through 2008; however water temperatures in the alcove were typically less than 15^{o}C, except for brief periods when the pond elevations were less than 918.1 ft (alcove water depth <1.5 ft). There has been an apparent shift in the peak hatch date from late-June to mid-July over the period of this study. This may be due to the fact that in recent years when the reservoir filled, it has filled several weeks later than in the earlier years of this study (Figure 6).

Oregon chub population abundance in Hospital Pond was lowest in 1993 and 1994, increased and was relatively stable from 1997 through the early 2000's, and peaked in 2004 and 2005, declined in 2006 and 2007, and then increased substantially in 2008. The population was dominated by the 1999 year-class in 2001 and 2002 and by the 2002 year-class from 2003 through 2006. In addition to density-dependent mechanisms mentioned above, cooler pond temperatures that occurred during the spring months of 2003 and 2004, years when the reservoir did not fill, may have acted to slow egg maturation and/or limit food abundance, resulting in reduced survival of early life stages.

We recommend the continuation of population and water level monitoring at Hospital Pond. If the reservoir continues to fill every 2 to 3 years as it has for the last decade, it appears that conditions in Hospital Pond will support regular Oregon chub recruitment and the population will show a stable trend in population abundance into the future. It does not appear that the spawning alcove provides much benefit to Oregon chub, unless water levels in the alcove are maintained at depths less than ~1.5 ft. Installation of a self-regulating mechanism on the culvert gate to fine tune water level management in the pond, excavation to increase the area of the alcove, and/or the excavation of additional alcoves or low terraces may create conditions that will promote successful chub spawning in years when Lookout Point Reservoir does not fill.

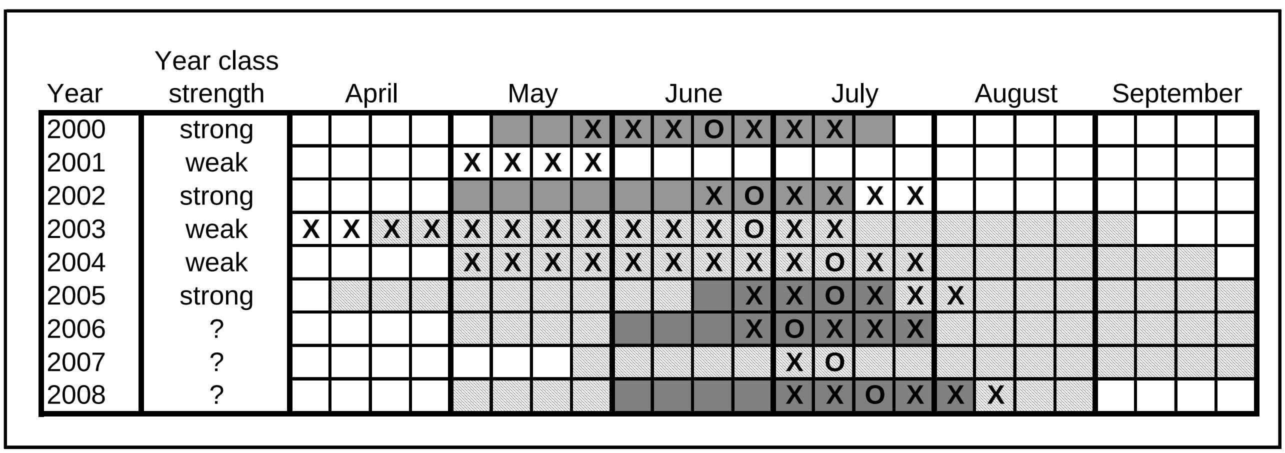


Figure 10. Relationships between year-class strength, time periods when the pond terrace was flooded (gray boxes), time periods when the pond alcove as flooded (hatched boxes), hatch date distributions (X's), and peak hatch dates (O's) at Hospital Pond, 2000-2008. Note: the reservoir did not fill in 2001, 2003, 2004, or 2007.

