WWC Submittal

Appendix 8 – Gunderson LLC Submittal on NRI, Habitat Classification, and Other Issues

183694

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March 31, 2010

Hand Delivered
Portland City Council

Subject: **Continuing Concerns with River Plan**
Gunderson LLC, Portland, OR

While we appreciate the time and effort spent on the proposed River Plan to date, Gunderson LLC continues to have concerns with the River Plan as proposed and supports the Working Waterfront Coalition's efforts to develop a process that is both good for the environment AND good for business. These concerns have been highlighted on a number of different occasions and include, but are not limited to:

- The Natural Resource Inventory is not accurate for the Gunderson site as previously identified and reconfirmed in newly commissioned reports, attached.
- Vegetation and its attributes to support habitat and/or river health and water quality have not been accurately identified for the Gunderson site and this appears to be the case for a significant portion of the North Reach.
- The likely attributes of and conclusions on habitat and other inventories do not appear to be consistent with other City or Metro generated documents and may contradict them. In addition, they do not appear to be consistent with evaluations performed by other types of agencies (local, state, and federal), nor commonly held professional opinion; for example:
  - The Grey to Green Program Development Charter provides a very clear statement of intent to fight invasive plants:

    "Invasive plants are the second largest threat to native biodiversity (behind habitat loss) and they are one of the primary factors that lead to a species listing under the Endangered Species Act. Invasive plants degrade water quality, reduce biodiversity, impair habitat, decrease tree populations and growth rates, increase the likelihood and spread of fire, decrease the ability of stormwater infiltration, and increase soil erosion. Removing invasive species and planting native

vegetation is a critical strategy for improvement and maintenance of watershed health..."
    - From BES, "The proliferation of invasive, non-native plant species can also increase the risk of erosion because the most dominant non-native plants have relatively shallow root systems."
    - From Portland General Electric newsletter, "Brought from Europe in the late 1800s, the noxious weed has since spread widely, displacing native vegetation while failing to provide the shade and shelter salmon need. Plus, the bushes' shallow roots don't hold soil well during floods and heavy rains, leading to reduced water quality."
- Mapping sufficient to support implementation has not been provided for comment; for example, the Top of Bank is not identified.
- Information required to evaluate the adequacy of the various zoning requirements and inventories has not been made publicly available or in sufficient detail to provide adequate comment or rebuttal.
- Industrial land will be inappropriately converted.
- The description of the restoration sites and their habitat functions are not currently available, were not provided for public review and comment, and have not been demonstrated to meet the needs for restoration that will be required in the implementation of the River Plan.

We hope for an opportunity to constructively work together to resolve these issues.

Sincerely,

David J. Harvey

David J. Harvey
Environmental Director

Enclosures

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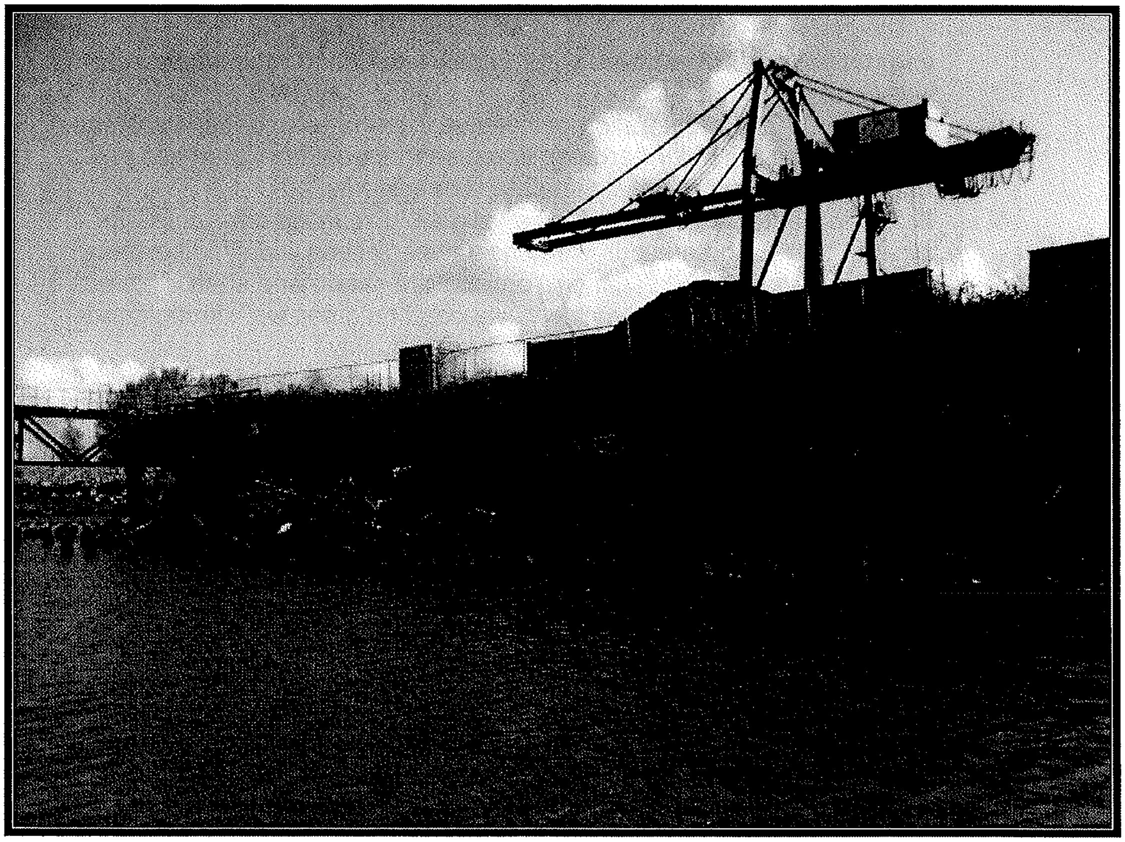
Willamette River Natural Resource Inventory Comparison in the North Reach



March 2010

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Willamette River Natural Resource Inventory Comparison of selected sites

Executive Summary

The City of Portland over the course of the last three decades has undertaken the task of developing inventories of natural resources associated with the functions and values offered by the Willamette River riparian areas and its ability to provide wildlife habitat areas.

New technologies available such as GPS location, high resolution air photography and GIS allow for more precise remote data collection. Recent efforts to update existing riparian inventories have relied on the precision of this technology however have not leveraged its ability to accurately quantify the complex and diverse nature of the riparian conditions on the lower Willamette River. The conclusion of this review is that the November 2009 draft Natural Resource Inventory, included in the city's Proposed River Plan, does not accurately reflect current riparian conditions. Historic inventories appear to more accurately describe current riparian conditions at many sites where changes have been negligible. In some cases it appears that the mere presence of any vegetation of any kind significantly lifted the assessed relative rankings.

If the values assigned to these North Reach sites are artificially high, the management and planning efforts for the sites may reduce the likelihood for restoration or public acquisition as well as limiting the options for stakeholders for appropriate use of the area and adjacent upland property.

The new inventory appears to be poorly ground truthed and generalizes functions in the riparian cross section. The inventory could be improved by:

- Better coordination rankings with existing field conditions
- Utilizing the power of the GIS system to develop a ranking system tied to actual habitat benefit.
- Correlating the interrelation of shallow water, deep water, and riparian and upland features.

I. Purpose and Scope

The portion of the report under consideration is called The River Plan, North Reach, Natural Resources Inventory: Riparian Corridors and Wildlife Habitat and is currently in draft form as of November 2009. The River Plan, North Reach, is intended to serve the following purpose as indicated in the introduction:

"The inventory is intended to inform and support a broad array of City and community activities relating to the Willamette River corridor in Portland. Such activities include implementing and updating city programs to manage natural resources, identifying priority areas for restoration, enhancement, and public acquisition, designing development and redevelopment projects, and meeting regional, state, and federal regulatory requirements."

With significant implications for management it is imperative that the data accurately reflect the conditions of the various sites. Many stakeholders have an interest in the limitations or opportunities provided by the indications of the City sanctioned inventory.

The assessment and evaluation undertaken in this comparison, while limited in scope is an effort to assess and compare ten sites selected based on their similarity and ranking in the River Plan, North Reach. Considerations for similarity included size, development status, previous habitat value scores (as determined in the Lower Willamette River Wildlife Habitat Inventory, cir; March 1986) and lack of surface expression of non-riverine source water (i.e. small stream channels, wetlands, other open water). All the sites are in the North reach and are downstream from the Freemont Bridge to approximately 0.5 miles downstream from the inlet to the Multnomah Channel.

Concern that these sites and other similar sites may have inaccurate relative rankings in The River Plan, North Reach, Volume 3A, gives rise to the perception that opportunities (for development or restoration) may have limitations due to the resulting policy and management prescriptions. While the sites included in this assessment all fit within a narrow range of function and value, the range of possible function and value is compared within the potential limits of an urban river setting.

High value sites would be expected usually to be large (over 7.5 acres) natural areas with native river substrates and bank material and conditions, full strata of vegetation containing mostly native vegetation, with large woody debris, presence of other water features (wetlands, in tact stream channels, significant upland features; ESH habitat) and adjacent natural areas and an absence of contamination. *Medium value* sites would usually be medium (over 2.5 acres) to large natural areas lacking natural conditions in one or more of the other parameters unless significant ESH habitat is present which could boost the status to high value. *Low value* areas are usually small (less than 2.5 acres) to medium and lack natural conditions in most of the parameters and are sometimes capable of ESH species presence although usage is typically limited to migration and lack capacity for spawning and rearing (for salmonids).

