Fish Monitoring at Floodplain Wetland Restoration Sites in the Pacific Northwest U.S.A.

2002 Annual Report

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Ducks Unlimited, Inc. Fish Monitoring Program

Executive Summary

Water-control structures are used as a restoration tool to improve ecological function in floodplain wetlands that have been impacted by altered hydrologic regimes. This active restoration approach has been used at sites where main stem dams have reduced duration and predictability of inundation during the winter and spring and at sites where the riverine-floodplain systems have been disconnected by dikes and the hydrology modified from irrigation withdrawals. Increasing the duration and predictability of inundation in floodplain wetlands promotes native biota, which are adapted to these seasonal hydrologic cycles and the seasonally available, highly productive, off-channel habitat in the river floodplain. In the past, juvenile salmon had greater access to floodplain wetland habitat that they may have used for over-wintering or for feeding and resting stops during their seaward migration. Because of the reduced connectivity between riverine-floodplain systems, access to this habitat has been limited. The goal of this work is to describe the use of seasonal floodplain wetlands by salmonids throughout the winter and spring at select restoration sites across the Pacific Northwestern United States and confirm passage capability through types of water-control structures commonly used in this area. This work is a joint report that accompanies the "Sauvie Report" which was written separately to satisfy a permit commitment to NOAA Fisheries. Results from both reports are discussed in this paper. During the 2002 water year, we found salmonids using every floodplain wetland under study that had connectivity with the river. Patterns of seasonal use by salmonids and other native and introduced fishes are described in the Lower Columbia River and comparisons made with sites on the Washington Coast and a site in eastern Washington. Downstream passage capability by salmonids and other fishes have been confirmed at full- and half-round riser water-control structures. Upstream passage by salmonids has been confirmed at sites with pool-weir-chute water-control structures. Data presented in these reports should be regarded as early results for which sampling protocols are still being refined. Hypotheses are being formed as sampling capability and patterns of fish use of this habitat are discovered. Other researchers are being sought to corroborate our results and help answer questions about this restoration approach, which will provide guidance to managers and restoration practitioners alike. From the regulatory perspective, this information will provide local examples of fish use and passage capability through the structures to aid in decision-making for permitting this type of restoration approach. From the research and development perspective, this information will help those who use water-control structures for habitat enhancement to improve their design if they are not operating as intended. Results thus far are promising but long-term monitoring is required to answer questions about habitat use and passage capability at sites with considerable natural hydrologic variability.

Acknowlegements

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Introduction

Wetland degradation is the consequence of altered river hydrology and development in floodplains. It has been pervasive in temperate zone floodplains after technology for flood control was developed (Junk 1999). One approach to restoring the ecological functions of floodplain wetlands is to actively manage water levels by using dikes to hold water in an area and water-control structures to regulate the water-surface elevation.

Water control structures are used to retain water on the floodplain during the winter and spring in areas with hydrology that has been severely altered by main-stem dams with the intention of mimicking the natural hydrology. Active restoration is done in places where historic wetlands were drained and dikes installed to prevent river water from inundating the land, usually for development of agriculture but later residential and commercial development may follow. Not all sites of this type have significant hydrologic effects from upriver dams but the dikes have disconnected the river-floodplain system. Often, it is not an option to simply breach a dike because adjacent landowners may not want their land flooded. In this case, cross levees and water control structures allow water on the restoration site without flooding neighboring property that is outside a wetland restoration site or conservation easement.

Conceptual Framework

This restoration approach is intended to mimic the natural hydrograph in terms of duration and predictability but not magnitude, frequency or timing of flood events. Water control structures act to retain water on the floodplain wetland for longer periods, as would be the case, for example, in the Lower Columbia River, if dams were not influencing the hydrology. Retaining water on the floodplain until June when the wetlands would have naturally drawn down increases the predictability of the period of inundation. Native fauna are adapted to the predictability of high-flow events (Moyle and Vondracek 1985). Community structure can be strongly influenced by the availability of refugia from high and low flows (Schlosser 1990). The historic magnitude and frequency of flooding cannot, however, be reproduced from installing water control structures. This, of course, requires a large volume of water. The restoration approach of creating a controlled flood makes it possible to approach the historic magnitude and frequency of flooding and it has been tried on the Colorado River (Konieczki et al. 1997) but this is not a likely scenario for the Columbia River.

As in most large basins throughout the world, the Columbia River has been altered by flood control and hydroelectric dams, channelization for river navigation, bank armoring, irrigation and wetland drainage for agriculture. The natural flow regime (Poff et al. 1997, Ward et al. 1999) is critical for sustaining native biodiversity and ecosystem integrity in rivers. The flood pulse (Junk et al. 1989, Bayley 1995) is essential to enhance diversity and productivity on the floodplain, which is described as that part of the river-floodplain ecosystem that is regularly flooded and dried and represents a type of wetland. Hydrological alterations threaten the ecological balance favoring non-native species. However, it is widely recognized that natural environmental disturbances, that include variation around the natural flow regime, are important for sustaining native species richness and diversity (Reeves, et al. 1995, Resh, et al. 1988, and Stanford and Ward 1992). Passive approaches to restoration may slow further ecological degradation but cannot restore ecological functions that are currently inhibited by dams that have altered the natural hydrology or dikes that prevent flooding where simply breaching is not an option.

Restoration of floodplain wetlands is directly linked to restoration of the hydrologic regime that originally created the wetlands. Historically, in the Lower Columbia River and other unconfined reaches, water from winter floods and spring runoff would spread out onto the floodplains. As the water receded in the late spring or early summer, seasonal wetlands would dry up. Much of the floodplains were inundated during the winter and spring but now, due to dam regulation of water levels in the river, inundation patterns on the floodplain have changed such that water is probably not occupying these areas for as long a duration through the winter and spring seasons as before dam regulation. A similar pattern exists for basins that have little hydrologic interruption but have been drained and dikes installed to increase agricultural production. Before the draining and diking, high water in the winter and spring would have had access to floodplain wetlands. Now, floodwater is kept off the land by levees, so the inundation patterns in the wetlands have been changed such that water is probably not occupying these areas for as long of a duration through the winter and spring seasons as before diking occurred.

Management of the floodplain wetland system with water control structures is designed to simulate the historic hydrologic regimen because water is retained on the wetland and drawn down in the early summer when the seasonal wetlands are allowed to dry up. This is referred to as flooding and drawdown management. Different plant communities can be encouraged to develop depending on how long water remains on the soil. Areas low in the floodplain that remain wet develop a more permanent seasonal emergent wetland community, like sedges (*Carex sp.*) and rushes (*Juncus sp.)* Wetlands higher in the floodplain are often under moist soil management where the land may be disked every third year, for example, and the native seed source re-establishes an early successional wetland community, such as wapato (*Sagittaria cuneata*) and smartweed (*Polygonum punctatum*). This style of water management has been a successful restoration technique for controlling introduced, invasive plant species, such as the reed canary grass (*Phalaris arundinacea L.*) (Paveglio and Kilbride 2000) while encouraging native, emergent, plant species (Naglich 1994). Wetlands also provide benefits to a variety of wetland dependent birds (Reid et al. 1989), mammals (Novak et al. 1987), and native amphibians (Richter 1997).

Recent literature suggests a benefit to juvenile salmon from using floodplain wetlands as seasonal rearing areas or more transient rest stops on their way to the ocean (Sommer et al. 2001a, 2001b). It is not known, however, if fishes, particularly salmonids, are able to pass through the water control structures or if there are stranding and migration delay of juvenile salmon in the wetlands. To manage for species diversity, water levels should mimic historic hydrological conditions with the capability to manipulate these levels for the specific floodplain being restored while allowing movement of aquatic biota. Passage, stranding and delay of juvenile salmon is a concern due to the many threatened and endangered species of salmon in the Pacific Northwest. There are large gaps in our understanding of how salmon historically used this habitat that was once widespread, since humans altered these systems before baseline data was collected.

We recognize that over the very long term (i.e. several decades or centuries) man-made structures are not a substitute for true hydrological restoration. They present a short-term option that may increase the probability of survival of threatened stocks and provide a demonstration of the ecological effect of natural flooding.

Need for Fish Research in Floodplain Wetlands

Ducks Unlimited, Inc. (DU), known for wetland conservation, recently began working with state and Federal agencies and other non-governmental organizations in the Pacific Northwest on wetland restoration projects in floodplain wetlands of the Columbia River Basin and on the Oregon and Washington coasts. Questions pertaining to how anadromous fish populations will respond to these hydrologic restoration techniques remain a concern from the regulatory point of view, due to the Endangered Species Act listing of many stocks of salmon in the Pacific Northwest. Ducks Unlimited, Inc. seeks to investigate salmonid response to active restoration techniques by searching for seasonal patterns of habitat use by native and non-native fishes, emphasizing salmonids, in floodplain wetlands over a broad area with different hydrologic regimes. Measuring passage capability of fishes through the various types of water-control structures used in active wetland restoration is a second aspect of this work. The goal of active wetland restoration, using water control structures, is to restore the ecological function of a wetland by restoring some part of the historic hydrologic regime. We intend to demonstrate that habitat created from inundation due to water-control structures provides a benefit to salmon and other natives species and that fish are able to pass in and out of a wetland with a water-control structure so they can take advantage of the beneficial habitat re-created by this restoration technique.

From the regulatory perspective, this information will provide local examples of juvenile salmon use and passage capability through the structures and should aid in decision making with respect to permitting wetland restoration projects using water-control structures. Regulators are understandably using the precautionary principle, due to the lack of data lending support to the active wetland restoration approach. Ducks Unlimited, Inc. is also working with independent researchers to corroborate our fish-monitoring results.

From a research and development perspective, DU has invested heavily to collect this fish-monitoring data to verify that water-control structures are not an impediment to fish passage into and out of wetlands and to improve the design of those structures that may not be operating as designed. Research is in its early stages. Our protocol for capturing fishes in wetlands has progressed due to some trial and error, though we do not yet have capture efficiencies from which we can use to make abundance estimates. As patterns emerge, research questions will be generated that will allow us to test hypotheses to further our understanding of how native and introduced species use this habitat, the response of salmon to restoration activities, and to confirm fish-passage capability through the various types of structures. We encourage the larger research community to collect data independently from us and participate in scientific debate to help us refine goals, interpret ecological meaning from data collected, and decipher how this information should influence restoration projects.

Key questions of salmonid use of wetland habitat with respect to restoration efforts are:

- Do juvenile salmon and steelhead use floodplain wetland habitat, if so, what age classes?
- What are their use patterns with respect to season, locale in Oregon and Washington, hydrology, and temperature?
- What is the capability of salmonids, by age and/or size class, to pass through various types of water-control structures?
- What opportunity, through the season of floodplain inundation, do salmon and steelhead have for bi-directional passage through water-control structures?
- Is there evidence of stranding after spring draw-down?
- Does the inundation pattern and connectivity of the river with floodplain habitat re-created by active wetland restoration mimic the historic condition?

Key assumptions of this research are:

- Using water-control structures in floodplain wetlands, where the hydrology has been altered, mimics some aspects of historic hydrologic patterns, such as duration of inundation of the floodplain, timing (of spring draw-down, not of flood events) and rate of spring draw-down.

  - Water-control structures facilitate increased connectivity between the river and floodplain system.

- Habitat re-created by water-control structures functions similarly as that created by historic hydrologic conditions.
- Native flora and fauna are adapted to the historic hydrologic regime and will respond positively to habitat re-created by water-control structures; conversely, introduced species ability to survive and flourish will be diminished.

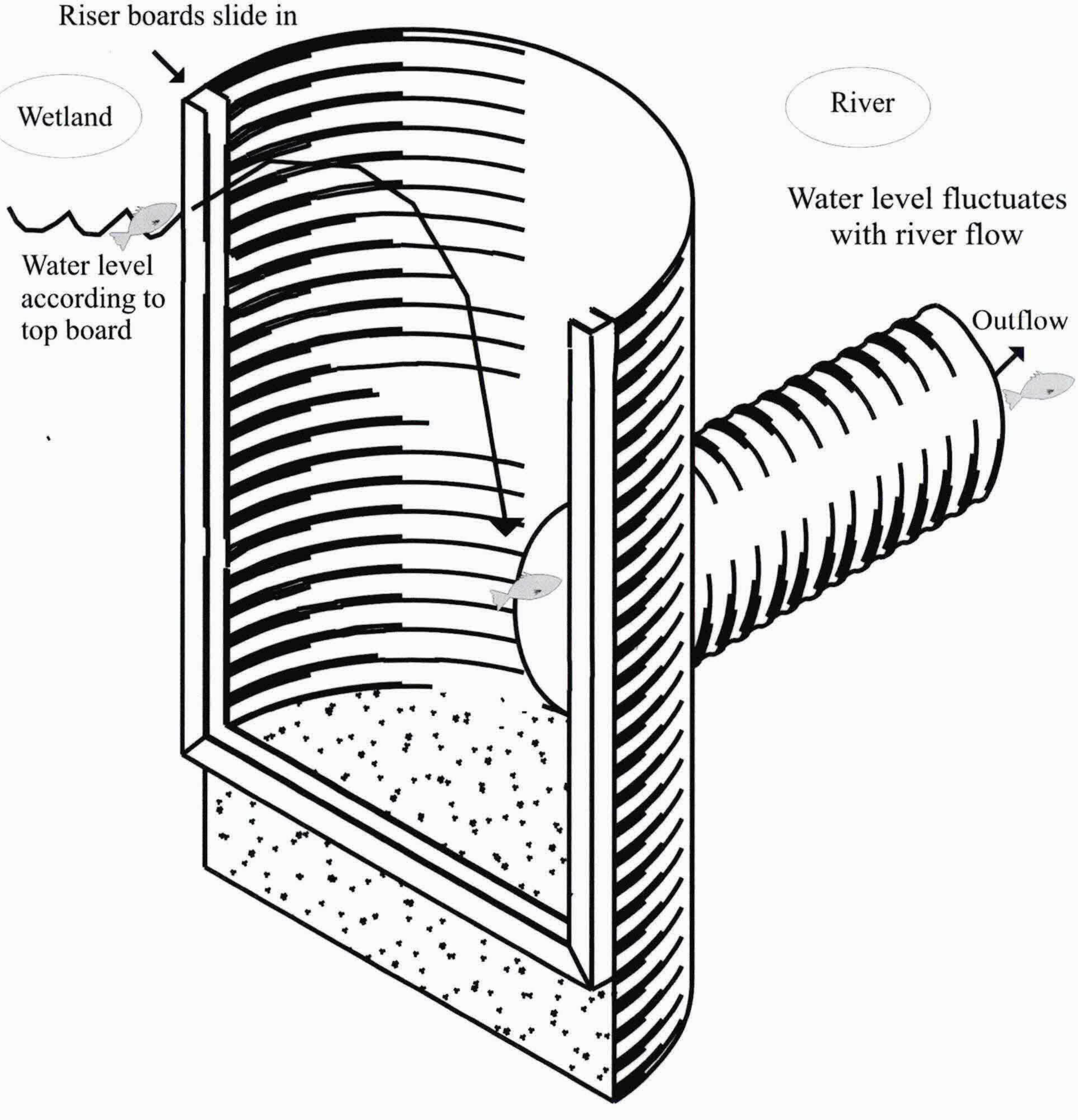
Description of water control structures and fishways used by DU

There are three main types of water control structures used by DU to hold water on the floodplain: the half-round and full-round risers and the pool-weir-chute (Figures 1,2 and 3).

The half-round riser (Figure 1) is by far the more common structure used by DU. The purpose of this structure is to reduce water flow out of a channel draining a wetland so that water is ponded and retention is increased. It is constructed using a culvert cut in half and standing vertically with a smaller diameter culvert welded perpendicularly. Boards, usually 2x6 lumber, are placed into a slot running parallel on either side of the vertically-standing culvert that has - been halved. These boards slide down to hold water at the desired level.

This structure is not designed to pass fish both ways but they are usually low (3-4 ft. height) so that water may overtop them during the season. Fish pass over the riser board and

Figure 1. Half-round riser water-control structure.

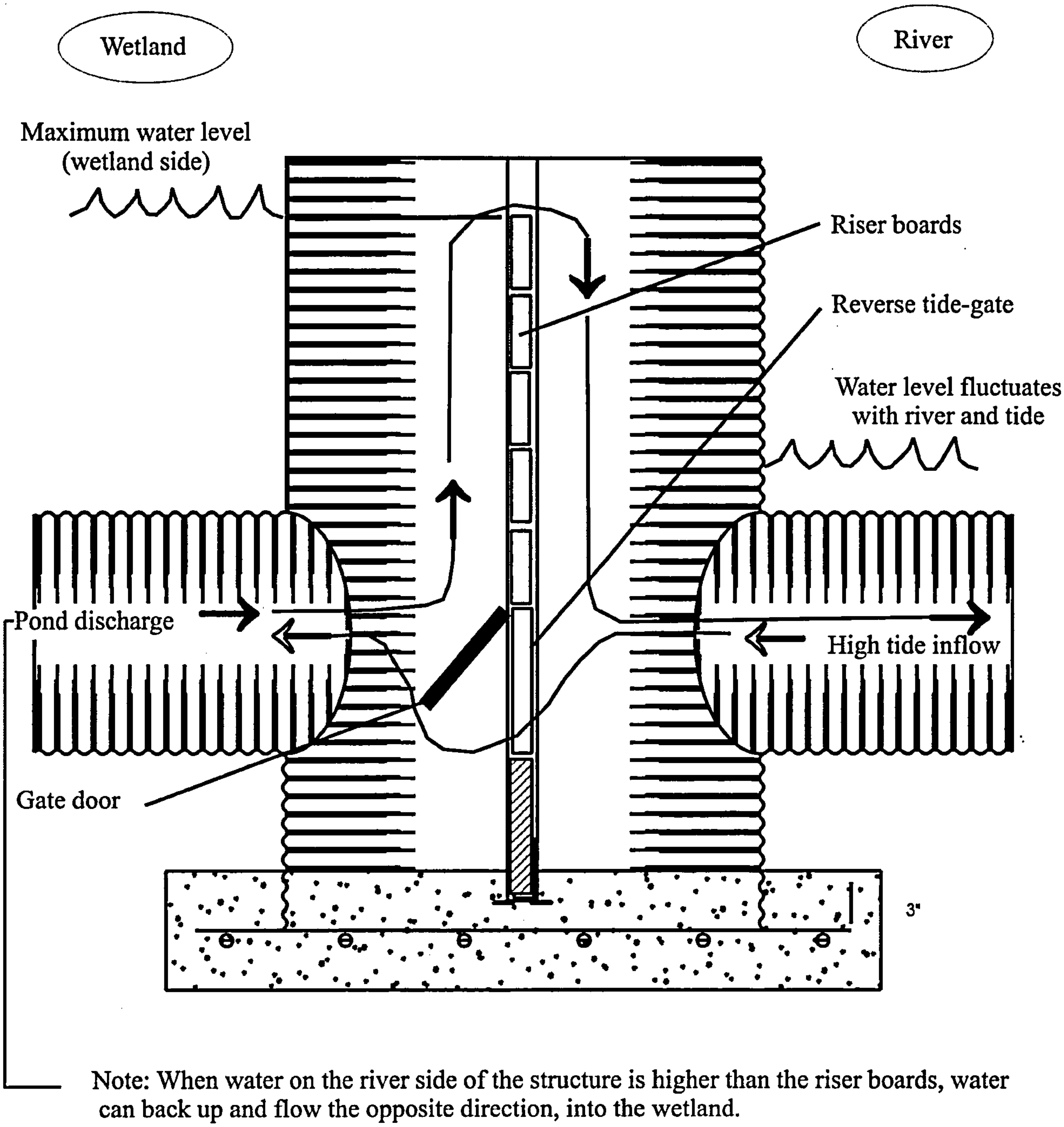


down through the horizontal culvert to get out. The top board is often notched for water flow. There is usually some water flowing over the splashboards as water from the streams, groundwater, or tidewater fill the wetlands. Occasionally, water may not constantly flow into the wetland so that water no longer flows over the splashboards, then fish may not be able to get through the structure. The splashboards can be removed, one at a time, to draw the wetland down incrementally but the goal is typically to let water stand on the wetland until late spring.

The concern for fish passage for this type of structure is if fish can find their way out of the wetland, be able to pass over the top board or simply go through the notch, and exit the wetland unharmed. Fish can enter only if water overtops the structure but are free to leave as long as water is flowing over the splashboards. These half-round risers can be managed such that the splashboards are low enough for fish migrating upstream to have access to the wetland and feeder streams in which they may spawn. The disadvantage of this type of structure, from an engineering perspective, is that beaver tend to use the half-round riser as a starting point for their dam construction because they have easy access to the water flowing over the splashboards. This causes maintenance problems.

The full-round riser (Figure 2) looks like two half-round risers joined, in which splashboards are slid down a slot in the middle of the vertically standing culvert. In estuarine areas, there is sometimes a reverse tide-gate below the splashboards, directly in line with the smaller diameter culvert extending perpendicularly from the larger culvert in either direction. Water on the riverside of the structure fluctuates in elevation with the river and tide and water behind the structure is checked to a higher elevation. Water may enter the wetland by going over the structure, either over the riser boards or over the dike, during high water or through the reverse tide gate if the water surface elevation on the riverside is higher than the wetland side,

Figure 2. Full-round riser water-control structure.



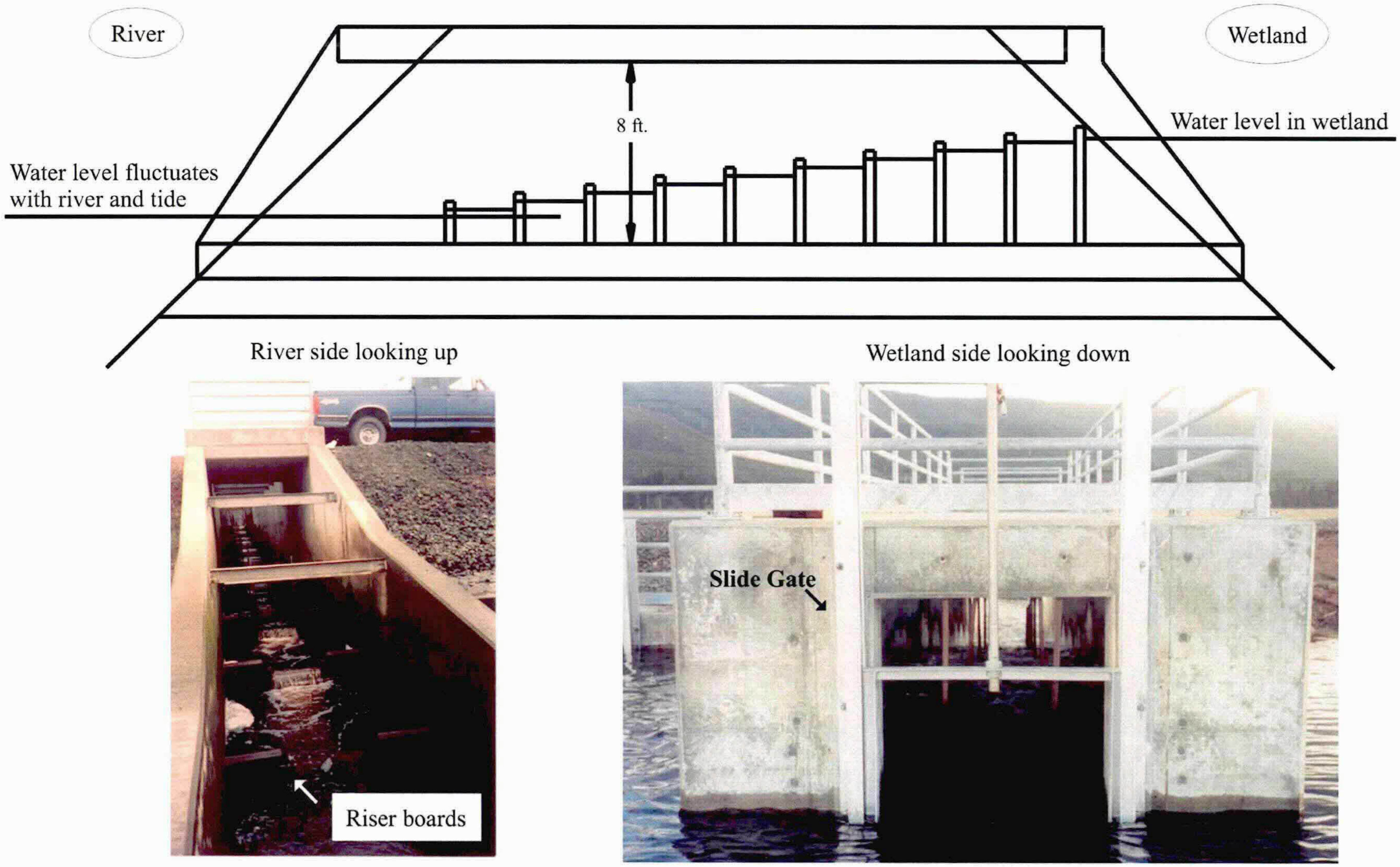
which would open the door of the tide-gate.

On an incoming tide, if the water level outside the wetland is greater than inside, the tide-gate opens and allows bi-directional passage of fishes. When the tide is out-going, if the water level inside is greater than it is on the outside of the structure, the tide-gate shuts so that water is retained in the floodplain wetland. When a reverse tide-gate is not included in the design, this structure acts the same as the half-round riser with the advantage that beaver's dam building activities are reduced. In order for the beaver to get to the flowing water and dam it up, they would have to enter the culvert, which runs horizontally below the water surface, and go up the vertically standing culvert to the top of the splashboards.

The full-round riser style of water control structure gives the fish the option to leave or enter when the tide-gate is open, when the structure is overtopped, or leave when the tide-gate is closed by either passing over the riser or finding the smaller, adjacent culvert that acts as a fishway. There is the potential to hold fish in the wetland if water is not flowing over the riser board when there is no constant water source.

The third type of water control structure used by DU is the pool-weir-chute (Figure 3). This structure consists of a series of pools, in the manner of a fish ladder. A slide gate on the wetland side controls the water level. Additionally, riser boards act as weirs at the downstream end of each pool. This type of structure performs well at high flows and can hold water to a higher elevation than the previous water control structures mentioned, but its purpose is to pass fish. Two pool-weir-chute fishways were installed September 2001 at the Willapa Bay National Wildlife Refuge and are included in this program. They can hold 12 feet of water and drain Lewis 1 and Porter Point Creeks into Willapa Bay. Adjacent to the pool-weir-chute structures are culverts that sit on the lowest point of the wetland and can allow more complete drainage

Figure 3. Pool-weir-chute water-control structure.



than simply opening the sluice gate at the fore bay of the ladder.

Study Sites

Eleven sites, in four general areas represent wetlands on the mid- and central Washington coast, Lower Willamette River/confluence with the Columbia River, and inland on the Yakima River (Figure 4). Various types of water-control structures at these wetlands, including some reference sites, were monitored for fish use, passage capability through the structures, and stranding or migration delay. The sites include: Lewis and Porter Point units on the Willapa National Wildlife Refuge (NWR) on the SW Washington coast where two pool-weir-chute structures replaced old structures to allow fish passage back into freshwater wetland; half-round risers at Greenhead and Hoxit wetlands on the lower Chehalis River; full-round risers at Ruby and Wigeon Lakes on Sauvie Island Wildlife Area and a reference site on the west bank of the Multnomah Channel, owned by Metro; two reference sites on the Columbia Slough and North Columbia Slough near Smith and Bybee Lakes in Portland; a half-round riser at the Morand site on the Tualatin NWR; and a series of half-round risers at Satus Wildlife Area.

Methods

Two approaches to sample fish using wetland habitat in the Sauvie Island area were used; sampling fish moving in and out of the wetlands with two-way traps and also sampling fish within the wetlands, which may not include the more mobile species, with trap nets. At all other sites, only the within wetland sampling was done due to limitation of personnel.

Standard Seasonal Wetland Sampling

Sampling within wetlands was done seasonally using trap nets (Figure 5) with a standard protocol (2 box traps, 2 fyke nets and 1 Oneida Lake trap) with one or two 24-hour sets. The standard seasonal wetland sampling (SSWS) had three objectives; first to capture salmonids in

Figure 4. Fish monitorig sites in 2001-2002 and types of control structures.

