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Olympic mudminnow (*Novumbra hubbsi*) in the Green Cove Creek Watershed, Thurston County, Washington: Distribution and Recommendations for Protection

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Olympic mudminnow (*Novumbra hubbsi*) in the Green Cove Creek Watershed, Thurston County, Washington:
Distribution and Recommendations for Protection

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Abstract

Green Cove Creek, Thurston County, Washington is home to a Washington State sensitive species, the Olympic mudminnow (*Novumbra hubbsi*). In response to the threat posed to mudminnow habitat by rapid urban development within the Green Cove watershed, we initiated a systematic basin-wide survey to describe mudminnow distribution and habitat usage. Fish presence was ascertained using baited minnow traps, dipnets, and on rare occasion an electrofisher. Olympic mudminnows were documented at 23 of the 31 sample sites throughout the drainage, including headwater ditches and ponds, wetlands, and lower stream reaches. In addition to describing observed and potential mudminnow distribution throughout the watershed, we present management recommendations to protect Olympic mudminnow habitat from further degradation.

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Introduction

Olympic mudminnow (*Novumbra hubbsi*), one of five species worldwide in the family Umbridae and the only member of the genus *Novumbra*, occurs only in Washington. The current known range of the Olympic mudminnow includes the southern and western lowlands of the Olympic Peninsula, the Chehalis and lower Deschutes River drainages, and south Puget Sound, west of the Nisqually River. Populations have also been observed in rural Snohomish and King Counties. They are found nowhere else in the world. Olympic mudminnows (Figure 1) are usually found in slow-moving streams, ditches, wetlands, and ponds.

Figure 1. Olympic mudminnows, *Novumbra hubbsi,* from the Green Cove Creek watershed. The average length of adults is 2.1 inches (Wydoski and Whitney 2003).

Within these habitats mudminnows prefer a muddy bottom, little or no water velocity, and abundant aquatic vegetation. However, they have been observed using stream channels with faster flowing water and coarser substrate, possibly as migration corridors between preferred habitats. A number of studies have been conducted that describe in detail the life history, range, ecology, habitat preferences, and physiological attributes of the Olympic mudminnow. A bibliography of these studies is provided in Appendix A.

Olympic mudminnow was designated as a sensitive species in Washington (Mongillo and Hallock 1999) because of the continued loss of, and threats to, its habitat and because of its very limited range. This listing confers a measured level of protection for the species; state permitting rules and local Critical Areas Ordinances are the main regulatory vehicles to protect mudminnow habitat. However, as noted in the state's status report for the Olympic mudminnow (Mongillo and Hallock 1999), mudminnow habitat is still being lost every year, posing an immediate threat to local mudminnow populations. This continued loss of mudminnow habitat results from, in part, the lack of detailed mudminnow distribution data currently available to local and state agencies charged with making land-use decisions within the mudminnow's range. Further, many mudminnow habitats are mis-mapped or misclassified as "non-fish bearing" waters on the Washington State Department of Natural Resources regulatory water type maps, which could substantially reduce mudminnow habitat protection.

The current mapping of mudminnow distribution among area streams, ditches, and wetlands does not adequately identify specific locations where fish are present or where presence is presumed, and thus the regulations offer only limited protection for the species. In Thurston County in 2006 some critical mudminnow habitat was unintentionally compromised because of a lack of fish distribution information and coordination among agencies, emphasizing the need for higher resolution distribution data. Better dissemination of both existing and new mudminnow distribution information is also needed, as are specific recommendations for best management practices where mudminnows are known or suspected to reside.

In 2007 Washington Department of Fish and Wildlife (WDFW) compiled all known distribution data of the Olympic mudminnow from earlier WDFW surveys and observations by local fish biologists (Figure 2). This compilation highlighted gaps in survey data, and helpedguide the Green Cove Creek field surveys, the results of which are presented in this report.

Green Cove Creek is located on Cooper Point in Thurston County, within five miles of downtown Olympia. Recent and imminent residential and commercial development within the watershed has threatened the Olympic mudminnnow population there, and was the impetus for this study. Development which changes the hydrology (water diversions, increased storm flow, decreased summer-low flow, delivery of contaminants off impervious surfaces) and characteristics (substrate, vegetation) of a watershed can be detrimental to mudminnow habitat. This report presents the results of systematic surveys of select areas of known and suspected mudminnow presence in the Green Cove Creek watershed. Here we provide distribution data at a scale useful for permit review and road infrastructure maintenance decisions, and to guide future research including status and trend monitoring. In order to provide local and state governments with the tools necessary to better protect the habitat of this sensitive species, we are making these data available to all local jurisdictions, tribes, and state agencies.