II. Methodology

Sites were determined using the existing 1986 Lower Willamette River Wildlife Habitat Inventory sites and identify areas of similar size, upland use, and orientation to the river proper. Sites are identified using the codes used in the 1986 inventory. On site visual assessment from the water at or near low tide at each site and the area evaluated included the riparian strip of land from the existing water line (at the time of visit 3/18/2010, 3/212010) to the inland limit of vegetation if present or to the edge of the developed area if vegetation is not present. Factors assessed include:

- Site size
- Substrate type below the vegetation line
- Bank material above the vegetation line (or approximated line if no vegetation present)
- Presence and quantity of Large Woody Debris
- Vegetation by strata in percent cover and species identification when possible
- Adjacent habitat area presence
- Adjacent impervious (existing developed) areas

A value score was assigned using a scale with scoring from 0 being the lowest possible value to 10 being the highest possible value. Higher weighted values were assigned based on size of natural area and adjacent habitat presence other than the presence of the open water of the river.

III. Site Data

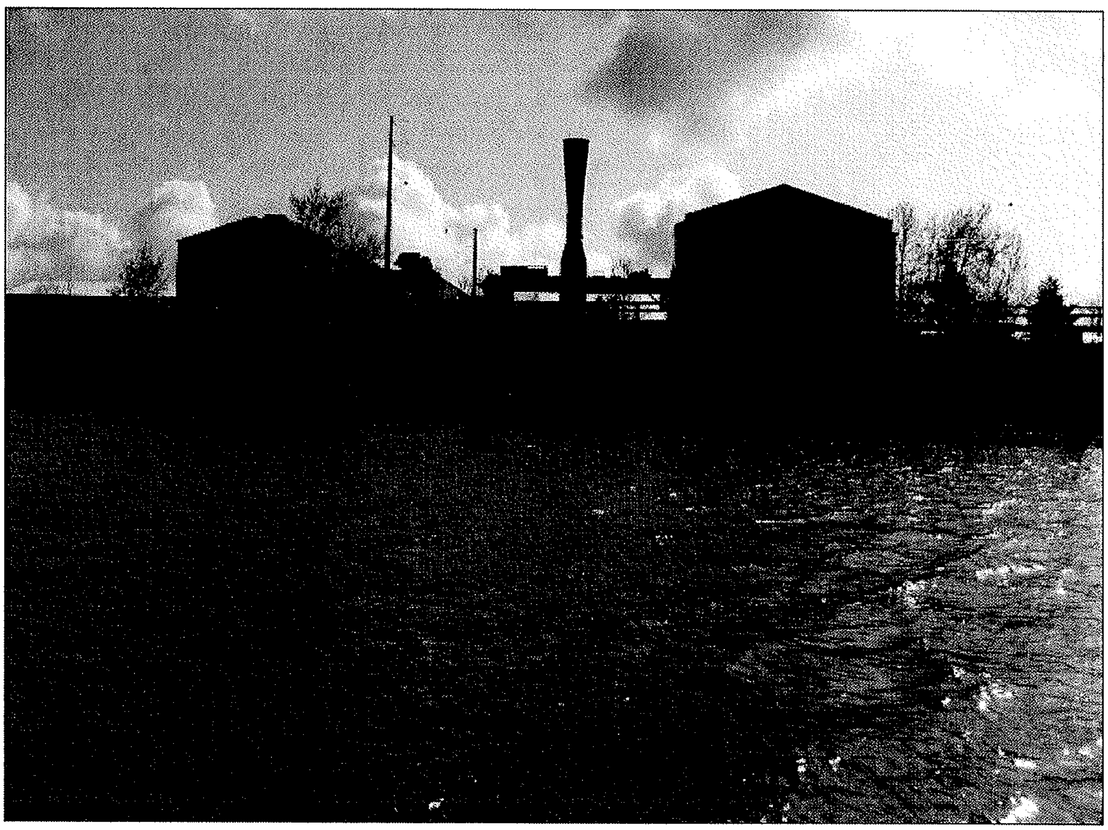
Site 3.3a

Rivergate excluding Terminals

Gravel substrate below the vegetation line includes some vertical cut bank from river erosion. Large woody debris is common. Large adjacent upland natural area noted. Vegetated riparian area is very thin (less than 50' from beginning of vegetation to developed impervious area in the upland. Vegetation includes Cottonwood in the tree stratum (30% cover) and a small amount of shore pine at the top of bank (5% cover) with blackberry bushes representing approximately 50% of the shrub stratum.

Combined wildlife functional value = 3 (low value).

North Reach Inventory mapped rank (Site WR2-Map 4) = Medium relative rank



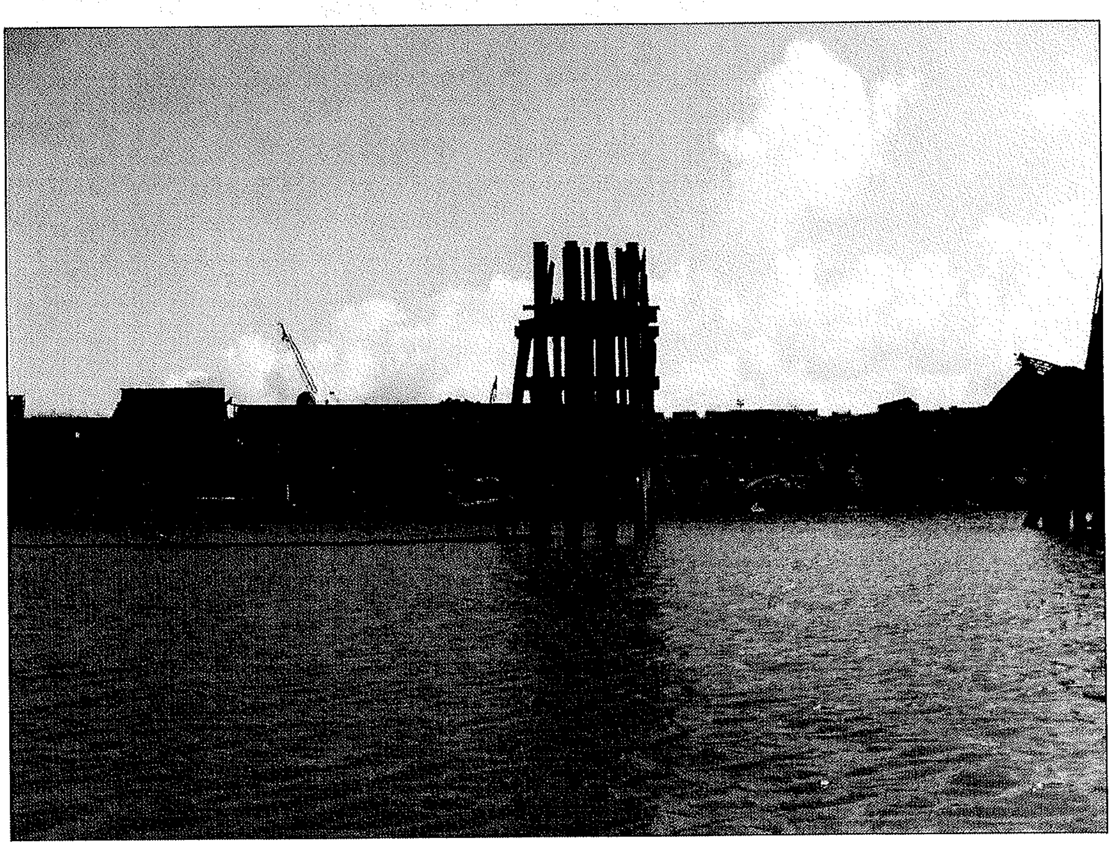
Site 3.2a

Terminal 4

Rip rap and concrete rubble down to the existing waterline with no natural substrate exposed and medium to small amounts of large woody debris, some vertical in water structure provided by relict piling. Vegetated area is thin (less than 50') Vegetation is absent in the tree stratum and contains approximately 70% cover in the shrub stratum and is entirely blackberry bushes. No other vegetation exceeding 1% of cover.

Combined wildlife function value = 2 (very low value).

North Reach Inventory mapped rank (Site WR5-Map 4) = Medium relative rank



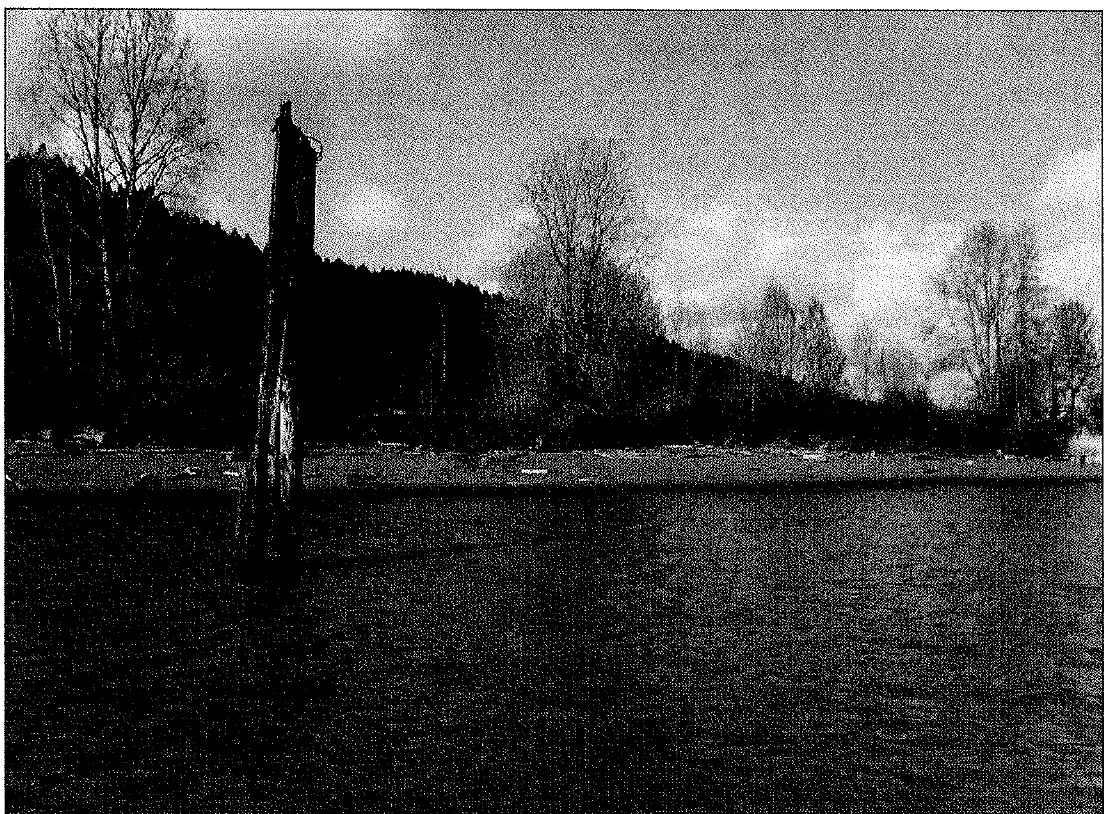
Site 5.2a

Property upstream from sawmill

Sandy substrate with natural bank contours into the vegetation zone. Medium amounts of large woody debris with some vertical structure in the water from relict pilings/dolphins. Vegetated area is thin (less than 40'). Vegetation includes 65% cottonwood in the tree stratum, a mix of willow and blackberry in the shrub stratum and an area dominated with Reed Canary Grass representing approximately 5% of the grass/herbaceous stratum.