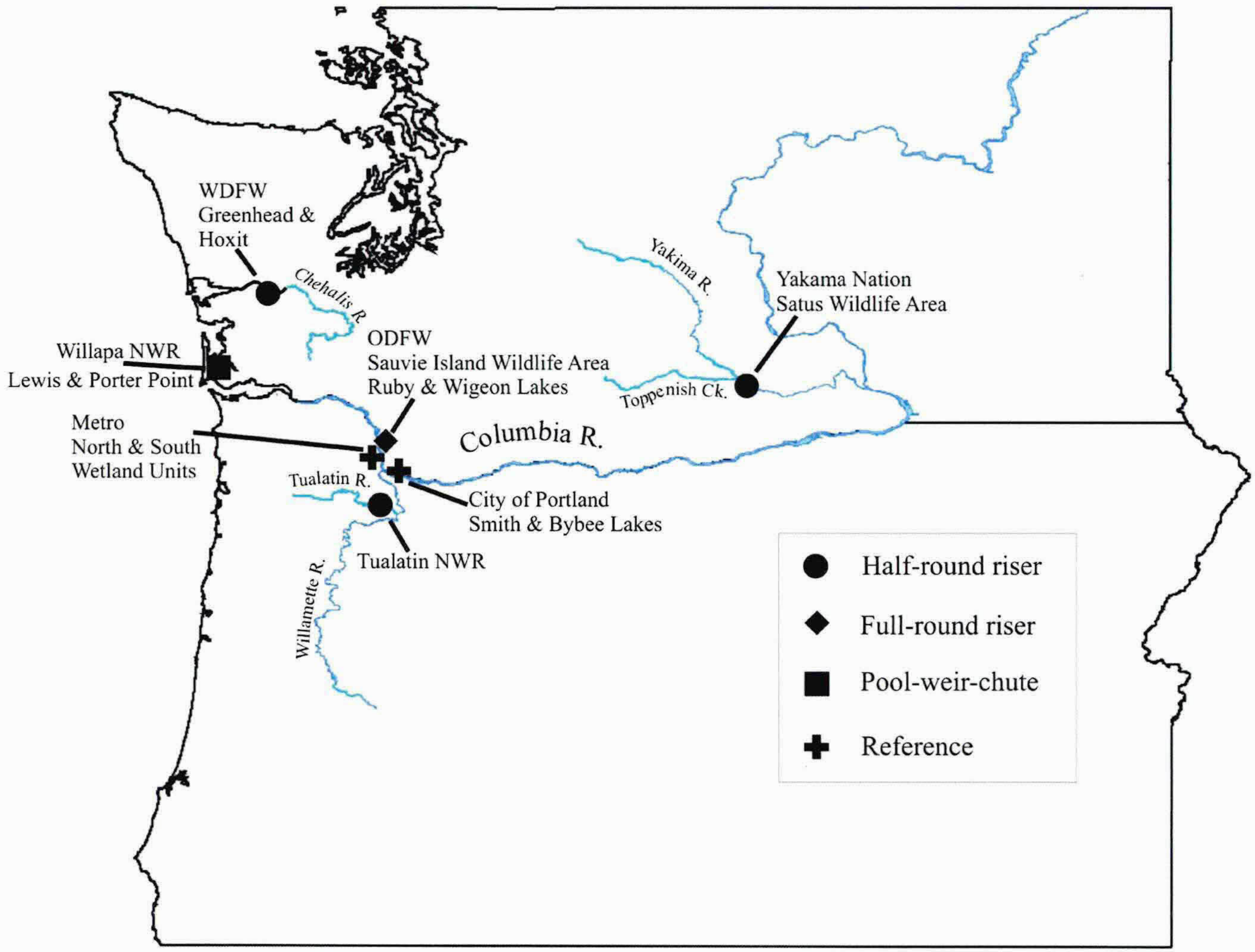


Figure 5. Trap nets used in sampling.

Box trap: 2 ft. tall, 3 ft. wide, 5 ft. long with a 25 ft. lead net, 3/16 in. mesh

Fyke net: 3 ft. tall, 4 ft. wide, 30 inch rings, 25 ft. wings, 3/16 in. mesh

Oneida Lake Trap: 4 ft. at mouth of trap, 25 ft. wings, 125 ft. Lead connects to trap at mouth, 3/16 in. mesh the wetlands prior to encountering the structures in order to tag the fish so that they could be captured later below the structure to determine wetland-residence time and perhaps growth rate (Sauvie Island and Hoxit sites only); second, so that catch of the assemblage of fishes in the wetlands, which may not include the more mobile fishes caught at the two-way traps, could be documented and compared; and third, because the sampling was done similarly at all sites, a comparison of relative abundance (catch per unit effort) and species composition could be made between sites.

Trap, location, duration of set, species, fork length (± 1mm) and wet weight (± 0.1g) (salmonids only) were recorded for fish caught during the SSWS. Salmonids were scanned for previous PIT (passive integrative transponder) tags, which are uniquely coded, and PIT tagged if greater than 70mm, if no previous tag has been inserted.

PIT tags were inserted into the body cavities of salmonids using a 12-gauge hypodermic needle and modified syringe (Prentice et al. 1990) after anesthetizing the fish in a bath containing 70mg tricaine methanesulfonate (MS-222) L^{-1} buffered with sodium bicarbonate to a pH of 7 and kept in a bath for 90s after losing equilibrium (Summerfelt and Smith 1990).

Two-way Fish Traps

Two-way traps fished below the water control structures in the Sauvie Island area allowed us to ascertain what fish, tagged or not, salmonids or other species, are leaving the wetlands. These traps were fished as soon as the water began flowing through the wetlands in late November until spring draw-down in late July. Traps were checked on a regular basis (daily or every other day). Salmonids were scanned for previous tags and tagged if no previous tag exists. Salmonids caught within a wetland were PIT tagged so that they could be detected lower in the river at a juvenile fish bypass PIT tag interrogator or by the PIT tag trawl in the Lower

Columbia River. Fish caught in two-way traps were identified to species and fork length (± 1mm), wet weight (± 0.1g) (salmonids only), trap type (*i.e.* fyke, 2-way), and direction (*i.e.* in, out for 2-way traps) were recorded.

Radio Telemetry

Salmonids at select sites were surgically implanted with radio transmitters (Lotek model NTC-3-1; 0.85g air weight, 0.6g wet weight, up to 23d battery life) to track movements through wetlands and over a full-round riser water-control structure. Fish were caught with trap nets or two-way traps, anesthetized with MS-222, and surgically implanted with the radio tag as described by Summerfelt and Smith (1990). After implantation, fish were kept in a large recovery container with aerated water until they appeared recovered and were released. The transmitters have an expected life of 23 days. Each transmitter has a unique code on a frequency (up to 212 codes per frequency), making each tagged fish individually recognizable. Fish were tracked with mobile antennae and receiver on a daily basis and fixed station antennae were installed at the Ruby Lake trap. Tag frequencies were coordinated with an ongoing study by Oregon State University Department of Fish and Wildlife. This study occurred during the same time on the Columbia, in which fixed station antennae were used to record radio tagged fish during downstream migration.

Results

Data from each site will be summarized in sections organized by type of water-control structure, except for sites in the Sauvie Island area, that have a full-round riser and two reference sites (Baker 2003). These sites were reported separately as per agreement as part of a biological opinion with NOAA Fisheries (formerly National Marine Fisheries Service). This document is a companion document to the aforementioned report and will be referred to as the 'Sauvie Report' hereafter. Data from all sites, including those in the Sauvie Report, will be synthesized in this document after being summarized.

Sites with half-round risers

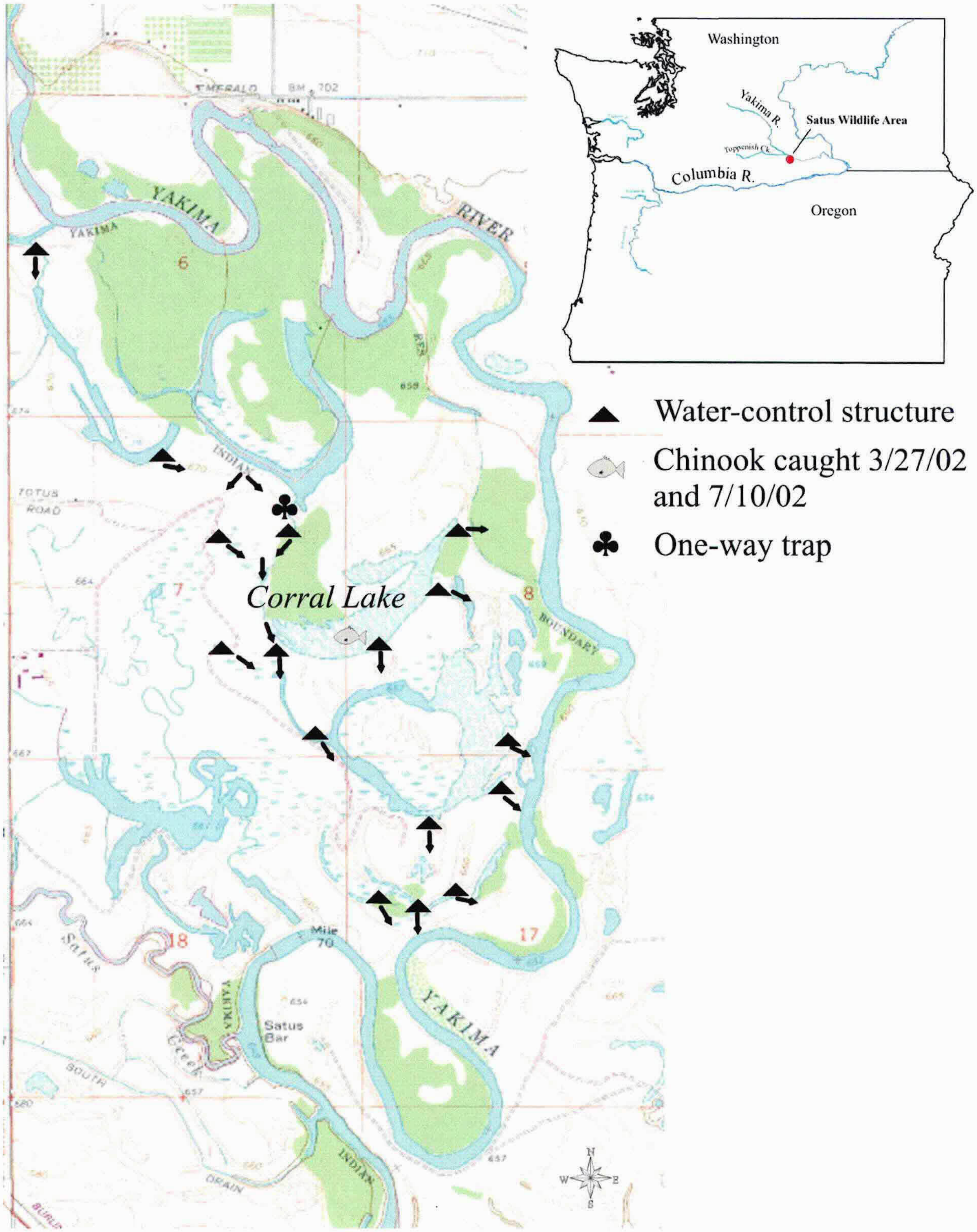
Satus Wildlife Area

The Yakima River's flow regime has been altered by five storage reservoirs and a number of irrigation diversions, which serve 464,000 acres of irrigable land (http://www.kid.org\yakimaproject.htm). The Satus Wildlife area is located on the west bank of the Yakima River in a low-gradient reach that meanders southward to the Columbia River 73 miles downstream. Many old oxbow ponds and sloughs in the floodplain have varying degrees of connectivity to unscreened Yakima River surface flows, according to river levels. In addition to the Yakima River flows, summer irrigation drain water enters the wetland complex at several locations. Many of these ponds and sloughs have been choked with exotic water lilies due to levee development and reduced duration of flooding from impoundments (Hames, pers. comm.). Low-head (3-4 feet), half-round riser structures and adjacent spillways in the floodplain provide partial control of water levels in the floodplain and allow management of water flow through the wetland. This management activity has resulted in the senescence of the lily infestations and re-establishment of native vegetation important to waterfowl, such as sago pondweed. Waterfowl have responded to these management activities positively, measured by increased abundance and diversity of wintering ducks (Hames, pers. comm.). It was not known whether salmonids use this off-channel habitat during their downstream migration or for over-winter rearing. The objective of this monitoring effort was to determine salmonid use of this habitat, describe relative abundance of the fish assemblage in the wetlands through the sampling period, and to confirm fish passage through the maze of structures in this wetland.

The Satus Wildlife Area is over 5,000 acres and contains a broad floodplain landscape 2-3 miles wide. This Tribal restoration property on the Yakama Reservation was chosen as a study site because of the arrangement of 16 half-round riser water-control structures (Figure 6) and presence of salmonids in the Yakima River. It was anticipated that juvenile Chinook salmon (*Oncorhynchus tshawtytcha*) and steelhead (*O. mykiss*) would use the floodplain wetland during the winter and spring. The plan was to capture these fishes, PIT tag them, and later recapture them in the wetland to confirm passage capability through the water-control structures and possibly downstream at juvenile-bypass facilities at the Prosser Dam on the Yakima River or Columbia River Dams. There was also a possibility of recapturing steelhead PIT-tagged by the Yakama Nation Fish and Wildlife Department and US Geologic Survey, Biological Resources Division, who were working in Toppenish Creek, which enters the Yakima River just upstream from the Satus Wildlife Area.

Historically, there were fall, spring and summer Chinook, coho (*O. kisutch*), sockeye salmon (*O. nerka*) and summer steelhead in the Yakima River (YIN 1990). Currently, the wild, summer Chinook and sockeye are extinct in the basin. Native, wild, spring Chinook currently exist in the upper Yakima River that Washington Department of Fisheries considers a depressed stock (SASSI: WDF et al 1993). A healthy stock of fall-bright Chinook are also present in the Yakima River. These fish are reported as a composite stock of unknown origin by the SASSI report (WDF et al 1993), which also reports a healthy stock of wild, native fall Chinook in the Marion Drain, a diversion on Toppenish Creek. Coho were extirpated in the 1980s but were reintroduced; the current run now includes a significant percentage of wild-origin adults. The Middle Columbia River steelhead were listed under the ESA as threatened in 1999. Satus Creek, Toppenish Creek and their tributaries are the most significant production areas for remaining

Figure 6. Water-control structures in the Satus Wildlife Area.



natural summer steelhead, accounting for as much as half of the production of this stock in the Yakima River Basin recently (Satus Watershed Analysis, 1998). Satus Creek enters the Yakima River just downstream of the study site. Wild, fall Chinook are not listed but just a remnant of the historic abundances remain. The Fall Chinook Supplementation Project, Spring Chinook Supplementation Project, and Coho Restoration Project provide hatchery-raised parr to the Yakima River from the Prosser Tribal Hatchery and the Yakima Tribal Coho Complex.

A one-way trap (Figure 7) was installed at the entrance of the floodplain wetland (Figure 6) in order to capture and record fish upon their entrance and PIT-tag salmonids. Trap dimensions were 42 inches (length, width, and height), covered with ¼ inch hardware cloth and the vertical slot was 3 inches wide with a rubber flap, which reduced the gap to 1.5 inches. The trap was checked about every other day by fisheries employees of the Yakama Nation from January 3, 2002 to March 18, 2002. This trapping effort was abandoned due to problems fishing the trap in high water. Sampling within the wetland was done in January, March, and July of 2002 to determine fish presence and relative abundance using trap nets.

Figure 7. One-way trap at Satus Wildlife Area.

One-way trap results

Catch from the one-way trap was limited. Only 147 fish and amphibians were caught between January 3rd and March 18th, 2002 (Table 1). Most (59%) of these were introduced bullfrog tadpoles (*Rana catesbiana*) but there were 36 (24%) native, redside shiner (*Richardsonius balteatus*) caught, and small numbers of other native and introduced warmwater fish species. No salmonids were caught in this trap. The trap was dislodged from its original location January 10th and moved 20 feet downstream. On February 23rd, the right wing became loose and was re-installed then the left wing was displaced March 18th and the trap was removed.

Wetland Sampling

Fishes in the wetland were sampled with the standard gear (2 box traps, 2 fyke nets and 1 Oneida Lake trap) for two 24-hour sets per trip in January, March and July 2002. There were 3,107 fish caught during the wetland sampling (Table 2) as well as 138 bullfrog tadpoles and 27 pond turtles (Table 3). A very high proportion of the fish catch were introduced species (98.5%), mostly yellow perch (*Perca flavescens*), black crappie (*Pomoxis nigromaculatus*), carp (*Cyprinus carpio*), and brown bullhead (*Ameiurus nebulosus*) (Figure 8). Of the native species caught were two Chinook salmon. Greatest catches were in January (65%) and declined through the

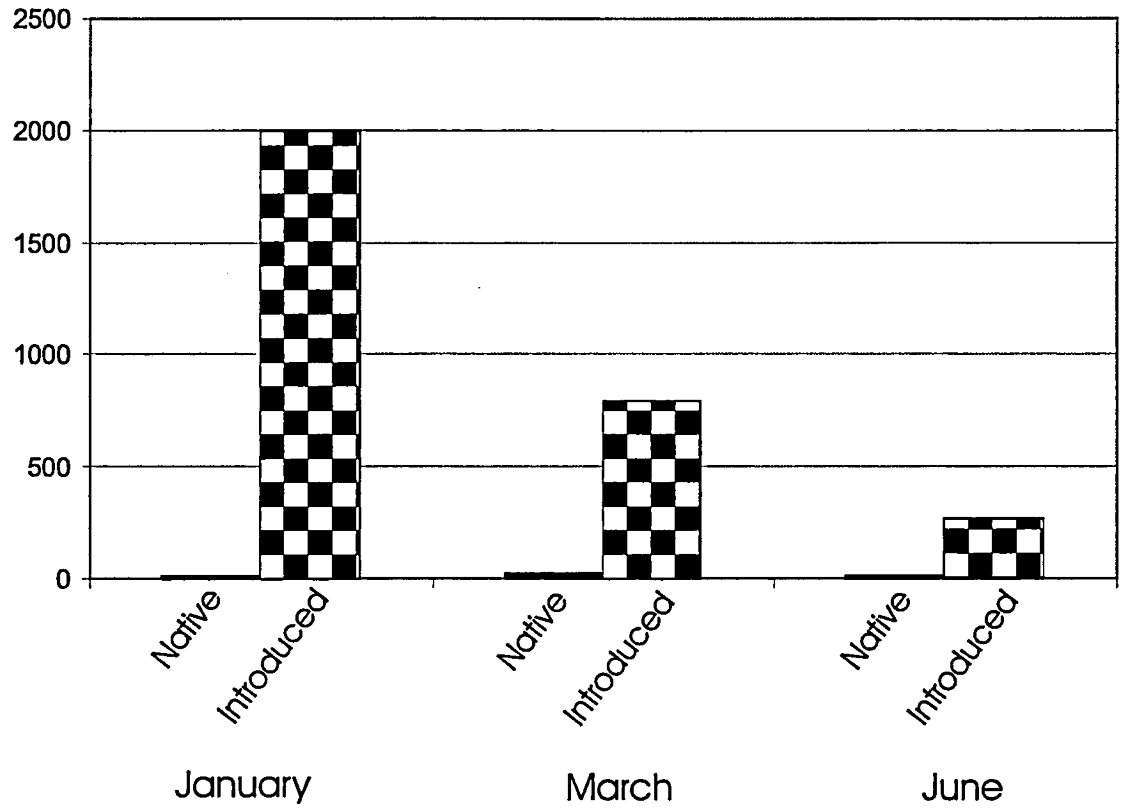
Table 1. Catch in one-way trap Jan 3-Mar 18, 2002 (*introduced species).

Common Name	Family	Number	Min. Fk. Len. (mm)	Max. Fk. Len. (mm)
largescale sucker	Catostomatidae	1	97	
chiselmouth	Cyprinidae	6	56	118
speckled dace	Cyprinidae	6	64	117
northern pikeminnow	Cyprinidae	3	54	188
redside shiner	Cyprinidae	36	37	116
bluegill*	Centrarchidae	1	44	
carp*	Cyprinidae	1	61	
goldfish*	Cyprinidae	1	52	
brown bullhead*	Ictaluridae	4	52	60
yellow perch*	Percidae	1	77	
bull frog tadpole*	Ranidae	87	40	117

Table 2. Catch from wetland sampling at Satus Wildlife Area January, March, July 2002.

2002	Native Intro	Common Name	Family	Number	min fk len (mm)	max fk len (mm)	wt (g)
January	N	Largescale sucker	Catostomidae	7	75	406	1078
January	N	Prickly sculpin	Cottidae	2	70	86	11
January	N	Redside shiner	Cyprinidae	6	58	102	47
			Total Native =	**15**			**1137**
January	I	Black crappie	Centrarchidae	526	71	235	9589
January	I	Bluegill	Centrarchidae	70	51	176	2022
January	I	Largemouth bass	Centrarchidae	21	64	432	2150
January	I	Pumpkinseed	Centrarchidae	7	96	121	206
January	I	White crappie	Centrarchidae	6	70	87	30
January	I	Common carp	Cyprinidae	387	38	552	4484
January	I	Brown bullhead	Ictaluridae	165	59	292	4353
January	I	Yellow perch	Percidae	817	94	227	12883
			Total Introduced =	**1999**			**35717**
			Total January =	**2014**			**36854**
March	N	Largescale sucker	Catostomidae	5	176	394	972
March	N	Prickly sculpin	Cottidae	3	86	116	44
March	N	Northern pikeminnow	Cyprinidae	2	189	214	176
March	N	Redside shiner	Cyprinidae	9	52	88	30
March	N	Chinook salmon	Salmonidae	1	128	128	30
			Total Native =	**20**			**1251**
March	I	Black crappie	Centrarchidae	241	78	330	5152
March	I	Bluegill	Centrarchidae	37	42	130	811
March	I	Warmouth	Centrarchidae	2	81	97	40
March	I	Common carp	Centrarchidae	92	53	584	16204
March	I	Brown bullhead	Ictaluridae	235	46	359	9769
March	I	Yellow perch	Percidae	187	77	195	3633
			Total Introduced =	**794**			**35609**
			Total March =	**814**			**36861**
July	N	Largescale sucker	Catostomidae	1	133	133	25
July	N	Chiselmouth	Cottidae	4	34	150	83
July	N	Northern pikeminnow	Cyprinidae	2	135	179	86
July	N	Redside shiner	Cyprinidae	3	74	84	18
July	N	Chinook salmon	Salmonidae	1	104	104	17
			Total Native =	**11**			**230**
July	I	Black crappie	Centrarchidae	54	30	235	2004
July	I	Bluegill	Centrarchidae	13	74	127	399
July	I	Largemouth bass	Centrarchidae	97	17	22	6
July	I	Pumpkinseed	Centrarchidae	2	87	110	49
July	I	Common carp	Cyprinidae	28	20	460	2652
July	I	Brown bullhead	Ictaluridae	52	23	226	2145
July	I	Yellow perch	Percidae	22	50	220	633
			Total Introduced =	**268**			**7888**
			Total July =	**279**			**8118**

Figure 8. Native and introduced fishes at Satus Wildlife Area Jan.-June 2002, catch by numbers.



Native and Introduced Fishes at Satus Wildlife Area
(% catch, by numbers)

Native	**%**	**Introduced**	**%**
Redside shiner	0.6	Yellow perch	33.0
Largescale sucker	0.4	Black crappie	26.4
Prickly sculpin	0.2	Common carp	15.1
Northern pikeminnow	0.1	Brown bullhead	14.5
Chinook salmon	0.1	Bluegill	3.9
Chiselmouth	0.1	Largemouth bass	3.8
		White crappie	1.4
		Pumpkinseed	0.3
		Warmouth	0.1

species	**fork len.(mm)**	**date caught**
chinook	128	3/27/2002
chinook	104	7/10/2002

sampling season. The largest catch in a single net was 1,064 fish/24-hour set using a fyke net but the average catch was 115 fish/24-hour set with large variability (std. dev.=239 fish/24-hour set). In July, juvenile largemouth bass (*Micropterus salmoides*) was the most abundant fish, by numbers (35%), but were very small (17-22mm). The most abundant fish by weight that month was carp (33%). Most fish caught in the wetland habitat at Satus Wildlife Area were small (< 200mm). Only 102 out of the 3,107 (3%) fish caught were larger than 200mm (Table 4). Of these larger individuals, most were brown bullhead (44%), black crappie (25%), and carp (22%).

Only one northern pikeminnow (*Ptychocheilus oregonensis*) and two largemouth bass, which may prey on juvenile salmonids, were caught during the wetland sampling.
Two juvenile Chinook were caught during the sample period, both in Corral Lake (Figure 6). They were released back into Corral Lake after capture. One was caught March 27, 2002 (128mm, 24.2g) and the other was caught July 10, 2002 (104mm, 13.8g). Both fish had adipose fins and are presumed wild. It is not known if they are fall or spring Chinook or what their age was at the time of capture. Based on size and date of capture, the first fish was likely a yearling

Table 3. Bullfrog tadpoles and pond turtles caught at Satus Wildlife Area.

Month	**bullfrog tadpoles**	**pond turtles**
January 4-5, 2002	24	1
March 26-27, 2002	114	2
July 10-11, 2002	0	24

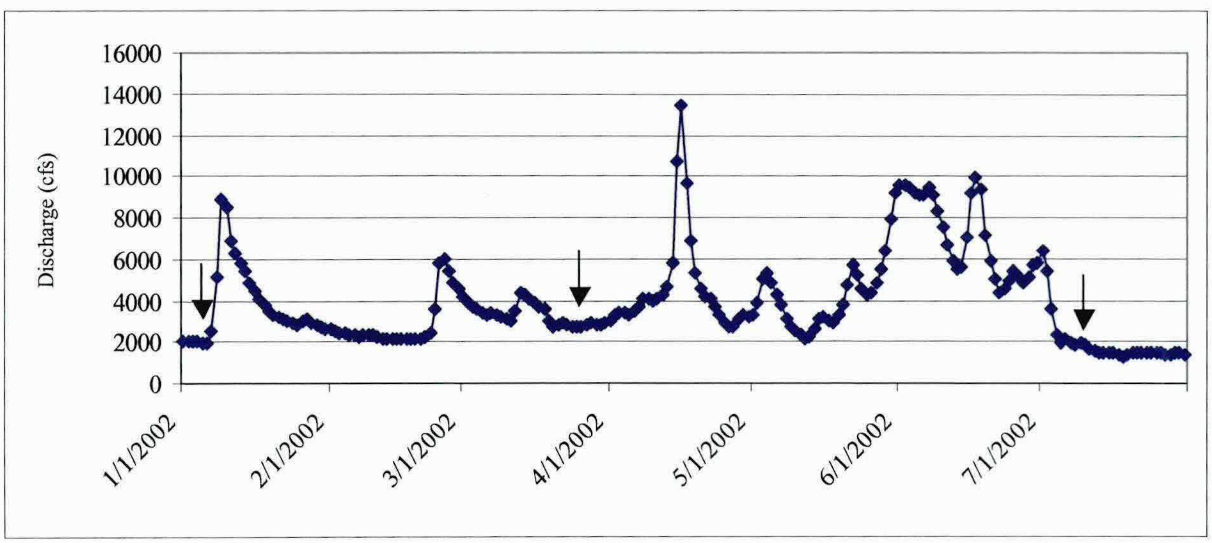
Table 4. Fish caught > 200mm in fork length (* introduced species).

Name	**Family**	**Number**	**min fk len (mm)**	**max fk len (mm)**
largescale sucker	Catostomidae	4	228	406
northern pikeminnow	Cyprinidae	1	214	214
black crappie*	Centrarchidae	26	203	330
brown bullhead*	Ictaluridae	45	204	359
common carp*	Cyprinidae	22	208	584
largemouth bass*	Centrarchidae	2	311	432
yellow perch*	Percidae	2	220	227
	Total =	**102**	**203**	**584**

spring Chinook and the second was a sub-yearling fall Chinook. The Chinook caught in March was PIT-tagged. The one caught in July was not because the PIT-tag reader was on loan and had to be returned before sampling. The PIT-tagged Chinook was detected 159 miles downstream at the juvenile bypass facility at McNary Dam on May 8, 2002, 42 days after it was released back into the wetland. Data on fish size and weight were not recorded at the dam. The combined yearling and sub-yearling Chinook passage indices for outmigrant timing characteristics at McNary Dam show that the date that 50% of these outmigrants passed through the dam was on May 17 and July 1, 2002, respectively (www.cbr.washington.edu/rt/passage_bar/). This Chinook was able to navigate out of the wetland and passed through from two to four half-round risers or spillways to get back to the Yakima River (Figure 6).

Between the time the Chinook was caught and tagged in March and when it was recaptured at McNary Dam, the flow in the Yakima River above the Prosser dam spiked to 13,555 cfs (Figure 9). This may have prompted the fish to leave and made it easier to pass over the structure/spillways and find it's way out of the wetland.

Figure 9. Discharge (cfs) above Prosser Dam on the Yakima River (RM 47), arrows indicate samping periods.



Data summary

Fish catch at this site was dominated by introduced fishes, mostly smaller than 200mm in fork length. The length of 200mm was chosen as a convenient dividing point to describe the abundance of small fishes in the catch. Seasonal, floodplain wetlands, where high growth rates and production occur, favor small-bodied fishes (Bayley and Li, 1992).

Only two Chinook salmon were caught in the wetland. The PIT tagged Chinook provides an example of a salmonid's ability to navigate out of a wetland with half-round riser water-control structures. There may have been other juvenile salmonids moving through the wetland at higher water levels than what was sampled. Sampling was done at low water levels, around 2000 cubic feet per second (cfs), compared to the maximum of 13,355 cfs during mid-April. Salmonids were either not present during the sampling period or were not detected.

The very low catch of salmonids in this floodplain wetland indicates that there is either relatively low use of this habitat by salmonids or they are coming in and leaving at higher flows and therefore have low risk of stranding or migration delay from the low-head structures. The sampling effort is too great for such a limited example of salmon use and passage capability through these structures and since the site is a great distance from our base of operation, and sampling during flood peaks requires a quick response, this site was dropped from the monitoring program.

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Acknowledgments

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<u>Lower Chehalis River</u>

Hoxit Farm and Greenhead wetlands are located at rivermile 36.7 and 17, respectively, on the Chehalis River (Figure 10 and 11). Hoxit Farm is located off State Route 12 about three miles south of Porter. A levee and half-round riser water control structure, that has a six foot drop, was constructed in 1996 to increase wetland habitat from 0.17 acres to 8.6 acres, a 50-fold increase in surface area (Henning, 2000). There is an unnamed stream coming into the wetland, which provides a positive water source, so that there is a flow over the riser boards of the structure. This stream may not be accessible by anadromous fishes at lower flows due to a potential culvert, passage barrier at the railroad tracks near the wetland. The culvert is not a barrier during high winter flows (J. Henning, pers. comm.). Fish can only enter the wetland when water from the river overtops its banks and flows laterally into the wetland. An egress channel flows out of the wetland, just below the half-round riser, and joins the Chehalis River about one-half mile downstream. Hoxit Farm is above the area of tidal influence in the Chehalis River. Greenhead, however, is within the zone of tidal influence.