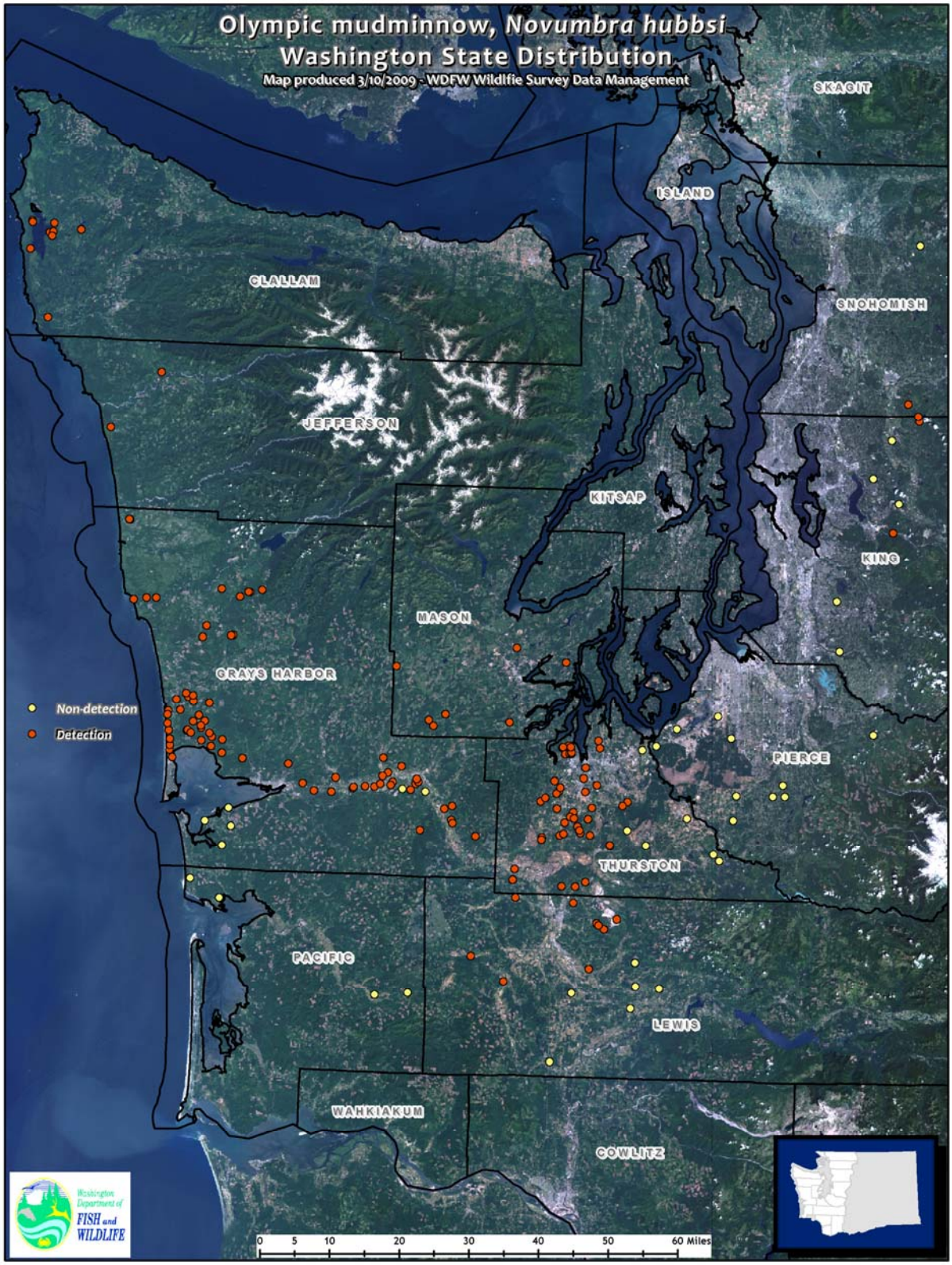

Figure 2. Olympic mudminnow, *Novumbra hubbsi*, distribution in Washington State.

Wild Fish Conservancy has also made available extensive fish and fish habitat distribution maps, which include Green Cove Creek among other Thurston County watersheds, at www.wildfishconservancy.org. Ultimately, we believe that if this unique and endemic fish population is to be adequately protected, the collection and dissemination of detailed distribution information is necessary throughout the entire range of the Olympic mudminnow so that their habitats can be known and protected.

Site Description

Green Cove Creek drains a 2,600-acre watershed located entirely in Thurston County on the west side of Olympia, Washington. It meanders in and out of lands owned by or under the jurisdiction of Thurston County, City of Olympia, State (The Evergreen State College), and private citizens or organizations. A total of 31 sites were sampled during the course of the study (Figure 3). The sites represent a range of habitat conditions including ponds, wetlands, ditched channels, and streams (Table 1).

The headwaters and much of the midsection of the watershed consists of an extensive complex of wetlands, intermittent and perennial ditched channels, and a small, low-gradient stream. The wetlands are extensive, but their extent and hydrology have been altered through the years as development and water drainage/diversions have taken place. As of 1989, approximately 250 acres, or 45%, of the basin's historic wetlands have been lost since the 1850s (Thurston County 1998). As of 2001, approximately 10% of the watershed was characterized as "urban" (Land Cover Mapping of Thurston County 2001). This percentage has likely increased significantly since 2001. In addition to Olympic mudminnows, the watershed's native fish community currently includes populations of coho (*Oncorhynchus kisutch*) and chum (*O. keta*) salmon, cutthroat trout (*O. clarki*), prickly sculpin (*Cottus asper*) (Wild Fish Conservancy South Puget Sound Watertype Assessment Project 2005), and steelhead (*O. mykiss*) (WDFW Salmonscape 2008). Additionally, as we observed during the Lake Louise warmwater fish removal effort, portions of the watershed are inhabited by introduced species including yellow perch (*Perca flavescens*), largemouth bass (*Micropterus salmoides*), bluegills (*Lepomis macrochirus*), and brown bullheads (*Ictalurus nebulosus*).