Combined wildlife function value = 3 (low value)

North Reach Inventory mapped rank (Site WR6-Map 4) = Medium relative rank except one bankline area is not ranked (vertical sheet pile wall)



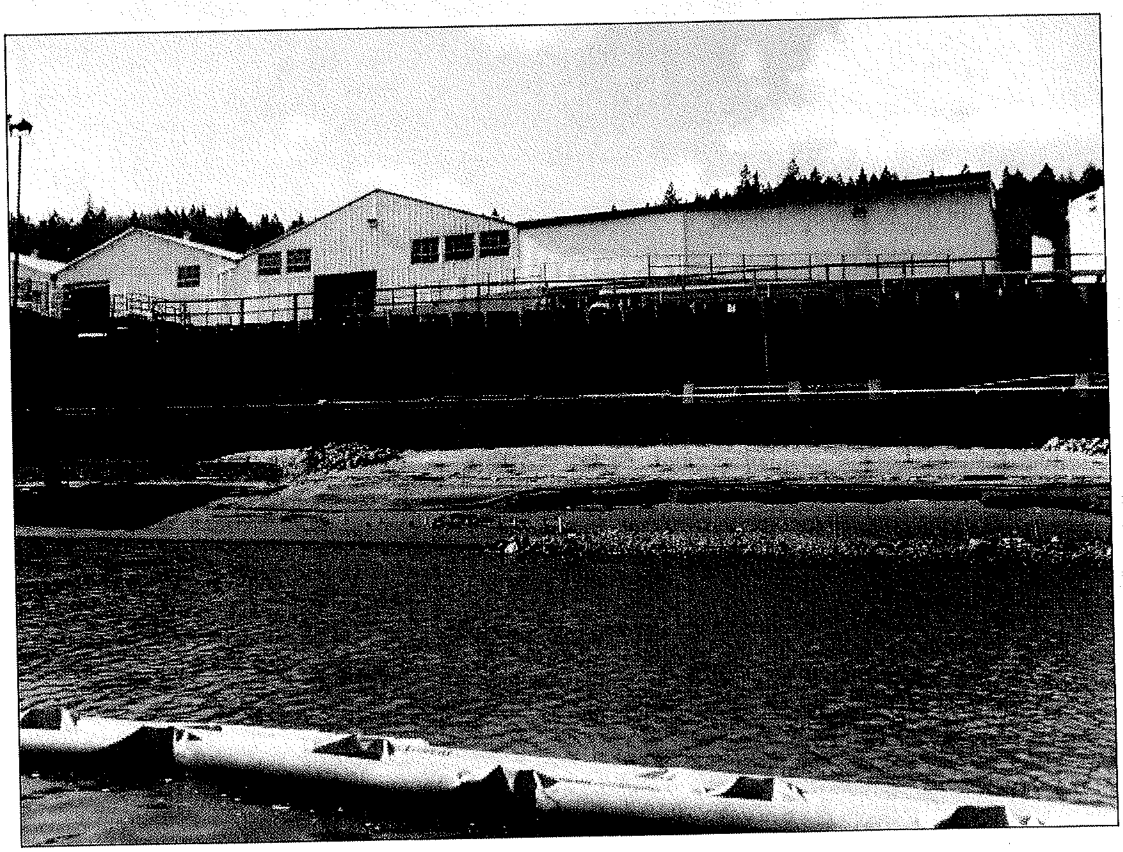
Site 5.4a

Mobil property

Substrate is sandy beach material from existing waterline to restoration treatment zone which is covered with jute netting for temporary stabilization prior to planting maturation. New riparian plantings are in a very thin strip (less than 30') and are bordered with an artificial bank condition containing vertical sheet pile. Rip rap finger barbs were observed and are assumed to be intended to create scour areas for habitat purposes when submerged. Few metal pilings present. Some early erosion of the sandy beach material is observed (see photo) and may indicate the potential for failure of the treatment with regard to substrate stabilization through establishment of a vegetated strip. Little to no adjacent natural areas observed.

Combined wildlife function value = 2 (very low value)

North Reach Inventory mapped rank (Site WR6-Map 4) = 25-30% Medium relative rank, 70-75% not ranked (vertical sheet pile with active restoration (plantings at beach elevation)



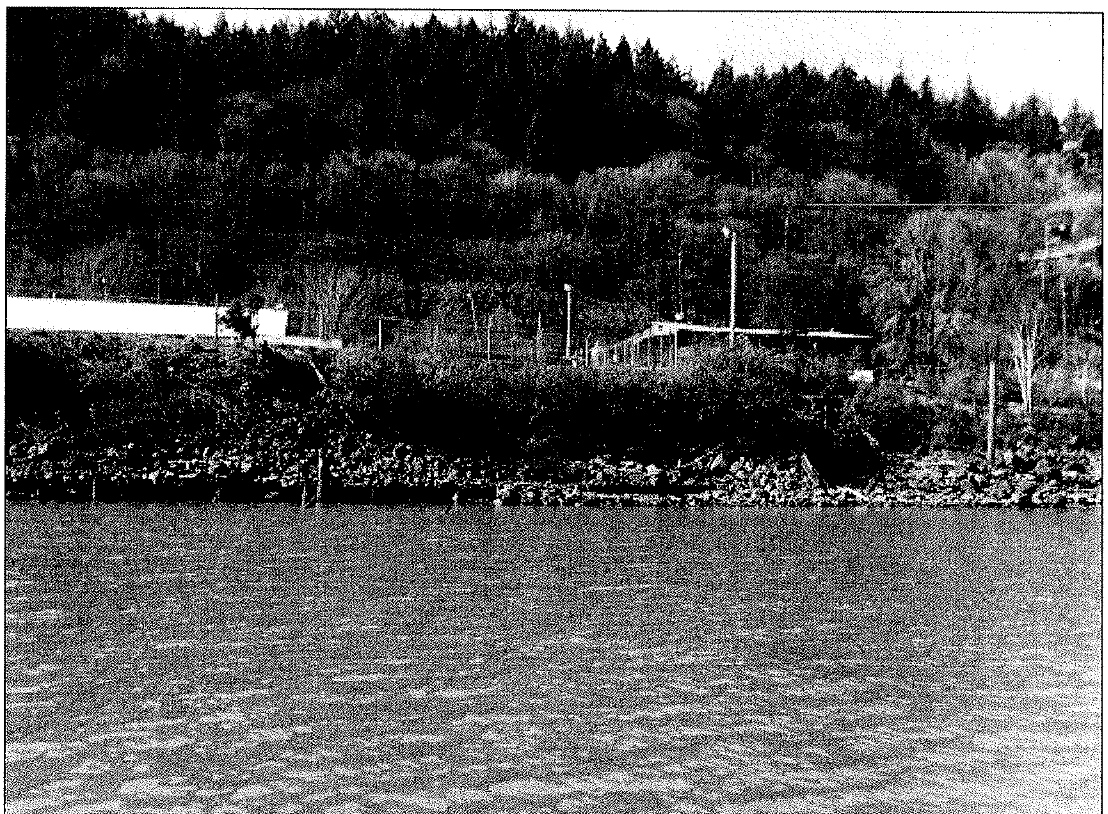
Site 5.5a

Corps of Engineers property

Rip rap from the existing water level to the top of bank. Wood piling toe. Very little large woody debris present. Vegetated area is very thin (less than 30'), butterfly bush 35%, scotts broom 10% blackberry 10%, cottonwood less than 5%.

Combined wildlife value = 2 (very low value).