Figure 10. Chehalis Basin

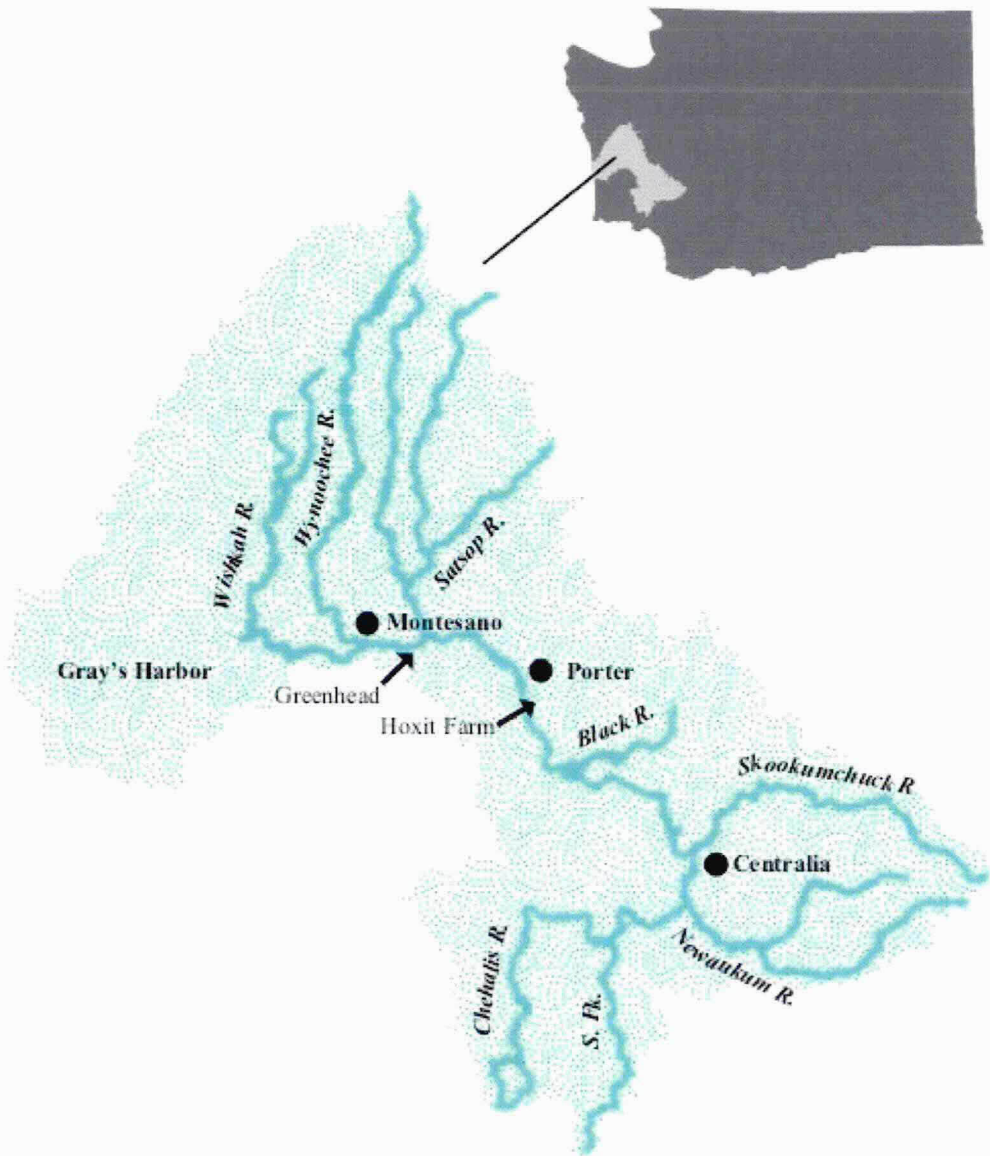
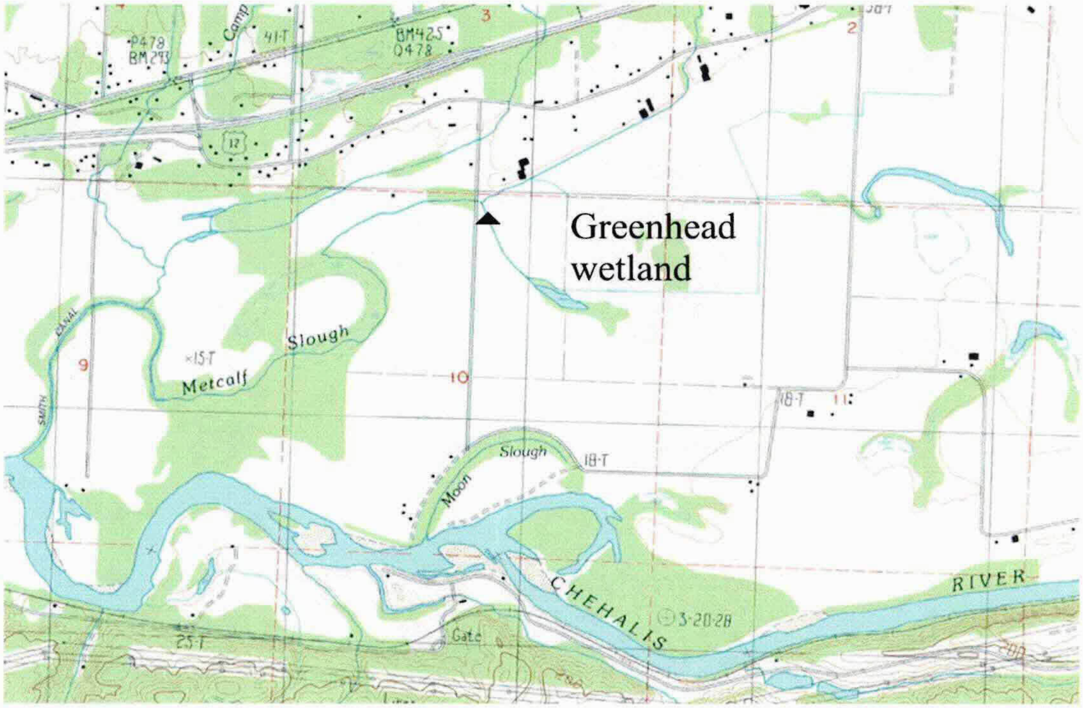
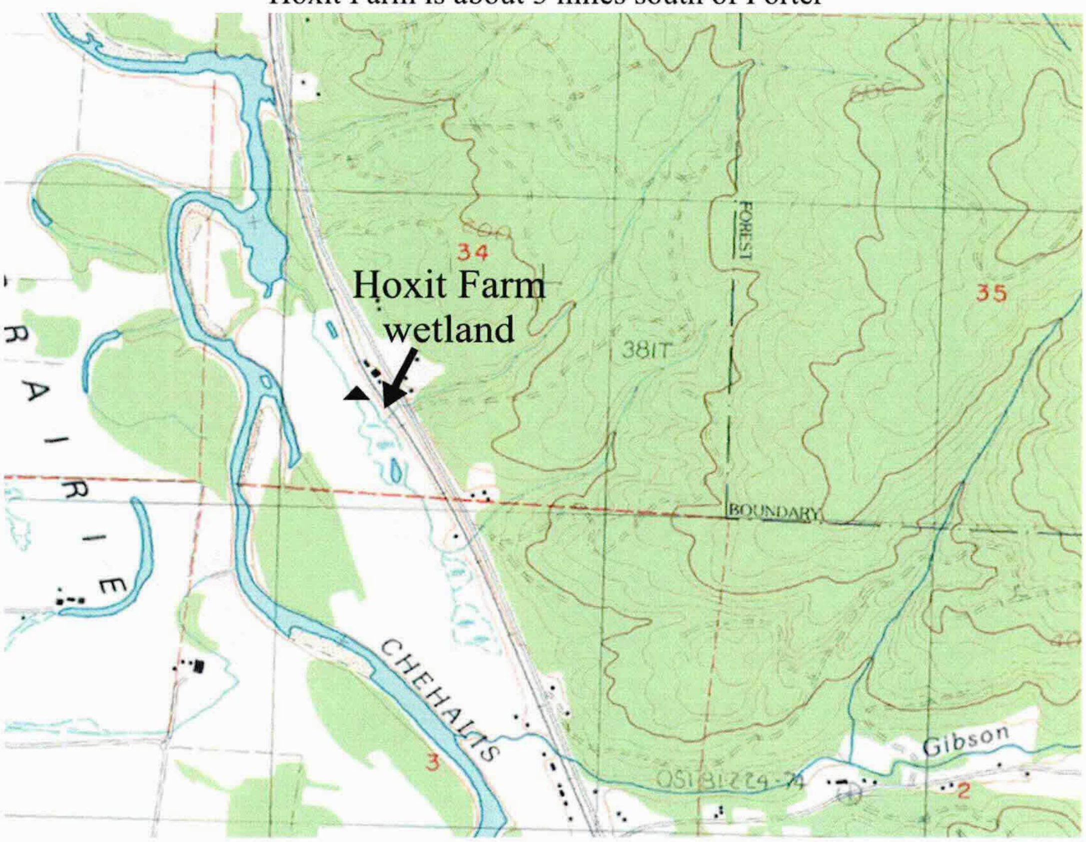


Figure 11. Site maps of Greenhead (RM 17) and Hoxit (RM 36.7) on the Chehalis River.

Greenhead is about 4.5 miles west of Montesano



Hoxit Farm is about 3 miles south of Porter

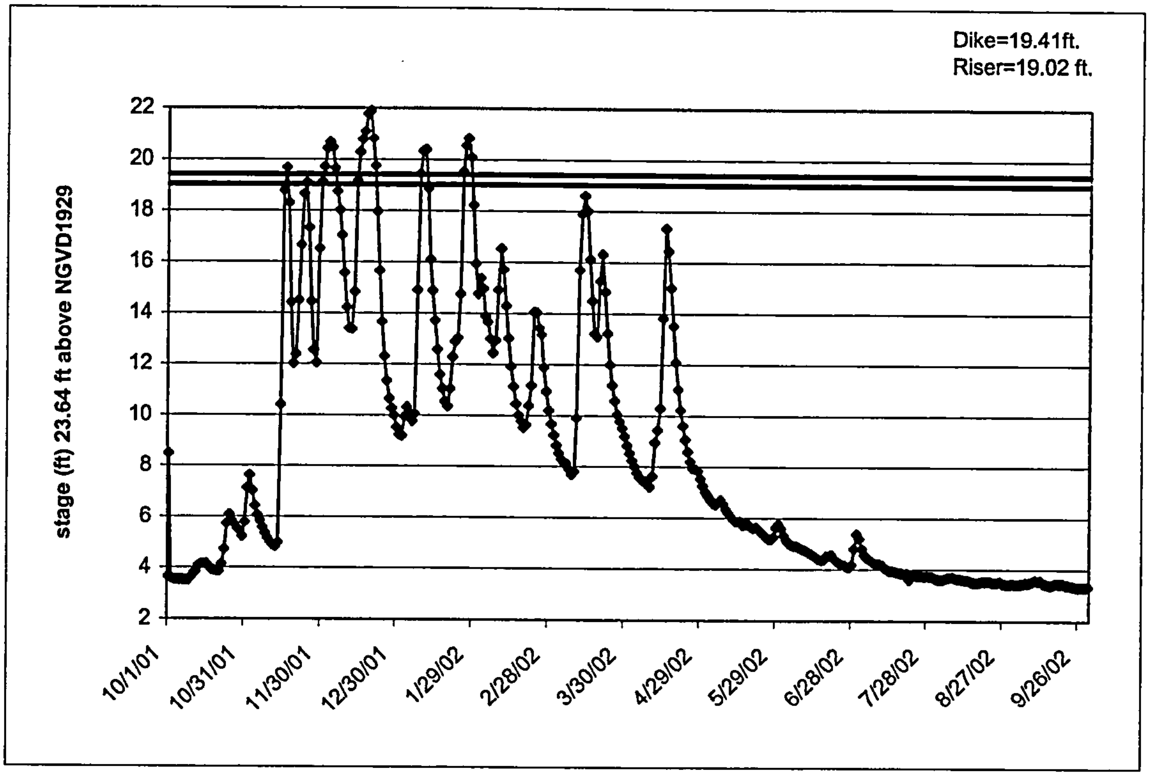


Greenhead is about 4.5 miles west of Montesano. It is an off-channel area of Metcalf Slough. The wetland is about 120 acres but, due to limited access back into the wetland, sampling has only been done in an area about 40 acres in front of the water-control structure at the slough entrance. There are three water-control structures at this site.

Connectivity of the wetlands with the riverine system is essential if fishes are to have access to these wetlands for over-winter rearing. Frequency of connection was calculated from finding the lowest point that water could enter the wetlands from the sloughs that connect them to the river and instantaneous gage height records at the nearest USGS stream gage was used to predict gage height at which water could enter the wetlands. A comparison of these elevations with the recorded gage heights give an estimate of frequency that fish can enter the wetlands.

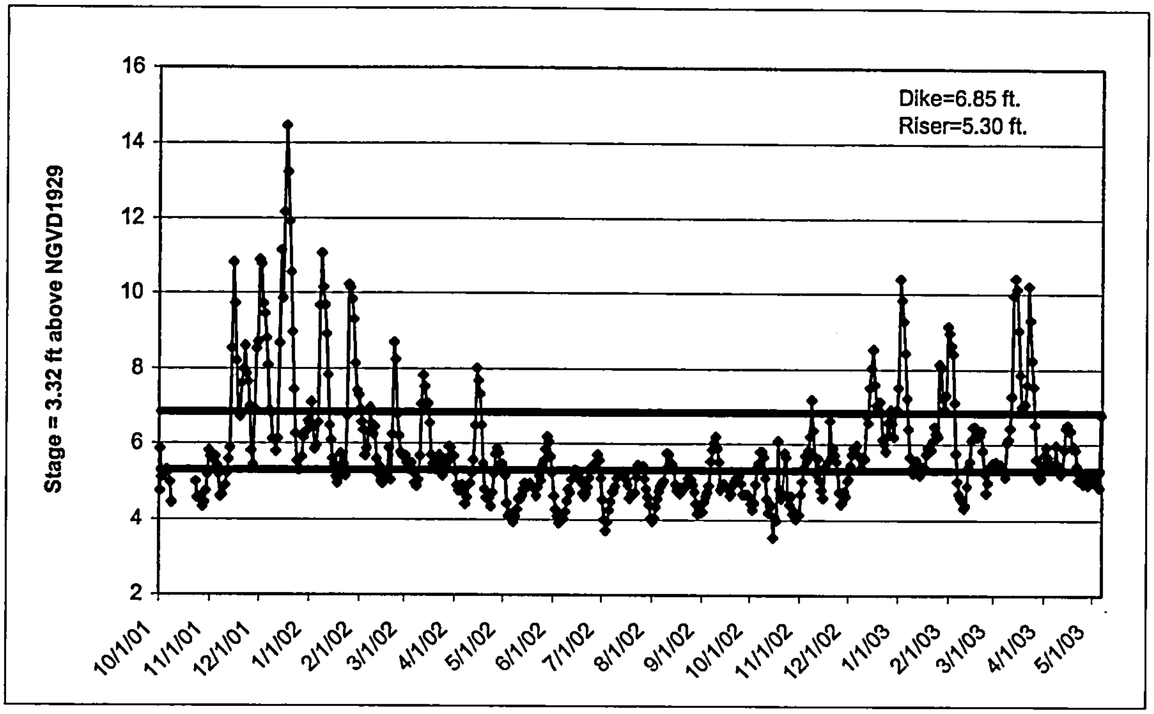
Water from the slough at the outflow of Hoxit Farm wetland has a 5.4% chance of overtopping the riser and 4.6% chance overtopping the dike from November through April. These values were calculated based on all daily average gage-height records at the Chehalis River at Porter (12031000), November through April, from 1987 to 2003. Daily averages may underestimate the frequency of overtopping the riser board and dike. Gage heights taken at 15-minute intervals from October 1, 2001 to September 30, 2002 show an 8.6% chance of overtopping the riser board and a 7.1% chance of overtopping the dike, occurring November 15, 2001 through March 25, 2002 (Figure 12- plotted as daily average values). The height from the top of the riser to the bottom of the culvert is six feet and there is a positive water source running through the wetland. Monitoring of fish passage into the wetland via this route has not been monitored as it not expected but is possible. It is more likely to occur at Greenhead because the difference in height is only about four feet and incoming tidewater can move into the wetland with substantial velocity.

Figure 12. Daily average stage for the Chehalis River at Porter, 2002 water year.



Frequency of water entering Greenhead from the slough is much greater than at Hoxit Farm. There was a 58% chance of flooding over the riser board and a 40% chance of overtopping the dike (Figure 13-plotted as daily average values). These values are based on daily gage-height values recorded at 15-minute intervals from 10/1/01 to 5/6/03 at the Montesano gage (12035100); limited data is available for this site (2001-03 compared to 1987 to 2003 at Hoxit Farm) so 2003 data was included for frequency of flooding estimate. This frequency estimate may be low because all of the riser boards were not immediately put into the structure in the fall but are added as water fills the wetland so there may be greater connectivity than what is represented by the estimate. Water entered the wetland from October 1 through May 6. Data from this site is more unreliable than at Porter because it is a flood-alert site, in which there is an alert issued when water exceeds a particular stage. The Porter gage is a standard monitoring site in which the records are reviewed annually and published.

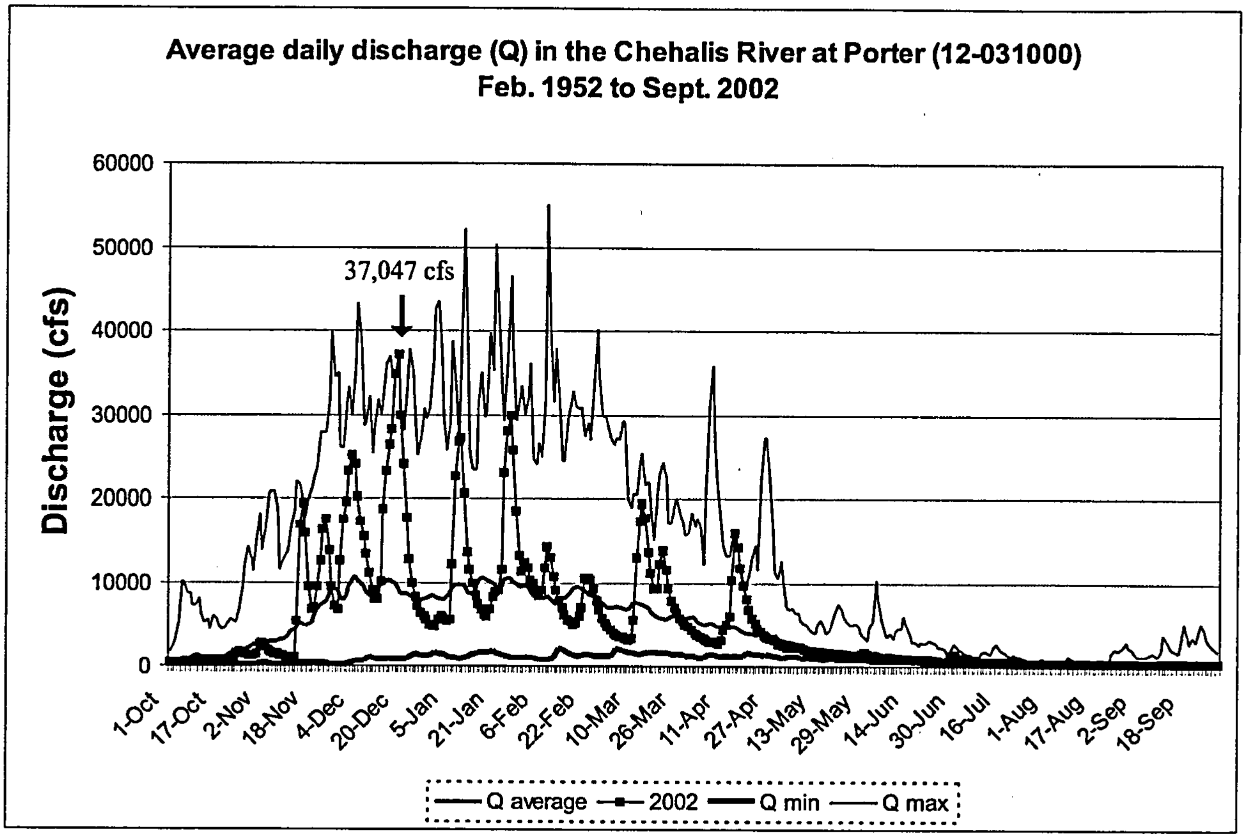
Figure 13. Daily average stage for the Chehalis River at Montesano, 10/1/02 to 5/6/03

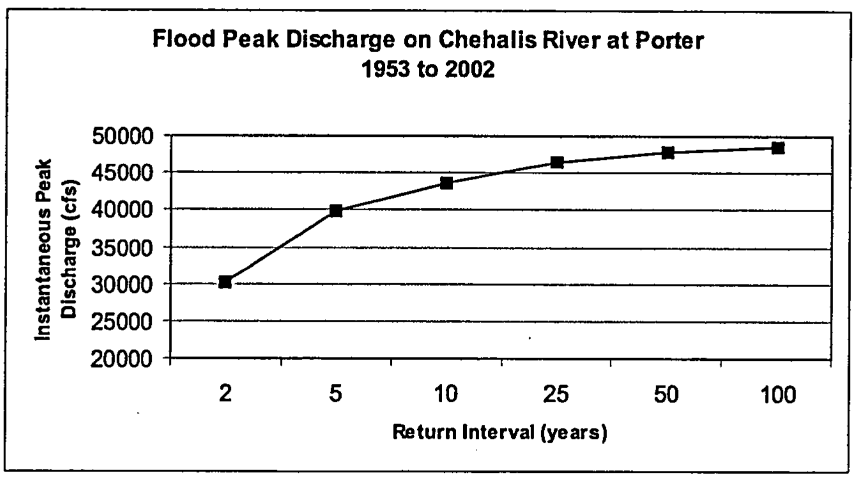


The stream gage on the Chehalis River at Porter has the longest period of record for the two gage sites (1959 to present) so the discharge data was used to calculate flood return intervals to describe water levels during the 2002 water year (Figure 14). The greatest flow (daily average) was December 19, 2001 at 37,047 cfs, which was only about a five-year event.

There are no dams on the main-stem Chehalis River but other small dams and diversions have been constructed in the basin (USFWS 1993). A recent level 1 assessment for the Chehalis Basin lists 70 dams in the basin (Envirovision, 2000). The two largest dams are on the upper Skookumchuck and Wynoochee, built in 1970 and 1974, respectively. The Skookumchuck reservoir (35,000 ac-ft.) was constructed on the Skookumchuck River at RM 21.9. The Skookumchuck River converges with the Chehalis River just below Centralia (Figure 10). The Wynoochee Reservoir (70,000 ac-ft.) is 51.8 miles upstream on the Wynoochee River, which enters the Chehalis River downstream of the study site, below Montesano (Figure 10).

Figure 14. Flow characteristics for the Chehalis River at Porter in 2002.





Return Interval	Discharge (cfs)
2	30171
5	39743
10	43525
25	46470
50	47802
100	48688

Riverfront land has been drained and dikes installed for agricultural development on the Chehalis River and it's tributaries, resulting in the loss of off-channel habitat. Based on 1999 data, Envirovision (2000) reports 769 water rights in the lower Chehalis Basin for a total allocated diversion/withdrawl amount of 2,901 cfs and volume limits at approximately 120,000 ac-ft. Fifty-three percent of the rights were attributed to irrigation and 26% for domestic use.

Presence of salmonids in the Chehalis River includes, bull trout (*Salvelinus confluentus*), coastal cutthroat (*O. clarki clarki*), spring, summer and fall Chinook, chum (*O. keta*), coho, and summer and winter steelhead. Details are given in the Salmon and Steelhead Stock Inventory report (WDF et al 1993) and are below summarized. Bull trout are native to the Chehalis River and are maintained by wild production but the stock status is unknown. Coastal cutthroat are a native fish that has widespread distribution in the basin. WDFW Aberdeen Hatchery once maintained an anadromous coastal cutthroat broodstock derived from Grays Harbor/Chehalis stocks so, they are considered native with composite production. Spring Chinook are a native stock with wild production in which spawning occurs in the Skookumchuck, Newaukum and upper main-stem Chehalis Rivers. The stock is reported as healthy. Summer Chinook, a mixed stock with wild production, are present in the Satsop River and their status is depressed. Fall Chinook occurs in all the major tributaries and the main-stem Chehalis River. Origin and production type are variable but all stocks were reported healthy. Coho are also present in all the major tributaries and river. Their origin is mixed stock with composite production and are reported healthy. Summer steelhead are present in the Chehalis River and winter steelhead can be found in most tributaries and the main-stem Chehalis River. The winter steelhead varies in origin, production, and status.

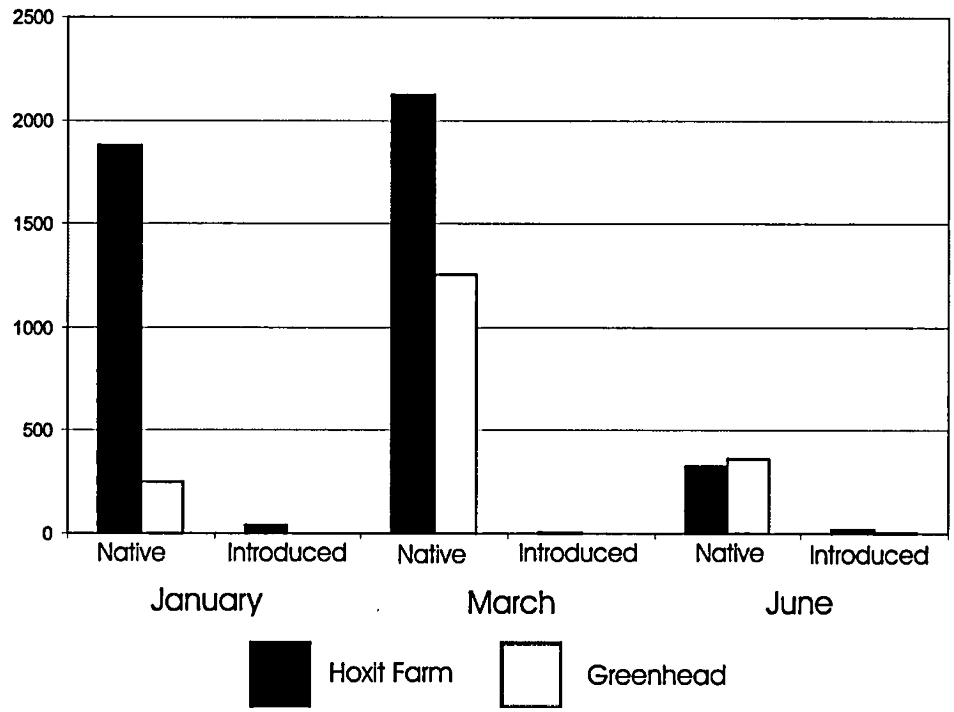
Wetland Sampling

Sampling within the Hoxit Farm and Greenhead wetlands was done January 7-9, March 18 and 19, and June 6 and 7, 2002. Nets were set for a 24-hour period per wetland per trip. Fishes within Hoxit Farm wetland were sampled with the standard gear (2 box traps, 2 fyke nets and 1 Oneida Lake trap). At Greenhead wetland, the January sample was done with the standard compliment of gear but the Oneida Lake trap was not used during the March and June sampling periods due to the shallow water in the wetland.

There were 4,401 fish caught at Hoxit Farm and 1,875 fish caught at Greenhead wetlands (Tables 5 and 6). At Hoxit Farm, native species dominated the catch (98% of catch by numbers, 85% by weight) throughout the seasonal wetland sampling (Figure 15). Threespine stickleback (*Gasterosteus aculeatus*) was the most abundant species and had the greatest biomass in March and June, while largescale sucker (*Catostomus macrocheilus*) had the greatest biomass in January. Of the introduced species there were few caught but the brown bullhead dominated the catch by weight. Only 1% of the fish caught at Hoxit Farm had a fork length greater than 200mm (Table 7).

Nine coho, that were probably in the 1+ age class, and 23 salmon fry were caught in the Hoxit Farm wetland. The fry were caught in March and were 37 to 60mm in fork length but it was not clear if they were coho or Chinook. Other species of interest are the Pacific lamprey (*Lampetra tridentata*), in which two were caught in January, and the Olympic mudminnow (*Novumbra hubbsi*), which were caught in January (28 caught) and March (63 caught). The Pacific lamprey is on the federal species of concern list and the Olympic mudminnow are a Washington state species of concern.

Figure 15. Native and introduced fishes in Hoxit Farm and Greenhead Wetlands, 2002 (catch by numbers).



Native and Introduced Fishes at Hoxit Farm and Greenhead wetland
(% catch [by numbers] by site)

Native	H	G	Introduced	H	G
Threespine Stickleback	79.3	69.4	Yellow Perch	0.3	0.2
Olympic Mudminnow	2.1	26.6	Brown Bullhead	0.3	
Coho parr	0.4	0.4	Black Crappie	0.3	
Salmon fry	0.5	0.1	Bluegill	0.3	
Prickly Sculpin	0.1	0.1	Pumpkinseed	0.3	
Northern Pikeminnow	3.4	0.1			
Redside Shiner	8.2	2.6			
Largescale Sucker	4.5	0.6			
Pacific Lamprey	0.05				

Site	Species	Min FL	MAX FL	Number
Hoxit Farm wetland	coho	80	163	17
	salmon fry	37	60	23
			Total Hoxit Farms=	40
Greenhead wetland	coho	108	135	8
	salmon fry	48	48	1
			Total Greenhead=	9
			Grand Total=	49

Table 5. Catch from wetland sampling at Hoxit Farm January, March and June, 2002.