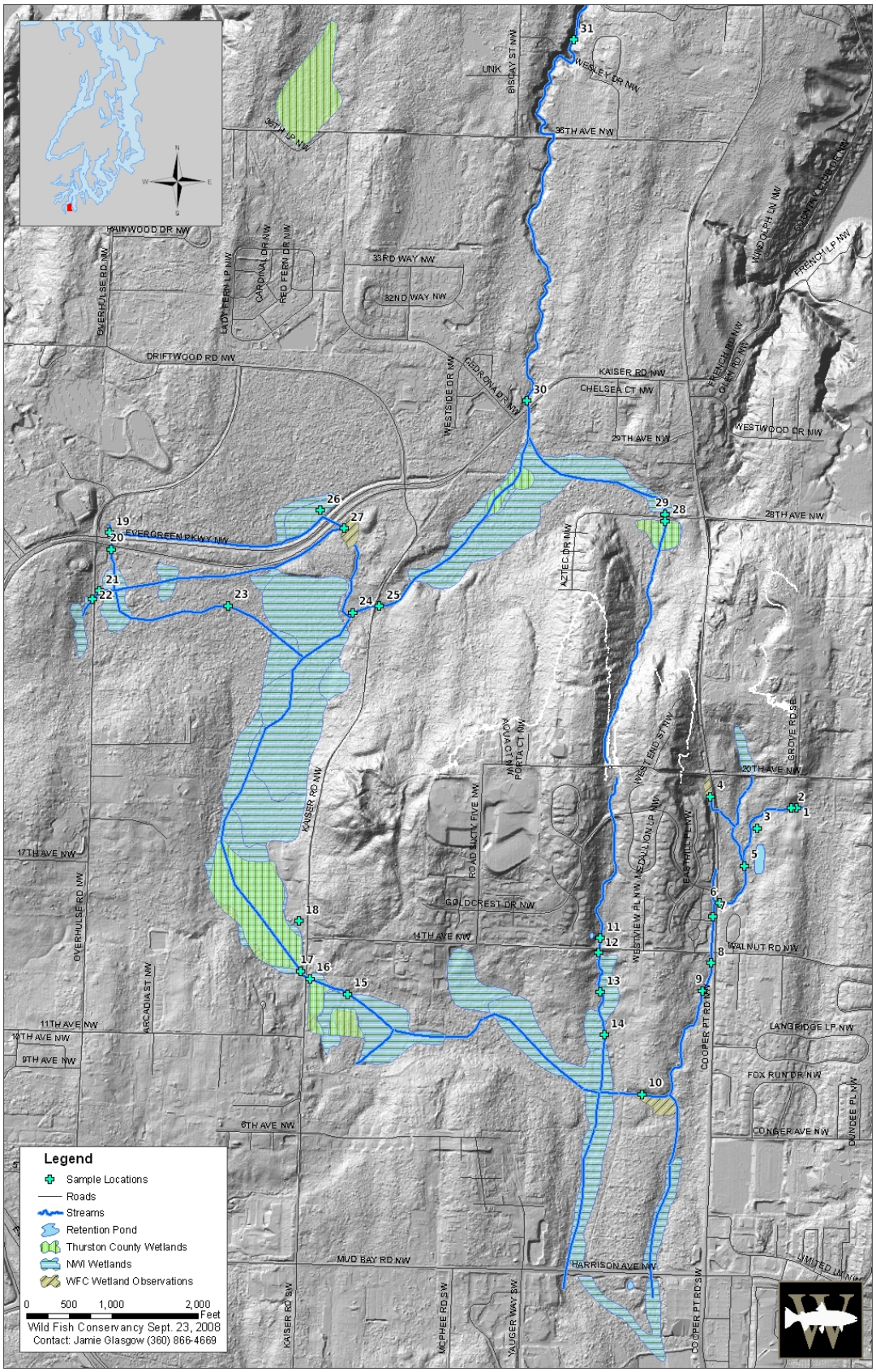

Figure 3. Green Cove Creek watershed in north Thurston County, Washington. Olympic mudminnow sample site locations are depicted by the numbered points

Table 1. Location description of Olympic mudminnow sampling sites. Coordinates are in NAD 83 datum.