North Reach Inventory mapped rank (Site WR8-Map 4) = 80% Medium relative rank, 20% unranked (no obvious reason observable)



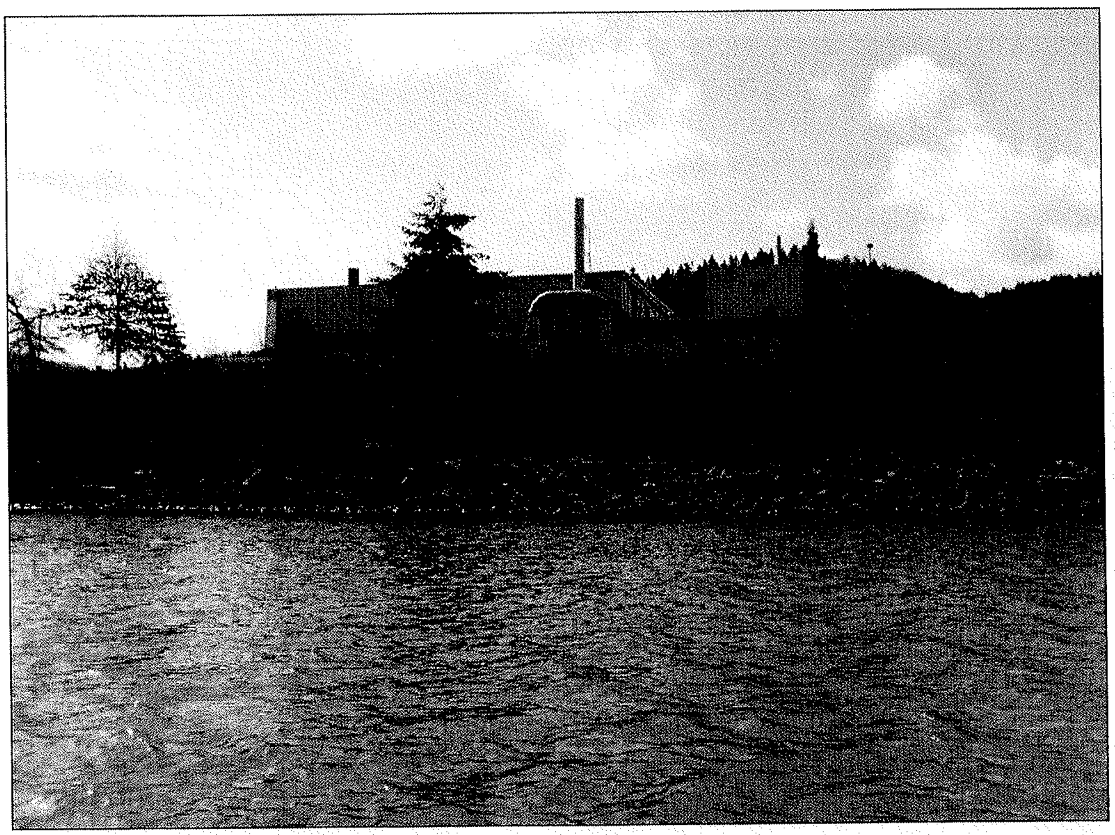
15.2a

Wacker Siltronic property

100% rip rap with no natural substrate. Few large woody debris present. Sparsely vegetated with total vegetation cover at less than 30%. Vegetation observed includes willow 10%, blackberry 5%, unknown shrubs less than 5% with fir plantings less than 5% at the top of bank.

Combined wildlife value 2 (very low value)

North Reach Inventory mapped rank (Site WR8-Map 6) = low relative rank



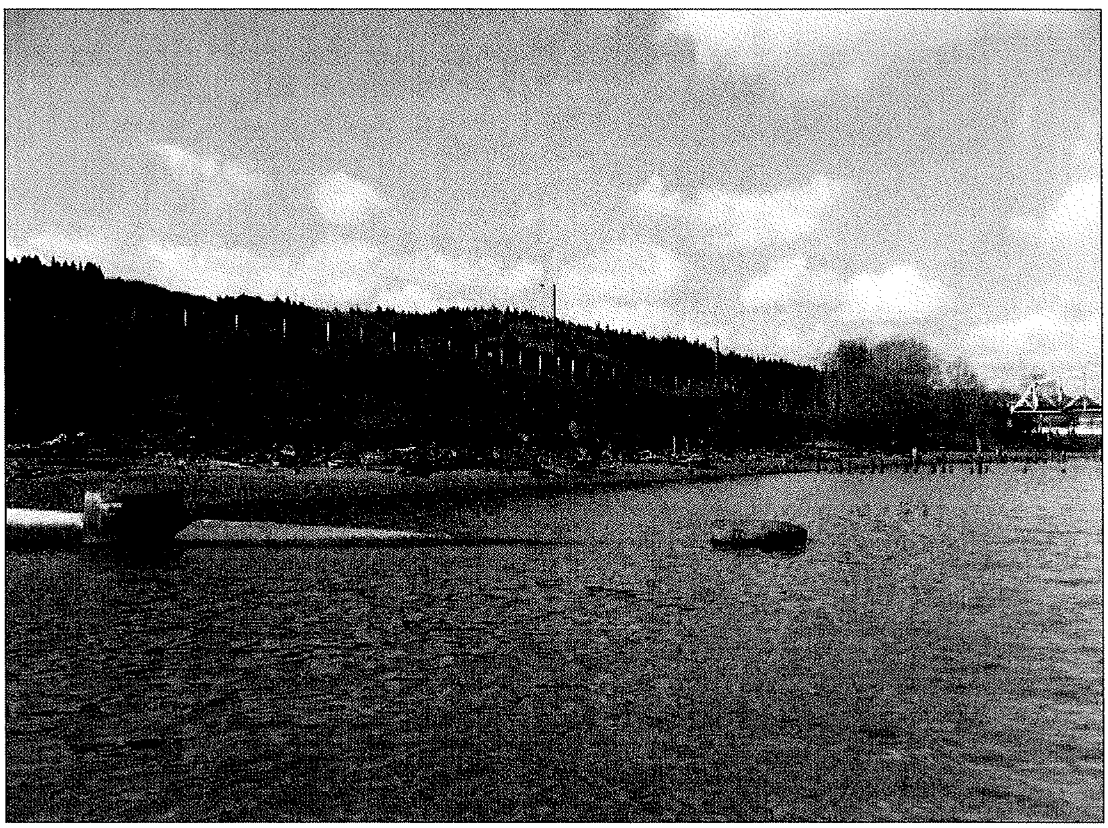
15.4a

Penwalt Chemical property

Sandy gravely mix in the beach substrate below the vegetation line. Rip rap and rubble above the vegetation line. Medium amount of large wood presence. Narrow vegetated area (less than 40' including blackberry 80%, butterfly bush 15%, scotts broom 5%, willow 1%, reed canary Grass 1%. No tree stratum.

Combined wildlife value = 2 (very low value)

North Reach Inventory mapped rank (Site WR8-Map 6) = 75% High relative rank, 25%Medium relative rank



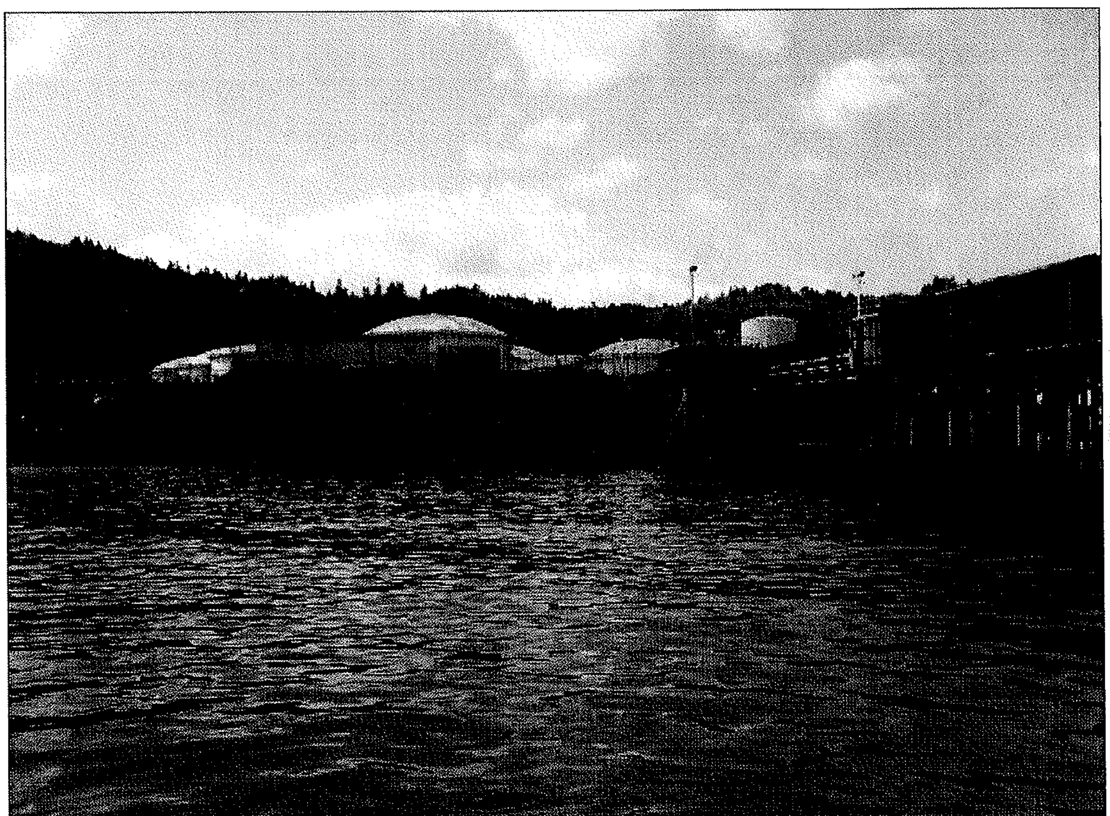
Site 15.6a

Shell, Chevron, Union 76 dock

Sterile rip rap and course (pit run) gravel. No large woody debris. One solitary butterfly bush 1% cover. No tree stratum or grass or herbaceous vegetation present. No structural diversity.

Combined wildlife habitat value = 1 (very low value).