2002	Native Intro	Common Name	Family	Number	min fk len (mm)	max fk len (mm)	wt (g)
January	N	Largescale sucker	Catostomidae	191	50	320	10093
January	N	Northern pikeminnow	Cyprinidae	105	29	155	720
January	N	Redside shiner	Cyprinidae	351	60	124	3253
January	N	Threespined stickleback	Gasterosteidae	1196	28	49	468
January	N	Pacific lamprey	Petromyzontidae	2	100	115	4
January	N	Coho salmon	Salmonidae	8	93	118	141
January	N	Olympic mudminnow	Umbridae	28	40	75	56
			Total Native=	**1881**			**14734**
January	I	Black crappie	Centrarchidae	14	49	78	44
January	I	Bluegill	Centrarchidae	9	40	165	221
January	I	Brown bullhead	Ictaluridae	11	135	245	1118
January	I	Yellow perch	Percidae	9	55	282	808
			Total Introduced=	**43**			**2190**
March	N	Largescale sucker	Catostomidae	4	49	55	7
March	N	Unidentified sculpin	Cottidae	1	68	68	4
March	N	Prickly sculpin	Cottidae	1	120	120	21
March	N	Northern pikeminnow	Cyprinidae	36	30	98	45
March	N	Peamouth	Cyprinidae	1	66	66	3
March	N	Redside shiner	Cyprinidae	11	34	70	19
March	N	Threespined stickleback	Gasterosteidae	1974	36	51	1147
March	N	Coho salmon	Salmonidae	8	80	140	144
March	N	Salmon fry*	Salmonidae	23	37	60	43
March	N	Olympic mudminnow	Umbridae	63	40	78	132
			Total Native=	**2122**			**1567**
March	I	Bluegill	Centrarchidae	1	47	47	2
March	I	Yellow perch	Percidae	3	93	124	46
			Total Introduced=	**4**			**48**
June	N	Largescale sucker	Catostomidae	3	41	50	3
June	N	Unidentified sculpin	Cottidae	1	66	66	3
June	N	Northern pikeminnow	Cyprinidae	7	38	89	14
June	N	Threespined stickleback	Gasterosteidae	319	26	49	109
June	N	Coho salmon	Salmonidae	1	163	163	56
			Total Native=	**331**			**185**
June	I	Bluegill	Centrarchidae	3	48	64	10
June	I	Pumpkinseed	Centrarchidae	13	54	148	138
June	I	Brown bullhead	Ictaluridae	4	76	258	465
			Total Introduced=	**20**			**613**

*Salmon fry too small to identify

Table 6. Catch from wetland sampling at Greenhead January, March, June 2002.

2002	Native Intro	Common Name	Family	Number	min fk len (mm)	max fk len (mm)	wt (g)
January	N	Largescale sucker	Catostomidae	11	37	105	30
January	N	Prickly sculpin	Cottidae	1	123	123	23
January	N	Northern pikeminnow	Cyprinidae	1	109	109	13
January	N	Redside shiner	Cyprinidae	47	30	104	98
January	N	Threespined stickleback	Gasterosteidae	111	30	65	85
January	N	Coho salmon	Salmonidae	2	108	109	38
January	N	Olympic mudminnow	Umbridae	78	44	79	152
			Total Native=	**251**			**439**
January	I	Yellow perch	Percidae	2	76	78	12
			Total Introduced=	**2**			**12**
March	N	Northern pikeminnow	Cyprinidae	1	71	71	4
March	N	Redside shiner	Cyprinidae	2	43	58	3
March	N	Threespined stickleback	Gasterosteidae	908	30	61	741
March	N	Coho salmon	Salmonidae	6	110	135	160
March	N	Salmon fry*	Salmonidae	1	48	48	2
March	N	Olympic mudminnow	Umbridae	339	44	72	706
			Total Native=	**1257**			**1615**
March	I	Yellow perch	Percidae	1	79	79	6
			Total Introduced=	**1**			**6**
June	N	Threespined stickleback	Gasterosteidae	280	20	51	50
June	N	Olympic mudminnow	Umbridae	80	31	66	89
			Total Native=	**360**			**139**
June	I	Brown bullhead	Ictaluridae	4	88	128	77
			Total Introduced=	**4**			**77**

*Salmon fry too small to identify

Table 7. Fish caught at Hoxit Farm > 200mm in fork length (* introduced species).

Name	Family	Number	min fk len (mm)	max fk len (mm)
largescale sucker	Catastomidae	32	210	320
brown bullhead*	Ictaluridae	6	214	258
yellow perch*	Percidae	5	205	282

Catch, by numbers, at Greenhead was almost all native fishes (99.6%). The most abundant fish was the threespine stickleback. Olympic mudminnow had the greatest biomass in January and June, but the threespine stickleback had the greatest weight in March. The introduced species consisted of three yellow perch and four brown bullhead. There were two coho, probably in the 1+ age class, in January and six 1+ caught in March along with one fry

(48mm). For a state species of concern, the Olympic mudminnow are apparently abundant at Greenhead; there were 497 caught during the 2002 sampling season. There were no fish caught with fork length greater than 200mm. The largest fish caught in this wetland was a 135mm coho salmon.

Amphibians at these sites are listed in Table 8. The red-legged frog, a federal species of concern, is present at both Hoxit Farm and Greenhead wetlands. Also of interest is the presence of bullfrog tadpoles at Hoxit Farm, which has accounted from 4 to 21% of the total catch of fish and amphibians. The effects of these introduced frogs are unknown to native species but may include competition or predation.

Table 8. Amphibians caught in Hoxit Farm and Greenhead wetlands in 2002 by SSWS.

Species	January		March		June	
	Greenhead	Hoxit	Greenhead	Hoxit	Greenhead	Hoxit
Long-toed salamander	4	0	0	0	0	0
Northwestern salamander	5	39	2	0	1	3
Rough-skinned newt	1	1	7	1	1	0
Red-legged frog	30	23	1	0	104	76
Bullfrog tadpole*	0	521	0	95	0	87

*introduced species

One-way Trap Sampling

A one-way trap was set up at the outflow culvert of the half-round riser at Hoxit Farm (Figure 16). A block-net was wrapped around the 36-inch culvert, attached with a ratchet strap and sewn to make a tube. This block-net tube was then attached to a wooden box trap via an 8-inch pipe. This trap was fished on the receding limb of the hydrograph after a high-water event in March by WDFW (Figure 17). Water level in the wetland receded with the river level. The trap was set March 20, 2002 and checked seven times until March 30, 2002. Almost all fishes were native species, except for a bluegill and 478 bullfrog tadpoles (Table 9). Threespine stickleback was the most abundant species caught, followed by redside shiner and northern pikeminnow. There were 224 coho fry (39mm average fork length, based on a sample of 44) and 15 coho parr from 78 to 155mm fork length. One coho, batch marked January 8, 2002 (n=8, 93-118mm, av. 104mm), was recaptured 3/26/02 at a length of 152mm. In 77 days that coho grew 48mm (calculated from the average length of 104mm in January), which was a 32% increase in fork length. During this period, minimum temperature was 2.9°C (1/29), maximum temperature was 12.16 °C (3/25), and average daily average temperature was 6.6°C (see also Figure 18).

Table 9. Catch from one-way trap at Hoxit Farm March 21-30, 2002**.

Fish/Amphibians	**21-Mar**	**22-Mar**	**24-Mar**	**26-Mar**	**27-Mar**	**28-Mar**	**30-Mar**	**TOTAL**
coho fry	0	0	6	65	51	15	87	**224**
1+ coho	0	0	0	9	5	1	0	**15**
Stickleback	0	15	161	639	235	41	317	**1408**
redside shiner	0	1	105	135	153	23	118	**535**
northern pikeminnow	0	21	130	107	118	22	93	**491**
largescale sucker	0	3	31	28	31	7	16	**116**
Olympic mudminnow	0	3	16	10	8	11	11	**59**
Sculpin	0	0	2	0	0	2	2	**6**
Cutthroat	0	0	0	1	0	0	0	**1**
bluegill*	0	0	1	0	0	0	0	**1**
red-legged frog	0	0	0	1	0	0	0	**1**
bullfrog tadpole*	5	21	169	62	107	23	91	**483**

*introduced species

** data courtesy of Julie Henning, WDFW, Montesano

Figure 16. One-way trap below the half-round riser at Hoxit Farm.

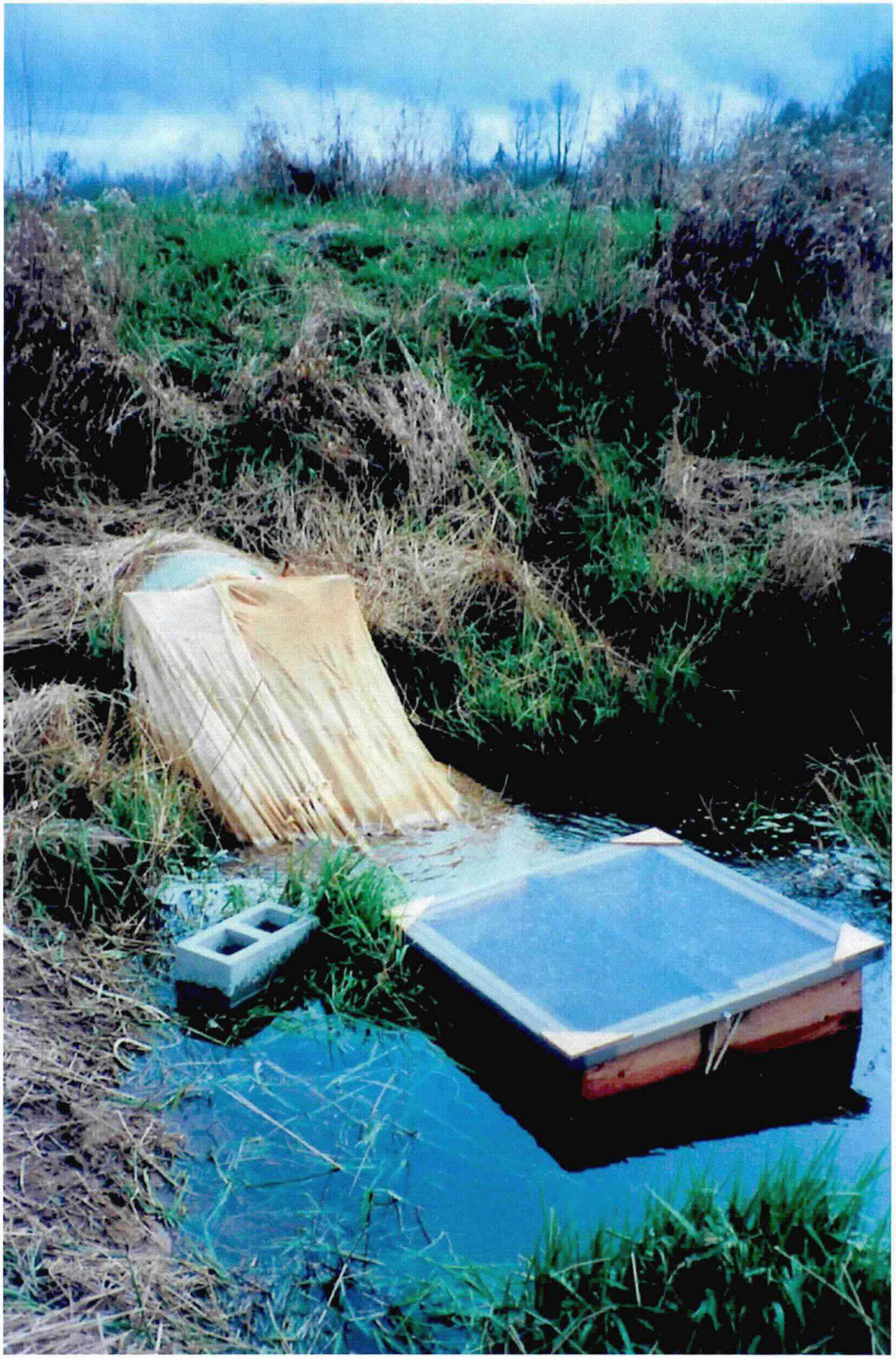


Photo courtesy of Julie Henning, WDFW

Figure 17. Average daily discharge in the Chehalis River at Porter (12-031000) during the one-way trapping effort.

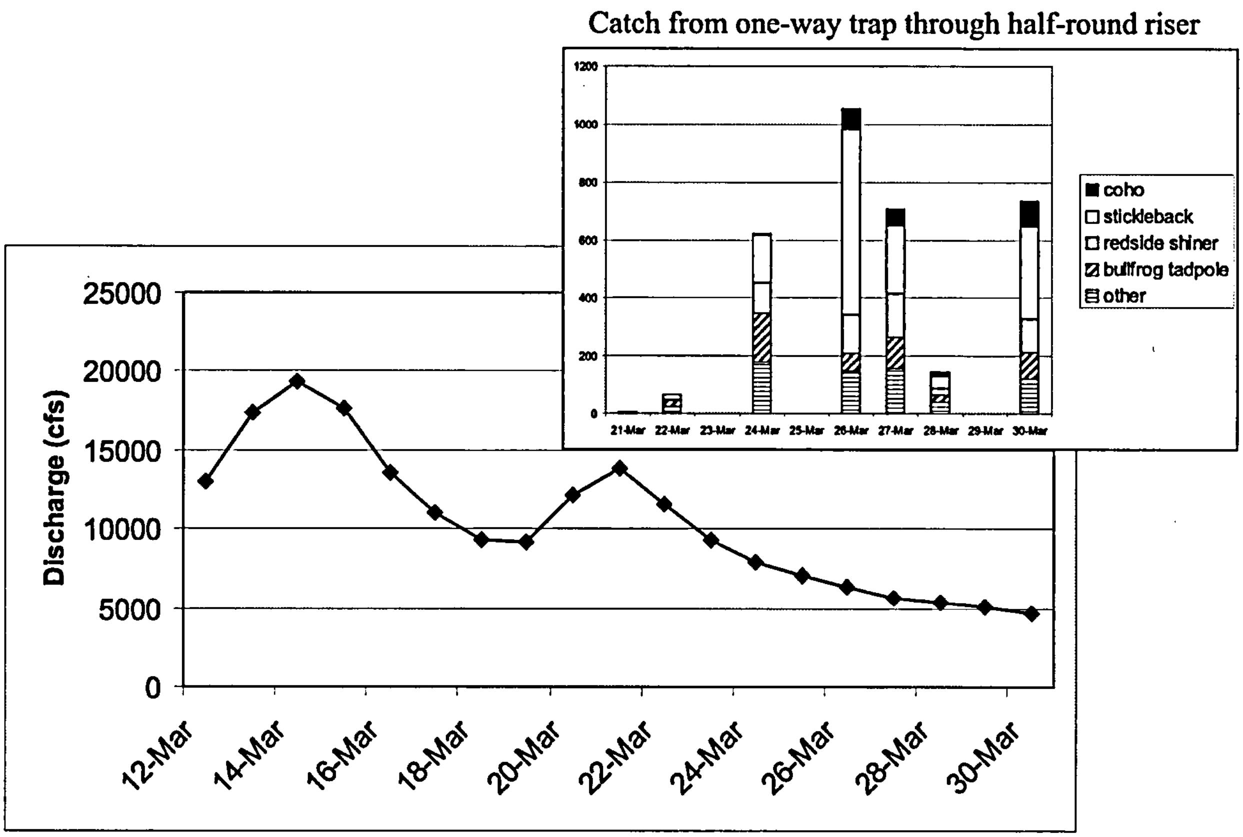
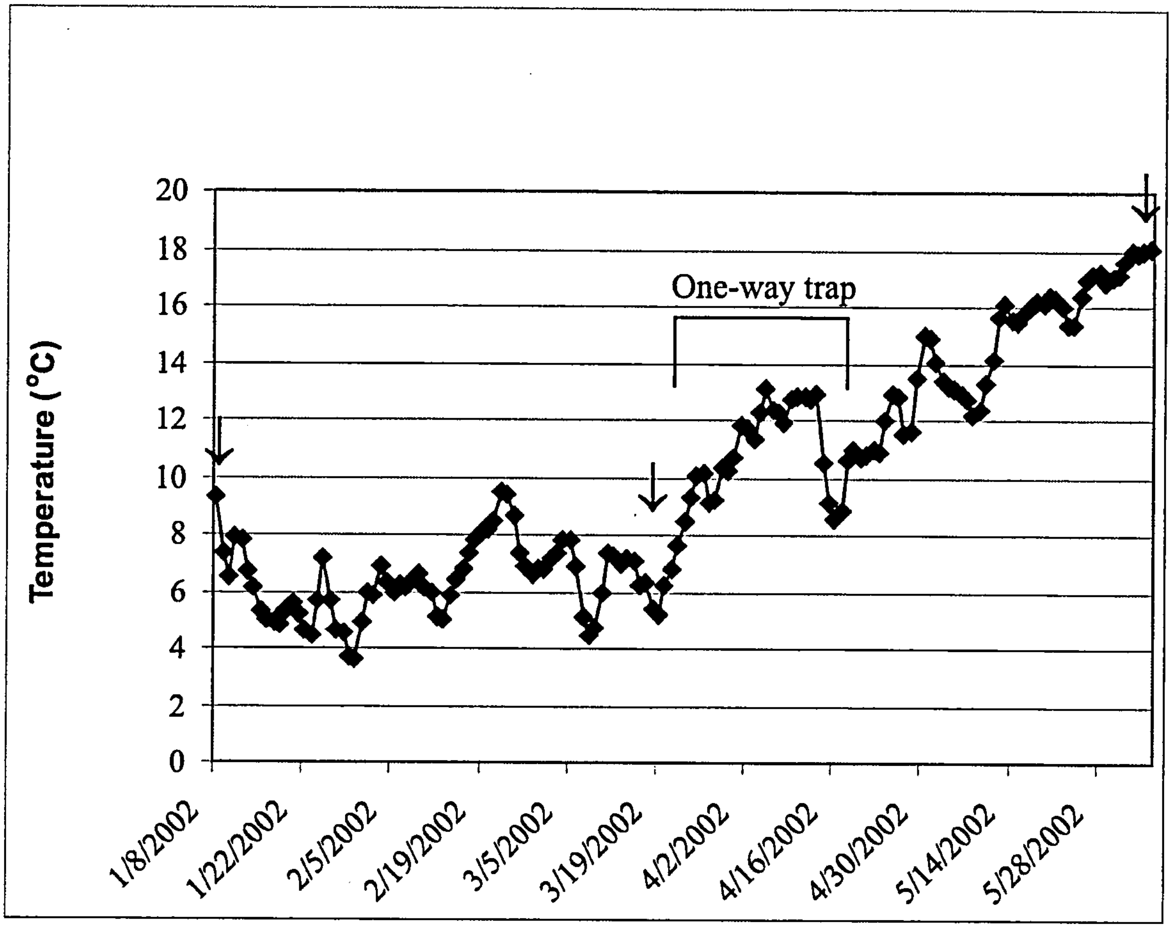


Figure 18. Average daily water temperatures at Hoxit Farm Wetlands.



Data Summary

These sites appear to have very few introduced fish species, based on catch but Hoxit Farm has a fair abundance of introduced bullfrog tadpoles. Both 0+ and 1+ age classes of coho were found. It is not clear whether some of the fry were coho or Chinook. Two fish species, the Pacific lamprey and Olympic mudminnow, and an amphibian, the red-legged frog, are listed as state sensitive species or federal species of concern. Twenty-seven percent of the catch, by numbers, at Greenhead were Olympic mudminnow.

No fish greater than 200mm fork length were caught at Greenhead and few were caught at Hoxit Farm. Some deep-water (6-8 ft) habitat was sampled at Hoxit Farm. Greenhead is a much larger wetland some of which has difficult accessibility, so the area sampled may not have represented deeper habitat that may exist.

An interesting observation made at Hoxit Farm was the presence of what seemed great abundances of Limnophillid caddisfly nymphs in January and March. When nets were pulled, they were covered with cased-caddis nymphs that had colonized the nets overnight. This provides an example of what productive habitat wetlands can be for fish and other animals that may prey on these invertebrates.

Catch in the one-way trap below the 6-foot half-round riser confirms passage capability through this water-control structure. No injuries to fishes that passed through the structure were reported. Fifteen coho parr and 224 coho fry came out of the wetland and into this trap in a nine-day period, in addition to 144 other fishes. Sampling fish coming out of the wetland was done on the receding limb of the hydrograph but it appears that fish began moving out in greater numbers as the flow through the structure declined. Further sampling of out-migrating fishes will be required to confirm this pattern. Fish can detect current flow as low as 0.03mm s^{-1} (Bleckman 1993). The sensitivity of their lateral line is very high; put another way, fish can detect water moving as slowly as four feet in one hour. Their ability to detect low velocities and navigating out of wetlands is a topic germane to monitoring fish in wetlands with water-control structures.

These sites represent an example of restoration efforts in a lowland coastal basin where water management for agricultural practices, which include water storage and withdrawals, have affected the historic hydrologic regime.

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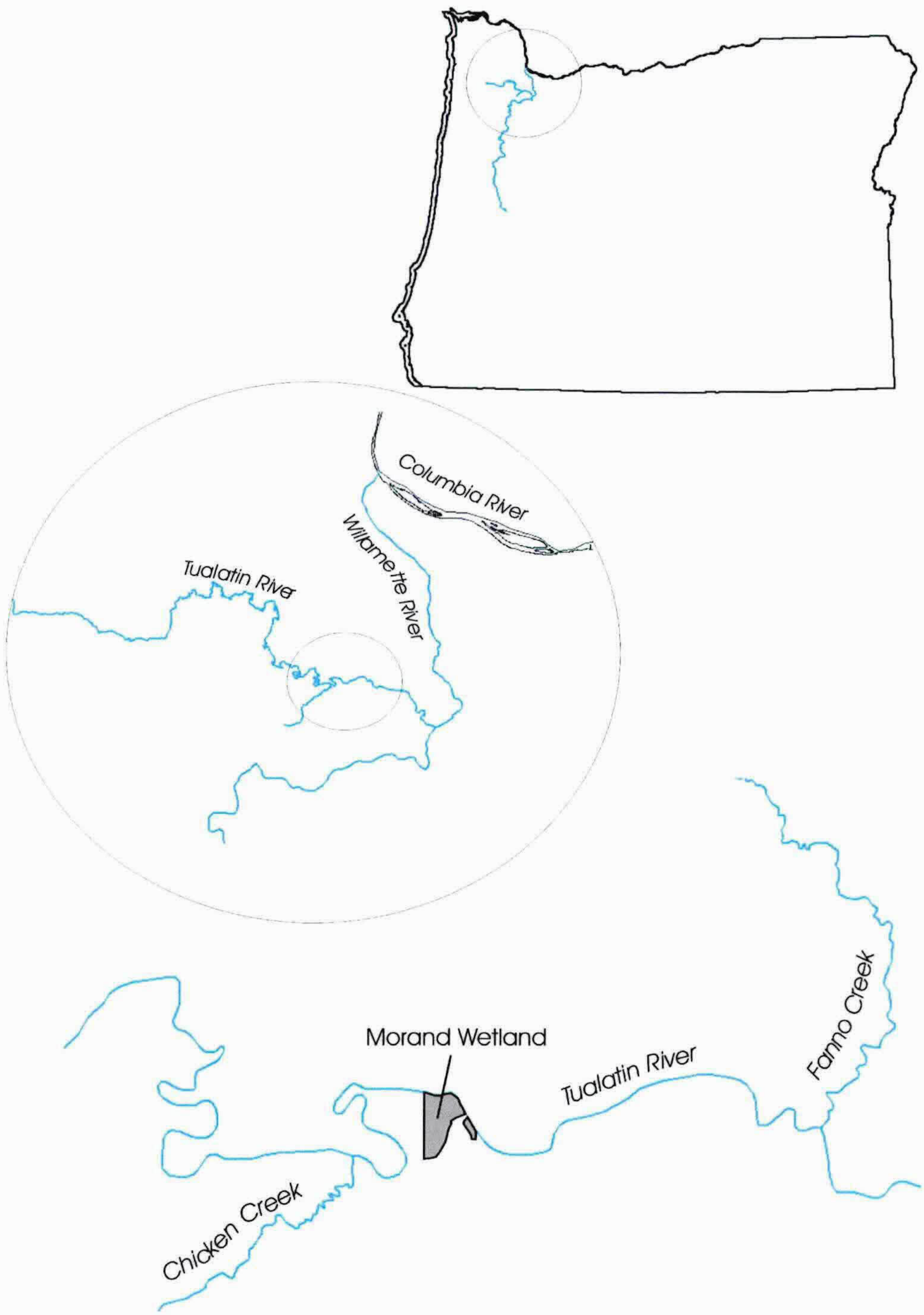
Acknowledgements

Ducks Unlimited, Inc. thanks Greg Schirato, Julie Henning, and Shannon Sewalt, our partners in restoration projects and research at Washington Department of Fish and Wildlife in Montesano.

Tualatin River National Wildlife Refuge

Tualatin River National Wildlife Refuge (NWR), located on the Tualatin River, a tributary of the Willamette River (Figure 19) was established in 1992. The Tualatin Basin has been under

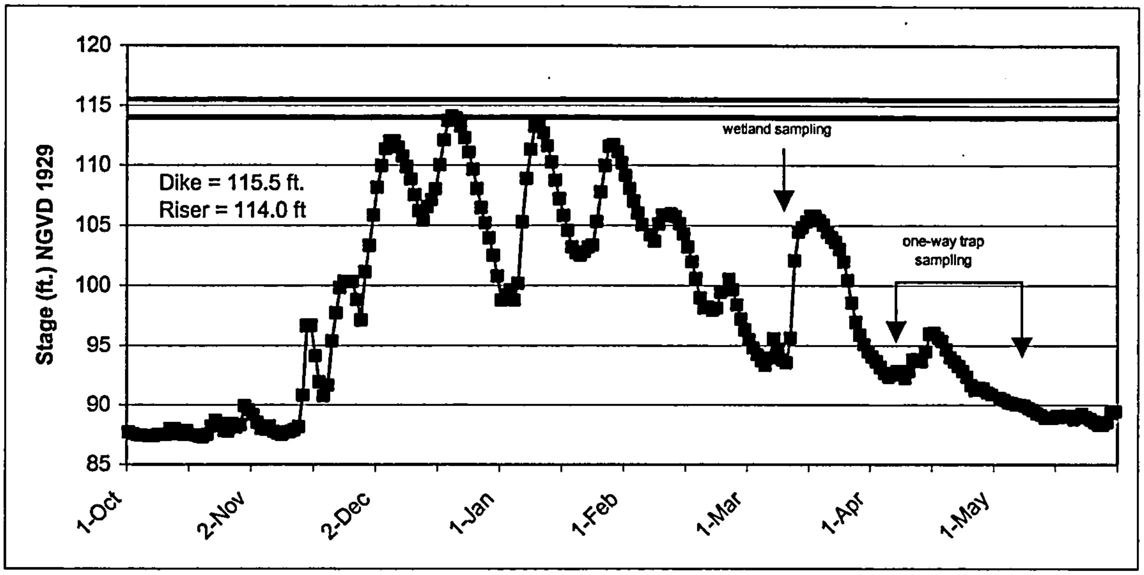
Figure 19. Morand wetland,Tualatin River NWR.



agricultural production since early in the 19th century and has been heavily urbanized more recently. Following major floods in 1996 and 1997, the Tualatin NWR bought land in private ownership to protect undeveloped land and to restore that used for agricultural purposes. The refuge will total over 3,000 acres and preserve a floodplain wetland ecosystem when final acquisition of land is completed. There are seasonal and emergent wetlands, Oregon ash riparian hardwood/forested wetland, riparian shrub, coniferous forest and Oregon white oak plant communities, which are considered remnant Willamette Valley habitats. The Morand site, 12.8 miles from the confluence of the Tualatin River with the Willamette River, was in agricultural production but is now owned by Metro. The Tualatin River NWR entered into a perpetual agreement with Metro to manage the Morand parcel as part of the National Wildlife Refuge System and complete restoration.

A half-round riser was installed in September 2001 to create a six-acre wetland. This structure is 5.5 feet high and holds a maximum of 4.5 feet of water. The purpose of monitoring this site was to provide an example of fish passage through a water-control structure in the floodplain of a Willamette River tributary that has at least some chance of flooding and salmon entering the wetland. It was anticipated that the levee at the Morand wetland (115.5 ft. NGVD 1929) would overtop when the Tualatin River reaches flood stage (132.5 feet NGVD 1929 at Farmington) and that this would occur occasionally (perhaps every other year) based on the experience of refuge personnel (Pete Schmidt, pers. comm.). Water did not overtop the dike but did reach the height of the top of the riser (114.0 ft. NGVD 1929) December 19-21, 2001 for 37 hours, based on hourly gage height records (Figure 20) during the 2001-2002 sampling season. River water may have backed up and entered the wetland over the riser during this period.

Figure 20. Average daily discharge for the Tualatin River at Farmington Rd (142-06500) adjusted to the Morand wetland from Oct 1, 2001 to Mar 31, 2002



Cutthroat, coho and Chinook were recently caught in the upper main-stem Tualatin River, near the mouth of Gales Creek (rm 56.0 to 56.5) (Leader, 2002). Oregon Department of Fish and Wildlife surveyed the Tualatin River for fish and crayfish distribution using boat electrofishing in the main-stem at three locations (fall 1999) and by backpack electrofishing sixteen tributaries (summer 1999). They found carp, largescale sucker, largemouth bass, pumpkinseed (*Lepomis gibbosus*), sculpin (*Cottus sp.*) and yellow perch at the mouth of Fanno Creek is 3.8 miles downstream from the Morand wetland (Figure 19). The nearest tributary sampled was lower Chicken Creek, which is 2.4 miles upstream from the Morand wetland (Figure 19). Here, Western brook (*Lampetra richardsoni*) and Pacific lamprey, cutthroat trout, redside shiner, largemouth bass, reticulate sculpin (*Cottus perplexus*) and crayfish were found. Leader (2002) reports that coho were not historically abundant in the Tualatin River even though they are native to the Willamette River. Hatchery releases of them have recently been discontinued in the Tualatin River. The Tualatin River is above Willamette Falls in Oregon City and coho historically did ascend the falls.