Site ID	Latitude	Longitude	Site Descriptor	Habitat type
1	47.0620961	-122.9375614	South of 20th, east of Cooper Pt. Rd. in perennial headwater stream/pond complex	stream
2	47.0620853	-122.9378308	South of 20th, east of Cooper Pt. Rd. in perennial headwater stream/pond complex	stream
3	47.0614197	-122.9393707	SE corner of 20th Ave NW and Cooper Pt Rd	pond
4	47.06237285	-122.9416203	SW corner of Cooper Pt Rd and 20th Ave NW	wetland
5	47.06020182	-122.9391851	Upstream 400 ft from the Cooper Pt Rd Rd crossing	stream
6	47.05898628	-122.9410412	Upstream (east) of Cooper Pt Rd at culvert inlet	stream
7	47.05854135	-122.9413483	660 ft north of NW corner of Cooper Pt Rd and 14th Ave NW	stream
8	47.05707003	-122.9413369	SW corner of Cooper Pt Rd and 14th Ave NW	stream
9	47.05617271	-122.9417121	Downstream from site 08, west of Cooper Pt Rd.	stream
10	47.05781126	-122.9467114	Double culvert under sewer line trail just east Grass Lake Complex	wetland/stream
11	47.05729078	-122.9466475	Culvert inlet on 14th Ave NW about 1000 ft west Cooper Pt Rd.	retention pond/stream
12	47.05603704	-122.9464926	Culvert outlet/pool on 14th Ave NW about 1000 ft west of Cooper Pt Rd	seasonal stream
13	47.05603704	-122.9464926	Single culvert sewer line trail	seasonal stream
14	47.05467675	-122.946254	East edge of Grass Lake behind homeless camp	wetland
15	47.05616797	-122.9600963	Lake Louise, far west lobe	wetland
16	47.05616797	-122.9600963	Upstream of culvert on Kaiser Rd at Lake Louise outlet	stream
17	47.05639948	-122.960547	Downstream of culvert on Kaiser Rd and Lake Louise outlet	stream/wetland
18	47.07019289	-122.9701158	West of Kaiser Rd and 14th Ave NW intersection, just off Kaiser Rd shoulder	wooded wetland
19	47.07019289	-122.9701158	Culvert outlet pool NE corner Evergreen Parkway and Kaiser	stream
20	47.06967113	-122.9700144	SE corner Evergreen Parkway and Kaiser beside transfer station	wetland
21	47.06804422	-122.9708359	Overhulse Rd Wetland	wetland
22	47.06804422	-122.9708359	West of Overhulse Rd/wetland	wetland
23	47.06798501	-122.9644731	Overhulse-Kaiser wetland connection	stream
24	47.06812236	-122.9573815	Kaiser Wetland at sewer pump station	wetland/stream
25	47.06812236	-122.9573815	East of Kaiser Rd at sewer pump station about 100 feet	stream
26	47.07111869	-122.9603064	North side Evergreen Parkway	wetland
27	47.07057063	-122.9591643	South side Evergreen Parkway	wetland
28	47.07111592	-122.9441253	600 ft west of Cooper Pt Rd and just south 28th Ave NW	stream
29	47.07133349	-122.9441384	660 feet west of Cooper Pt Rd and just north 28th Ave NW	stream
30	47.07481524	-122.9507799	Downstream side of culvert at Kaiser Rd.	stream
31	47.08636898	-122.9491052	East of Biscay Court NW in mainstem Green Cove Creek ravine	stream

Methodology

To describe the distribution of Olympic mudminnows within the Green Cove Creek watershed during the winter/spring and summer seasons, fish presence sampling was conducted by dipnetting, deploying baited 24 hour minnow trap sets, or (rarely) electrofishing. The sampling techniques were first tested in areas of known mudminnow presence to establish their efficacy.

Dipnetting was used as our first sampling method because if mudminnows were present it was the most efficient use of time. When dipnetting in soft substrate, we used a sweeping motion that included the uppermost one or two inches of substrate. Careful examination of the contents of the net was necessary to locate the mudminnows.

Where dipnetting did not yield mudminnows, we set minnow traps. The traps were baited with an approximately 0.5 ounce block of frozen chironomid larvae or "bloodworms", tethered to adjacent vegetation or staked in place, and left for approximately 24 hours. Typically, the traps were set in the wetland, pond, stream, or ditch habitat in a site with enough water to cover the top of the trap, and near overhanging vegetation or instream cover when possible (Figure 4).

Electrofishing was only used at Sites 15 and 31. Site 15, Lake Louise, was a warmwater fish removal project and Site 31, lower Green Cove Creek, was an electrofishing training session. Olympic mudminnows were incidental captures at both sites.

The majority of the sites were sampled in May 2007 when, based on past observations, distribution was at its greatest; however many of the sites were also sampled at other times of the year as well to document seasonal changes in Olympic mudminnow distribution. Sampling was conducted from the headwaters of Green Cove Creek downstream to a point within one half mile of the watershed's mouth in Puget Sound's Eld Inlet.

Figure 4. Baited minnow trap deployed at Site 9 in the Green Cove Creek watershed.

Results and Discussion

Olympic mudminnows were captured at 23 of the 31 sites sampled (74%). At five sites, mudminnows were encountered during some, but not all, of the sampling efforts (Table 2, Figure 5).

Table 2. Olympic mudminnow presence/absence.

