Monitoring of Hospital Pond (2001):

Willamette Basin Oregon Chub Investigations, Monitoring & Management

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INTRODUCTION

The Oregon chub *Oregonichthys crameri* is endemic to the Willamette Valley of western Oregon. This species was formerly distributed throughout the Willamette Valley in off-channel habitats such as beaver ponds, oxbows, stable backwater sloughs, and flooded marshes, which are characterized by little to no water flow, silty and organic substrate, and abundant aquatic vegetation and cover for hiding and spawning. In the last 100 years, these habitats have disappeared rapidly 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. Oregon chub were listed as endangered in 1993 under the federal endangered species act (Rhew 1993).

ODFW's prior monitoring of the effects of water storage and flow management operations at Lookout Point Reservoir indicated that changes in reservoir elevation directly affected water levels, water temperatures, and available Oregon chub habitat in Hospital Pond (Scheerer and McDonald 2000; 2001). Changes in reservoir and pond elevations have the potential to adversely affect Oregon chub, due to their effect on water temperatures and, consequently, reproductive behavior and success.

Due to drought conditions in the Willamette Valley in 2001, Lookout Point Reservoir did not fill. Consequently, conditions in Hospital Pond were different that in previous years (1998-2000) when life history investigations were conducted. Previous data suggested that filling of the reservoir was necessary for successful Oregon chub spawning in Hospital Pond. The drought conditions allowed us to directly test this hypothesis. We expanded our investigations in 2001 to include determination of population age structure. These data were collected to assess the risk of potential recruitment failure to the chub population in single and successive years. On June 12, 2001 the U.S. Army Corps of Engineers installed a gated water control structure in the outflow culvert at Hospital Pond. The control structure was installed in an attempt to artificially raise the water levels in Hospital Pond to mimic reservoir filling. The gate was marginally effective. The water level in the pond increased only ~1 foot and stabilized. Leakage of water around the culvert, and possibly at other locations through the road fill, equaled inflow volume. The water level increase resulted in a minimal increase (<5%) in the surface area of the pond and did not flood the vegetated bench.

This report contains the results of research conducted in 2001 at Hospital Pond, including monitoring of air temperatures and water temperature profiles, monitoring of reservoir and pond level elevations, and collection and analysis of related Oregon chub biological data. These data will be useful to the U.S. Army Corps of Engineers for near-term and long range water storage and flow management planning related to the protection of Oregon chub and their habitat in Hospital Pond.

OBJECTIVES

Objective 1: Monitor temperatures and habitat conditions at Hospital Pond and relate these parameters to Lookout Point Reservoir elevation and temperature. Determine the effects of reservoir operations on Oregon chub spawning

success.

Task 1.1: Monitor temperatures in Hospital Pond, Lookout Point Reservoir, and air temperatures from May-September 2001.

Task 1.2: Monitor effects of reservoir elevation on quality and quantity of available spawning habitat in Hospital Pond from May-September 2001.

Task 1.3: Monitor spawning success of Oregon chub by determining approximate hatch dates from a sample of surviving juvenile Oregon chub captured in the fall of 2001. Relate hatch date distribution to pond temperatures and habitat conditions. Compare results from 2001 with hatch date distributions for 1998 and 2000.

Task 1.4: Determine the effect (risk) of year-class failure resulting from drought conditions in 2001 (Lookout Point Reservoir did not fill and this may result in recruitment failure of the 2001 brood). Determine the population age structure from of a random (representative) sample of 50 adult chub using otolith aging techniques.

Objective 2: Monitor natural and introduced populations of Oregon chub on U.S. Army Corps of Engineers' properties.

Task 2.1: Obtain population estimates for naturally occurring Oregon chub populations in Hospital Pond and Dexter Reservoir alcoves in 2001. Provide assistance in researching management options for Dexter Reservoir alcoves.

Task 2.2: Monitor reintroductions of Oregon chub at Fall Creek Spillway Ponds, Foster Pullout Pond, and Menear's Bend in 2001.

Task 2.3: Evaluate potential reintroduction sites on Corps' properties.

Observations and Background Data Regarding Oregon Chub and Hospital Pond

Following is a summary of research results and observations regarding Oregon chub and the potential impacts of mainstem Willamette River flow augmentation on chub populations, particularly operations that might alter the management of Lookout Point Reservoir during periods that are critical for Oregon chub spawning and juvenile survival (Scheerer and McDonald 2000; 2001).

- The Oregon chub Recovery Plan states that in order to downlist the species to threatened, at least ten populations of Oregon chub, numbering 500 or more adults per population, must be maintained. These populations must exhibit a stable or increasing trend in abundance for a period of at least five years.
- In 2001, nine populations met this criteria. The population in Hospital Pond was one of these populations.