Wetland Sampling

Two box traps and two fyke nets were used during the wetland sampling at the Morand wetland; the Oneida Lake trap was not used because of the difficulty in finding an appropriate place that was deep enough yet the lead net could reach shore without brush obstructions. Nets were set for two, 24-hour periods on March 12 and 13, 2002. There were only five fish caught during the sampling period; three native and two introduced fishes (Table 10). Since this was a newly restored wetland with no previously ponded water, it was unexpected that fish would be present in the catch. It is speculated that they may have entered the wetland during the brief period that river water potentially backed up through the water-control structure.

The rough-skinned newt (*Taricha granulosa*), a native amphibian, was the dominant vertebrate in the wetland catch accompanied by a native long-toed salamander (*Ambystoma macrodactylum*) and an introduced bullfrog tadpole (Table 10).

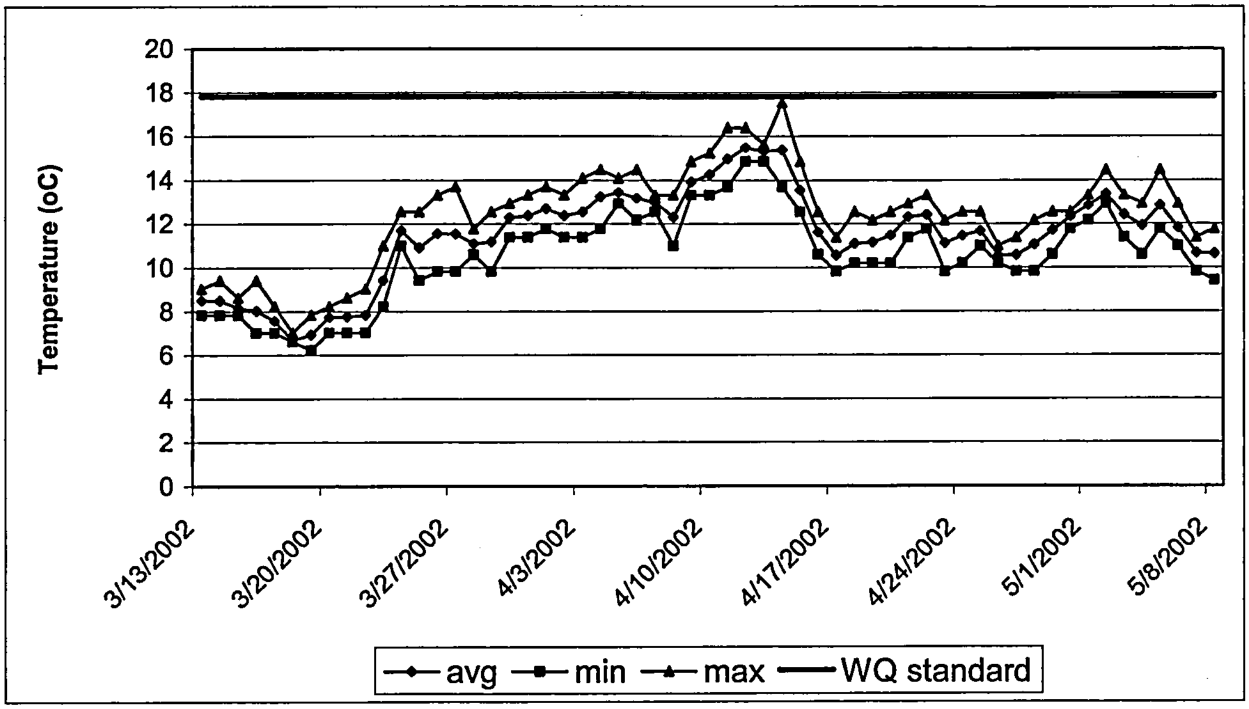
Table 10. Fish and amphibians caught during wetland sampling at Morand wetland, Tualatin River NWR.

Fish	**Family**	**Number**	**min FL (mm)**	**max FL (mm)**
Redside shiner	Cyprinidae	1	73	73
Threespined stickleback	Gasterosteidae	2	47	48
Bluegill*	Centrarchidae	1	85	85
Warmouth*	Centrarchidae	1	112	112
Amphibians	**Family**	**Number**		
Long-toed salamander	Ambistomidae	1		
Rough-skinned newt	Salamandridae	342		
Bullfrog tadpole*	Ranidae	1		

* introduced species

Water surface temperature (1m depth) was recorded March 13, 2002 to May 8, 2002. (Figure 21). Water temperature approached the Oregon water quality standard of 17.8°C (for seven day average, fig 21. is daily average). This standard pertains to basins for which salmonid fish rear [OAR 340-041-0006(54)].

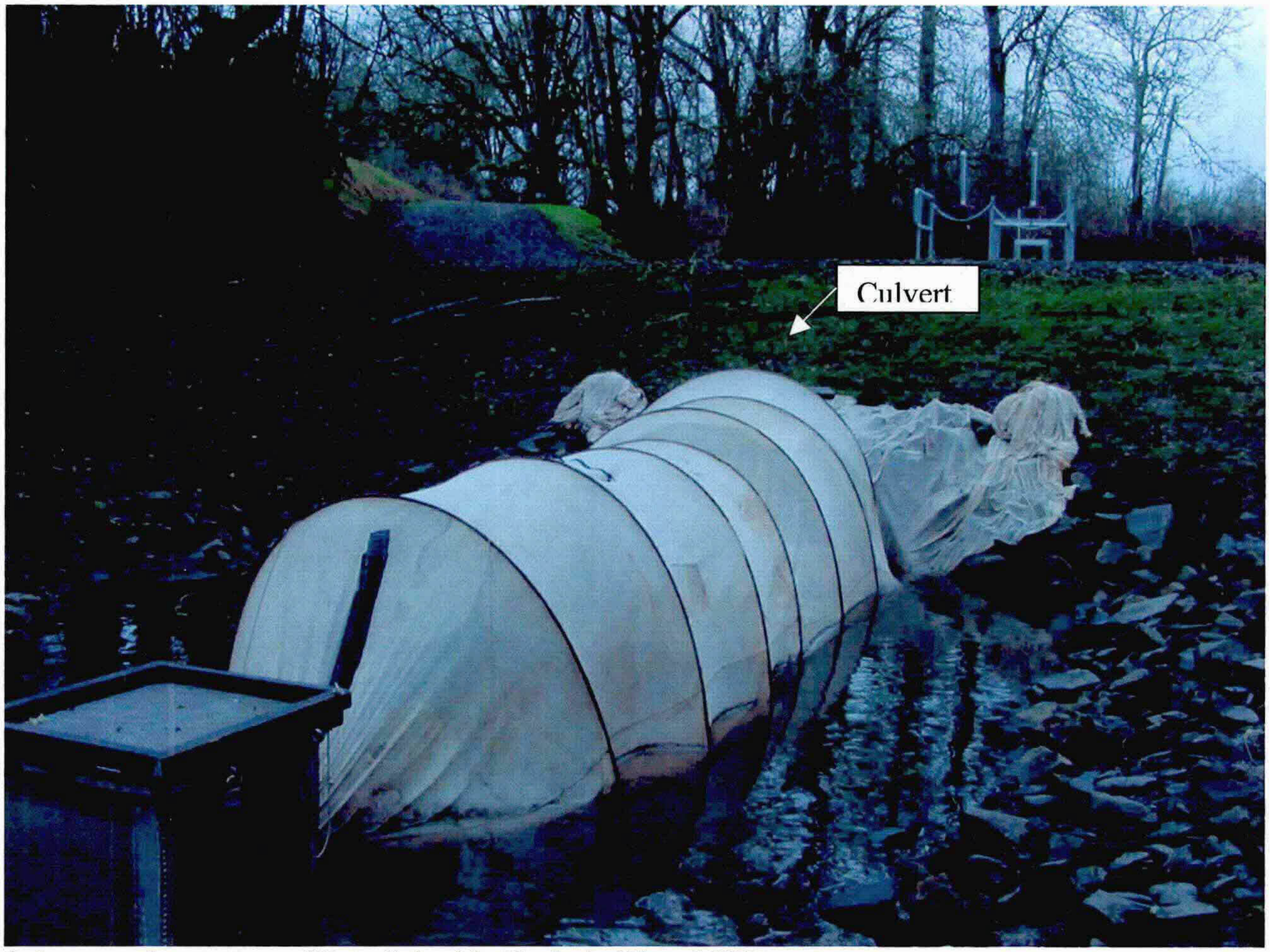
Figure 21. Daily average, minumum and maximum temperature at Morand wetland.



One-way trap

One objective of sampling this site was to document passage of fish and amphibians through the half-round riser water control structure. A trap net was borrowed from the USFWS Ecological Services office in Vancouver. This fyke net had an 8-foot tall wing that extended above the 4-foot tall frame, which completely enshrouded the culvert at the outflow of the structure (Figure 22). Pete Schmidt from the Tualatin River NWR checked the trap periodically, which was fished from April 11 to May 9, 2002. The most abundant species was the rough-skinned newt and bullfrog tadpoles (Table 11). Most of the catch was recorded on the last day the trap was fished, May 9, and consisted of rough-skinned newts and "countless" bullfrog tadpoles (Figure 23).

Figure 22. Trap at the outflow of the Morand water-control structure at the Tualatin National Wildlife Refuge*.



*photograph courtesy of Pete Schmidt, Tualatin River NWR

Table 11. Fish and amphibians caught in the one-way trap at outflow of half-round riser at Morand wetland, Tualatin River NWR***.

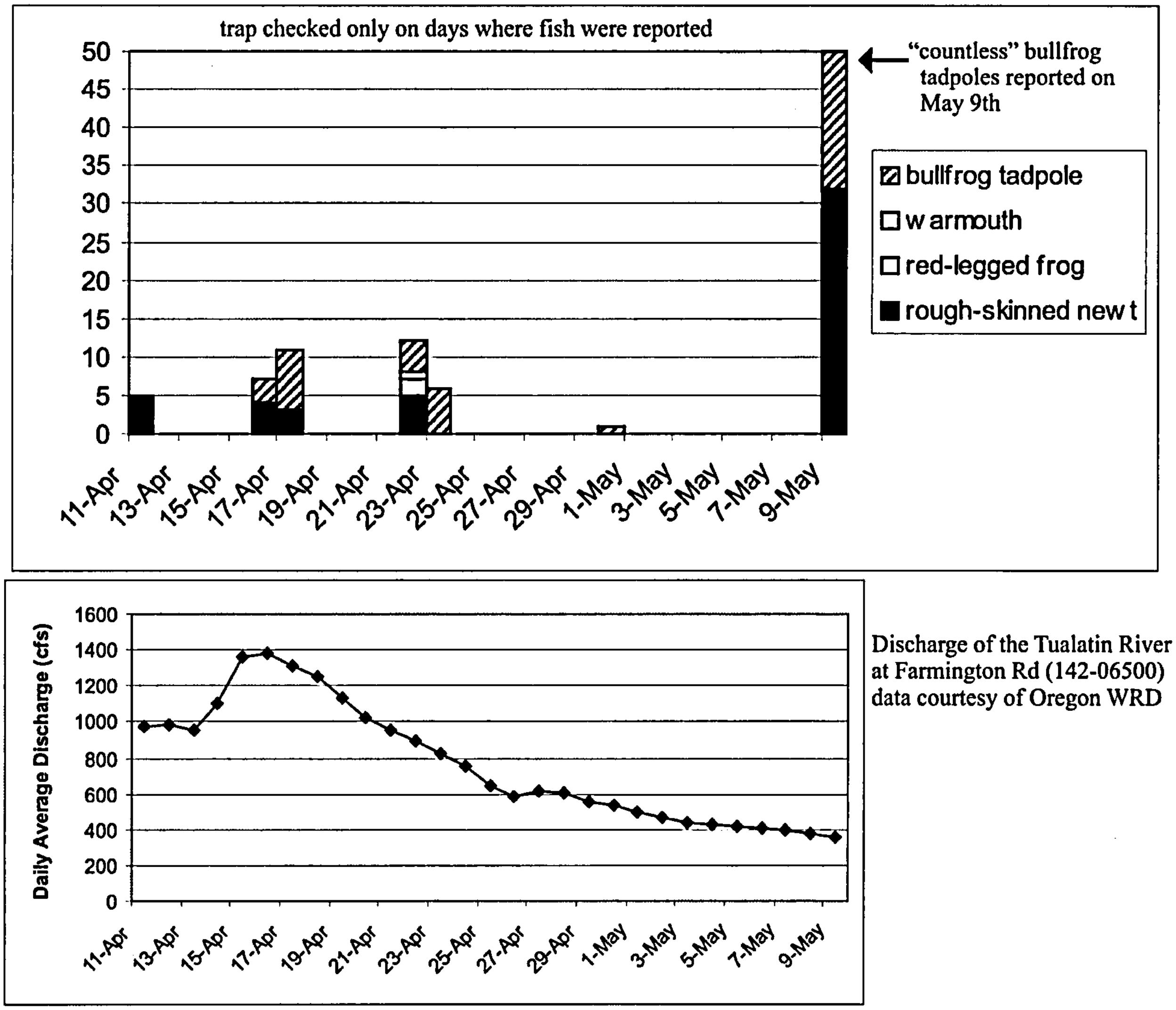
Species	**Family**	**number**	**length range (mm)**
Red-legged frog	Ranidae	2	55-80
Rough-skinned newt	Salmandridae	49	
Bullfrog tadpoles*	Ranidae	21**	25-45, 145
Warmouth*	Centrarchidae	1	35

* introduced species

** May 9, 2002 there were "countless" bullfrog tadpoles reported

***data courtesy of Pete Schmidt, Tualatin River NWR

Figure 23. Fish and amphibian movement out of the Morand wetland through the half-round riser.



Data Summary

A site in the Willamette Valley with regular, winter flooding that has a good chance of salmonids entering the wetland is still being sought to demonstrate passage capability through a water control structure. If the Morand site floods in the future, sampling will be done and there is a small chance of capturing salmonids since they are present, albeit in small numbers, in the Tualatin River. Catch at the Morand site consisted of mostly rough-skinned newts and bullfrog tadpoles. It is not known how the fish entered the wetland but the most likely explanation is that the river backed up over the structure. This site is probably not the most likely site as winter rearing habitat for juvenile salmonids since the abundance of salmonids in the basin and the frequency of flooding is so low.

References

Leader, K.A. 2002. Distribution of fish and crayfish and measurement of habitat in the Tualatin River Basin. Oregon Department of Fish and Wildlife, Clackamas, OR, 70p.

Pete Schmidt, Wildlife Biologist, Tualatin River National Wildlife Refuge. Personal communication, May 2003.

Acknowledgements

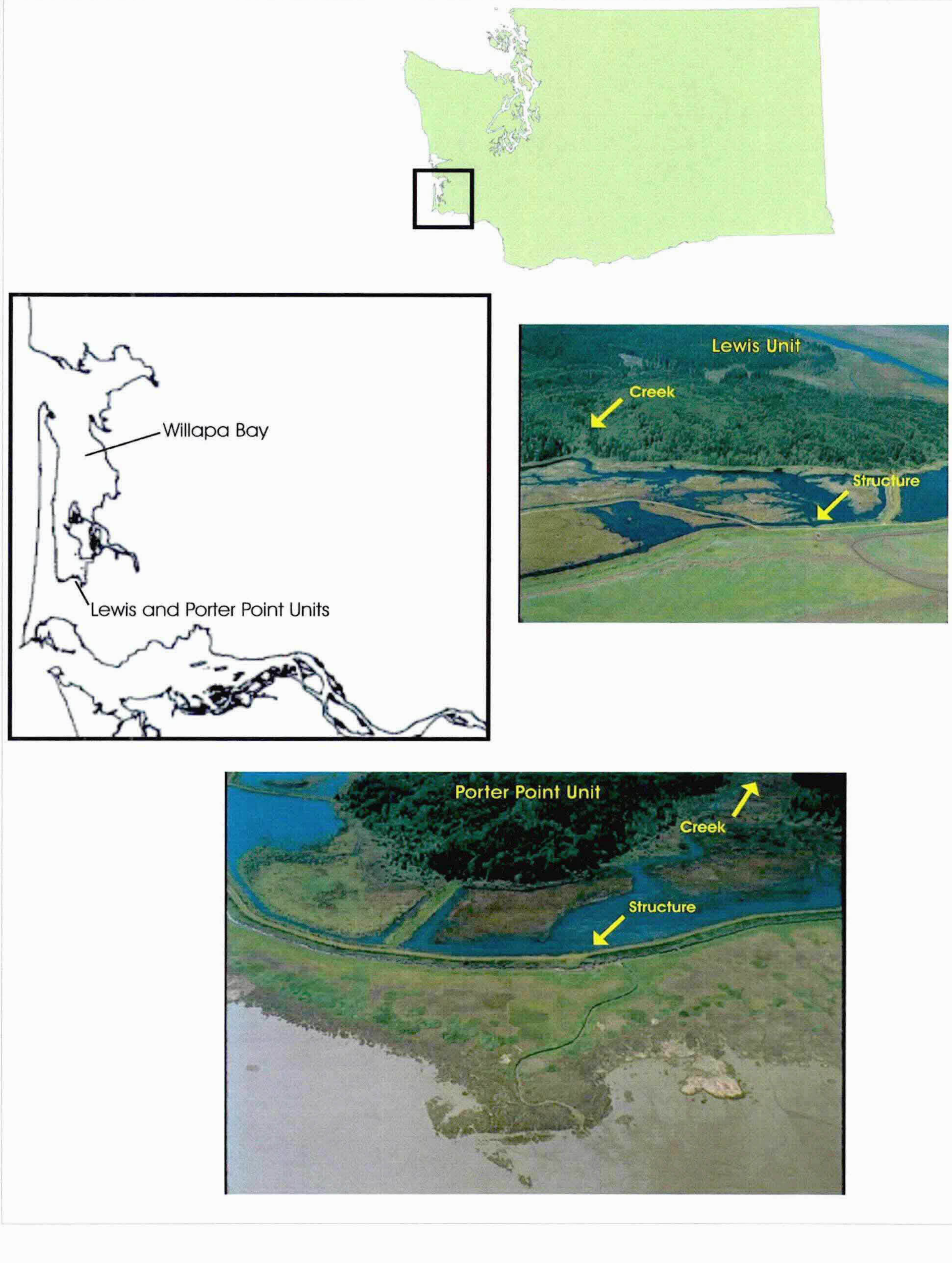
Ducks Unlimited, Inc. thanks Pete Schmidt and Jane Bardolf at the USFWS Tualatin National Wildlife Refuge for help in sampling fish, Pete provided information for the report and helped edit. We also thank the USFWS Ecological Service office in Vancouver for use of the trap net.

Sites with pool-weir-chute structures

<u>Willapa Bay National Wildlife Refuge</u>

The Lewis and Porter Point units are part of the USFWS Willapa Bay National Wildlife Refuge, which was established in 1937. The Willapa Bay NWR is on the southern end of Willapa Bay (Figure 24), in the Bear River estuary. The Lewis and Porter Point units are artificial freshwater wetlands that were created by dikes, ditches and drains in the early 1950's by the refuge to convert tidelands to pastureland for Canada geese feeding habitat (Willapa NWR, 1980). The original water-control structures had tide-gates below flashboard-riser structures and prevented fish passage into the wetlands. The old structures were replaced in the summer of 2001 with pool-weir-chute structures (Figure 3) to re-establish passage to anadromous fishes that

Figure 24. Lewis and Porter Point units, Willapa Bay NWR.



once likely inhabited the streams that feed these two wetland units. Both structures have the same design with a maximum drop of 0.8 feet. The actual drop is 0.5 ft. at the upper 9 weirs and the lower 3 weirs, which has an 0.8 feet drop, was expected to be submerged by tides most of the time. It was expected that rising tides would carry fish up the fish-way some distance and the velocity through the structures would be low (2.5 to 3.0 feet per second). Other design criteria were minimum pool depth of 2.5 feet and minimum flow depth over the weirs of 6 inches (Golder Associates, 2001).

The two unnamed streams that drain into the Lewis and Porter Point wetlands are small with drainage areas of 476 and 397 acres, respectively and the wetlands are 99 and 148 acres, respectively (Golder Associates, 2001). These creeks drain into the Bear River, which enters Willapa Bay. Coho, fall Chinook, and chum salmon and winter steelhead spawn and rear in the Bear River (www.streamnet.org). Historically, these salmon and steelhead, plus sea-run cutthroat had access to the feeder streams at Lewis and Porter Point and may have used them for spawning and/or rearing. Before construction of the new structures, resident cutthroat trout were the only salmonids found within the streams draining into Lewis and Porter Point wetlands (Barndt, S.A. et al. 2000).

The Willapa Bay NWR has recently planted some chum and coho into the Lewis and Porter Point units. In 2000, 50,000-60,000 chum fry were released into Porter Point. January 2, 2002, 30,000 coho eggs, set in three incubation trays, were put into the stream that feeds the Lewis unit and 10,000 (1 incubation tray) was put into the stream in the Porter Point unit (Terri Butler, pers. comm.).

Wetland Sampling

Fishes in the wetlands were sampled with the standard gear (2 box traps, 2 fyke nets and

1 Oneida Lake trap) except for the first sampling period in December when an older Oneida Lake trap and only two fyke nets were used because the new gear had not yet arrived. Nets were set for one, 24-hour period per wetland, per trip on December 2 and 3, 2001, February 17 and 18, 2002, April 22 and 23, 2002, on June 4, 2002 in the Porter Point unit, just before draw-down, and in the Lewis unit on July 14 and September 4, 2002. The Lewis unit was not drawn down in 2002.

Table 12. Catch of fishes at the Lewis Unit, Willapa Bay NWR.

2002	Native Intro	Common Name	Family	Number	min fk len (mm)	max fk len (mm)	wt (g)
December	N	Threespined stickleback	Gasterosteidae	654	32	60	510
December	N	Coho salmon	Salmonidae	11	81	114	143
		Total Native=		**665**			**653**
		Total December=		**665**			**653**
February	N	Unidentified sculpin	Cottidae	2	78	82	12
February	N	Threespined stickleback	Gasterosteidae	381	35	65	403
February	N	Coho salmon	Salmonidae	3	120	128	79
		Total Native=		**386**			**494**
February	I	Brown bullhead	Ictaluridae	1	48	48	2
		Total Introduced=		**1**			**2**
		Total February		**387**			**496**
April	N	Threespined stickleback	Gasterosteidae	1957	40	72	3134
April	N	Coho salmon	Salmonidae	7	154	179	413
		Total Native=		**1964**			**3547**
April	I	Brown bullhead	Ictaluridae	1	174	174	71
		Total Introduced=		**1**			**71**
		Total April=		**1965**			**3624**
July	N	Unidentified sculpin	Cottidae	1	69	69	4
July	N	Threespined stickleback	Gasterosteidae	7390	26	72	8426
July	N	Coho salmon	Salmonidae	1	156	156	50
July	N	Coastal cutthroat trout	Salmonidae	1	188	188	84
		Total Native=		**7393**			**8564**
		Total July=		**7993**			**8564**
September	N	Threespined stickleback	Gasterosteidae	981	24	64	128
		Total Native=		**981**			**128**
September	I	Brown bullhead	Ictaluridae	4	56	172	78
		Total Introduced=		**4**			**78**
		Total September=		**985**			**206**
		Grand Total=		**11395**			**13541**

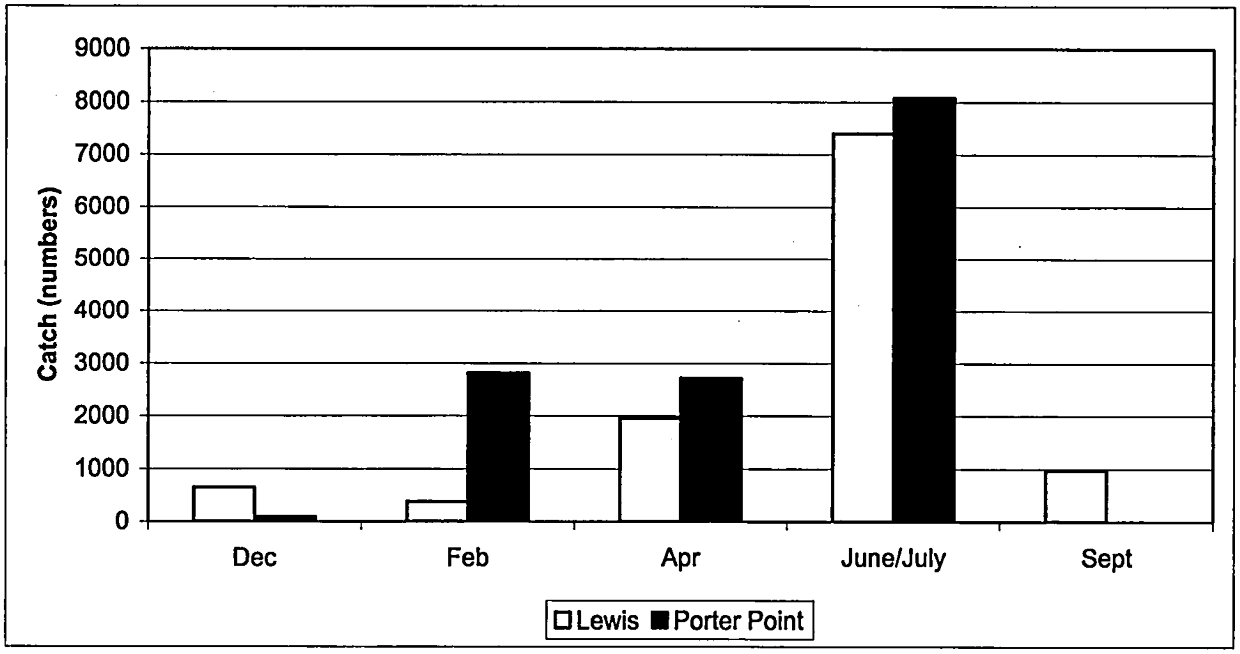
There were 11,395 fish caught at the Lewis Unit (Table 12) and 13,820 fish caught in the

Porter Point unit (Table 13) during sampling in the wetlands between December 2001 and September 2002. Species diversity of native fishes in the catch was low with threespine stickleback being the most dominant, by far (99.7% by numbers in Lewis and 99.2% in Porter Point – figure 25), followed by coho salmon, sculpin and one cutthroat trout was caught in the Lewis unit. The only introduced fish caught was the brown bullhead, which totaled 6 in Lewis and 32 in Porter Point. Few fish larger than 200mm were caught. Twelve, brown bullhead, greater than 200mm (201-252mm), were caught in Porter Point. No brown bullhead greater than 200mm was caught in Lewis (largest was 174mm). The largest fish caught in the Lewis unit was a 185mm cutthroat trout caught in July.

Table 13. Catch of fishes in the Porter Point Unit, Willapa Bay NWR.

2002	Native / Intro	Common Name	Family	Number	min fk len (mm)	max fk len (mm)	wt (g)
December	N	Threespined stickleback	Gasterosteidae	90	37	60	77
			Native species=	**90**			**77**
			Total December=	**90**			**77**
February	N	Unidentified sculpin	Cottidae	10	52	100	49
February	N	Threespined stickleback	Gasterosteidae	2815	31	70	2666
February	N	Coho salmon	Salmonidae	1	110	110	20
			Native species=	**2826**			**2735**
February	I	Brown bullhead	Ictaluridae	8	45	201	122
			Introduced species=	**8**			**122**
			Total February=	**2834**			**2857**
April	N	Unidentified sculpin	Cottidae	17	70	115	153
April	N	Threespined stickleback	Gasterosteidae	2718	49	65	4134
April	N	Coho salmon	Salmonidae	13	131	191	781
			Native species=	**2748**			**5068**
April	I	Brown bullhead	Ictaluridae	3	50	220	158
			Introduced species=	**3**			**158**
			Total April=	**2751**			**5226**
June	N	Unidentified sculpin	Cottidae	42	69	110	319
June	N	Threespined stickleback	Gasterosteidae	8080	23	67	11564
June	N	Coho salmon	Salmonidae	2	54	61	7
			Native species=	**8124**			**11890**
June	I	Brown bullhead	Ictaluridae	21	49	252	1700
			Introduced species=	**21**			**1700**
			Total June=	**8145**			**13590**
			Grand Total=	**13820**			**21750**

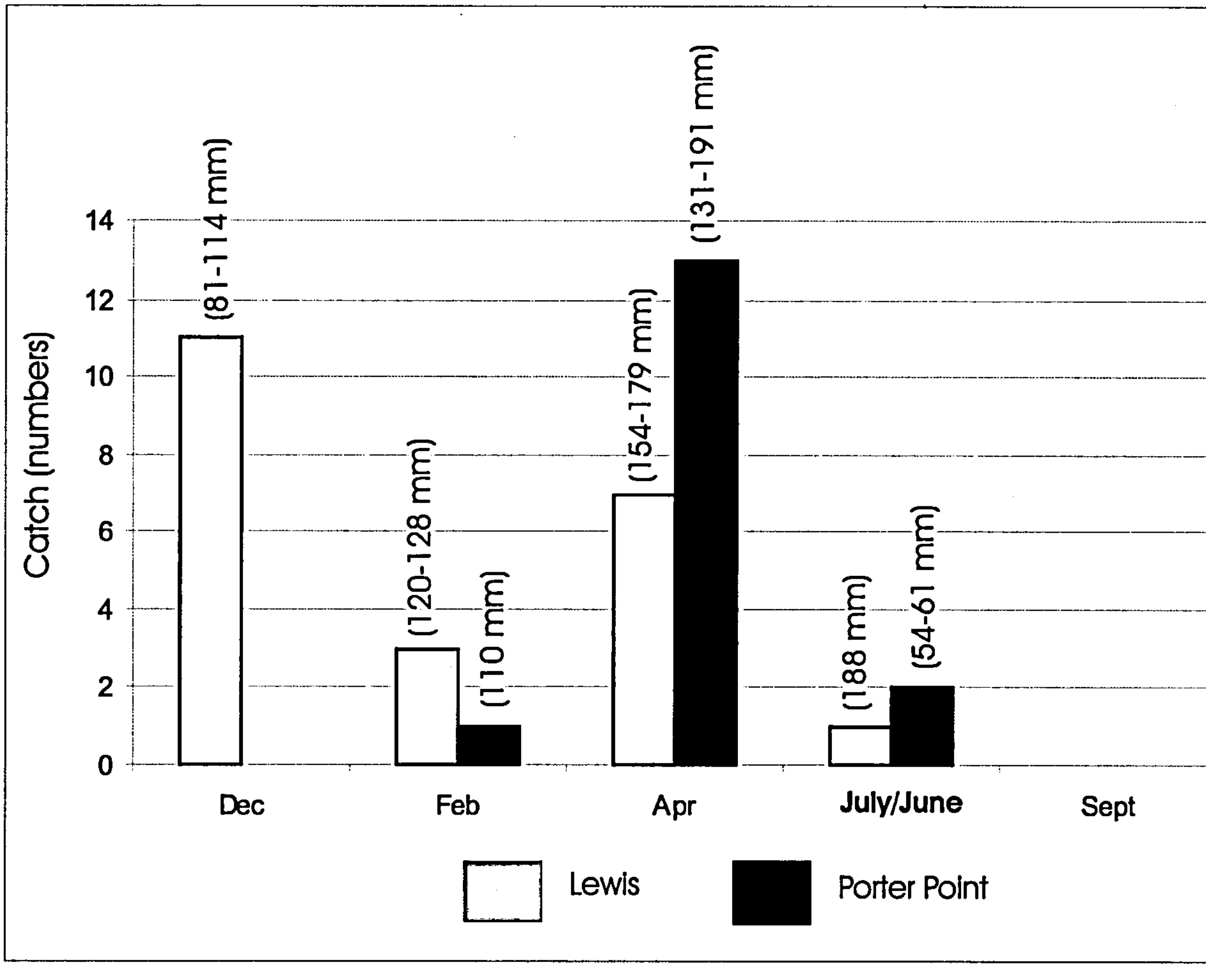
Figure 25. Threespine stickleback caught in Lewis and Porter Point, Willapa Bay NWR.