	Date Trap Set								Water
Site ID	Month	Day	Year	Method	Bait	Set time	OMM pres	Number	Temp, °C
1	3	1	2007	Minnow trap	Chironomid	48 hr	no	0	-
2	3	1	2007	Minnow trap	Chironomid	48 hr	no	0	-
3	3	1	2007	Minnow trap	Chironomid	26 hr	no	0	-
3	5	8	2007	Minnow trap	Chironomid	26 hr	yes	8	12.8
4	5	16	2007	Minnow trap	Chironomid	24 hr	no	0	18.2
5	5	8	2007	Minnow trap	Chironomid	26 hr	no	0	13.1
6	1	18	2007	Dipnet	n/a	n/a	yes	>5	-
6	3	1	2007	Minnow trap	Chironomid	24 hr	yes	24	-
7	9	15	2006	Dipnet	n/a	n/a	yes	>5	-
7	1	18	2007	Dipnet	n/a	n/a	yes	>5	-
8	9	15	2006	Dipnet	n/a	n/a	yes	>20	-
8	1	18	2007	Dipnet	n/a	n/a	yes	>5	-
9	5	8	2007	Minnow trap	Chironomid	26 hr	yes	59	-
10	3	13	2007	dipnet	n/a	n/a	no	0	-
10	3	28	2007	Minnow trap	Chironomid	24 hr	yes	7	-
11	3	28	2007	Minnow trap	Chironomid	24 hr	no	0	-
11	5	8	2007	Minnow trap	Chironomid	26 hr	no	0	-
12	6	15	2005	Dipnet	n/a	n/a	yes	2	-
12	3	13	2007	Dipnet	n/a	n/a	no	0	-
12	3	28	2007	Minnow trap	Chironomid	26 hr	no	0	12.6
12	5	8	2007	Minnow trap	Chironomid	24 hr	no	0	-
13	3	28	2007	Minnow trap	Chironomid	26 hr	no	0	12.1
14	5	8	2007	Minnow trap	Chironomid	25.5 hr	no	0	16
15	9	9	2006	Electrofish	n/a	n/a	yes	7	-
15	10	24	2007	Electrofish	n/a	n/a	no	0	-
16	5	8	2007	Minnow trap	Chironomid	24.5 hr	yes	20	13
17	5	8	2007	Minnow trap	Chironomid	25 hr	yes	7	13
18	7	22	1993	Dipnet	n/a	n/a	yes	5	-
18	5	8	2007	Minnow trap	Chironomid	25 hr	no	0	-
19	5	9	2007	Minnow trap	Chironomid	22 hr	yes	1	10.7
20	3	13	2007	Dipnet	n/a	n/a	yes	1	-
21	9	15	2006	Dipnet	n/a	n/a	yes	>50	-
21	10	31	2007	Dipnet	n/a	n/a	yes	>50	-
22	5	9	2007	Minnow trap	Chironomid	21 hr	yes	36	15
23	5	9	2007	Minnow trap	Chironomid	22 hr	yes	3	-
24	3	13	2007	Dipnet	n/a	n/a	yes	>20	-
24	3	28	2007	Dipnet	n/a	n/a	no	0	-
24	10	24	2007	Dipnet	n/a	n/a	yes	1	-
25	5	9	2007	Minnow trap	Chironomid	21.5 hr	no	0	11.8
26	3	28	2007	Minnow trap	Chironomid	24 hr	yes	1	-
27	3	28	2007	Minnow trap	Chironomid	24 hr	yes	34	-
28	6	28	2005	Dipnet	n/a	n/a	yes	>20	-
29	6	28	2005	Dipnet	n/a	n/a	yes	>20	-
30	5	9	2007	Minnow trap	Chironomid	21.5 hr	yes	13	12.8
31	7	10	2007	Electrofish	n/a	n/a	yes	1	-