North Reach Inventory mapped rank (Site W11B-Map 6) = 80% High value relative rank, 5% Medium value relative rank, 10% low value relative rank



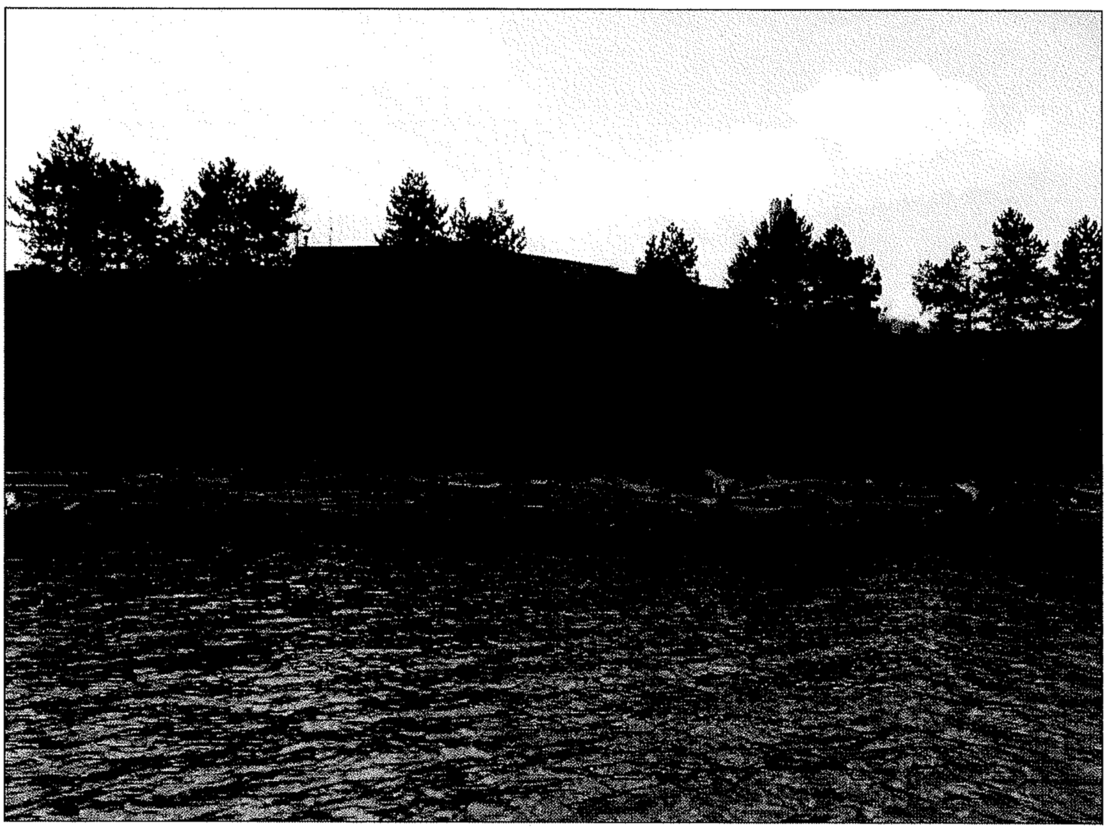
Site 15.8a

Acme Trading property

Gravely beach below vegetation line observed. Vegetated rip rap above beach area elevations. Common large woody debris observed. Narrow to medium vegetated bank area 50'. Vegetation consists of willow and cottonwood in the tree stratum (15%) with shore pine at the top of bank (20%) blackberry vines (50%) and willow (10%) in the shrub stratum.

Combined wildlife value = 3 (low value)

North Reach Inventory mapped rank (Site W11B-Map 6) = 40% High value relative rank, 10% Medium relative rank, 30% Low relative rank, 20% unranked



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Site 15.9a

Gunderson Property

Unconsolidated rip rap below and above vegetation line. Some vertical support structures present. Medium amount of large woody debris. Vegetation is very sparse with blackberry vines (5%) and butterfly bush (5%).

Combined wildlife value = 2 (very low value)

North Reach Inventory mapped rank (Site W11B-Map 6) = 10% High value relative rank, 10% Medium relative rank, 80% Low relative rank,

Site 14.4a

Southern Pacific Railyard

Gravel and course gravel mixed up to the vegetation line where it becomes rip rap until the top of bank where it becomes developed and impervious. Few large woody debris observed. Some partially exposed pilings below the existing waterline. Vegetation intermittent including cottonwoods (35%) in the tree stratum, Blackberry vines (60%) in the shrub stratum with a few willows (5%) and unknown grasses (5%).

Combined wildlife value = 3 (low value)

North Reach Inventory mapped rank (Site WR13B-Map 6) = 75% High value relative rank, 15% Low value relative rank, 10% unranked.

IV. Conclusion

As stated in the introduction, this assessment is limited in scope and is intended to compare specific sites that share commonalities and represent a narrow range in the spectrum of diversity of sites possible within the North Reach of the Willamette River. The sites in question all have narrow vegetated strips of land between the open water of the river and the upland which in most if not all cases is developed and impervious above the top of bank. The river bank between OLW and OHW is highly disturbed and steeply sloped. They all lack a preponderance of natural features as would be expected in a non disturbed natural riparian area. Instead, the beaches are narrow and bounded by rip rap or vertical structures such as sheet pile. Flood plane connectivity is lost as is natural hydrologic function of the river when at flood stage. Vegetation varies from sparse to moderate and is predominantly non native and generally provides low to very low habitat value. Specifically, monocultures of Himalayan blackberries do not provide diverse habitat conditions, meaningful shade for the river, or bank stabilization. Large woody debris when present is very transitory in nature due to the lack of existing structure and natural shoreline conditions. Adjacent natural areas are limited to the open water of the river, an occasional adjacent property with similar conditions or completely sterile riverbank, or in one case a significant upland natural area.

Wildlife habitat relative ranks attributed to many of the sites in the River Plan, North Reach, that were also assessed were mapped with medium wildlife value relative rank status in the inventory. The data expressed in Volume 3B; Appendices lumped many of these sites together on the data for which is labeled 2.3w and although all the scores for riparian function and wildlife habitat value were assigned either a 0 or 1 ranking in a possible score of from 4 being the highest in some categories with 6, and 8 being the high score possible in other categories. Why then does the mapping indicate medium value for these areas? This is in contradiction of the protocols indicated in the body of the report with regard to value assignment and is also in contrast with the identified examples of high, medium and low value areas. This example from page 16 of the main report 3A:

"Typically, the riparian corridor model assigns aggregated relative ranks to natural resource features as follows:
- ***High** – Rivers, streams and wetlands; forest or woodland vegetation within a flood area, in close proximity to a water body, and woody vegetation on steep slopes*
- ***Medium** – Shrubland and herbaceous vegetation within a flood area or in close proximity to a water body*
- ***Low** — Vegetation outside the flood area and further from a water body; developed flood areas; and hardened, non-vegetated banks of the North and Central reaches of the Willamette River"*

The criteria for ranking supports the conclusion that the areas would have low riparian corridor function which is highly correlated with wildlife function and yet the overall wildlife function is ranked medium for most of the sites identified here.

It does not appear that inventoried sites in the River Plan, North Reach, Volume 3A reflect that the appropriate values are assigned to these areas. If the values assigned to these North Reach sites are artificially high, the management and planning efforts for the sites may reduce the likelihood for restoration or public acquisition as well as limiting the options for stakeholders for appropriate use of the area and adjacent upland property. While it is recognized that all riverbank areas have some wildlife function even if they are vertical pile structures or sterile non-vegetated rip rap, the assignment of values for management purposes must reflect the relative value of these areas and the code designations and resulting restrictions or planning requirements should be in concert with those value assignments.

Gordon Dunkeld is a wetland and environmental consultant and has operated Dunkeld Environmental Consultation LLC in Western Oregon for 6 years and has varied practical experience in environmental permitting and enforcement resolution for terrestrial, wetlands, and aquatic sites. He spent 8 years working as a Natural Resource Coordinator and Enforcement Specialist for the Oregon Department of State Lands working under the Oregon Removal-Fill Law (ORS 196.800-196.990). He holds a Bachelor of Science in Education from Portland State University and a certificate of training as a Wetland Technician in a joint program from Chemeketa Community College and the Oregon Department of State Lands. He also has a Certification of Training in Interagency Wetland Delineation from the Army Corps of Engineers and US Fish and Wildlife Service. He has also completed numerous other specialized training courses and seminars in Botany, Hydric Soils, Wetland and Riverene Hydrology, Endangered Species Act Consultations, and Compensatory Wetland Mitigation.

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183694

Date: March 30, 2010
To: David Harvey, Director of Environmental, Health & Safety, Gunderson
From: Steve Johnson, Senior Fish/Aquatic Ecologist
Subject: Willamette River Natural Resource Inventory

SWCA recently conducted an assessment of riparian vegetation along Gunderson's approximately 4,000 foot long Willamette River property in northwest Portland. This memorandum addresses several key elements of the City of Portland's recommended draft Willamette River Natural Resource Inventory (NRI) dated November 2009 and how they apply to the vegetation present in the Gunderson riparian area. Two issues of concern are noted with regard to the City's inventory results:

- The classification applied to vegetation on the Gunderson site and other areas in the North reach in the NRI; and
- The sites used to verify "representative" vegetation communities in the North Portland Harbor area.

Vegetation coverage by area on the Gunderson riverbank is in excess of 90% invasive plant species. The draft NRI identifies vegetation types on the Gunderson site (Site WR11a Map 3) as shrubland vegetation. The City of Portland's 2009 NRI Vegetation Mapping Project defines shrubland vegetation as generally greater than 0.5 m in height with individuals or clumps generally forming more than 25% of cover. Vegetation dominated by woody vines, such as Himalayan blackberry, is usually included in this class.

The NRI states riparian vegetation communities fall into four classes using the National Vegetation Classification System (NVCS) developed by the Nature Conservancy for classifying terrestrial vegetation (Grossman et al. 1998). The four classes of vegetation are forest, woodland, shrubland, and herbaceous. The system does not include a category for the non-native "invasive" vegetation communities that are prevalent in the Portland Harbor area. Invasive species are non-native or alien species to the ecosystem whose introduction is likely to cause economic or environmental harm or harm to human health. Since the invasive plant policy is an integral part of the City's natural resource protection program, these areas should receive an appropriate classification aligned with the City's goals.