- Hospital Pond is a long (`300 meter), narrow (~6-10 meters), deep (2.0-4.0 meters), spring-fed pond, that was created during the construction of the North Shore Road near Lookout Point Reservoir.
- The culvert that connects the pond to the reservoir has an elevation of 917 feet. Full pool elevation for Lookout Point Reservoir is 926 feet.
- We monitored pond temperatures in 1997-2000 and found that pond temperatures remained relatively constant and cold (8-12^{o}C) during most of the year and warmed up in the spring (June – July) when Lookout Point Reservoir elevation exceeded 921 feet in elevation.
- In 2000, as the reservoir filled, the pond elevation increased (up to ~9 feet). When the pond elevation increased, the surface area also increased (width increased to ~20 meters) and a shallow, vegetated terrace was flooded. In 2000, we found that the pond temperature warmed (to ~15-18^{o}C) due to the effects of solar radiation heating water on the shallow vegetated terrace and closely paralleled changes in air temperatures.
- Spawning observations in the field found that Oregon chub spawned primarily from mid-May through July when temperatures exceeded 16 ^{o}C. Oregon chub spawned in dense vegetation and had adhesive eggs.
- Laboratory spawning experiments were conducted in 1997. No spawning occurred (no noticeable gonadal development) in treatment groups exposed to constant 12-13^{o}C and natural photoperiod. Spawning occurred in control treatments and treatments exposed to constant 16-17 ^{o}C and 20-21 ^{o}C temperatures and natural photoperiod from June through mid-August.
- Otolith analyses were conducted on chub captured from Hospital Pond in 1998 and 2000 to determine hatch date distributions. Hatch date distributions for juveniles showed that hatching occurred from the end of May through early July and peaked during June. Juvenile survival was highest for fish hatched between mid-June and early-July. Spawning occurred ~7-10 days prior to hatching.
- Spawning occurred when the pond temperatures were warm (exceeded 16 ^{o}C) and no juveniles were collected with hatch dates after early-July, when the reservoir levels dropped below 920 feet, the shallow terrace became exposed, and pond temperatures dropped.
- Otolith aging (non-random sample) was conducted in 1997-1998. We found the majority of fish in the populations were ages 0-3 years, but we could not determine population age structure. However, we collected no fish from the 1992 and 1994 year classes (years the reservoir did not fill), suggesting possible recruitment failure.
- Length-at-age analysis found that the majority of the Oregon chub vulnerable to our sampling gear (minnow traps) were age 1+ or older. Examination of gonadal development found most age 1+ fish (>35 mm) were developing or fully developed and are presumed to be capable of spawning.
- Monitoring of Oregon chub reintroductions found that Oregon chub can expand their numbers rapidly, and fish are recruited into the adult population at age 1+. Also, we monitored trends in abundance of naturally occurring populations of chub and found that major increases in abundance from one year to the next can be largely attributed to the recruitment of the age 1+ fish into the population.
- Oregon chub populations at Hospital Pond were lowest in 1993 (n=690; 95% CI= 470-1,300) and 1995 (n=780; 95% CI= 510-1,390) and highest in 1997 (n=3,160; 95% CI= 2,480-4,370), 1998 (n=3,030; 95% CI= 2,050-5,780), 1999 (n=3,020; 95% CI= 2,330-4,290), 2000 (n=2,980; 95% CI=2,050-5,410), and 2001 (n=2,700; 95%

CI=1,830-5,140) (Scheerer et al. 2002). The reservoir did not fill in 1992 or 1994. These data suggest that when reservoir did not fill recruitment was poor and in the following year population abundance was reduced.

- These data suggest that successful spawning and recruitment in Hospital Pond may be dependant upon Lookout Point Reservoir being full in June and early-July.

MATERIALS & METHODS

Temperature Monitoring

Temperature recorders (Hobo®) were placed at four locations in and around Hospital Pond. Three recorders were placed in Hospital Pond. One recorder was placed on the bottom of the pond, near the culvert at the southwest end of the pond, a second recorder was attached to a cable that was anchored to a stump and was floated in the pond approximately 0.15 meters below the surface at the northwest end of the pond, and a third recorder was placed on the shallow vegetated bench on the south side of the pond. This recorder was only submerged when the reservoir elevation exceeded ~922 feet, which did not occur in 2001. Air temperature was monitored with a recorder placed on a branch of a tree (approximately 2 meters above the ground) growing on the edge of the shallow vegetated bench of the pond. This recorder was covered with moss and remained in the shade throughout the day. In 2000, the temperature of Lookout Point Reservoir was monitored with a recorder placed approximately five meters east of the outflow culvert at elevation ~917 feet. This recorder measured the temperature of the reservoir water at the strata or level that entered Hospital Pond culvert when the reservoir exceeded ~917 feet in elevation. Because the reservoir did not fill in 2001, the reservoir and bench recorders are omitted from further discussion. Recorders were set to record at five hour intervals. The maximum temperature recorded each day was used to determine whether the threshold temperature necessary for Oregon chub spawning to occur (~16° C) was exceeded (Scheerer and McDonald 2000).

Adult Aging

In May 2001, we collected a random, representative sample of 50 adult Oregon chub from Hospital Pond using baited minnow traps. The fish were collected to determine the age structure of the population. The fish were sacrificed and placed in 95% ethanol. Samples were taken back to the lab to be processed. Standard, fork, and total lengths were measured to the nearest millimeter. The right lapillus was removed from all Oregon chub 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 (0.5mm) that included the otolith core. Thin sections were mounted on glass slides in Crystal Bond® and polished using Buehler® Gamma Micropolish alumina solution (0.05 micron) and 1500 grit Carbimet® paper discs. Adult otoliths were aged using transmitted light at 100X under a compound scope. 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 otolith.

Hatch Date Distribution

In October 2001, we collected 12 juvenile Oregon chub from Hospital Pond to determine 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 were polished using 1500 grit Carbimet® paper discs and 0.05 micron Buehler® Gamma Micropolish alumina solution. 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. Spawning dates were estimated to be seven days prior to the hatch date. Since data for incubation time was not available for Oregon chub, we used available data (~7 days) for redside shiner Richardsonius balteatus (Weisel and Newman 1951). Otoliths from juvenile fish were read twice by one reader. If the first and second age differed by >6 days, then a third count was made. A final age was assigned that was closest to the third count.