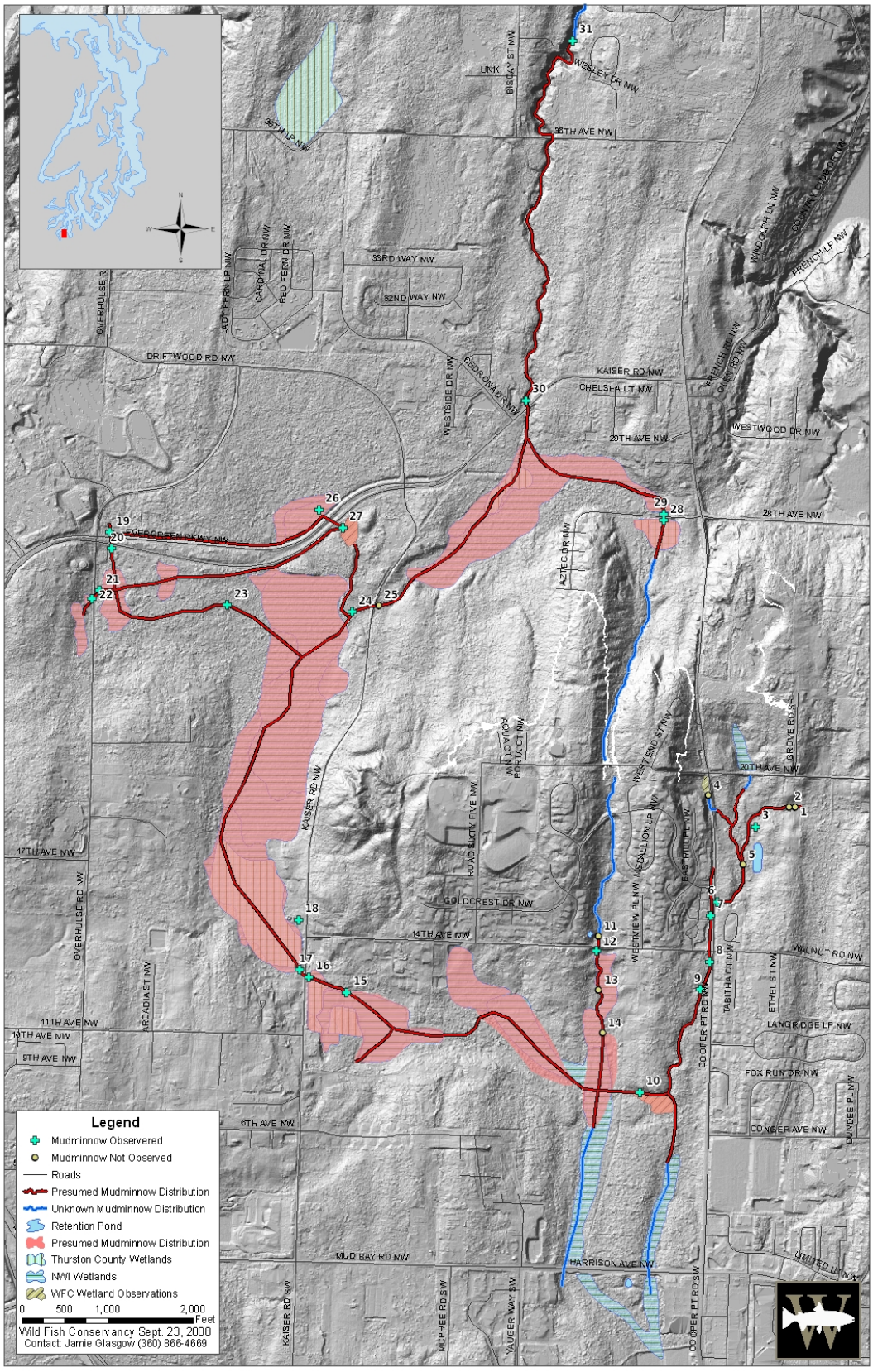

Figure 5. Presumed Olympic mudminnow distribution in the Green Cove Creek watershed extends throughout those channel reaches shown in red, as well as throughout the wetland habitats, mapped and unmapped, that are adjacent to and perennially or intermittently connected to them.

Our experience demonstrated that none of the sampling techniques we used were 100% effective. For example, during the course of the study there were sites where minnow traps yielded mudminnows within hours after dipnetting yielded none. Also, in one location (Site 3) the baited minnow trap produced no mudminnows during the initial visit, but produced an abundance of mudminnows on a subsequent visit two months later, despite the relatively isolated nature of this site. Due to the lentic nature of most of the mudminnow's preferred habitats, the baited minnow traps were generally the most efficient and effective of the sampling approaches we utilized.

From our surveys we concluded Olympic mudminnows are widespread throughout the Green Cove drainage. Although our surveys were not quantitative, overall the fish appeared healthy and, where they were present, they were generally abundant.

Because we sampled and visited sites throughout the year, we were able to roughly assess the seasonal dispersal of mudminnows in the Green Cove Creek watershed. The habitat available to mudminnows in Green Cove Creek contracts and expands seasonally. During winter and spring months, the amount of available habitat was substantially greater than that available during summer and fall. Some of the habitats found to support mudminnows in the wet months were completely dry during the summer. Two sites (9 and 10) were completely dry in late summer but wetted and inhabited by mudminnows in winter.

With seasonal increases in water levels, it is likely that groups of mudminnows that are isolated from each other during summer months have an opportunity to interact and reproduce during the winter and spring. These opportunities for exchange of genetic material are likely critical to the overall health of the population, underscoring the importance of identifying and protecting seasonal migration corridors, especially those that may be dry for much of the year.

Habitat and Movement Observations

In general, Olympic mudminnows prefer low-gradient lentic environments, such as the standing water in ditches and wetlands that have soft mud substrates and aquatic and overhanging vegetation. Olympic mudminnows were most often observed in this type of habitat within the Green Cove watershed. See Appendix A for a bibliography of studies that describe in detail observed mudminnow habitat preferences. However, we did observe mudminnows in areas that are not typically considered ideal mudminnow habitat. The most striking observation was at Site 9, where Green Cove Creek is more a stream than a wetland, and does not exhibit what is generally considered good mudminnow habitat.