The vegetation types that dominate the Gunderson site may be better described as herbaceous, or more accurately, as invasive vegetation types. Herbaceous vegetation is generally less than 0.5m tall, is a dominant species, and generally forms at least 25% of vegetative cover. The two dominant species on the Gunderson site, Himalayan blackberry and butterfly bush, are classified as prohibited and nuisance species, respectively, in the Portland plant list.

This classification, which is given a rating of medium in the NRI, does not accurately represent the habitat value, or lack of value, of the invasive vegetation community in this area.

With regard to NRI model, the City used two models to rank and map the relative quality of natural resources: a riparian corridor model and a wildlife habitat model. Riparian corridors and wildlife habitat are ranked "high," "medium'" or "low" based on the aggregate GIS model-based scores for specific functions and attributes. A number of sites adjacent to the lower Willamette River were used to "calibrate" the GIS model.

Site visits supplemental to the original site assessments conducted in 1999 and 2000 were visited by City staff teams from the bureaus of Planning and Environmental Services in the fall of 2005 and the spring of 2006. Site assessment forms that included type and diversity of vegetation were produced for each site. The sites included Kelley Point Park, Kelley Point/Port of Portland, Chimney/Pier Park, Linnton northern portion, and Linnton southern portion. Many sites were City of Portland managed properties and characterized as sites with forest or woodland canopies. These sites are not representative of the steep-banked, invasive species-dominated vegetation communities that occur on river banks throughout the lower river. Vegetation identified at these "representative" sites does not appear to be representative of many of the industrial sites in the North Portland Harbor.

183694

Description and Categorization of Nearshore Habitat in the Lower Willamette River

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April 2004

INTRODUCTION

The loss of natural habitat is one of the most important factors leading to the decline of native fish stocks in rivers and streams (Behnke 1992). Fish depend on natural habitat complexity for feeding, rearing, and spawning. Habitat complexity in lotic systems is a result of a combination of factors, including: 1) riparian vegetation that provides complex root systems and woody vegetation that help stabilize stream banks and provide stream cover, 2) large woody debris that creates important instream habitat for salmonids, 3) undercut banks that provide cover for fish, and 4) off-channel stream habitat that provides rearing areas (Hicken 1984; Meehan 1991). When riparian habitat is removed, many of the factors that contribute to habitat complexity are lost, bank erosion occurs, and sediment loads can increase.

Rock revetment (riprap) is often used to stabilize banks after riparian habitat is removed; however, this solution can result in a reduction of fish habitat and cause channelization (Hjort et al. 1984; Schmetterling et al. 2001). Riprap is often unvegetated, which results in a loss of large woody debris recruitment and stream cover (Dykaar and Wigington 2000). Riprap also prevents any lateral movement or erosion of the stream channel, which causes reductions in secondary channel habitat and undercut bank habitat (Hjort et al. 1984; Schmetterling et al. 2001). Knudsen and Dilley (1987) documented short-term detrimental effects on juvenile salmonids *Oncorhynchus* spp. during construction of bank reinforcements, and Garland et al. (2002) reported Chinook salmon *O. tshawytscha* densities were significantly lower at riprapped sites than at sites consisting of smaller substrates.

The development of the lower Willamette River has transformed much of the natural bank habitat into riprap and seawalls to stabilize banks and control flooding. In addition, commercial shipping has altered the natural landscape and river bottom of the lower reach through construction of docks and channel dredging.

The Willamette River is also used by several evolutionarily significant units (ESUs) of anadromous salmonids listed as threatened under the federal Endangered Species Act (ESA). These include: upper Willamette River spring Chinook salmon (NOAA 1999a) and winter steelhead *O. mykiss* (NOAA 1999b), and lower Columbia River winter steelhead (NOAA 1998) and Chinook salmon (NOAA 1999a). In addition, naturally propagating coho salmon *O. kisutch* in the lower Columbia River ESU are listed as endangered by the State of Oregon (Chilcote 1999). The lower Columbia River ESU includes the Willamette River up to Willamette Falls.

Following a workshop conducted by the City of Portland's ESA Program with regional scientists and fisheries agencies, the decision was made to study habitat use and rearing by these stocks in the lower Willamette River. In May 2000, the Oregon Department of Fish and Wildlife (ODFW), funded by the City of Portland, implemented a four-year study of aquatic habitat and nearshore developments in the lower Willamette River with respect to their use by resident and anadromous fish species. The study was intended to assist the City with permitting, planning, and enforcement, and to maximize the protection of listed species.

The objective of this portion of the study was to describe and categorize nearshore habitats and development types in the lower Willamette River. The identification of habitat categories was intended specifically to help characterize habitat use by resident and anadromous fishes and to develop management recommendations for protecting listed species (see Friesen et al. 2004 and Pribyl et al. 2004). In addition, we identified parameters that contributed most to the separation of habitat groups; these are likely to have the greatest effect on fish use, and may provide managers with specific recommendations pertaining to habitat protection.

A list of abbreviations and acronyms used in this report is provided in Table 1. We refer to habitats and structures constructed by people (e.g. riprap, seawall, pilings) as "artificial"; all others are referred to as "natural."

METHODS

Selection of Sampling Sites

We conducted the study from Willamette Falls at river mile (rm) 26.5, river kilometer (rkm) 42.6, downstream to the confluence with the Columbia River (rm 0.0, rkm 0.0; Figure 1). A list of potential sampling sites was developed based on bank qualification data modified slightly from Greenworks et al. (2000). Each site was identified by a location code consisting of the river mile and bank designation (east or west). For example, 012W denotes a site with a lower bound at rm 1.2 located on the west bank. Alcove sites, which consisted of mixed habitat (no predominant habitat; usually a mixture of beach and riprap) and provided natural or artificial refugia in off-channel areas, were identified by an additional "A" in the location code (e.g. 148WA). Some sites (048E, 051E, 100W) were considered for inclusion because they had been used in a previous study (Ward et al. 1994) or were specifically identified by the City of Portland (006E, 136E). From this list, we randomly selected at least two replicate sites of each habitat type. Several sites were replaced based on reconnaissance surveys during May 2000 or eliminated (031W, 118W, 126E, and 203W) when factors such as distribution within the study area, proximity to nearby sites, consistency of bank habitat, access, and navigational hazards were considered. When differences existed between sites of a general habitat type, they were assigned to subcategories. Selection of subcategory replicates was attempted but was not always possible due to the criteria identified above and a limitation on the overall number of sites that could be sampled. This process resulted in the selection of 19 sites distributed throughout the study area from rm 0.6 to 24.3 (rkm 1.0-39.1). A "bio-engineered" site (133W) and six alcove sites were added in October 2000, resulting in a total of 26 sites (20 "standard" sites and 6 alcove sites; Tables 2 and 3).

We initially segregated sampling sites qualitatively into 12 types based on physical appearance and functionality (Table 4). For most analyses, we combined similar habitat types to increase sample sizes and improve our ability to describe differences among types. These categories included: 1) alcoves, 2) beach, 3) riprap, 4) rock outcrop, 5) seawall, and 6) mixed habitat. The habitat at the bio-engineered site was primarily riprap and was categorized accordingly. We also combined vegetated and non-vegetated riprap sites. "Piling" and "floating" categories were reclassified based on their associated bank type (e.g., a site with a floating dock could also have a riprapped bank).

Table 1. List of abbreviations and acronyms used in this report.

Abbreviation	Description
%10MFORB	Percent ground cover consisting of forbs 10 m above the waterline
%10MGRASS	Percent ground cover consisting of grass 10 m above the waterline
%10MNOVEG	Percent of bank with no vegetative cover 10 m above the waterline
%10MSHRUB	Percent ground cover consisting of shrubs 10 m above the waterline
%10MTREES	Percent ground cover consisting of trees 10 m above the waterline
%20MFORB	Percent ground cover consisting of forbs 20 m above the waterline
%20MGRASS	Percent ground cover consisting of grass 20 m above the waterline
%20MNOVEG	Percent of bank with no vegetative cover 20 m above the waterline
%20MSHRUB	Percent ground cover consisting of shrubs 20 m above the waterline
%20MTREES	Percent ground cover consisting of trees 20 m above the waterline
%ARTFILL	Percent bank substrate consisting of artificial fill
%BEACH	Percent bank substrate consisting of beach
%BEDROCK	Percent bank substrate consisting of bedrock
%CLAY	Percent clay composition (substrate samples)
%LGRIPRAP	Percent bank substrate consisting of large riprap
%ROCK	Percent bank substrate consisting of rock
%SAND	Percent sand composition (substrate samples)
%SEAWALL	Percent bank substrate consisting of seawall
%SILT	Percent silt composition (substrate samples)
%SMRIPRAP	Percent bank substrate consisting of small riprap
BANKSLOPE	Mean bank slope (degrees)
DENSITOM	Densitometer (overhead cover)
DEPTH20M	Depth 20 meters from shore (m)
DISTHAL	Mean distance to thalweg (m)
GIS	Geographic Information System
GPS	Global Positioning System
MRS	Mean river stage (ft)
OUTFALLS	Total number of outfalls
PCA	Principal components analysis
PILINGN	Mean number of nearshore pilings
PORTGAGE	River gauge height at Morrison Bridge (ft)
SCONDN	Mean nearshore surface conductivity (mS/cm)
SLOPEN	Mean nearshore river bottom slope (degrees)
STEMPN	Mean nearshore surface water temperature (^{o}C)
SUBSIZE	Mean substrate size (μm)
SURF0_2N	Mean nearshore surface dissolved oxygen concentration (mg/l)
TRANSPN	Mean nearshore transparency (cm)