Population Estimates

Population estimates were obtained for naturally occurring Oregon chub (Hospital Pond and Dexter Reservoir Alcoves) and for introduced Oregon chub (Fall Creek Spillway Ponds and Foster Pullout Pond) on Corps' properties. Minnow traps (23cm x 46cm with 64mm mesh) were used to capture chub. These traps were baited with a half slice of bread and set for 3-18 hours. We marked fish with a partial caudal fin clip and returned them to the water. This procedure was repeated for several days. Each subsequent day we marked all unmarked fish and counted all previously marked fish in the sample. Population estimates were made each day and the ratio of the number marked to the total estimate was compared to determine the approximate percentage of the total population that was marked. Fish were marked until approximately 15 percent of the population was marked. All fish were returned to the water. Population size was estimated using single-sample mark-recapture procedures (Ricker 1975). To calculate population abundance, we used the total number of marked fish and the catch and recaptures from the last sample date. Confidence intervals were calculated using a Poisson approximation (Ricker 1975). Fish smaller than ~35 millimeters in length were not captured by the minnow traps, and were not included in the estimates. Excluded from estimates were all age 0+ fish.

RESULTS

Temperature Monitoring

Temperatures in Hospital Pond varied substantially depending on the location of the temperature monitor (Figure 1). Because Lookout Point Reservoir did not fill completely in 2001, no temperatures were recorded on the vegetated bench of Hospital Pond or in Lookout Point Reservoir at the culvert elevation of 917 feet (both were dry). For reservoir levels to have an impact on water levels in Hospital Pond the reservoir elevation must exceed 917 feet.

Changes in water temperature measured near the pond surface (mean 15.6 ^{o}C; range 10.9-18.4 ^{o}C) closely paralleled changes in air temperature (mean 20.3 ^{o}C; range 10.9-27.9 ^{o}C). Water temperatures were substantially cooler on the bottom of the pond (mean 10.8 ^{o}C; range 10.0-12.6 ^{o}C). The cold, dense spring water that enters the pond at the east end sinks to the bottom, flows through the pond, and exits out of the culvert at the southwest end. The warmer surface strata covers this cold strata and extends ~0.25 meters down from the surface. There is very little pond edge habitat exposed to these warmer temperatures when the reservoir elevation is <917 feet.

After the water control structure was installed on June 12, 2001, the water temperatures on the bottom of the pond averaged ~1^{o}C cooler than those recorded the previous 4-6 weeks, possibly because the cooler water was not able to exit the pond as freely through the culvert, although some leakage occurred.

Adult Aging

Ages of adult Oregon chub in Hospital Pond ranged from 1-7 years. The majority (82%) were less than 4 years old (Figure 2; Table 1). The fish were collected in May 2001 and ranged in size from 53-85mm (total length). Earlier investigations found annulus deposition to occur in June-July (Scheerer and McDonald 2000). Thus, age 1 fish were from the 1999 brood (nearly 2 years old) and age 2 fish were from the 1998 brood (nearly 3 years old), and so on. The chub age structure from the 2001 random sample was similar to that from the non-random sample collected in 1998 (Scheerer and McDonald 2000).

Hatch Date Distribution

An aging validation study was completed in 1997 (Scheerer and McDonald 2000). The rate of otolith increment deposition was determined to be one increment per day (*Number of increments deposited = -0.26 + 1.01 times the number of days post marking;* R^2 = .997). This regular rate of deposition allows us to determine approximate hatch dates from otoliths of juvenile chub via back-calculation.

In 2001, we spent ~10 hours (over a three day period) searching for and collecting juvenile Oregon chub. This effort yielded 12 fish, ranging in size from 37-52 mm in total length. Eight of these fish were age 0 (37-43 mm). The low catch rate was in stark contrast to collection efforts in 1998 and 2000, when we were able to easily collect 50 juvenile chub in ~45 minutes of sampling effort. This low catch per unit of effort in 2001 suggests recruitment of a very weak 2001 year-class. Redside shiner juveniles were also rare in our 2001 sampling.