At Site 9, a minnow trap set in one of the few small pool areas, just downstream from a small riffle, yielded 59 mudminnows, more than any other trap set during our sampling regime. This may have been due to the relatively small wetted area of the stream, whereas many of our traps were set in more open, larger waters. Alternatively, this may have been due to fish movement that may be part of the life history strategy adopted by this population of mudminnows. Upon release, most of the fish immediately and actively swam upstream through the riffle towards the Cooper Point Road ditch, rather than downstream towards Grass Lake wetland. Olympic mudminnows were observed at other sites that had characteristics of trout habitat more so than mudminnow habitat, including the stream connection between the Overhulse and the Kaiser Road wetland (Site 23), and the downstream mainstem sites of Green Cove Creek (Sites 30 and

31). Our observations in Green Cove Creek show that mudminnows will use lotic waters connected to conventionally preferred habitat.

Mudminnow presence was variable in both time and space. At Site 24, mudminnows were readily dipnetted upstream of the culvert on March 13, 2007, but when this site was sampled on March 28, 2007, none were found. A minnow trap set on May 09, 2007 at Site 25, approximately 60 feet downstream from the culvert yielded no fish. One fish was dipnetted upstream of the culvert in October 2007. Sporadic presence was also observed at Sites 3, 12, 15 and 18. Sampling efficiency may explain presence/absence in some surveys, but these observations could also highlight the spatial and temporal variability of mudminnow presence within portions of the watershed. Further, these observations emphasize the importance of protecting mudminnow's presumed habitats instead of just those habitats where they have been observed.

Grass Lake Refuge Area and Lake Louise Fish Removal

One of the areas Green Cove Creek flows through is Grass Lake Refuge, a 164.41 acre complex owned by the City of Olympia and managed by Olympia Parks, Art and Recreation Department. It is primarily an open-water wetland late fall through early to mid summer, but often dries to isolated pockets of stagnant water by mid to late summer. Roughly, its boundaries are 6thth Ave NW on the south, Kaiser Road on the west, 14th Ave NW on the north and Cooper Point Road on the east. Lake Louise, on the western edge of the wetland complex, is the deepest portion of the Grass Lake area. Approximately half of Lake Louise is within the Grass Lake Refuge boundary.

Olympic mudminnows have been captured in Lake Louise for decades, but large numbers have never been documented there. Warmwater fish species (yellow perch, largemouth bass, bluegills and brown bullheads) have been present in Lake Louise since at least the 1980s. The presence of these non-native piscivores is likely detrimental to the Olympic mudminnow population. In surveys of Olympic mudminnow populations, Mongillo and Hallock (1999) found Olympic mudminnow catch-per-unit-effort declined as the numbers of fish species present increased. Another study (Beecher and Fernau 1983) conducted on the Chehalis River oxbows did not document Olympic mudminnow presence whenever warmwater fish species were present: however, in this study we documented a small number of Olympic mudminnows occurring with the warmwater fishes in Lake Louise during fall 2006. Olympic mudminnows do not appear to coexist well with a diverse community of native or non-native fish species. They are likely competing for food, habitat, or are preyed upon.

In November 2006, before winter rains had begun, portions of Lake Louise were residual ponds. To determine what fish species were present, we undertook an electrofishing survey. During two days of electrofishing, we encountered an astonishing number (over one thousand) of juvenile and adult warmwater fish (yellow perch, smallmouth bass, bluegills, brown bullheads); only seven Olympic mudminnows were collected. The warmwater fish species, ninety percent of which were perch, were removed from the lake. In September 2007 we again conducted an

electrofishing survey in the Lake Louise pockets. We collected and again removed approximately 400 warmwater fish, almost all in the juvenile (2-3 inch) size range. No Olympic mudminnows were documented.

We also surveyed for mudminnows in a north-south drainage to Grass Lake Refuge. This drainage passes under 14th Ave NW, ¼ mile east of Cooper Point Road. Although two mudminnows were documented at the 14th Ave NW culvert (Site 12) in June 2005, subsequent sampling at this site and sites immediately upstream (Site 11) and downstream (Sites 13 and 14) into the Grass Lake Refuge yielded no mudminnows. This drainage is important to protect because it appears to have sporadic use by mudminnows and is a tributary to the Grass Lake Refuge.

Evergreen Parkway

East of Overhulse Road, narrow strips of wetland exist along the north and south sides of Evergreen Parkway NW. In March 2007 there did not appear to be much open water in these strips of wetland. However, trapping on the north and south sides of Evergreen Parkway about one quarter mile west of Kaiser Road (Sites 26 and 27) documented Olympic mudminnow presence. Because it is a small, modified, and seasonally isolated wetland area, it is the type of mudminnow habitat that is often overlooked and therefore rarely protected.

The Overhulse wetland (Site 21) and its connection to Green Cove drainage (Site 23) are located immediately south of the Evergreen College Parkway NW and east of the intersection of Overhulse Road NW. Extensive documented use by mudminnows makes this area an important core to protect. Fortunately, a portion of this part of the watershed is protected by Capitol Land Trust.