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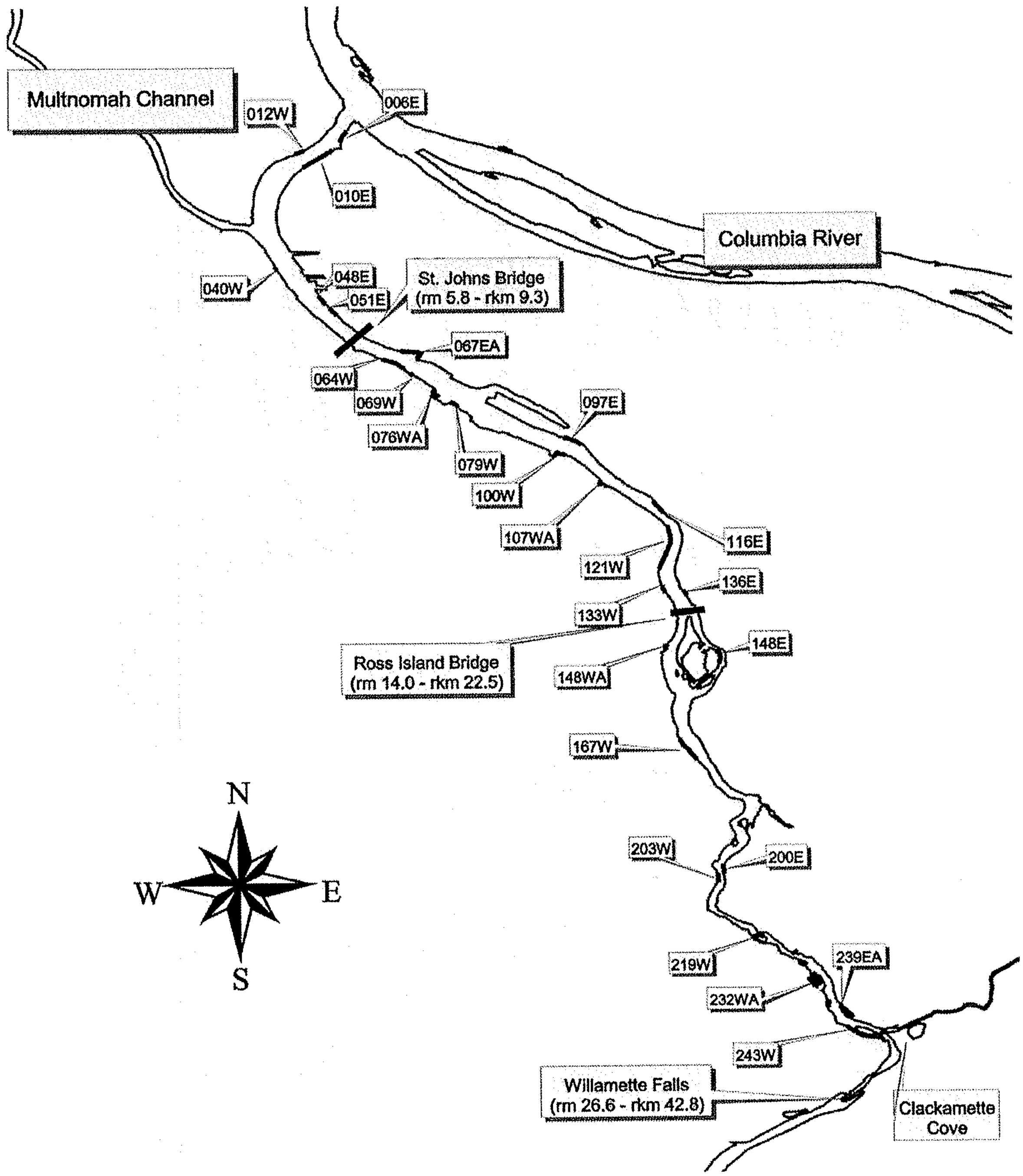

Figure 1. The lower Willamette River and associated features. Sampling site labels denote river mile (rm; xx.x) and east (E) or west (W) shore. A = alcove site; rkm = river kilometer.

Table 2. Description of standard sampling sites in the lower Willamette River, May 2000 - June 2003.

Habitat classification	Site[a]	River kilometer	Length (m)	General bank type[b]	Location / description
Undeveloped					
Beach (7)	006E	1.0-1.3	364	B	Kelley Point
	040W	6.4-6.5	64	B	Across from Terminal 4
	069W	11.1-11.3	--	B	Upstream from Doan Point
	097E	15.6-16.1	456	B	Across from Terminal 2
	148E	23.8-25.0	526	B	Behind Ross Island
	167W	26.9-27.8	804	B	Powers Marine Park
	243W	39.1-39.4	264	B	Downstream of Goat Island
Rock outcrop (2)	200E	32.2-32.6	333	RO	Lake Oswego Railroad Bridge
	219W	35.2-35.6	328	RO	Hog Island
Riprap (5)					
Vegetated (2)	012W	2.0-2.3	240	RR	Between day markers #6 and #10
	136E	21.9-22.0	183	RR	OMSI
Non-vegetated (2)	064W	10.3-11.0	564	Mixed (RR/B)	Doane Point
Bio-engineered (1)	133W	21.4-21.6	186	Mixed (RR/B)	Downstream of Marquam Bridge
Seawall					
Concrete wall (1)	121W	19.5-21.0	1,542	SW	Waterfront Park seawall
Metal sheetpile (1)	048E	7.7-8.0	286	SW	Terminal 4
Pilings					
Allowing light (3)	010E	1.6-2.4	905	Mixed (B/RR)	3 T-docks above Columbia Slough
	079W	12.7-13.0	255	RR	Olympic Tug T-dock
	116E	18.0-18.2	141	Mixed (RR/UNC)	T-dock above Fremont Bridge
Limiting light (1)	100W	16.1-16.2	78	RR	Terminal 2
Floating					
Limiting light (1)	051E	8.2-8.7	310	Mixed (RR/B)	Terminal 4 ship hull

[a] The first two digits represent river mile; the third digit represents river mile tenth. W=West bank, E=East bank
[b] B=beach; RO=rock outcrop; RR=riprap; SW=seawall; UNC=unclassified fill

Table 3. Description of alcove sites in the lower Willamette River, May 2000 - September 2003.

Category	Site[a]	River kilometer	Length (m)	General bank type[b]	Location / description
Natural	067EA	10.8-11.1	577	Mixed (RR/B)	Downstream of Doane Point
	148WA	23.8-24.0	206	Mixed (B/UNC)	Above Spaghetti Factory
	232WA	37.3-37.7	1029	B	Upstream of Cedar Oak boat ramp
	239EA	38.5-38.9	580	B	East side of Meldrum Bar
Artificial	076WA	12.2-12.4	317	Mixed (B/PAL)	Downstream of Chevron piers
	107WA	17.2-17.4	396	Mixed (PAL/UNC)	Below Fremont Bridge

[a] First two digits = river mile, third digit = river mile tenth; W=West bank, E=East bank, A=alcove.

[b] B=Beach; RR=riprap; UNC=Unclassified fill; PAL=Pilings-allowing light. For sites with mixed bank substrates, the predominant type appearing above normal low water is listed first.

Table 4. Definitions of bank nearshore habitat types in the lower Willamette River, May 2000 - March 2003.

Habitat type	Description
Beach	Shallow, shelving shorelines consisting of sand, silt, or gravel up to 64 mm diameter. This may also include native bank materials in their natural position and undisturbed by humans (e.g. clay bank). Vegetation cover varies but may include canopy, understory, and ground cover.
Rock outcrop	Natural bedrock formations consisting of angular ledges, protrusions, and sheer rock faces. May include some associated boulders.
Rock	Natural, round river rock >64 mm that does not fit into the riprap categories.
Seawall	Impervious vertical retaining walls generally composed of concrete, timber, or sheet pile, extending beyond ordinary low water. These habitats are uniformly deep and homogenous (e.g. house foundations in the water, bulkheads).
Vegetated riprap	Continuous stone revetments mechanically placed to curtail erosion and prevent alterations to the main channel. Vegetative cover varies but may include canopy, understory, and groundcover that occupy a minimum of 20% of the active bank below flood state (lower shore zone).
Non-vegetated riprap	Continuous stone revetment devoid (<20%) of vegetation.
Bio-engineered	Engineered banks that incorporate vegetation as a visible component of riprapped banks, but inert and artificial materials provide the physical structure that ensures bank stability. Bio-engineered banks rely on vegetation and natural fabric materials for banks stability (e.g. site 133W).
Unclassified fill	These areas appear to have been filled over time with miscellaneous unconsolidated materials (e.g. cement slabs). The surfaces of banks composed of unclassified fill have not been covered with engineered riprap or structures. Such banks generally contain debris of various types and may have become unstable because of erosion by river forces.
Pilings-allowing light	Stationary support structures consisting of concrete, metal, or timber used to elevate docks, buildings, etc. above the water. Elements of construction allow varying amounts of light to penetrate to the underlying habitat (e.g. T-docks)
Pilings-limiting light	Stationary support structures used to elevate docks, buildings, etc. above water. Construction is such that underlying habitat is not directly exposed to ambient light (e.g. site 100W).

Table 4 (continued)

Habitat type	Description
Floating-allowing light	Structures such as loading docks and piers that maintain buoyancy and move with fluctuating river levels. Design and construction materials allow light to penetrate the habitat below.
Floating-limiting light	Buoyant structures that do not allow light to penetrate the underlying habitat.