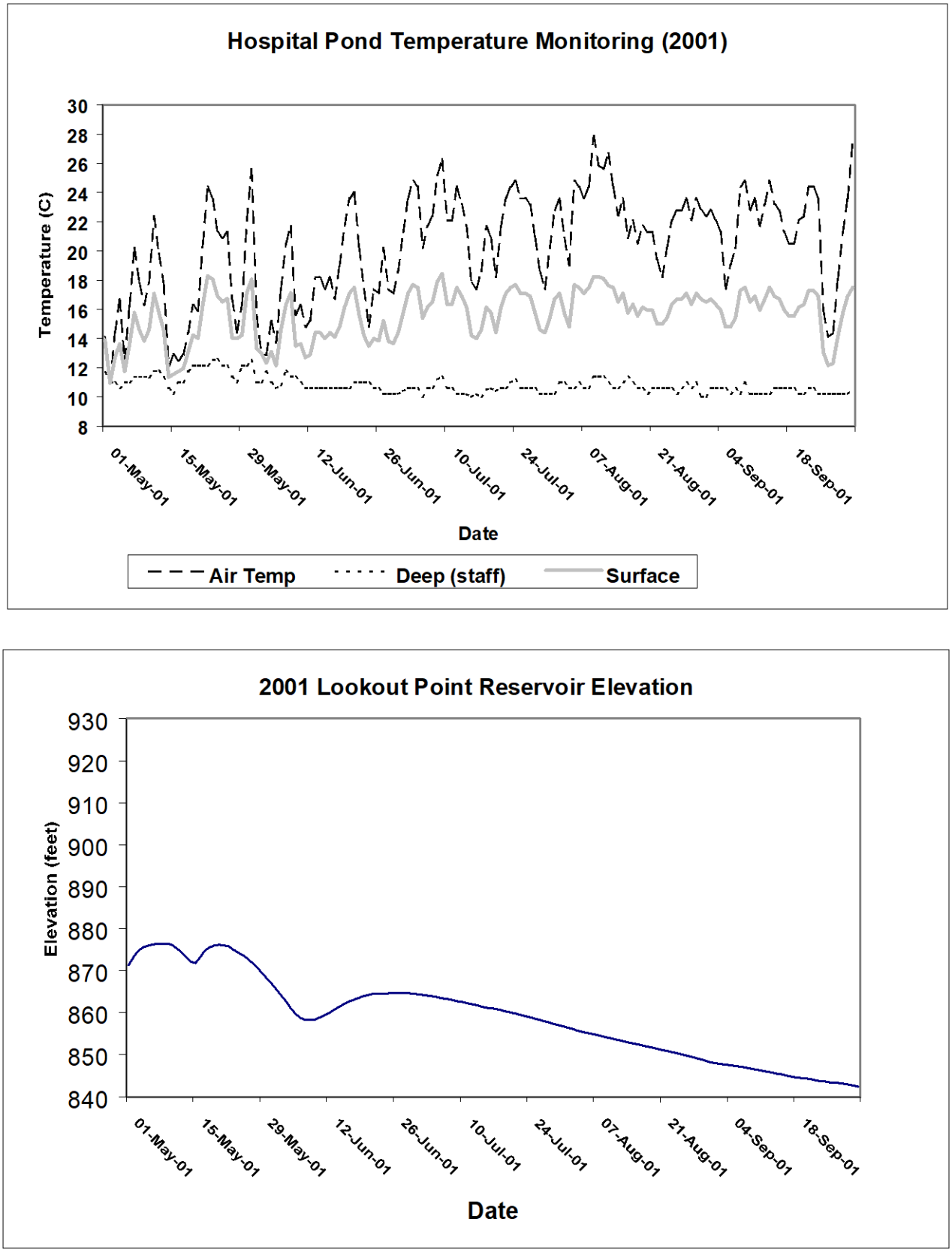


Figure 1. Hospital Pond and Lookout Point Reservoir temperatures and elevations for May through September 2001.

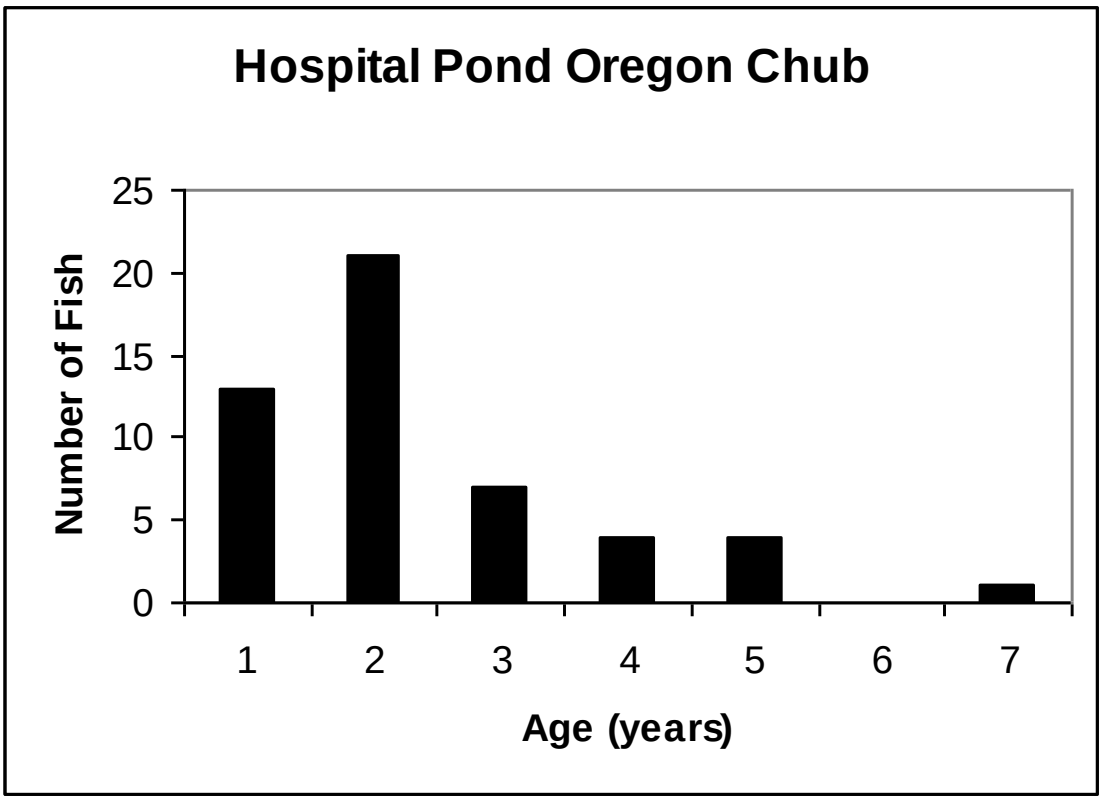


Figure 2. Age structure of the Oregon chub population in Hospital Pond in May 2001.

Table 1. Mean lengths at capture and 95% confidence intervals for Oregon chub in Hospital Pond in May 2001.

	Age (years)						
	1	2	3	4	5	6	7
Mean total length (mm)	55.3	63.4	65.3	72.0	72.5	-	85.0
95% confidence interval	(53.8 - 56.8)	(62.1 - 64.7)	(62.5 - 69.1)	69.7 - 74.3)	(63.6 - 81.4)		
Number of fish	13	21	7	4	4	0	1
Percentage of sample	26	42	14	8	8	0	2

Approximate hatch dates for the eight juveniles collected in 2001 extended from May 7 through June 4 (Figure 3). Pond temperatures when these fish were spawned in May 2001 averaged 14.3 °C (range 10.9-18.3 °C). The 2001 hatch date distribution was earlier than the 1998 and 2000 distributions. The hatch date distribution for fish collected in October 1998 from Hospital Pond extended from mid-June through mid-July and peaked near the end of June. Pond temperatures ranged from 16-17 °C during this period. The hatch date distribution for fish collected in October 2000 was similar to the 1998 distribution, extending from late-May through mid-July and peaking near the end of July (Figure 3). Pond temperatures ranged from 16-20 °C during this period. The 1998 and 2000 hatch date distributions were not significantly different ($p>0.10$).