Recommendations

Habitat Protection

Because of the spatial and temporal variabilty of mudminnow presence throughout the watershed as discussed above, and their documented use of perennially and seasonally connected wetlands, the recommendations listed below apply to the entirety of the Green Cove Creek watershed including those reaches not suspected to support mudminnow presence. All channels and wetlands in the watershed contribute to the health, function, and inteqagrity of channel reaches and wetlands known or suspected to support mudminnows.

The following recommendations are essential to protecting mudminnow habitat:

- Accurate mapping of mudminnow distribution and identification of potential habitat. Where mudminnow presence is confirmed in new locations, share the observational data (date, location, photographs, approximate abundance, etc.) with the affected local government (city or county) and with the Washington Department of Fish and Wildlife, Fish Program (360/902-2700). Data will be entered in WDFW WSDM mapping database.
- Prevent water diversions or other alterations to the hydrology (the timing, magnitude, and frequency of the delivery of water) of the Green Cove Creek basin. Considering the already-compromised status of the watershed, the cumulative effect of small diversions, withdrawals, and increases in impervious area can be substantial. Sponsors of development projects (including residential development and local government capital improvement projects) that will increase the amount of impervious area within the watershed or otherwise impact hydrology or sediment transport rates should be required to specifically address potential impacts to water quality and to the timing, magnitude, and frequency of the basin's surface water flow. Any creation of swales to mitigate hydrological impacts of development should incorporate design elements to protect mudminnows from stranding. If elements of development projects pose a potential threat to the quality or quantity of mudminnow habitat within the basin, they should not be permitted as designed.
- Design new culverts and modifications to existing culverts, to provide mudminnow passage. Existing Washington Administrative Code for fish passage criteria (WAC 220-110-070) are more specific to salmonids and are not appropriate for the relatively poor-swimming and poor-jumping mudminnow. Culverts within known or suspected mudminnow habitats should be designed or retrofitted to have zero hydraulic drop (abupt change in water surface elevation) throughout the culvert crossing. Culverts designed for mudminnow passage should be sized and set at-grade to be completely backwatered at most flows. Guidelines for culvert design options (stream simulation and no slope) that would allow mudminnow passage are available in the WFDW manual, *Design of Road Culvert for Fish Passage, 2003* (http://wdfw.wa.gov/hab/ahg).
- Maintain riparian vegetation adjacent to and overhanging mudminnow habitats. Maintaining a mowing buffer of at least seven feet from edge of the bankfull width of the channel.

- Non-native warmwater fish species should not be released anywhere in the watershed, and efforts should be undertaken to selectively extirpate those present in the Grass Lake Refuge.
- Herbicides, pesticides, fertilizers, or other lawn-care chemicals should not be used in or around streams, ditches, wetlands, or other areas of stream runoff that support or drain to habitats that support mudminnow.
- Dredging and culvert maintenance activities in known or suspected mudminnow habitats, even "ditches," should be performed only if there are no other alternatives, and only after consultation with a WDFW habitat biologist. If dredging is required for maintenance and no suitable alternatives are available, fish should be removed from the affected reach through the use of blocknets, dipnets, and minnow traps. Capture and relocation of fish will require a WDFW Scientific Collection Permit. Several days of trapping may be required. The captured fish should be relocated in an upstream habitat, and the affected reach should be isolated by blocknets during the dredging. When possible, the reach to be dredged should be isolated using a sandbag coffer dam and dewatered so the work can be done in the dry. Several inches of soft mud substrate should be left in place following the dredging operation.
- When sampling for mudminnow presence, we recommend the use of baited minnow traps in conjuction with dipnetting and/or electrofishing as appropriate. A small fyke net trap may also be effective in the lentic habitats. Whatever the sampling method, we recommend mesh size of 1/8 inch or less.
- While mudminnow sampling methods can be effective, they should not be relied upon to prove mudminnow absence. We recommend protecting habitat type, bearing in mind that habitat characteristics change seasonally and important winter habitats may be dry during the summer.

Data Gaps

We were able to intensively sample the headwaters of Green Cove Creek and some of its drainage area (Overhulse wetland area), but we have a large data gap in the mainstem from the Lake Louise outlet essentially to the mouth. In particular, it may be useful to assess steam/wetland usage between Lake Louise and the lowest Kaiser Road culvert crossing (Site 30). We recommend future sampling efforts focus in this area. We presume Olympic mudminnow use of this area is likely given their documented presence at the upstream and downstream sites bracketing this reach.

We also recommend undertaking an intensive mudminnow tagging effort to better describe the extent and timing of the Green Cove Creek mudminnow movements. Options for marking small fish are increasingly available. Visible implant elastomer tags (VIE) may work well and a very small passive integrated transponder tag (PIT) is currently under development .

In addition, analysis of mudminnow population genetics is needed to elucidate inter- and intra-basin population relationships. To this end, a study utilizing tools such as microsatellite or Single Nucleotide Polymorphism (SNP) DNA analysis would be useful.

Finally, we suggest evaluating the hydrology and the sediment transport into and through Grass Lake and Lake Louise portions of the watershed. Anecdotal evidence suggests that the Grass Lake Refuge now provides substantially less wetted fish habitat during the summer than it did historically. This may be due, in part, to modification of its hydrology and sediment transport processes.

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