There were 22 coho salmon caught in the Lewis unit and 16 caught in Porter Point (Figure 26). Of these, two had adipose clips indicating hatchery origin. These individuals were caught in the Lewis unit, February 2002, and were both 120mm. The nearest hatchery is the Naselle Hatchery on the Naselle River but the Nemah Hatchery is also nearby, just to the north, in Willapa Bay. Both hatcheries produce Chinook and coho and release them at the hatcheries. The Nemah Hatchery also produces some chum for the refuge. The Naselle Hatchery has a volitional release of coho (all marked) in mid-April at 14 fish per pound. Coho would average 150mm in length at this weight. If fish have not left by mid-May, they are flushed out of the hatchery. Not all coho that are released are ready to smolt, though. There are some pre-smolts that may residualize in the bay or other nearby waters to overwinter, which is probably the case with these two coho that were 120mm in mid-February in the Lewis unit (Mike Queener, pers. comm.). Coho in the Lewis unit appeared to be all one-year-old fish (or close to one-year in December), while two coho caught in Porter Point in June were probably young-of-the-year.

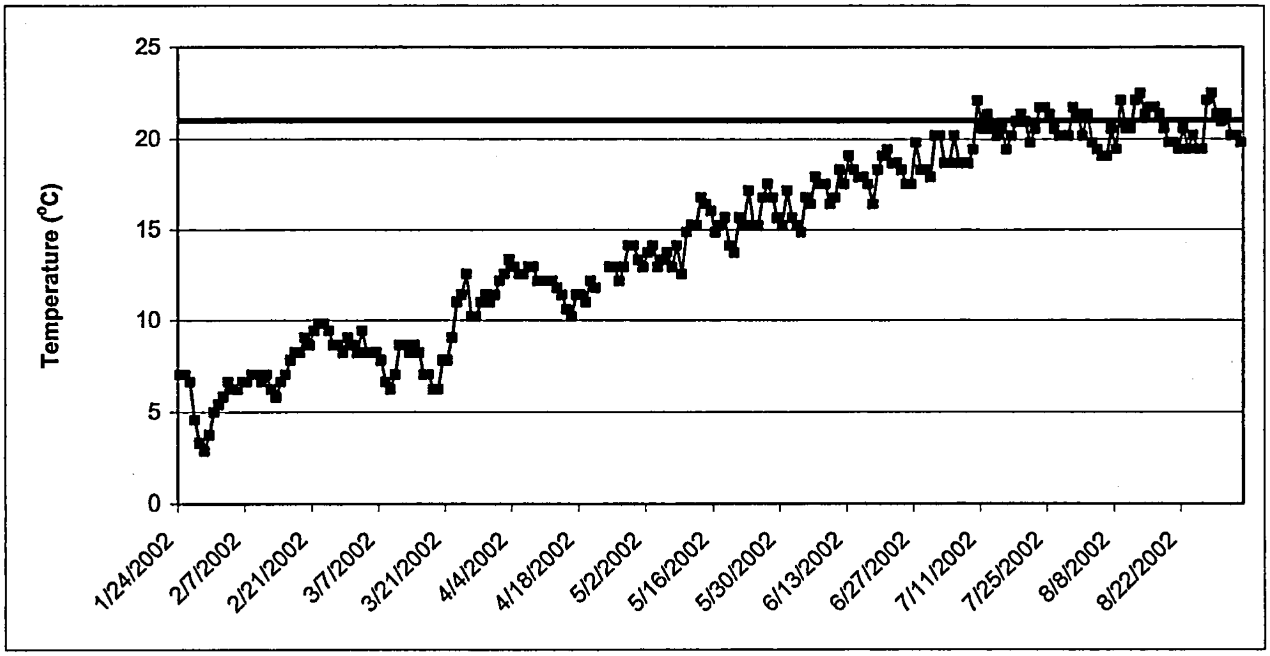
These sub-yearlings may have originated from the incubation trays put into the units in early January by the refuge.

Figure 26. Coho Salmon caught in Lewis and Porter Point, Willapa Bay NWR.



Coho were caught in the Lewis unit during the mid-July sampling period but not in September. They may have left the wetland due to warming water temperatures (Figure 27). The water temperature in the Lewis unit exceeded the Washington State water quality criterion for temperature (WAC 173-201A-030) where salmonids rear but do not spawn (Class B waters) in which the one-day maximum water temperature reached 21°C for 20 days between July 10 to August 31,2002.

Figure 27. Maximum daily temperature at Lewis unit January 24 - September 3, 2002



All amphibians caught in the Lewis and Porter Point units were native species (Tables 14 and 15). There were 711 amphibian caught in Lewis and 1,239 caught in Porter Point. The most abundant species is the red-legged frog, which is a federal species of concern. Tadpoles were very abundant in the spring, during the February and April sampling periods and during the June sampling period in the Porter Point unit. Water level draw-down in the Porter Point unit was delayed, due to the large catch of juvenile red-legged frogs in June, until their limbs developed further.

Two-way traps

In December 2001, two-way traps were made and set into the Lewis and Porter Point pool-weir-chute structures in the second pool nearest the wetland. They were made of 2x4 wooden frames, 66-inches tall, covered in 3/16-inch nylon mesh cloth. They were only fished a couple of days and then pulled. Fine debris entrained in the water column built up on the traps. There was a danger of raising the water level in the wetlands such that the freshly excavated material around the structures in the dike would erode and possibly cause a massive failure.

Table 14. Amphibians in the Lewis Unit, Willapa Bay NWR.

Date	Common Name	Family	Number
12/28/2001	Red-legged frog	Ranidae	1
12/28/2001	Rough-skinned newt	Salamandridae	14
	Total December		**15**
2/12/2002	Pacific giant salamander	Dicamptodontidae	1
2/12/2002	Red-legged frog	Ranidae	22
2/12/2002	Rough-skinned newt	Salamandridae	22
	Total February		**45**
4/29/2002	Northwestern salamander	Ambystomatidae	1
4/29/2002	Red-legged frog	Ranidae	204
4/29/2002	Rough-skinned newt	Ranidae	27
	Total April		**232**
7/15/2002	Northwestern salamander	Ambystomatidae	4
7/15/2002	Red-legged frog	Ranidae	378
7/15/2002	Rough-skinned newt	Salamandridae	31
	Total July		**413**
9/4/2002	Rough-skinned newt	Salamandridae	6
	Total September		**6**
	Grand Total		**711**

Table 15. Amphibians in the Porter Point Unit, Willapa Bay NWR.

Date	Common Name	Family	Number
	Total December		**0**
2/27/2002	Red-legged frog	Ranidae	1
2/27/2002	Rough-skinned newt	Salamandridae	14
	Total February		**15**
4/29/2002	Red-legged frog	Ranidae	50
4/29/2002	Rough-skinned newt	Ranidae	76
	Total April		**126**
6/20/2002	Northwestern salamander	Ambystomatidae	18
6/20/2002	Red-legged frog	Ranidae	1042
6/20/2002	Rough-skinned newt	Ranidae	38
	Total June		**1098**
	Grand Total		**1239**

There are difficulties with getting a two-way trap to work in this case because of the debris building up on the trap and the large size of the trap, in which to get the fish out. These sites are ideal for use of a two-way trap because the structures are the only way into and out of the wetlands with a low chance of water going through the spillway and a very low chance of water overtopping the dike. Salmon entering the wetland can be pit-tagged so they can be caught and identified in the outbound trap and individual growth rates and residence times can be collected. An effort to improved trap design will be made in the future.

Data Summary

Three weeks after water filled the wetlands juvenile coho salmon were found in the Lewis unit. These fish may have come from the Bear River or perhaps were displaced from nearby streams that drain into Willapa Bay by high water, were not ready for brackish water and sought refuge in the wetlands. Coho were found in one or both units from December to June or July. Coho fry were caught in the Porter Point Unit in June. It is possible that these fish originated from the hatch box placed in Porter Point Creek in January but could have come from the Bear River, as well. Nearly all fishes caught were native and most were threespined stickleback, a fish important to the food web, as many birds, fishes and mammals are known to feed on them (Reimchen 1994). The only introduced fish caught in the wetland were the brown bullhead.

All amphibians caught were native species. Red-legged frogs, a federal species of concern, dominated the amphibian catch and the wetlands appear to be good rearing habitat for tadpoles.

A new two-way trap design that will fit into the structures will be developed and tested so that patterns of movement, and individual residence times and growth rates can be obtained.

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Acknowledgements

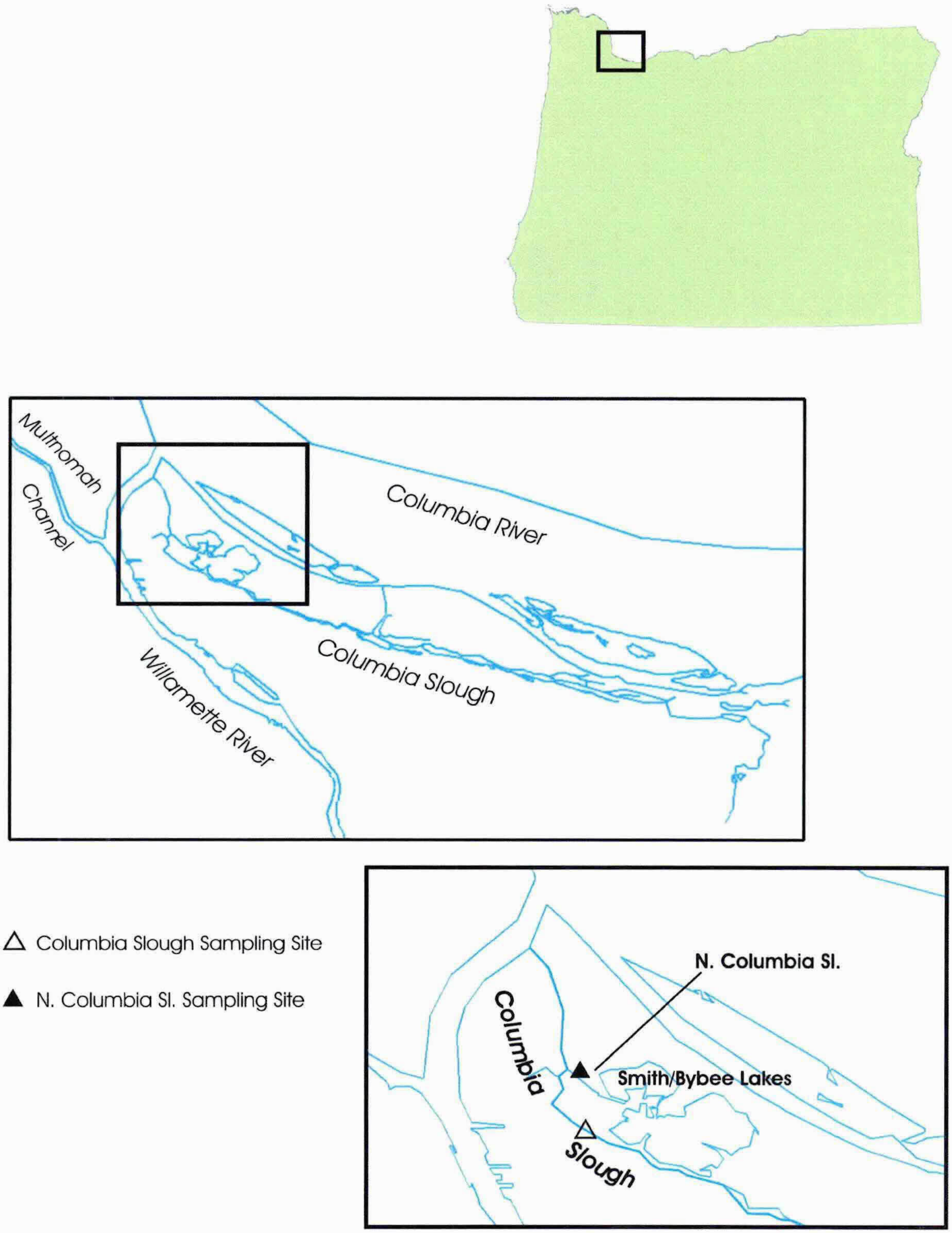
Ducks Unlimited, Inc. thanks Charlie Stenval, Terri Butler, Jonathan, Royce, Marie, and all the folks at the USFWS Willapa Bay National Wildlife Refuge for their help in this effort.

Pre-project monitoring

Columbia Slough

Smith (800 acres) and Bybee Lakes (600 acres) are seasonal emergent and forested wetland habitat in Portland, Oregon. They are connected by Smith Channel and drain into the North Columbia Slough, which then converges with the Columbia Slough and enters the Willamette River, near the mouth (Figure 28). The wetlands are connected to the North Columbia Slough only during high flow events (that exceed 11 ft. NGVD 1929), usually several times per year (Figure 29). The surrounding landscape has been severely altered due to the 0installation of a dike at the west end of Bybee Lake, industrial and municipal (St. John's) landfills, and an earthen dam with water control structure installed in 1982 (Figure 30).

Figure 28. Coulmbia Slough



Historically, land surrounding Smith and Bybee Lakes was dimpled with seasonal, emergent and forested wetlands, but were filled to accommodate development, including nearby Ramsey Lake, which was about the same surface area as Smith Lake. This dramatic change can be seen by comparing 1939 aerial photos with recent photos (METRO Parks). Smith and Bybee Lakes represent remnant habitat historically available to native fauna, which may have been important for over-wintering juvenile salmonids.

Figure 29. Number of days the Columbia Slough at Lombard St. (USGS 14211820) exceeded 11ft. (by water year).

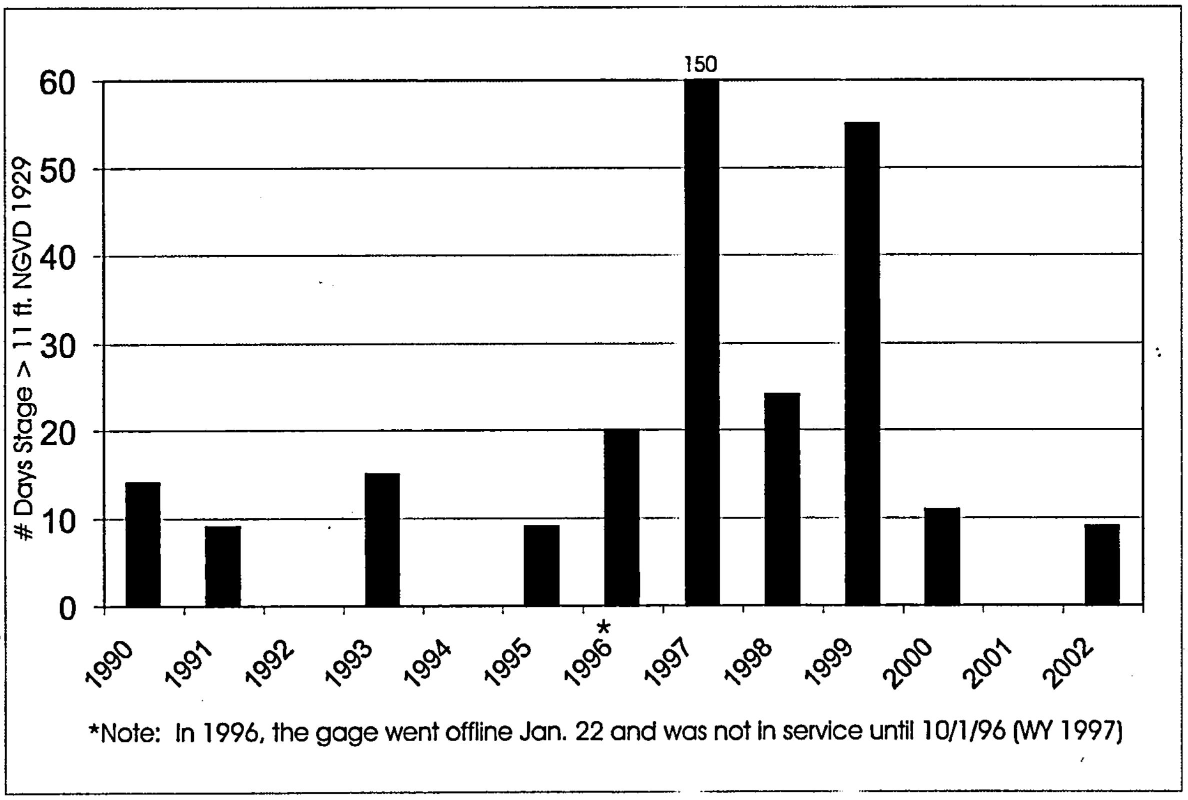
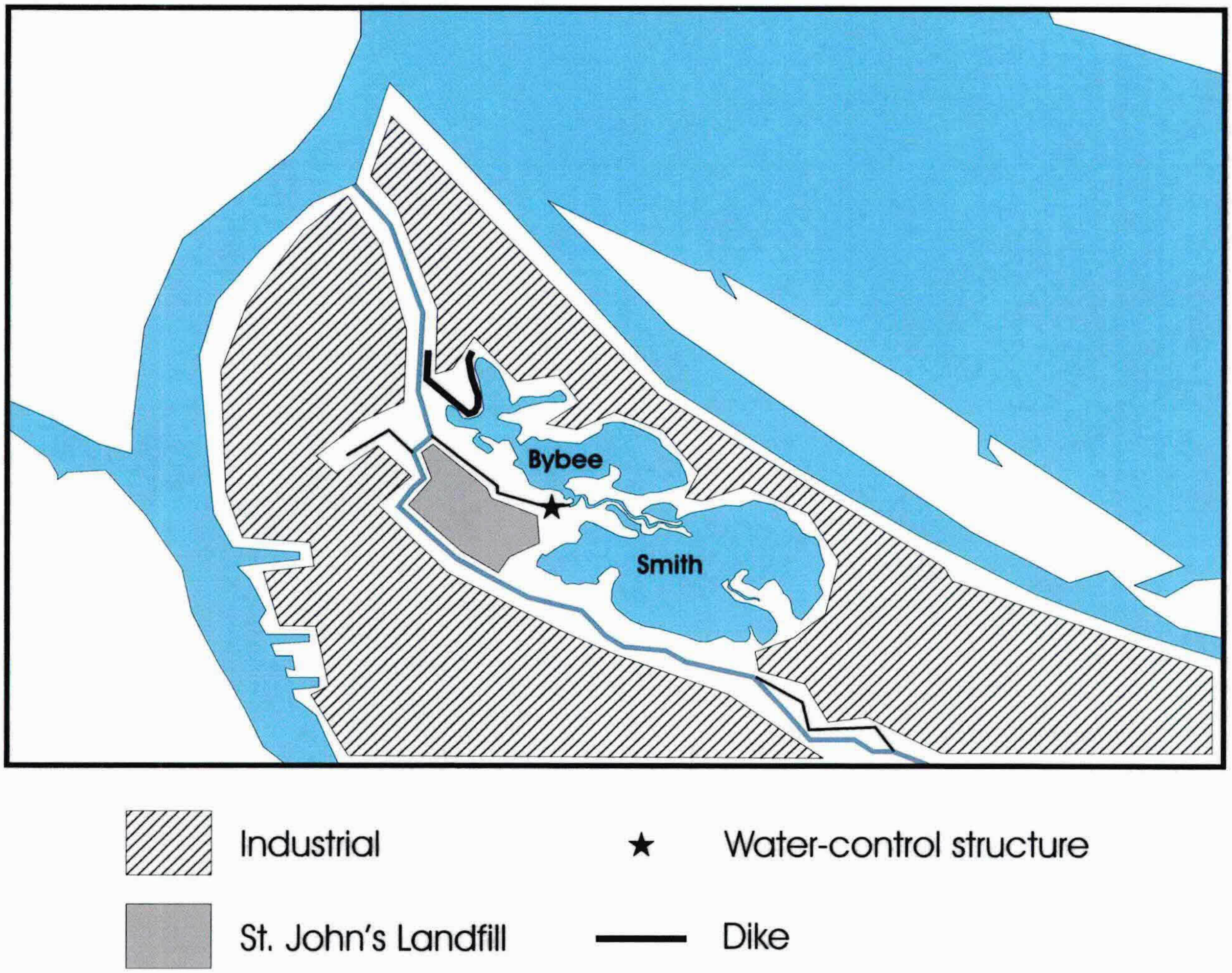


Figure 30. Landforms and features near Smith and Bybee Lakes.



This is a pre-project monitoring effort. The objective is to sample the Columbia Slough and North Columbia Slough for species presence seasonally to determine what species may be utilizing the slough, particularly juvenile salmonids, which would then be able to enter the lakes after the existing water control structure is replaced. An existing dam with tide gate at Smith and Bybee Lakes, which disconnects the lakes from the North Slough except at high-flow events, is scheduled for replacement during the summer of 2003. With the existing structure, the lakes essentially functions as reservoirs, which optimizes conditions for the spread of exotic plants (*e.g.* reed canary grass), promotes nuisance fauna (*e.g.* carp, bullfrogs) and the constant inundation has destroyed more than 350 acres (140 ha) of bottomland forest (Elaine Stewart, METRO Parks, pers. comm.). The new structure will allow fish passage into the wetland via a fish ladder and still hold water during the winter and spring, though water management will change from holding it at a static level to allowing the historically seasonal wetland to dry in the summer months. This water-level management strategy is aimed at controlling reed canary grass and nuisance fauna, encouraging native emergent (*e.g.* rushes and sedges) and aquatic (*e.g.* smartweed, wapato, *etc.*) vegetation and allowing fish passage into and out of the wetland. After the new structure is in place, the wetland will also be brought into the monitoring effort.

The current structure in the dam does not allow water-level manipulation because the apparatus is rusted shut. Water can flow out through the tide gate at some minimum level, set above the invert of the culvert by part of the rusted structure. No water can flow into the wetlands from the slough, except during high-flow events that overtop a low area between the Columbia Slough and the west end of Bybee Lake. The dam was installed to restrict water flow between Smith and Bybee Lakes and the North Columbia Slough to stop outbreaks of avian botulism in Smith Lake by maintaining a higher water level (Geiger, S., 1987). A secondary reason was to prevent degraded slough water from entering the lakes. Poor water quality in the Columbia Slough system has been documented since 1971 by the City of Portland.

Water quality was compromised in the slough due to disposal of meat-packing wastes, storm sewer outfalls, combined sewer overflows, septic tanks and cesspools in North Portland and east Multnomah County leaching in, industrial wastes, surface water leachates from the adjacent St. John's Landfill, and turbidity from carp (Geiger, S., 1987). Since the early 1970's, much has been done to improve water quality. The City of Portland no longer allows meat packing and industrial wastes to be disposed of in the slough. Combined-sewer overflows were almost completely eliminated by separating storm and sewer pipes so that raw sewerage no longer flows into the slough. In the lower Columbia Slough, near Smith and Bybee Lakes, land use is dominated by industrial uses so there is limited residential septic tank leaching into the water but, in the upper Columbia Slough, where land use is more residential, most homes have been connected to city sewer. The St. John's Landfill is now closed and is covered with a geotextile barrier to prevent the formation of new leachate. METRO, the elected regional government that provides services for the Portland metropolitan area and the City of Portland, currently monitor water quality in Smith and Bybee Lakes and the Columbia Slough system (Paul Vandenberg, Metro Solid Waste Department, pers. comm.). Recent hydrologic modeling indicates that after the new structure is installed, water that will enter Smith and Bybee Lakes from the slough will be primarily Willamette River water coming into the wetlands on an incoming tide (Elaine Stewart, METRO Parks, pers. comm.).

Habitat use in Smith and Bybee Lakes and the Columbia Slough by juvenile Chinook salmon, as well as 15 other taxa of fishes, have been documented (Fishman, P.A., 1986b). Fishman sampled 29 stations in the Columbia and North Columbia Sloughs, and Smith and Bybee Lakes by boat electrofishing periodically from April 30 to October 25, 1986. He found a "large number of juvenile salmon everywhere in the system" during the April 30, May 2 and May 9 sampling periods, which represented 12% to 30% of the catch. He also sampled outflow from Bybee Lake through a breach in the dike, which occurred during a high-water event in the fall of 1985, using a beach seine with a bag (fishing it like a fyke net) and collected 14 juvenile Chinook in three hours on April 11, 1986. A number of the Chinook leaving the wetland were also observed, leaping over the structure, during high water associated with spring run-off June 5, 1986. Carp was the most abundant fish in all sampled habitats during this study. There were also many crappie, yellow perch, largemouth bass and bluegill.

Slough Sampling

Sampling in both Columbia and North Columbia Sloughs was done with Oneida Lake traps with one overnight set per site per sampling period. Sampling in the Columbia Slough occurred on March 14 and May 23, 2002 and in the North Columbia Slough on November 26, 2001, February 11 and May 23, 2002. There were 19 fishes caught in the Columbia Slough and 245 caught in the North Columbia Slough (Table 16 and 17). One juvenile salmon (42mm), too small to differentiate between Chinook or coho, was caught in the Columbia Slough March 14, 2001. Other native fishes were the prickly sculpin, peamouth, and northern pikeminnow. Introduced fishes included Centrarchids such as the black crappie, warmouth, and pumpkinseed, both yellow and brown bullhead in the catfish family, and the yellow perch. The largest fish caught was a 246mm peamouth but there were also some larger bullhead (207, 244mm).

Table 16. Catch of fishes in the Columbia Slough.

Date	Common Name	Family	Number	Min FL (mm)	Max FL (mm)	WT (g)
3/14/2002	Prickly sculpin	Cottidae	2	149	160	93
3/14/2002	Peamouth	Cyprinidae	3	212	246	445
3/14/2002	Unknown salmon	Salmonidae	1	42	42	2
	Total Native=		**6**			**540**
3/14/2002	Black crappie	Centrarchidae	1	183	183	99
3/14/2002	Yellow perch	Percidae	1	177	177	64
	Total Introduced=		**2**			**163**
	March Total=		**8**			
5/23/2002	Prickly sculpin	Cottidae	1	101	101	12
5/23/2002	Northern pikeminnow	Cyprinidae	1	130	130	23
5/23/2002	Peamouth	Cyprinidae	1	137	137	31
	Total Native=		**3**			**66**
5/23/2002	Pumpkinseed	Centrarchidae	4	61	133	134
5/23/2002	Warmouth	Centrarchidae	1	73	73	11
5/23/2002	Brown bullhead	Ictaluridae	1	244	244	197
5/23/2002	Yellow bullhead	Ictaluridae	1	207	207	127
5/23/2002	Yellow perch	Percidae	1	197	197	87
	Total Introduced=		**8**			**556**
	Grand Total=		**19**			**1325**

Table 17. Catch of fishes in the North Columbia Slough.