Although spawning was noted as early as mid-May (determined from otolith aging of a sample of juveniles collected in mid-July 1998), no fish that hatched prior to mid-June were found in the October sample collected that year (Scheerer and McDonald 2000). Similarly, we found low survival of early hatched Oregon chub in East Fork Minnow Creek Pond in both 1997 and 1998 (Scheerer and McDonald 2000). This suggests that early spawned Oregon chub, hatched prior to mid-June, have poor survival rates and are not substantially represented in the adult population.

Population Estimates

Currently, there are six populations of Oregon chub in habitats on U.S. Army Corps of Engineers properties. Naturally occurring populations are found at Hospital Pond and the Dexter Reservoir Alcoves, both located in the Middle Fork Willamette River drainage. Introduced populations are found at Fall Creek Spillway Pond (Middle Fork Willamette drainage), Foster Pullout Pond (Santiam drainage), and Menear's Bend (Santiam drainage). The 2001 population abundance estimates for these locations are presented in Table 2. Also included in Table 2 are estimates for prior years at these locations.

The 2001 population estimate for Hospital Pond was 2,700 adult chub (95% CI: 1,830-5,140). This was similar to population estimates for this location in 1997-2000 (2,980-3,160). The 2001 estimate for Dexter Reservoir Alcove "The Pit" was 800 adult chub (95% CI: 600-1,210). The population abundance of chub at this location has fluctuated substantially since 1992. The 2001 estimate for Dexter Reservoir West Alcove near the RV park was 1,950 adult chub (95% CI: 1,690-2,310). The 2001 population estimate was higher than previous estimates at this location. The population abundance at this location has also fluctuated substantially over the past five years. The years when population abundance was lowest in the Dexter Reservoir Alcoves (1996 in The Pit and 1999 in Dexter RV Alcove), were the only times when largemouth bass were collected from these locations. ODFW and the Corps have discussed options to protect Oregon chub populations by restricting movement of non-native fish from Dexter Reservoir into the alcoves.

In 1996, Oregon chub were introduced into the Fall Creek Spillway Ponds, located in the overflow channel below Fall Creek Dam. The ponds were formed by beaver dams that blocked the spillway overflow channel. These dams have been in existence for approximately ten years. A total of 500 Oregon chub were moved from Shady Dell Pond (n=150) and East Fork Minnow Creek Pond (n=350) in 1996. The population abundance increased rapidly. In 2001, the chub population totaled 7,770

adults (95% CI: 6,480-9,690), the second largest chub population in the Willamette Valley (Scheerer et al. 2002).