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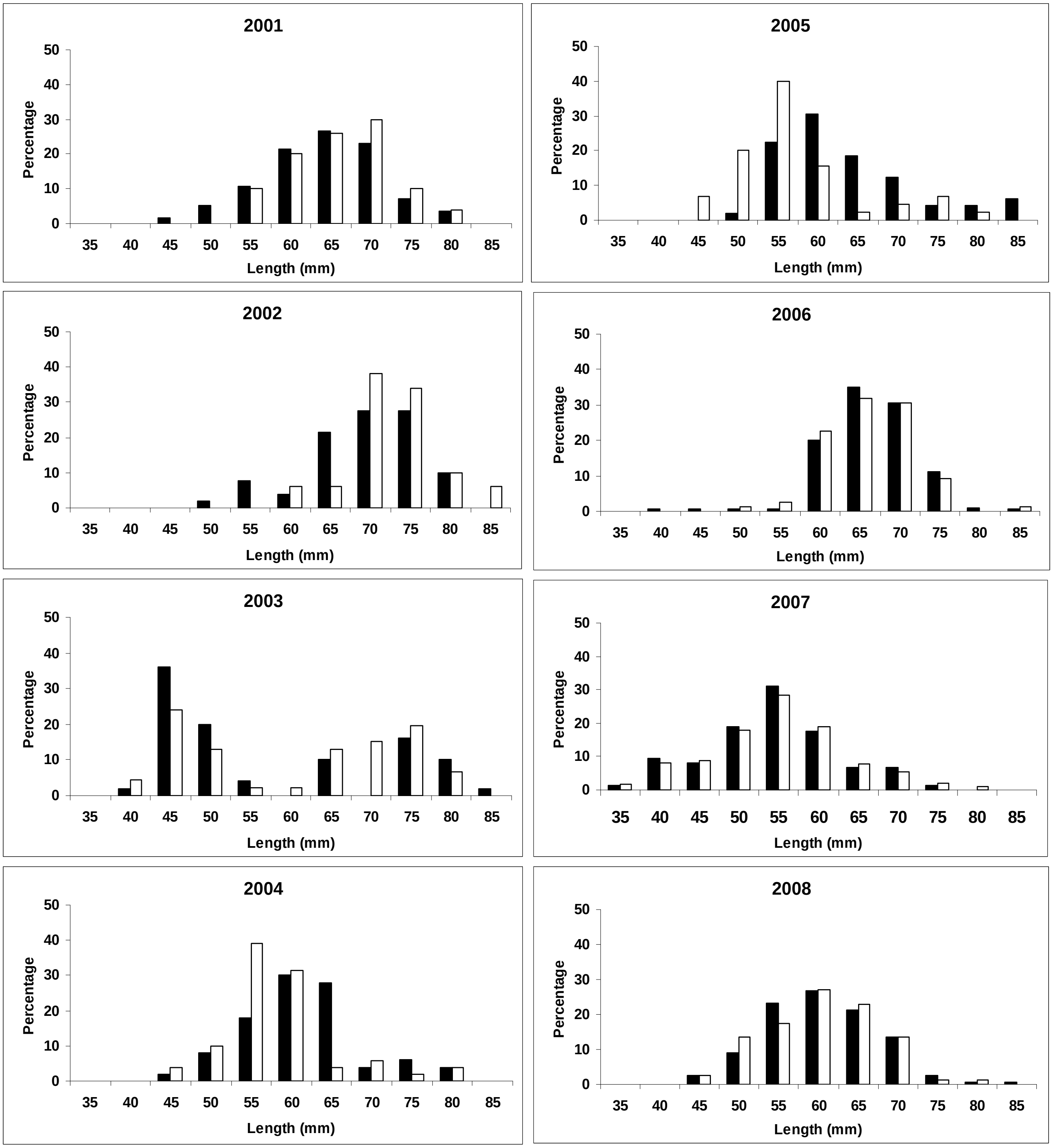
APPENDIX A. Mean lengths-at-capture and ranges of lengths for Oregon chub aged 1 to 10 years from Hospital Pond, 2001-2008.

	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

APPENDIX A (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	
2007								
Mean total length (mm)	38	43	54	58	69			
Range of values	(38-38)	(42-45)	(47-59)	(50-62)	(64-76)			
Number of fish	1	10	21	30	12			
Percentage of sample	1	14	28	41	16			
2008								
Mean total length (mm)	-	49	56	62	69	74		
Range of values	-	(45-53)	(45-64)	(54-70)	(66-73)	(68-79)		
Number of fish	0	8	34	25	5	2		
Percentage of sample	0	11	46	34	7	3		

APPENDIX B. Comparison of length-frequency histograms of Oregon chub collected for aging (open bars) and for chub measured during population estimates (solid bars) in Hospital Pond, 2001-2008.



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