Date	Common Name	Family	Number	Min FL (mm)	Max FL (mm)	WT (g)
11/26/2001	Largescale sucker	Catostomidae	2	385	437	1489
11/26/2001	Prickly sculpin	Cottidae	22	75	165	649
11/26/2001	Northern pikeminnow	Cyprinidae	1	101	101	11
11/26/2001	Peamouth	Cyprinidae	2	55	97	13
11/26/2001	Threespined stickleback	Gasterosteidae	88	50	60	120
11/26/2001	Chinook salmon	Salmonidae	7	105	145	198
11/26/2001	Coho salmon	Salmonidae	6	76	125	95
	Total Native=		**128**			**2574**
11/26/2001	Black crappie	Centrarchidae	1	175	175	86
11/26/2001	Largemouth bass	Centrarchidae	2	205	280	464
11/26/2001	Warmouth	Centrarchidae	17	70	90	215
11/26/2001	White crappie	Centrarchidae	9	70	200	148
11/26/2001	Common carp	Cyprinidae	3	84	130	36
11/26/2001	Banded killifish	Cyprinodontidae	2	85	88	15
11/26/2001	Brown bullhead	Ictaluridae	2	200	270	375
11/26/2001	Yellow perch	Percidae	10	150	258	852
11/26/2001	Banded killifish	Centrarchidae	46	70	280	2193
	Total Introduced=		**174**			**4767**
2/11/2002	Prickly sculpin	Cottidae	20	100	163	586
2/11/2002	Threespined stickleback	Gasterosteidae	7	55	168	71
2/11/2002	Chinook salmon	Salmonidae	2	111	111	41
2/11/2002	Unknown salmon	Salmonidae	3	46	49	7
	Total Native=		**32**			**705**
2/11/2002	Bluegill	Centrarchidae	1	43	43	2
2/11/2002	Yellow perch	Percidae	7	73	202	451
2/11/2002	Bluegill	Centrarchidae	8	43	202	453
	Total Introduced=		**40**			**1157**
5/23/2002	Prickly sculpin	Cottidae	13	85	160	336
	Total Native=		**13**			**336**
5/23/2002	Black crappie	Centrarchidae	2	211	243	386
5/23/2002	Pumpkinseed	Centrarchidae	4	65	113	83
5/23/2002	Common carp	Cyprinidae	4	317	560	3140
5/23/2002	Goldfish	Cyprinidae	1	225	225	104
5/23/2002	Brown bullhead	Ictaluridae	3	250	256	662
5/23/2002	Yellow bullhead	Ictaluridae	3	252	313	1081
5/23/2002	Yellow perch	Percidae	1	95	95	11
	Total Introduced=		**18**			**5466**
	Grand Total=		**245**			**11726**

In the North Columbia Slough, greater numbers of salmonids were caught. Both Chinook (7) and coho (6) were caught in November 2001, and two Chinook and three unidentified juvenile (46-49mm) were caught the following February. In addition to the native species caught in the Columbia Slough, there were largescale sucker and threespine stickleback caught in the North Columbia Slough, as well. Banded killifish, bluegill, carp and goldfish were additional introduced species caught in the North Columbia Slough.

The large catch of Asian freshwater shrimp, especially in the North Columbia Slough is notable (Table 18). There were 646 caught in late November 2001 and 889 caught February 2002. Much fewer fish were caught in the Columbia Slough than the North Columbia Slough. Asian freshwater shrimp were not reported during a previous survey in the mid-1980's (Fishman, 1986a).

Table 18. Non-fish species caught in the Columbia Slough (CS) and North Columbia Slough (NCS).

Site	Date	Common Name	Number	Length Range (mm)
CS	3/15/02	Asian Freshwater Shrimp	7	37-53
CS	5/24/02	Asian Freshwater Shrimp	62	44-61
CS	5/24/02	Crawfish	2	64,93
NCS	11/27/01	Asian Freshwater Shrimp	646	42-65
NCS	2/12/02	Asian Freshwater Shrimp	889	39-67
NCS	5/24/02	Asian Freshwater Shrimp	21	42-60

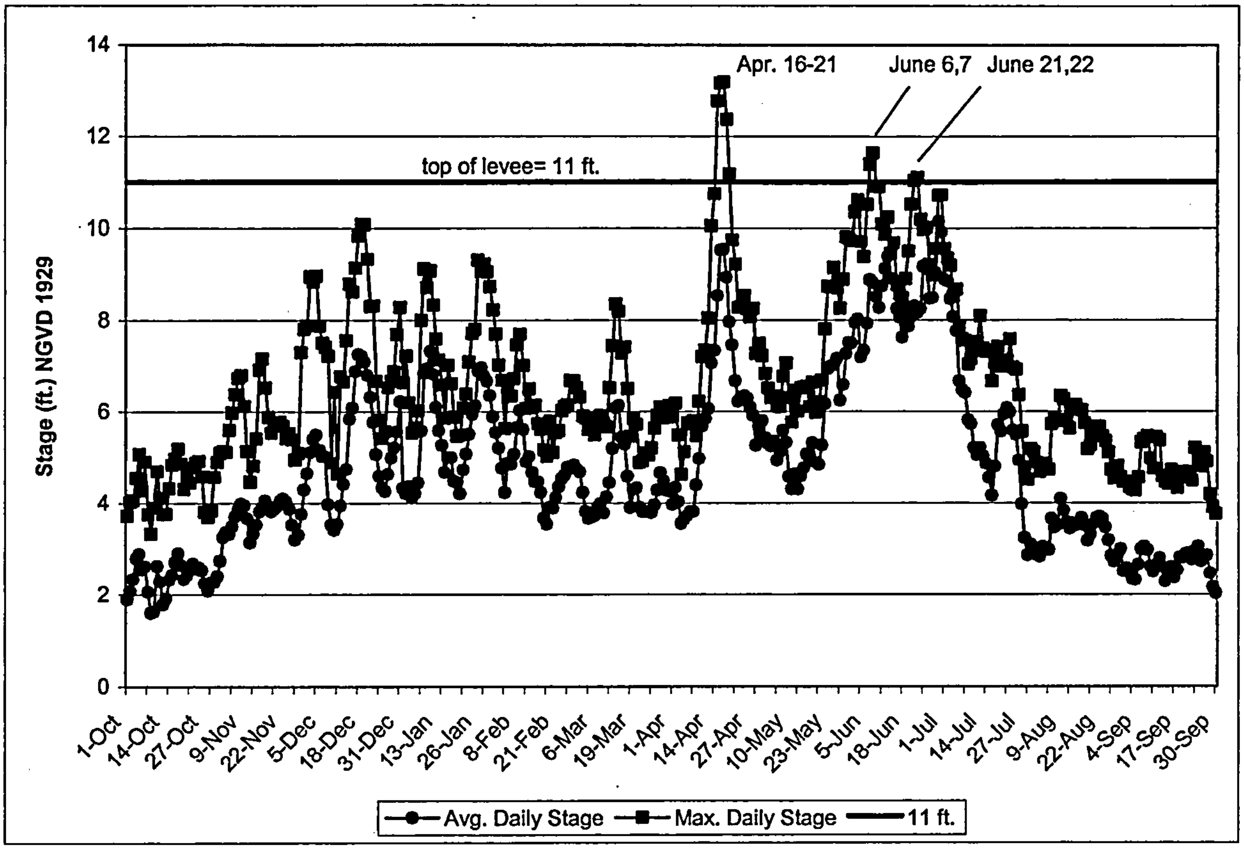
Data Summary

Fewer fishes were caught in the Columbia Slough than the North Columbia Slough, 19 and 245, respectively. There is probably less capture efficiency with setting a large trap net in swift current of the Columbia Slough, bowing the lead net and wings, than the slower current in the North Columbia Slough. Current velocity can be swift between high and low tides in the main channel, to the degree that the net has to be set at slack tide and extra anchoring is required.

Both Chinook and coho were found in the Columbia Slough system and what appears to be two different age classes of Chinook. Juvenile salmon are known to be present in the lower Willamette and Multnomah Channel when freshets spur fish to move in the fall, during the winter and through the spring run-off. Juvenile spring Chinook migrated downstream through the bypass system at the Sullivan Plant at Willamette Falls (RM 26.6) every month in 1997 (Domina, 1997). Fall Chinook passed through the plant May through August, coho in May and steelead migrated downstream April and May. Friessen et al. (2003) also found juvenile Chinook present in the lower Willamette River (below Willamette Falls) during 2000 and 2001 every month except October when no sampling was conducted. Catch rates of juvenile salmon by electrofishing peaked November (Chinook, 35 catch-per-unit-effort [cpue]) and December in 2001 (all salmonids 45 cpue). In 2002, catch rates increased from December to March, peaked in April (64.9 cpue), but were still present in May. They report most salmonids captured by beach seining were sub-yearling Chinook. Catch of juvenile salmon by seining in 2001 and 2002 began in December and peaked in April and May (18.5 and 18.8 cpue, respectively), and declining in June (about 9 cpue). While Chinook were the most abundant salmonid in their catch, coho were observed "in relatively high numbers…during May and June" and steelhead were rare.

According to hydrologic data, the water-surface elevation in the slough exceeds the height of the low region along the Columbia Slough that allows water into Bybee Lake annually, except in dry years (Figure 29), allowing fish access to Smith and Bybee Lakes. During 2002, fish had access to these wetlands in mid April, early and late June for a total of 9 days (Figure 31). Through the period of record (1990-present), the USGS gage on the Columbia Slough at Lombard Street (14211820) shows that the water level exceeded the 11-foot elevation, allowing fish access into the wetlands periodically from November through June (Figure 32).

Figure 31. Stage in the Columbia Slough at Lombard St. (USGS 14211820) WY 2002 (Oct. 1, 2001-Sept. 30, 2002)



Different species and age classes of salmonids may use the Slough system and wetlands throughout the winter and spring. Catch in the Columbia and North Columbia Slough indicate the juvenile salmon are probably approaching one-year of age in November 2001. In February and March 2002, both 0+ and 1+ were caught. During these sampling periods there probably were not any juvenile salmonids entering Smith and Bybee Lakes because a high-water event that topped the natural levee between the Columbia Slough and Bybee Lake did not occur until April 16, 2002. Subsequent sampling in May did not produce any salmonids in the catch, though there might have been some present during this time. The capture efficiency of the trap nets is unknown but probably very low and does not assure all species of fishes present will be captured during a sampling period.

Figure 32. Days water-surface elevation in the Columbia Slough at Lombard St. (USGS 14211820) exceeded 11ft. NGVD 29, 1990 to 2002.

★ Note: January 22,1996, the gage went offline and was not in service until 10/1/96 (WY 1997).

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December

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January

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
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Figure 32

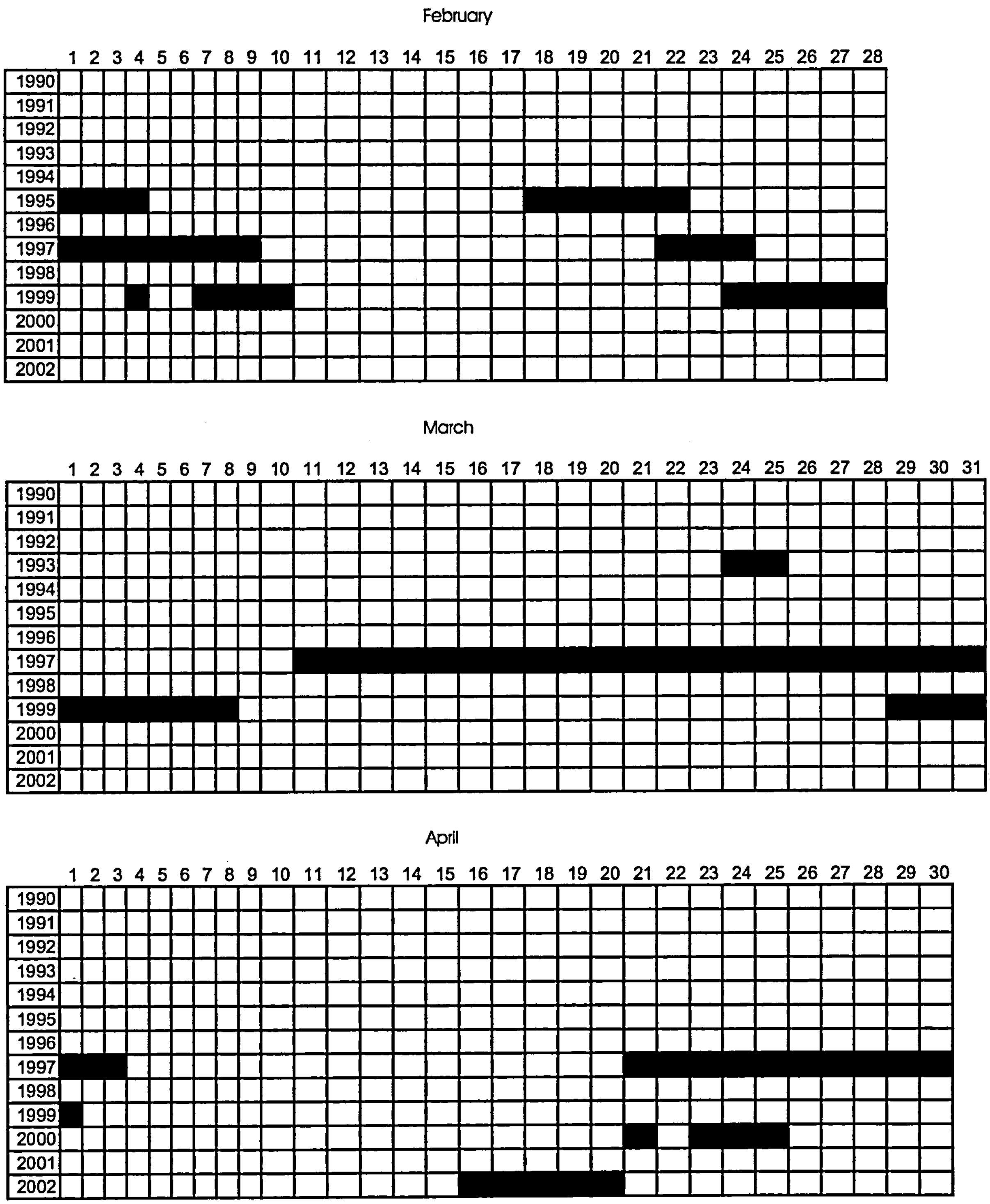
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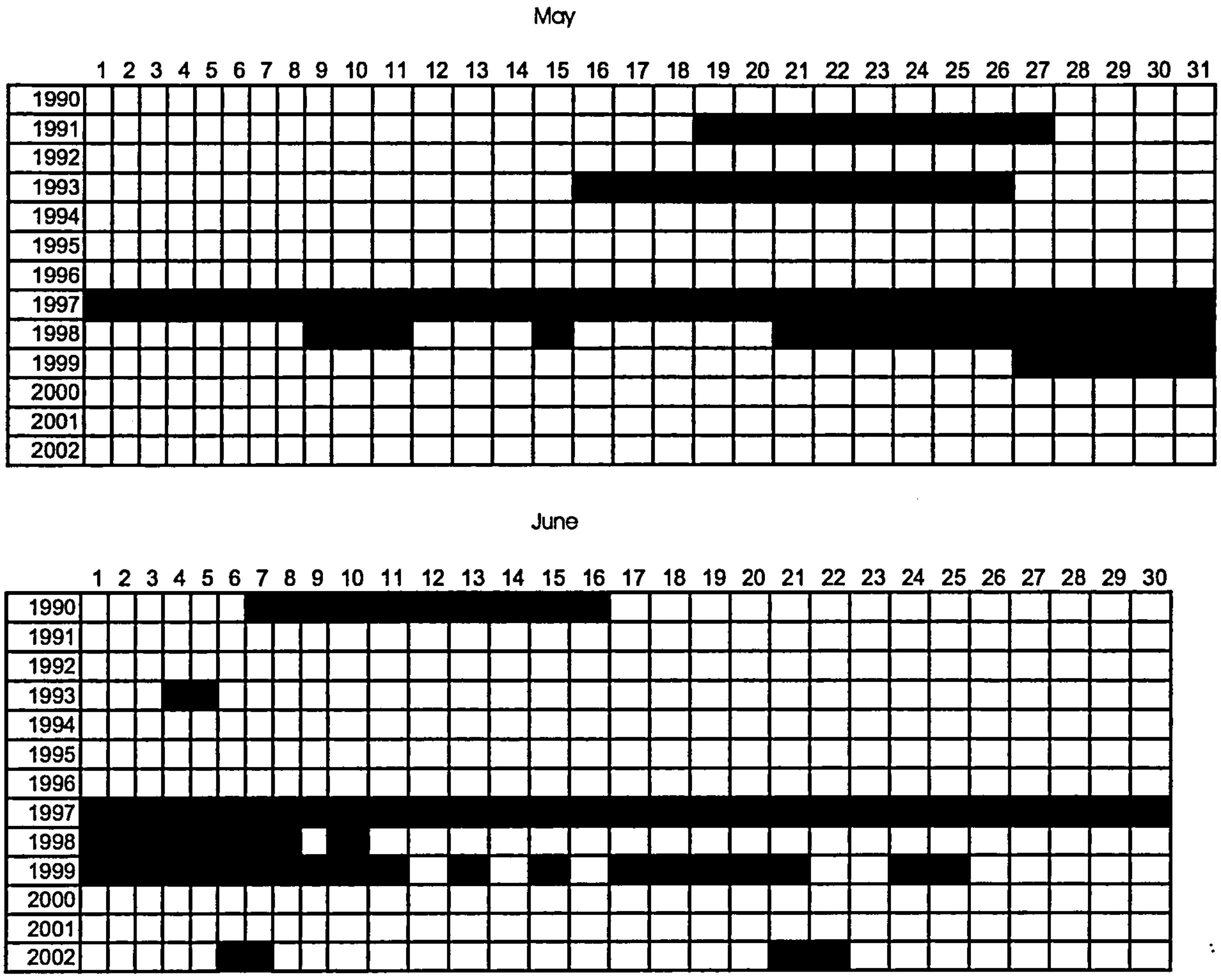
Figure 32.



The overtopping of the natural levee at high water into Bybee Lake on a nearly annual basis, which may occur anytime between November and June, and the presence of juvenile salmon in the Columbia Slough system, makes a likely scenario for juvenile salmon entering Smith and Bybee Lakes regularly. The new structure with improved fish passage will provide increased opportunity for fishes to pass into and out of the lakes over the currently limited passage situation created by the existing dam. The management regime of allowing water levels to fluctuate in the lakes, mimicking the natural pattern, should provide high-quality, productive, over-winter rearing habitat for juvenile salmonids.

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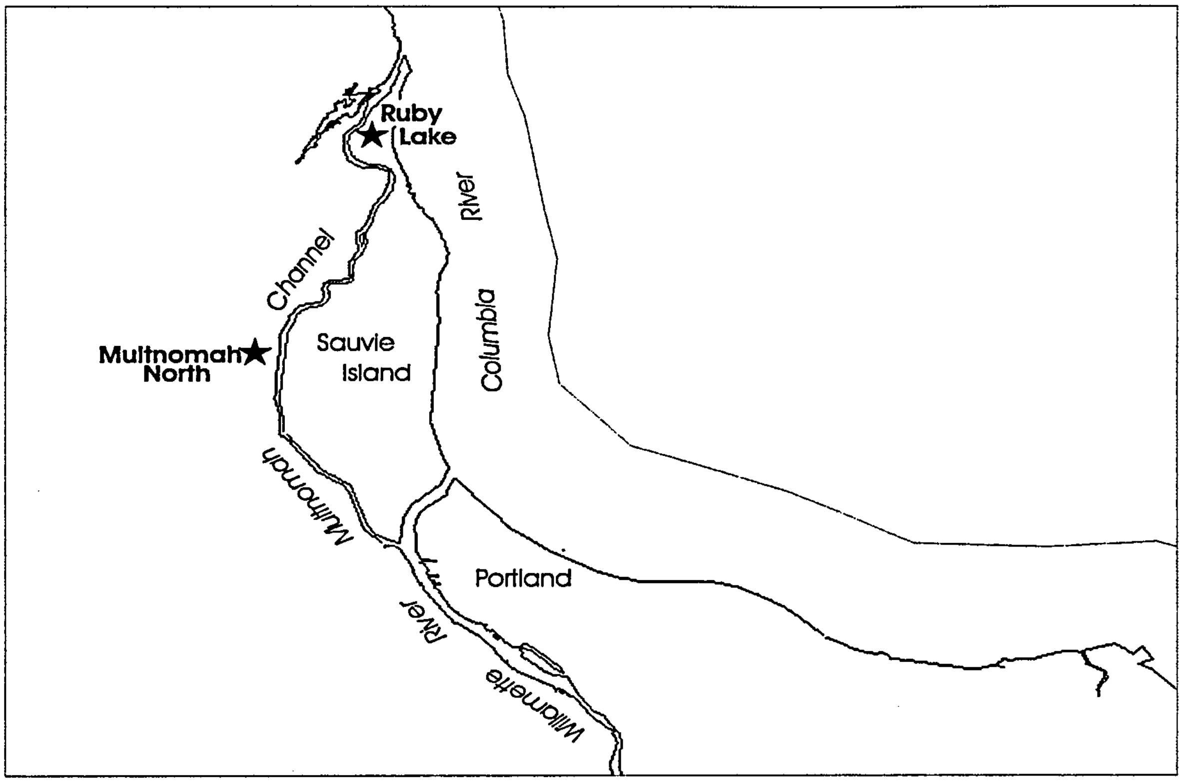
Pilot study using radio telemetry

Radio Telemetry in the Sauvie Island area in the Lower Columbia River

Sixteen juvenile salmon were surgically implanted with radio transmitters and their movements in two wetlands tracked during the spring of 2002 in the Sauvie Island area near Portland, Oregon (Figure 33). The objectives were: 1) to confirm passage through the full-round riser water-control structure at Ruby Lake on Sauvie Island; and 2) to study micro-habitat use in

Figure 33. Vicinity map of radio telemetry sites.



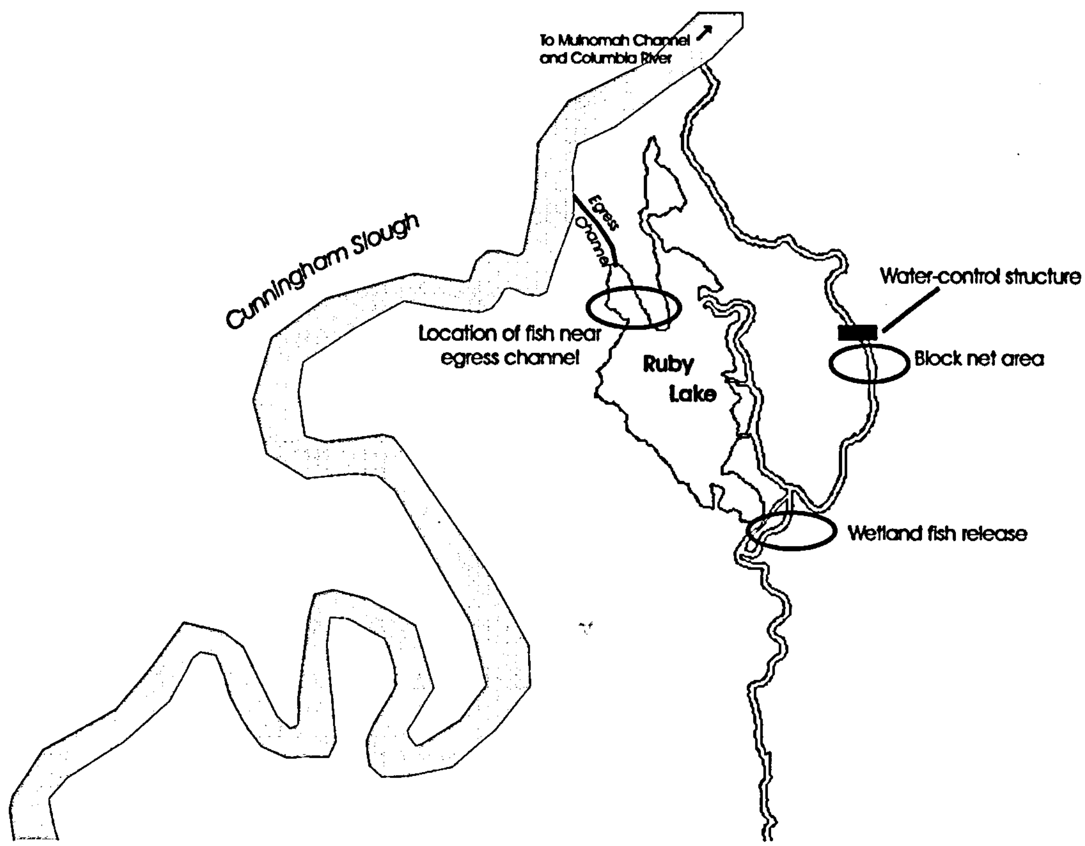
wetlands by juvenile salmon. The initial plan was to implant all the radio transmitters at once into juvenile salmon at the Ruby Lake wetland only, in which 10 would be held in a block net near the structure and 10 would be released into the wetland. It was anticipated that juvenile salmon would pass through the structure from the block net area, be caught in the two-way trap and released back into the wetland for one more run through the wetland to study movement. The 10 fish that were released in the wetland, which would have had no previous knowledge of the structure, would be allowed to move down river once they passed out of the wetland. Once fish were allowed to move down river, it was thought that an Oregon State University study that we were coordinating with, which had fixed-station antennae from Bonneville Dam to the mouth of the Columbia River, would detect fish tagged at Ruby Lake since the tags were on the same frequency but different codes were used. The plan was to capture salmon that were 160mm in fork length, in which the tag (0.6g wet weight) would have been 2% of the fish's body weight. Fish would be captured in the two-way traps during the spring when it was expected that many salmon would be moving through the two-way traps on Sauvie Island.

Ruby Lake Results

Catch was lower than expected and fish caught were smaller than expected. We were not able to begin keeping fish to tag as early as expected because the Lotek sales representative, that was to come out to Ruby Lake to instruct in the set up of the fixed station antennae, was not available until early May. We received the tags in late April of 2002. We tried to hold a few fish but mortality was occurring so that effort was discontinued. The 2% body weight criterion was relaxed to 5% body weight (Brown et al. 1999) so fish around100mm in fork length were tagged. Only four Chinook in the range of 95 to 128mm fork length were caught and tagged at Ruby Lake and released into the block net area on May 9, 2002 (Figure 34). On May 13, 2002, five more Chinook were implanted (95-150mm) and released, three in the block net area and two in the wetland. On May 15, 2002, one more Chinook (101 mm) was tagged and released into the block net area. Ten juvenile Chinook were tagged and released in Ruby Lake. Of the eight Chinook in the block net area, five remained there and three escaped over the block net where two were detected back in the wetland and one was never seen again. Some carp in the channel near the structure got their dorsal spine hung up on the block net and provided an opportunity for escape over the net. The three escapees were the largest individuals tagged (128, 150 and 151mm fork length). On May 15, 2002, two escapees plus one of the wetland-released fish were detected near a channel that connects Ruby Lake to Cunningham Slough (Figure 34). The following day (May 16), the three fish that were near the egress channel were never seen again and presumed to have gone through the channel and out Cunningham Slough or became prey.

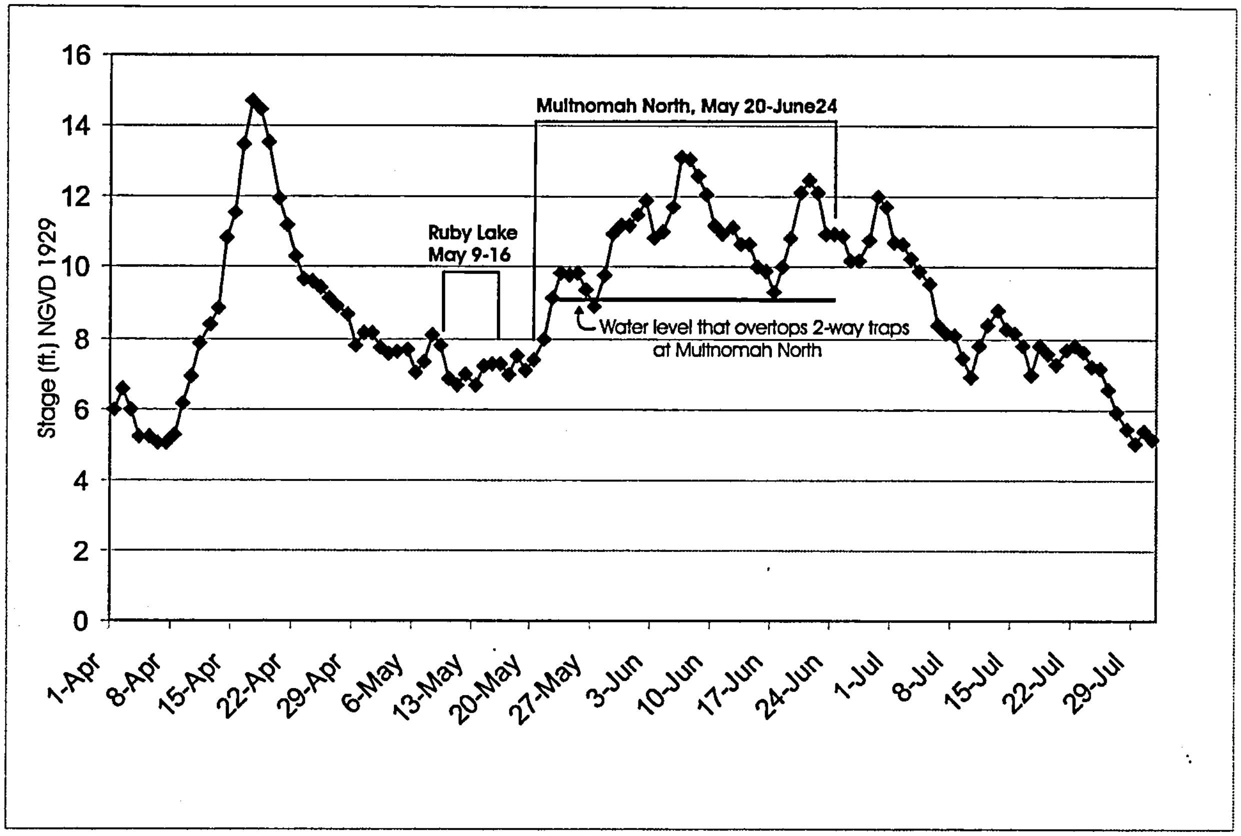
One of the wetland-released fish stayed in the same place as it was released and was presumed dead. The five Chinook that remained near the block net never went through the water-control structure, despite water spilling over the riser boards. However, two of these fish seemed too stationary from day to day so, they may have perished as well, and the other three just milled around the structure.