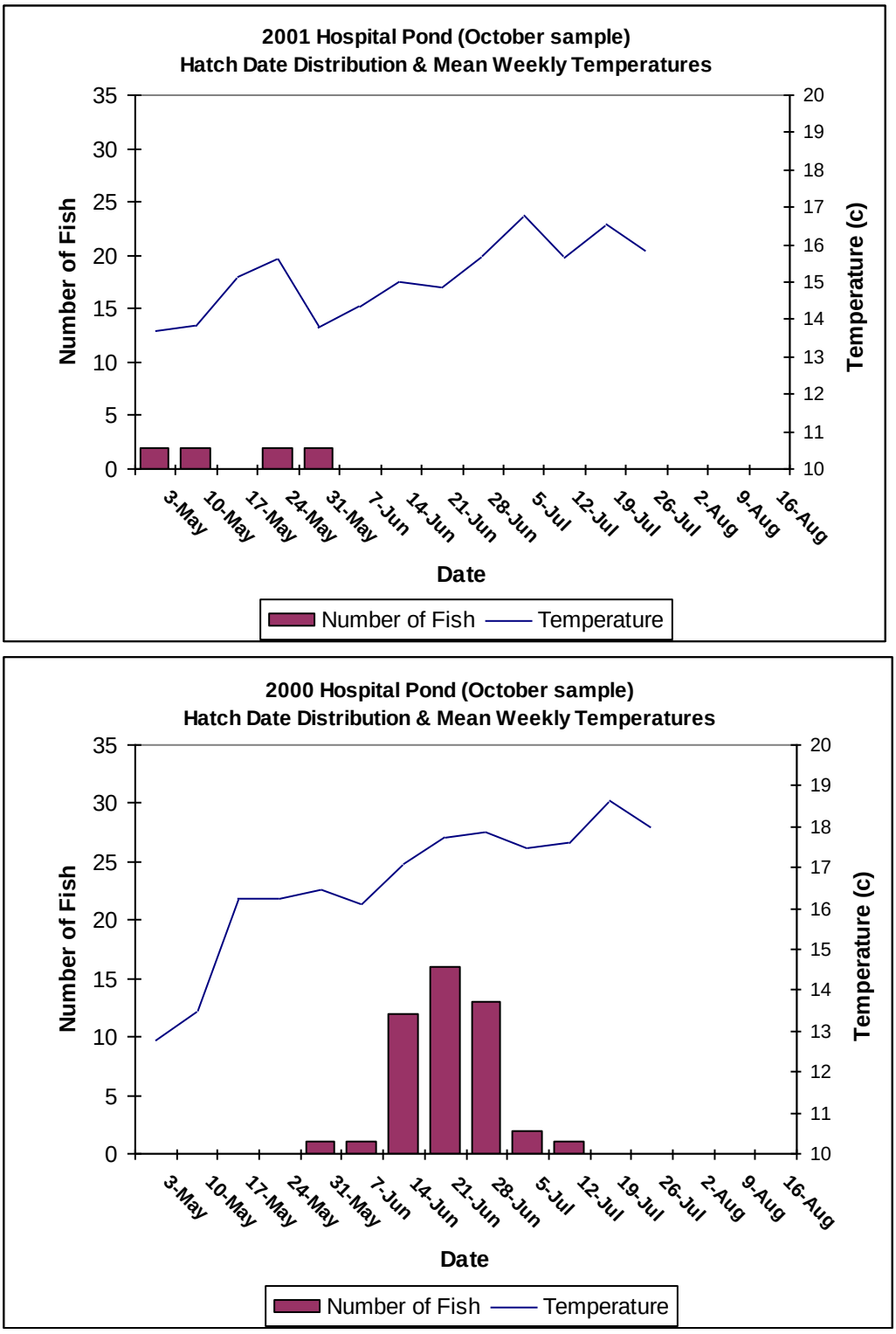
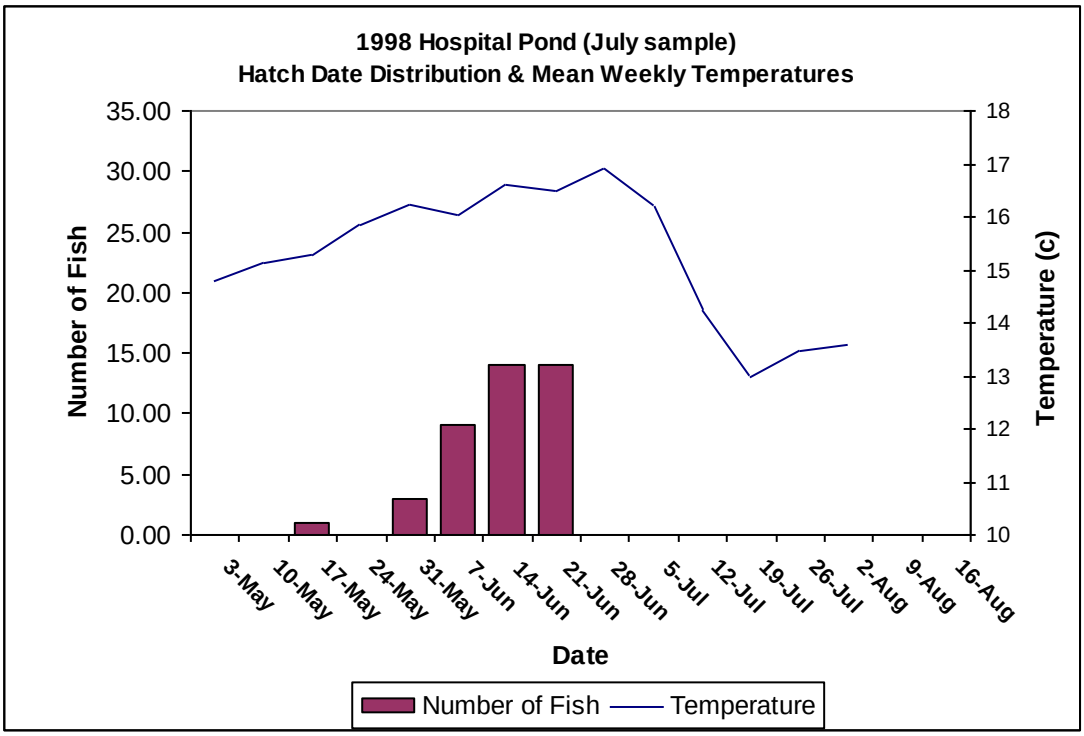


Figure 3. Oregon chub hatch date distributions and mean weekly temperatures in 1998, 2000, and 2001.



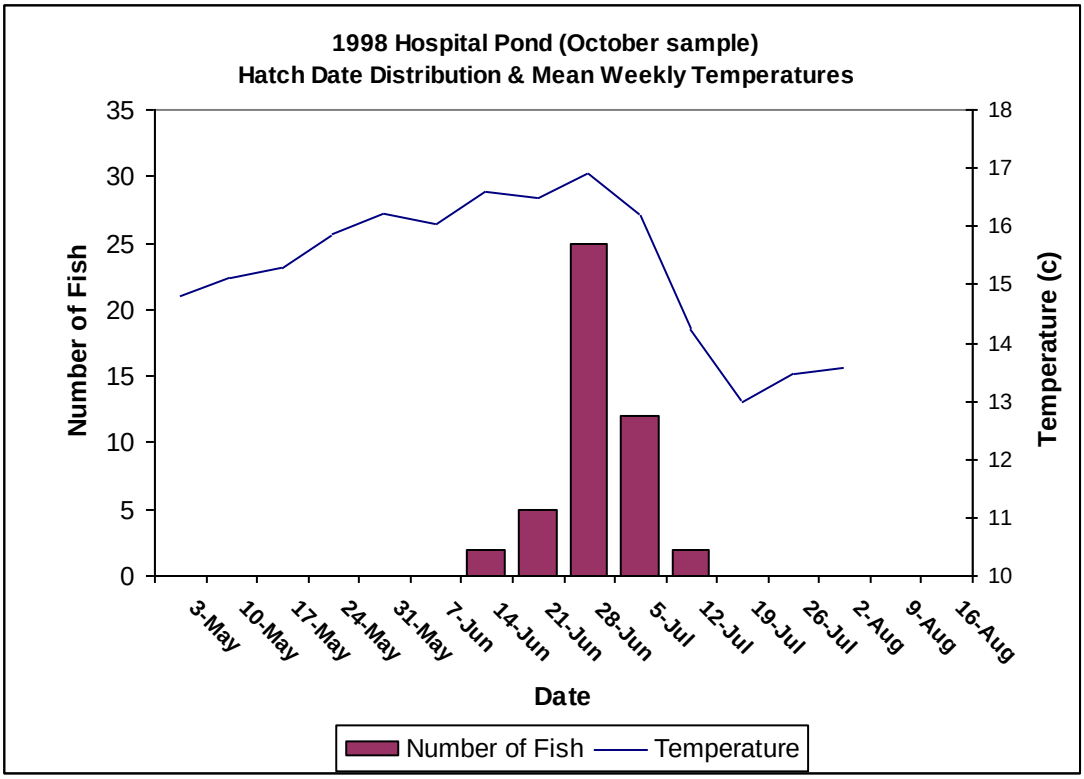


Figure 3. (continued).

Table 2. Estimates of the population abundance of Oregon chub at locations on U.S. Army Corps properties in the Willamette Valley, Oregon from 1992-2001.

Location	Date	Estimate	95% Confidence Limits lower	upper
Foster Pullout Pond[1]	October 2000	80	40	320
	May 2001	210	130	700
Menear's Bend[1]	May 2001	7		
Dexter Reservoir Alcove (RV Park)	September 1997	1,330	990	2,060
	September 1998	830	590	1,410
	September 1999	50	20	100
	September 2000	880	580	1,770
	September 2001	1,950	1,690	2,310
Dexter Reservoir Alcove (The Pit)	May 1992	780	560	1,100
	May 1995	140	80	400
	September 1996	40	20	200
	September 1997	920	760	1,170
	September 1998	450	380	540
	September 1999	1,130	910	1,480
	September 2000	1,440	1,030	2,440
	September 2001	800	600	1,200
Hospital Pond	May 1993	690	470	1,300
	May 1995	780	510	1,390
	May 1997	3,160	2,480	4,370
	May 1998	3,030	2,050	5,780
	May 1999	3,020	2,330	4,290
	May 2000	2,980	2,050	5,410
	May 2001	2,700	1,830	5,140

Table 2. (continued).

Location	Date	Estimate	95% Confidence Limits lower	upper
Fall Creek Spillway Ponds[1]	September 1997	480	400	590
	September 1998	1,400	960	2,660
	September 1999	6,300	5,460	7,450
	September 2000	5,030	4,060	6,620
	September 2001	7,770	6,480	9,690

[1] Introduced populations of Oregon chub.

Foster Pullout Pond is located on the north shore of Foster Reservoir in the South Santiam River drainage. The pond is perched several meters above the reservoir full pool level (isolated), is spring-fed, and the water level is maintained by a beaver dam at the outflow. Oregon chub were introduced from Geren Island, in the North Santiam drainage, in 1999 (n=85), 2000 (n=20), and 2001 (n=75). In 2001, prior to the latest transfer of fish, the chub population estimate was 210 fish (95% CI: 130-700).

Menear's Bend Pond is located in the Middle Santiam drainage upstream of Foster Reservoir. The pond is a small beaver pond that is fed by a small tributary and springs. Oregon chub (n=15) were introduced from Geren Island in 2000. Seven chub were captured in 2001.

A habitat enhancement project, Hospital Impoundment Pond, is located in Lookout Point Reservoir (Middle Fork Willamette drainage) adjacent to Hospital Pond. It was constructed by the U.S. Forest Service and the U.S. Army Corps of Engineers in 1994. This pond was excavated in a former railroad grade, in the drawdown zone of the reservoir. The outflow from Hospital Pond was diverted into the pond. The project was designed to benefit western pond turtles and Oregon chub. 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, 1997, 1998, 1999, 2000, and 2001. Only a few Oregon chub were collected in 1995, 1997, and 1999 (Scheerer et al. 2002). 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/recruitment in Hospital Pond (Scheerer and McDonald 2001).

In 2001, drought conditions occurred in the Willamette Valley and Lookout Point Reservoir did not fill completely. Consequently, reservoir levels did not rise enough to influence water levels in Hospital Pond and the shallow vegetated terrace in the pond was dry. Aquatic vegetation, the surface upon which chub lay their adhesive eggs, is rather limited in the pond, except on the vegetated terrace. Because the pond is deep and narrow with a substantial inflow of cold spring water, pond temperatures remain cool unless the terrace is flooded. When the terrace is flooded (when reservoir elevations exceed 922 feet) both the area of available spawning habitat and the pond temperatures increase substantially.

Realizing that the drought conditions might impact Oregon chub recruitment, we collected data regarding population age structure of this population to assess the risk of recruitment failure in single and successive years. Several age classes (year-classes) were represented in the Hospital Pond population. Most abundant were age 2 fish (42% of the population), which represent the 1998 year-class. Chub lay down their annulus in June-July, thus these age 2 fish (collected in May) became age 3 fish later during the summer of 2001. Age 1 fish (1999 year-class) comprised 26% of our sample, followed by age 3 fish (1997 year-class) at 14%, age 4 fish (1996 year-class) at 8%, age 5 fish (1995 year-class) at 8%, and age 7 fish (1993 year-class) at 2%. Consistent with aging conducted in 1998, the 1994 brood was absent from our sample. In 1994, drought conditions also occurred in the Willamette and the reservoir did not fill.

The presence of several year-classes suggests that the population age structure is broad enough for the population to withstand the effects of recruitment failure without dropping population abundance below levels where a genetic bottleneck might occur (~500 fish). For example, if the dominant year-class (age 2 fish) were absent from the 2001 population, then the population estimate of 2,700 (1,830-5,140) adult chub would be reduced by 42 percent to ~1,930 adult chub (1,070-1,570). Likewise, if the two most abundant year-classes (age 1 and age 2 fish) were absent from the 2001 population, then the population would be reduced by 68 percent to ~860 adult chub (590-1,640). Both scenarios result in a substantial reduction in the chub population, but these calculations suggest that the population abundance would not drop below 500. Likewise, we calculated the effect of recruitment failure on total egg production for the population. Oregon chub fecundity increases directly with fish length (Pearsons 1989). If successive year-classes (ages 1 and 2) were absent from the 2001 population, we calculated that total egg production for the population would be reduced between 54-64 percent (**APPENDIX A**).