Figure 34. Radio telemetry at Ruby Lake.



Radio telemetry results at Ruby Lake were disappointing. The only interesting observation was that the largest of the Chinook in the block-net area escaped and at least two of them went toward the natural channel that connects Ruby Lake to Cunningham Slough and possibly exited that way. During the radio telemetry at Ruby Lake, water levels were moderately low (Figure 35). Even though water was spilling over the riser, there may not have been enough to elicit movement in that direction from the tagged fish. The observation of the juvenile Chinook escaping from the block net, navigating through a large wetland with a low current velocity, and finding the egress channel demonstrates the capability of the lateral line system of these fishes.

Figure 35. Timing of radio telemetry with respect to the stage of the Columbia River at Vancouver (USGS 14144700) April-July, 2002.



Multnomah North

Because the radio telemetry study had been going so poorly at Ruby Lake and Multnomah North was known to have many juvenile Chinook, we began tagging fish at that location to try to salvage the operation and record some data about fish movement in a wetland with at a site that the water-control structure was not currently in operation. We knew that there were a greater abundance of juvenile Chinook salmon than what our wetland sampling at Multnomah North indicated because we experimented with fishing the Oneida Lake trap like a fyke net (no lead net was used) in the deeper, slough channels at Multnomah North and caught

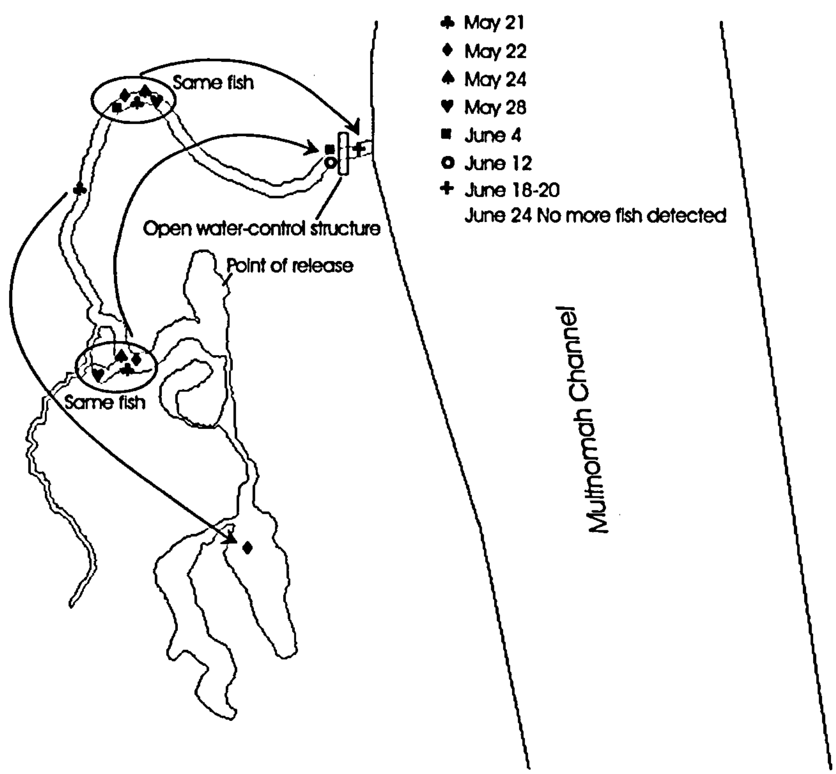
113 juvenile chinnok (73-100mm) in one overnight set on April 30, 2002.

On May 20, 2002, six Chinook (90-97mm) were tagged and released into the pond at Multnomah North (Figure 36). The next day (May 21), three of these could not be found and were never detected again despite extensive searching. They may have swam over the two-way traps as they were overtopped much of late May and June (Figure 35). The remaining three fish were found in the channel. On May 22, 2002, one of the three fish left the tidal channel was identified back in the wetland but was never detected again. The remaining two Chinook were detected moving around in the tidal channel but were detected near the same place until June 4 when one moved toward the structure. On June 12, the Chinook that moved toward the structure June 4 was detected in the same vicinity and was observed moving around in front of the structure. This fish was not detected again. The other Chinook that had been on the north end of the unit was detected near the structure or in the Multnomah Channel but a definite location could not be ascertained. From June 18 to 20, 2002 the Chinook that was on the north end of the wetland was detected in the tidal channel on the riverside of the structure. No more radio signals were detected after June 24, 2002, which was more than one month (since May 20) after the first transmitter was activated at Multnomah North.

From the six Chinook that were tagged at Multnomah North, only three produced some results and one of those was detected for only a day after it was released. The other two fish were detected in the tidal channel for at least three weeks then the batteries ran out, they were preyed upon, or they left the area. The two fish that were last detected at the mouth of the tidal channel also demonstrates the capability of juvenile Chinook to navigate out of a wetland, though Multnomah North has a greater tidal pulse than the wetland at Ruby Lake, since it is immediately adjacent to the Multnomah Channel.

Though the two Chinook that were tracked for about three weeks at Multnomah North appeared to have stayed in the tidal channel most of the time, the sample size was too small and individual behavior can vary greatly so, no generalizations about habitat preference can be made. Because of logistical problems of spending a great amount of time trying to catch juvenile salmon to tag, no mobile tracking at night was done. It is possible that these fish could have been making forays into the wetland at night when avian predation would likely be reduced. The two Chinook seemed to have high fidelity for particular areas of the tidal channel for a period of at least two weeks before migrating to the mouth of the tidal channel. All of the radio tags were not used because catch of juvenile salmon that were about 100mm dropped sharply shortly after the Chinook were tagged at Multnomah North. It is possible that the rising water level from spring runoff (Figure 35) triggered Chinook that were rearing or resting at Multnomah North to continue their downstream migration.

Figure 36. Radio telemetry at Multnomah North.



This approach had its merits but, in practice, it did not play out as expected. In retrospect, it would have been better to postpone this work for a season to have better understanding of when and how many and what size salmon to expect. The desire to quickly and unequivocally demonstrate the capability of juvenile salmon to pass through the structure and the lure of technology to expose the behavior of juvenile salmon in wetlands prevailed with mediocre results, unfortunately. This was a small-scale trial to learn how this technology may be used to research fish movement and passage capability in floodplain wetlands. Radio tags continue to improve as size decreases allowing smaller fishes to be studied but it is possible to get the same results with less expensive technology, such as PIT tags.

Acknowledgements

Ducks Unlimited, Inc. thanks Terry Key at Lotek for technical support and for coming out and setting up the fixed station antennae, Dr. Dave Jepsen and Mark Karnowski at Oregon State University for instruction on surgical procedures, coordinating with us on tag frequencies and sorting through their data in search of our fish, and much needed advice and morale support.

Discussion

Every site that was sampled between November 2001 and July 2002, including the four sites in the Sauvie Report (see pg.17), demonstrate juvenile salmonid presence sometime during that period, except the Tualatin River site, which had very limited connectivity. Both young-of-the-year and yearling salmon were collected at most sites. Coho and Chinook were common, whereas steelhead in the catch was rare. Salmonids were caught throughout the sampling period at some sites but only occasionally at others. To make sense of these patterns of salmonid presence, one must put them in context of season, locale, hydrology, temperature and sampling effort and ability.

There were two types of sampling effort used in the data collection. One was continuously sampling a constriction in which fish would pass using a one-way (Figure 16 and 22) or two-way trap (Sauvie Report, Figure 5). The other involved passive gear set in the wetlands (Figure 5). These two approaches involved different levels of effort and ability to collect data, which provide different levels of detail. Continuously sampling using one-way or two-way traps provides the finest level of detail as fish species, size or age classes, and numbers can be compared against water levels and other hydrologic characteristics and temperature. Information about passage capability through water-control structures can also be obtained by this method of sampling. Passive gear set in wetlands can provide information about patterns of species presence at sites seasonally, which can also be compared site to site. On a regional scale, course patterns of species presence using floodplain wetland habitat can be described.

Performance of the gear also contributes to the ability to discern patterns of habitat use. Sites in the Lower Columbia River where two-way traps were used produced data continuously collected from November through July, except for those periods during high water when water, and probably fishes, overtopped the traps. For example, at Multnomah North, two-way trap data collection began November 26, 2002. No salmon fry were caught in the inbound trap but during the SSWS, which took place December 27 and 28, 2001, fry were caught within the wetland. Water may have overtopped the traps twice during this period for several days at a time, which is likely when those fry came into the wetland. There may be sampling error associated with the two-way traps because fish may swim over the inbound trap and become caught in the channel between the water-control structure and outbound trap so that when they swim into the outbound trap it appears that they would have passed through the water-control structure. This is a difficult sampling problem to overcome because of the physical limitations of fishing a large trap and the large fluctuations in water levels at the site. We have had no recaptured fish that have been PIT tagged and released into the wetland and caught in the outbound trap as they may have left the wetland when the traps were overtopped or through another egress channel.

With this data, patterns of movement of salmonids into and out of the wetlands through the two-way traps with respect to hydrology and temperature at a fine scale (i.e. weekly) is not possible because of the overtopping issue. On a coarser scale (i.e. seasonally), 68% of the salmonids that entered the wetlands did so before April 1, 2002 and 83% of the salmonids in the outbound trap were caught after April 1 (See also Sauvie Report Figures 11-13). This indicates that salmon were more motivated to move into the wetlands during the winter and move out of the wetlands in the spring, which is what would be expected as high spring flows and warming temperatures likely trigger this exodus. Increasing numbers of introduced fishes are found in the catches beginning in late March when water temperatures begin to rise (Sauvie Report Figures 8-10 and 16-17).

There was no problem of water overtopping the one-way trap used at the outflow of the Hoxit Farm and Morand because a block net connected the traps and culvert such that fish could not swim over the trap (Figure 16 and 22). These traps worked well but they were only fished on an experimental basis for a short period. Greater effort using one-way traps on the Chehalis River is planned for next year. Because there was no way out but through the trap, finer-scale detail about fish movement with respect to hydrology and temperature could be discerned. Figures 17 and 18 show fish movement with respect to decreasing water levels and rising water temperatures at Hoxit Farms.

Passive trap nets used in the SSWS caught fishes from 17 to 589mm in fork length and have caught over 5,000 fishes in one set. Different sized nets were used according to the depth of the water. Sampling challenges in the wetlands involved being able to decide where the shoreline was at times and also making sure that the traps were set at low tides so that they would not become dry when the tide went out in areas of tidal influence, such as the sites in the Lower Columbia River. Wetlands with fluctuating water levels do not lend themselves to randomly setting nets at pre-designated areas. The nets have to be set in water depths that allow them to fish well, which is difficult to determine until one is at the site.

A mark and recapture population estimate of juvenile salmonids was attempted at the Multnomah North site during the winter in order to estimate capture efficiency of the gear. There were not enough fish marked or recaptured for such an estimate. In order to make a reasonable estimate one would need on the order of a few hundred fish marked but we were only able to mark on the order of tens of fish. Most of these were the YOY that came in with the high winter flows and were too small (35-50mm) to even batch mark. Capture efficiencies are likely quite low as these few small traps are used in large wetlands. At this time, we have only the ability to compare catch-per-unit-effort (CPUE) between sample periods or sites. Sometime in the future, determining capture efficiency to better quantify habitat use patterns will become a priority.

Patterns of fish movement relating to hydrology and temperature cannot be distinguished by the SSWS data. Species presence can be described seasonally at a site and a comparison made between sites. The eleven sites sampled during the 2002 water year can be categorized into three areas: the Lower Columbia River, which includes Ruby and Wigeon Lakes on Sauvie Island, Multnomah North and South, on the west bank of Multnomah Channel, and the Columbia Slough; the Washington Coast includes Lewis and Porter Point units at Willapa Bay NWR and Greenhead and Hoxit Farm on the lower Chehalis River; and Satus Wildlife Area in eastern

Washington.

In the Lower Columbia River, concerning salmon presence in floodplain wetlands, yearling Chinook and coho were present in the North Columbia Slough in November. In December, yearling coho and salmon fry, most likely fall Chinook, were caught at Multnomah North. More fry and yearling Chinook were caught at Multnomah North in January along with two yearling coho at Ruby Lake. In February, two yearling Chinook and three fry were caught in the North Columbia Slough. Yearling coho and Chinook fry were caught at Multnomah North in March and a fry was caught in the Columbia Slough. In April, YOY and yearling Chinook were caught at Multnomah North and two YOY Chinook were caught at Wigeon Lake. Yearling Chinook and coho were present in the Lower Columbia River sites from November through April and Chinook fry, which were probably from the fall run, were present in the catch from late December, shortly after they came out of the gravel, through April.

On the Washington Coast, yearling coho were caught at Willapa NWR in early December. Yearling coho were caught in floodplain wetlands on the Lower Chehalis River in January and again at Willapa NWR in February. In March, yearling coho and salmon fry between 38 and 60mm were caught on the Lower Chehalis River. It is not clear whether these fry were coho or Chinook. Again, yearling coho were caught at Willapa NWR in April and yearling coho and salmon fry on the Lower Chehalis River in June. One more yearling coho was caught at Willapa NWR in July. Yearling coho were caught at sites on the Washington coast from December through June and July. Salmon fry were caught on the Lower Chehalis River beginning in March. These could be from the spring, summer and fall runs of Chinook, or coho present in the Chehalis River but identification is uncertain at this small size.

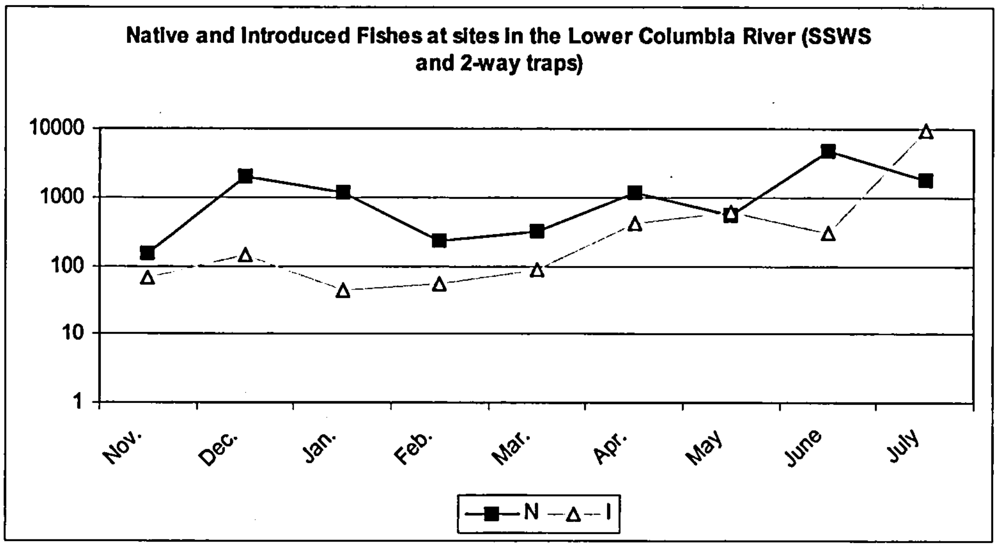
At Satus Wildlife Area in eastern Washington, there were only two Chinook caught; one in March and the other in July. The Chinook caught late March, at 128mm, was probably a yearling and the Chinook caught in July, at 104mm, may have been a YOY. There were probably so few salmonids caught at this site because the sampling schedule coincidentally coincided with lower flows in the Yakima River and the fish had not remained in the wetland or that our sampling efficiency was so low in that vast wetland that we had little chance of catching any salmonids.

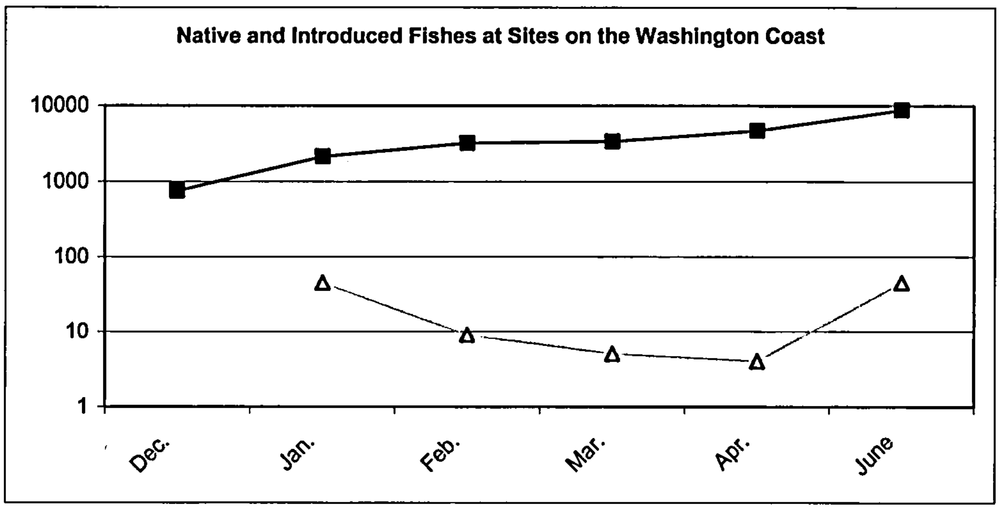
Of the 170 coho and Chinook caught by SSWS, only two had adipose clips indicating hatchery origin. Those clipped coho were caught in the Lewis wetland at Willapa Bay NWR. Of the 185 coho and Chinook caught in the two-way traps in the Lower Columbia River, only one was adipose clipped.

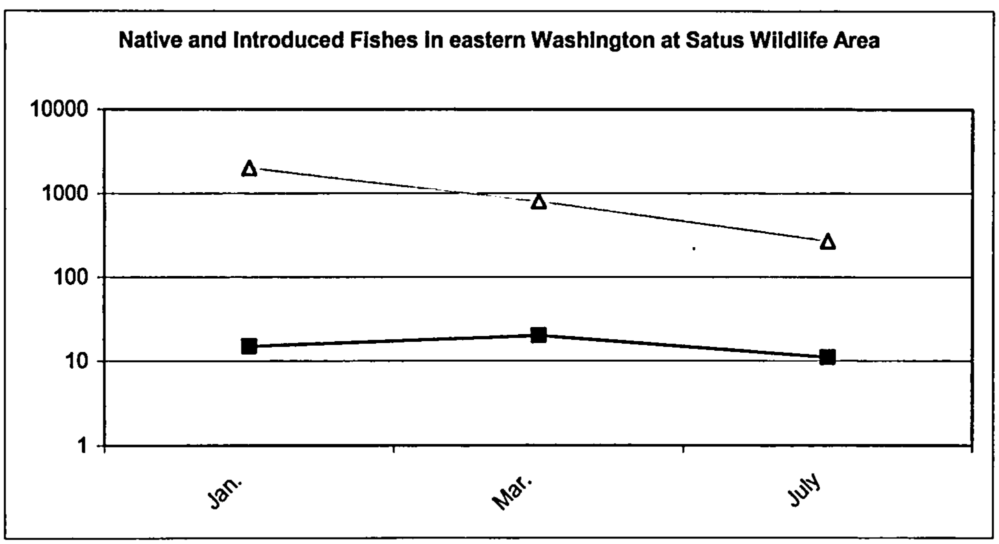
Native fishes were more abundant in the catch in the Lower Columbia River sites from November through April than introduced fishes (Figure 37). Threespine stickleback, prickly sculpin and salmonids dominated the catch during the winter and spring. Introduced fish abundance increased beyond native fish numbers late in the sampling season. This pattern is likely due to reduced activity of introduced warm-water fishes during the winter and early spring when the water temperatures drop. They are likely present in this habitat during the winter and spring but because of their metabolism requirement for warmer water, they remain lethargic thus are not caught during colder weather. After water temperatures began to warm in the spring more introduced fishes became active, then in June and July large numbers of YOY were caught.

On the Washington Coast, very few introduced fishes were caught. Native fishes dominated the catch by almost two orders of magnitude. The most numerous native fish was the threespine stickleback. Introduced fishes did not increase dramatically in the spring and early summer as they did in the Lower Columbia sites.

Figure 37. Native and Introduced Fishes across Oregon and Washington, WY 2002.







The pattern of native and introduced fish species is opposite at Satus Wildlife Area; introduced fishes far outnumbered native species during all three sampling periods. The most abundant native species at sampling sites west of the Cascade Mountains, the threespine stickleback, is not endemic to the east side. Yellow perch, black crappie, carp and brown bullhead were the dominant fishes.

Threespine stickleback are preyed upon by everything from dragonflies to many species of fishes, birds, and mammals (Reimchen, 1994) that may also be found in floodplain wetlands. Reimchen (1994) estimated that 562,000 threespine stickleback were consumed per year by 21 species of predators, including birds (15 spp.), fish (4 spp.), mammals (1 sp.) and odonates (1sp.) in Drizzle Lake (about 280 acres) in the Queen Charlotte Islands, western Canada. He found that cutthroat trout were by far the greatest predator of threespine stickleback, mostly consuming juveniles (10-40mm). Yearling coho that resided in the lake for a year before migrating seaward primarily ate insects and benthos, and only one incidence was found of stickleback eggs in the stomach contents of a coho. Avian predation accounted for 69% of the adult threespine sticklebacks in the estimate of 562,000. The common loon was the greatest avian predator, followed by the red-necked grebe. This estimate of partitioning causes of mortality at Drizzle Lake provides evidence of how the threespine stickleback is important for supporting the food web in lacustrine habitat. Though we may have different species of potential avian predators than western Canada, the threespine stickleback is likely an important part of the food web in floodplain wetlands.

Ninety-nine percent of all fishes caught by all gear in the wetlands were 200mm or less in fork length. One percent of the catch was larger than 200mm, from which carp and largescale suckers were the largest, up to 589 and 449mm, respectively. The next largest were black crappie and bullhead, which were caught as large as 330 and 360mm, respectively. The largest largemouth bass was 280mm and there were only five bass greater than 200mm. Other fishes that exceeded 200mm were yellow perch, peamouth and northern pikeminnow. The most numerous species greater than 200mm was the brown bullhead. Months with the greatest numbers of fishes caught greater than 200mm were April and May. The length of 200mm has no significance only that it was chosen as a point of division to demonstrate that most fishes caught in the wetlands were small. Bayley and Li (1992) explain that small-bodied fishes are favored in seasonal, floodplain wetlands where high growth rates and production occur. Describing the size of fishes found in floodplain wetlands also helps to understand the risk of predation of juvenile salmon by piscivorous fishes. Smaller predatory fishes also have a small gape, which limits the size range of fishes they are able to eat.

Data collected during the 2002 water year provide examples of fish passage through every type of water-control structure under study. Fish passage was documented at Ruby Lake, on Sauvie Island, through the full-round riser. Despite the potential error of fishes being caught between the water-control structure and traps and swimming into the outbound trap appearing as they came through the structure, certainly the majority of the fishes caught in the outbound trap did indeed go through the structure. Seven Chinook and 24 coho were caught in the outbound trap at Ruby Lake, as well as 166 other native fishes and 762 introduced fishes. Figures 18 and 19 (Sauvie Report) show the predicted water-surface elevation in the Slough at the outflow of Ruby Lake and the observed water-surface elevation on the wetland side of the structure. These figures illustrate the increased water depth, which translates to increased surface area of seasonal floodplain wetland habitat, that the water-control structure provided and the frequency that water flowed over the riser board, which gave fishes opportunity to pass through the structure. The hydrologic analysis indicated that fishes had the opportunity to pass over the riser boards and out the structure 30% of the time from mid-November through mid-July. This brings up the question of what frequency of overtopping is appropriate to allow fish passage into these wetlands through the season. This benchmark would determine at what height water-control structures are designed. Although structures with reverse tide-gates allow water and presumably fish in when open, once the water is held in the wetland at a level higher than what the water-surface elevation is in the tidal channel, the gate will not open and access then is only allowed by water backing up over the riser boards or overtopping the structure. High water events which produce overtopping of the structures is quite variable from year to year (Figure 32) so, this becomes a matter of professional judgment that must have some consensus among biologists in the aquatic ecology community.

Fish passage outbound was confirmed through half-round risers at Satus Wildlife Area on the Yakima River, Hoxit Farm on the Chehalis River and at the Morand site on the Tualatin National Wildlife Refuge on the Willamette River. A 128mm Chinook, caught March 27, 2002 at Satus Wildlife Area, was PIT tagged and released back into the wetland. This fish was subsequently detected by the PIT tag interrogation facility at McNary Dam on the Columbia River, 159 miles downstream of where it was originally caught, on May 8, 2002, 42 days later. This Chinook had to pass through from two to four half-round risers or spillways to get back to the Yakima River (Figure 6). The one-way trap set up at the outflow of the half-round riser at Hoxit Farm wetland on the Chehalis River provides evidence of fish passage through that structure. This trap was fished from March 20 to March 30, 2002 and caught 2,856 fish and 484 tadpoles, including 239 coho. The one-way trap at the Morand wetland was set similarly to the one at Hoxit Farm but caught much fewer fishes because that wetland had little connectivity to the Tualatin River, however, five fish were caught.

Fish passage into the wetlands at Willapa Bay NWR through the pool-weir-chute structure was confirmed when coho, which had to have originated from outside the wetland, were caught. On December 3, 2001, eleven yearling coho were caught in the Lewis unit, which was about three weeks after water began flowing through the fish ladder for the first time giving fish access to this habitat once again. There were 38 coho caught in the Lewis and Porter Point units during the sampling period in WY 2002. The refuge had planted some chum and coho, either as fry (chum) or incubation trays (coho), into these units but they could not have grown to the average size of coho caught during the SSWS. The smallest coho caught in the wetlands were sub-yearlings, 54 and 61mm, caught in June. These fish may have originated from the incubation trays put into the feeder stream at Porter Point in early January. These data provide confirmation that yearling and possibly young-of-the-year salmonids can ascend the pool-weir-chute water-control structure.

Confirming fish stranding in a wetland is even more difficult a task than sampling fishes in wetlands. Since sampling has to be done when water still remains in the wetlands, a final round of sampling is done just prior to, or during, the draw-down period, which gives some indication that salmon remain, if caught, and may be potentially stranded. In the Lower Columbia River, the only operating structure being monitored was at Ruby Lake, where there is a full-round riser. The last salmonid leaving the wetland through the two-way trap was May 17, 2002. Sampling within the wetland was done June 23 and 24 and the two-way traps were fished until June 29, 2002, and no more salmonids were caught. The egress channel, which connects Ruby Lake to Cunningham Slough, is an alternate route for fishes to enter and leave the wetland. It was connected during the entire sampling season according to elevations taken at the low point in the channel during survey compared with river staff gage records.

On the Washington Coast, the Porter Point unit was drawn down and the Lewis unit remained wet through the summer. There were two sub-yearling coho caught in Porter Point on 6/5/02 and the wetland was drawn down quickly shortly thereafter. Since there were coho caught just prior to draw-down, it is not known whether there were any mortality associated with the draw-down. On the Chehalis River, the last salmonid in the wetland at Greenhead was caught March 20, 2002 and the draw-down sampling was June 8, 2002. By this time, water in the wetland was getting low and warm so, it was not surprising to find no salmon. At Hoxit Farm, one last coho was caught June 7, 2002 just prior to draw-down.

At Satus Wildlife Area, the last Chinook was caught July 10, 2002. This wetland is large and our capture efficiency was probably very low. This fish indicates that salmonids can be present late in the year at this wetland and that there is a potential for stranding if they do not take the environmental cues to leave. A better way to study stranding rates of salmon in wetlands may be to set up a lab or field experiment and incorporate estimating capture efficiency of the gear so that stranding rates of salmonids can be estimated, perhaps with different treatments such as water flow over risers or vary pond depth. At this time, we do not have a good way of addressing the question of stranding rates. However, it should be recognized that fishes with lateral lines have an extraordinary ability for detecting very low current velocities, 0.03 mm/s (which is equivalent to water moving one-inch in sixteen minutes), with which they are able to navigate out of backwaters (Bleckmann, 1993). Some fishes also have an acute sensitivity to water temperature, being able to detect differences of 0.03°C (Wooton, 1998). These sensory features allow salmonids, and other fishes with lateral lines, to position themselves in the environment where they will achieve the greatest benefit from an energetic standpoint.

Conclusions

Data collected during the WY 2002 sampling effort at sites across Oregon and Washington indicates that yearling and sub-yearling coho and Chinook use seasonal floodplain wetland habitat. Only two steelhead, presumably on their smolting migration, were found to briefly stop over in a wetland on Multnomah Channel in May. The ability to discern use patterns at these sites with respect to season, hydrology, and temperature depended on whether one- or two-way traps were used and the frequency to which water overtopped the two-way traps. At sites with continuously monitored traps, such as Hoxit Farm, or sites in the Lower Columbia River, fish movement into and out of wetlands was expressed in the context of river flows and water temperatures. At sites with only SSWS, fish presence was described and compared across the region. Confirmation of fish passage out of full-round and half-round risers was given, as well as confirmation of passage of yearling and perhaps sub-yearling coho into a wetland through a pool-weir-chute water-control structure. There was no evidence of salmonids being stranded in wetlands after spring draw-down but it cannot be proven that it does not occur. Answering questions about the stranding of fishes after draw-down may require a lab or field experiment, in which the size of the wetland is limited and a high density of fishes are present, to better quantify results. The inundation patterns and degree of connectivity of the river with its floodplain cannot be compared with the historical condition, as we have not yet attempted to reconstruct the historic hydrologic regime through data analysis. Restoration projects may vary in the degree to which they are able to mimic the historic hydrologic regime but the goal is to restore the ecological function of the riverine-floodplain system and not merely try to replicate how the original habitat may have looked. With the altered hydrology across most of the Pacific

Northwest, water-control structures are a tool to be used to effect change so that the habitat functions more like it did historically, which serves a multitude of species, including Pacific salmon.

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