In 2000, we found that water temperatures in Hospital Pond vary substantially depending on the location of the temperature monitor. Pond temperatures measured on the shallow (~1 meter deep) vegetated bench were the highest water temperatures recorded, and typically exceeded 16°C (Scheerer and McDonald 2001). These temperatures closely paralleled changes in air temperatures (starting in mid-July) and were independent of reservoir temperatures. Changes in pond surface temperatures also closely paralleled changes air temperatures. Surface temperatures were not as warm as those recorded on the shallow bench, perhaps because the floating recorder was suspended over deeper, open water. Pond temperatures were consistently lower on the bottom of the pond and in the outflow riffle and independent of bench or pond surface temperatures. The cold, dense spring water that enters the pond at the east end apparently sinks to the bottom (stratifies), flows through the pond, and exits out the culvert at the southwest end. In 2001, water temperatures near the pond surface were the warmest and were similar to those recorded in 2000.

When Lookout Point Reservoir elevations exceed ~917 feet, Hospital Pond is connected to the reservoir. This occurred between May 2 and July 17, 1998 (77 days) and May 9 and July 26, 2000 (79 days). When the reservoir elevation exceeds ~922 feet, the vegetated terrace is flooded, the water on the terrace is exposed to solar radiation (and warm air), and the water temperature increases. This occurred between May 7 and July 9, 1998 (74 days) and May 12 and July 19, 2000 (69 days). In 2001, Lookout Point Reservoir elevation reached a maximum of only 876 feet (on May 9, 2001) and the vegetated terrace was never covered with water.

In 2000, we found that successful spawning of Oregon chub in Hospital Pond coincided with the period when the reservoir elevation exceeded ~922 feet and the vegetated bench on the south side of the pond was flooded (June through mid-July). When the reservoir dropped in mid-late July 2000, the water temperature dropped, and successful spawning ceased. In 2001, Oregon chub juveniles, as well as redside shiner juveniles, were very rare in the pond suggesting minimal successful spawning occurred.

Most of the aquatic vegetation in Hospital Pond is located on the shallow vegetated terrace. Because Oregon chub require vegetation for spawning, it is likely that most of the spawning occurs in this area of the pond. When the reservoir elevation drops below ~922 feet and the bench is exposed (dry), any eggs that were spawned in the vegetation on the bench will desiccate and die. We conclude that achieving and

maintaining the water level of Hospital Pond above ~922 feet during June and July is necessary for successful spawning and recruitment of Oregon chub.

To minimize potential adverse impacts to Oregon chub, we recommend that the U.S. Army Corps of Engineers (Corps) try to maintain Lookout Point Reservoir levels between 922 and 926 feet from late-May through the end of July of each year. In 2001, the Corps attempted to artificially raise water levels in the pond by installing a water control structure (gate) on the culvert. Unfortunately, leakage around the culvert and through the road fill resulted in pond levels stabilizing at ~918 feet of elevation (only a one foot increase) and water never covered the vegetated terrace. Currently, the Corps plans to attempt to plug leaks around the culvert and through the road fill with a bentonite clay mixture. Ideally, this would allow the Corps to artificially raise pond water levels in 2002, if drought conditions recur/persist and Lookout Point Reservoir does not fil, and/or allow the Corps to draft Lookout Point Reservoir for flow augmentation while still maintaining water levels for chub in Hospital Pond.

Management options that have been discussed to protect populations of Oregon chub in the Dexter Reservoir alcoves (The Pit, and West Alcove near RV Park) include the installation of water control structures or screens to prevent movement of nonnative fish from Dexter Reservoir into the alcoves. Past ODFW surveys indicate that years when nonnative fish were collected in the alcoves, chub populations declined substantially. Water control structures could also be designed to maintain minimum water levels in the alcoves and to minimize daily fluctuations in pond levels that result from reservoir operation. Dexter Reservoir is operated with daily water level fluctuations of up to 5 feet (1.5 meters). Minimizing daily fluctuations, especially during the chub spawning season, may improve recruitment by reducing mortality of eggs spawned on vegetation that might be exposed to the air (desiccate) when reservoir levels drop.

Oregon chub introductions have been highly successful within the Willamette Valley (Scheerer et al. 2002). Although no new introduction sites were identified on Corps properties in 2001, it remains a high priority to identify and monitor potential sites.

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APPENDIX A. Fecundity estimates calculated for different age-classes of Oregon chub in Hospital Pond in 2001. Fecundity was estimated using the exponential regression model from Pearsons (1989), where fecundity = $e^{(2.7 + 0.06 \times \text{total length})}$. The regression was for fish ranging in size from 41-64mm total length (TL). Table A extrapolates fecundity beyond the original data used to develop the regression. Table B uses a calculated fecundity for a 64mm fish (n=692 eggs) for all fish >64 mm TL.

A.

Age (yr)	2001 Chub abundance	Mean length (mm)	Calculated fecundity	Sum of fecundity for the age-class	Percent of summed fecundity for all age-classes
1	702	55.3	411	288,351	15
2	1,134	63.4	668	757,294	39
3	378	65.3	748	282,913	15
4	216	72.0	1,119	241,658	12
5	216	72.5	1,153	249,017	13
6	0				
7	54	85.0	2,441	131,793	7
Total	2,700			1,951,025	100

B.

Age (yr)	2001 Chub abundance	Mean length (mm)	Calculated fecundity	Sum of fecundity for the age-class	Percent of summed fecundity for all age-classes
1	702	55.3	411	288,351	18
2	1,134	63.4	668	757,294	46
3	378	65.3	692	261,576	16
4	216	72.0	692	149,472	9
5	216	72.5	692	149,472	9
6	0				0
7	54	85.0	692	37,368	2
Total	2,700			1,643,533	100