Study Area Habitat Evaluation

We conducted an inventory of habitat types and nearshore structures in the study area during January and August 2001 to quantify available habitats. Mean river stage (MRS), defined as the average river elevation for a given sampling period, was based on datum from the U. S. Geological Survey gauge (14211720) at the Morrison Bridge (rm 12.7; rkm 20.4) and ranged from 1.9-4.2 feet. The inventory was conducted by driving a boat as close as possible to the shoreline and recording beginning and ending waypoints (latitude and longitude) of each bank type along all shorelines (approximately 53.0 shoreline miles). The inventory was divided into upper (above Ross Island; rkm 42.8 - 22.6) and lower (below Ross Island; rkm 22.5 - 0.0) sections of the study area. If the shoreline of a continuous habitat unit was sinuous, multiple waypoints were logged to increase accuracy. For any habitat unit <30 m in length, one mid-length waypoint was recorded and length (±1 m) was measured with a laser rangefinder (Bushnell Yardage Pro 1000). We logged waypoints with a handheld Global Positioning System (GPS) receiver (Garmin GPS III) equipped with a differential antenna (±3 m accuracy). Data was layered onto an Oregon Lambert-projected ortho-photo (2' resolution) with ArcView 3.2a software. Waypoints were repositioned onto the shoreline and the length (m) of each bank habitat unit was measured as the distance between waypoints. Lengths of nearshore structures (piers, docks, wharves, and other stationary structures incorporated into, or adjacent to the riverbank) were measured directly from the ortho-photo.

Habitat Transition

Although consistent bank type was an important consideration in the initial selection of sampling sites, low precipitation before and during the study period resulted in abnormally low river levels. As water levels dropped during the study period, it became apparent this anomaly could potentially reduce the homogeneity of bank substrate within several sampling sites as river levels receded to the transition zone between the bank habitat and the riverbed. To evaluate the potential degree of change in bank material within sampling sites, and to determine if bank types should be reclassified seasonally, we evaluated bank substrate from about 5 feet below to 10 feet above ordinary low water (+3 feet; City of Portland datum; Greenworks et al. 2000) during December 2000 and January 2001. Percentages of each bank substrate type were visually estimated throughout each site length in 1-foot elevation increments using criteria in Table 4. Similarly, underwater substrate type was qualified below the waterline by tapping and "feeling" the bottom with a PVC pole throughout the length of the site. By standardizing these classifications to the U. S. Geological Survey river gauge (14211720) at the Morrison Bridge, the waterline bank substrate type at all sites could be estimated at any river stage (Table 5).

To assure subsequent analysis of fish catch rate data (Friesen et al. 2004, Pribyl et al. 2004) were applied to the appropriate habitat type, we assumed the waterline bank substrate should remain predominant (≥80%) to a depth 3 feet below the mean river stage (MRS-3). If a different substrate became predominant from MRS-3 and below, the bank substrate was reclassified accordingly. We adopted these rules to ensure the habitat extended into the water far enough to realistically have an effect on fish use. In January 2003, we surveyed each sample site to ensure seasonal bank substrate classifications were accurate. Six of the 20 standard sampling sites had some bank habitat transition during the year; the most common transition was from riprap to beach during low water conditions.

Habitat Surveys

Field Measurements

Habitat surveys were conducted during various times of the year from 2000 to 2003 to evaluate changes in measurements throughout the year due to fluctuations in river levels and water chemistry; surveys encompassed all seasons, and we performed several seasonal "ground truthing" assessments. The first habitat surveys were conducted in autumn 2000, followed by winter and spring 2001, winter, spring, and autumn 2002, and winter, spring, summer 2003. We collected an array of physical and chemical habitat measurements at each sampling site to group sites and determine similarities and differences among habitat types (Tables 6 and 7). Measurements were divided into two categories: nearshore and onshore. Onshore parameters included: bank slope, shoreline substrate, vegetative cover, number of outfalls, and buffer width. Instream parameters included: depth contour, water temperature, dissolved oxygen, conductivity, transparency, overhead cover, artificial light density, river bottom slope, distance to thalweg, and the number of pilings.

To accurately characterize the physical and chemical components of each sample site, measurements were made along a series of transects perpendicular to the shoreline (Figure 2). Depth contours and onshore parameters were usually measured along five "percentiles", which encompassed the length of the shoreline for each sample site. Instream parameters were usually measured in four "quartiles" (the area between each percentile) at randomly selected nearshore (within 25 m of shore) and offshore (26-50 m from shore) points. At sites with very short shoreline lengths, measurements were made at three percentiles and two quartiles. Water quality measurements were taken at the surface, in the middle of the water column, and at the bottom when depths permitted.

Table 5. Bank substrate percentages by river stage at select sampling sites in the lower Willamette River, May 2000 - June 2001. Ranges of consistent, dominant (≥75%) bank substrates are highlighted. The dashed line indicates normal low water elevation.

	Sampling site and bank substrate type																						
	010E		012W		051E		064W		079W		100W		112E			118W		133W		136E		203W	
Stage[a]	B	RR	B	RR	B	RR	B	RR	B	RR	B	RR	B	RR	UNC	B	RR	B	BE	B	RR	B	RO
13.1-14.0	75	25	0	100	0	100	0	100	0	100	0	100	0	56	44	0	100	0	100	0	100	37	63
12.1-13.0	75	25	0	100	0	100	0	100	0	100	0	100	0	56	44	0	100	0	100	0	100	37	63
11.1-12.0	75	25	0	100	0	100	0	100	0	100	0	100	0	56	44	0	100	0	100	0	100	37	63
10.1-11.0	75	25	0	100	0	100	0	100	0	100	0	100	0	56	44	0	100	0	100	0	100	37	63
9.1-10.0	87	13	0	100	0	100	0	100	0	100	0	100	0	56	44	0	100	0	100	0	100	37	63
8.1-9.0	87	13	0	100	0	100	0	100	0	100	0	100	0	56	44	0	100	0	100	0	100	37	63
7.1-8.0	87	13	0	100	0	100	0	100	0	100	0	100	0	56	44	6	94	0	100	0	100	37	63
*6.1-7.0	87	13	0	100	0	100	19	81	0	100	0	100	0	56	44	0	100	0	100	0	100	37	63
5.1-6.0	87	13	0	100	13	87	19	81	0	100	0	100	0	56	44	0	100	38	62	0	100	37	63
4.1-5.0	87	13	0	100	13	87	19	81	0	100	0	100	0	56	44	0	100	38	62	0	100	37	63
**3.1-4.0	87	13	0	100	13	87	19	81	0	100	0	100	0	56	44	0	100	50	50	0	100	50	50
2.1-3.0	94	6	0	100	19	81	38	62	6	94		c	6	50	44	0	100	50	50	0	100	50	50
1.1-2.0	100	0	0	100	28	72	63	37	25	75		c	6	50	44	0	100	87	13	0	100	50	50
0.1-1.0	100	0	0	100	81	19	94	6	88	12		c	6	50	44	0	100	94	6	19	81	50	50
-1.0- 0.0	100	0	100	0			100	0	88	12		c	68	12	19	44	56	94	6	57	43	50	50
-2.0- -1.1	100	0	100	0			100	0	88	12		c	81	6	13	68	32	94	6	94	6		

[a] Stage based on U. S. Geological Survey gauge 142411720 at the Morrison Street Bridge (river mile 12.7).

[b] B=beach; RR=riprap; UNC=unclassified fill; BE=bio-engineered; RO=rock outcrop

[c] Either riprap or cement, but likely riprap

* Spring 2000 mean river stage (MRS)=6.2; ** Summer 2000-Spring 2001 MRS=3.1-3.5

Table 6. Description of nearshore habitat parameter measurements at sampling sites in the lower Willamette River, May 2000 - March 2003.

Parameter	Equipment	Measurements	Description of methods
Temperature (°C)	Hydro-lab Quanta multimeter	24	Measured at surface (1 m below), mid-water, and bottom (1 m above substrate) at 1 random site within 0-25 m and 26-50 m from shore by site quartile (0-25, 26-50, 51-75, and 76-100 % of site length).
Conductivity (mS/cm)	Same as above	24	Same as temperature.
Dissolved oxygen (mg/L)	Same as above	24	Same as temperature.
Depth contour (m)	Fathometer (various models)	35	Measured at 5, 10, 15, 20, 30, 40, and 50 m from shore along each percentile. The 0 percentile represented the upstream end of the site and 100 percentile represented the downstream end.
Velocity (cm/s)	General Oceanics mechanical flow meter (model 2030R)	8	Measured at surface (1 m below) and bottom (1 m above substrate) at 1 random site within each site quartile. Measurements conducted 0-25 m from shore in quartiles 2 and 4 and 26-50 m from shore in quartiles 1 and 3. All measurements taken from a stationary boat (anchored or tied to piling).
Water transparency (cm)	Secchi disk (20 cm)	8	Measured at 1 random site within each site quartile at 0-25 m and 26-50 m from shore. The first depth is recorded when the secchi disk is lowered into shaded water and disappears; the second depth is recorded when the disk is lowered deeper and slowly raised until it reappears. The two values are then averaged.
Overhead cover density	Geographic Resource Solutions densitometer/ densiometer	40	Measured percent presence/absence of overhead cover at 0, 5, 10, 15, 20, 30, 40, and 50 m from shore along each percentile of the site.
Pilings	None	1	Count of all pilings at each site.
Outfalls	None	1	Separate counts of active (visible flow) and inactive (no flow) outfalls (sewer or drain pipes) within each site.

Table 7. Description of onshore habitat parameter measurements at sampling sites in the lower Willamette River, May 2000 - March 2003.

Parameter	Equipment	Measurements	Description of methods
Bank slope (degrees)	Suunto Clinometer	5	Measured at five perpendicular axes to the shoreline (0, 25, 50, 75, and 100% of site length).
Vegetative cover (%)	Tape measure	5	Measured within a 2 m wide by 10 m long swath perpendicular to the waterline at each percentile of the site. This measurement is conducted twice, for a total length of 20 m from the waterline. Vegetation percentages are visually estimated; classifications include: no vegetation, grasses, forbs, shrubs, and trees.
Buffer width (m)	Bushnell Yardage Pro 1000 laser rangefinder	5	Measured as the distance (m) from the shoreline to the nearest impervious structure or surface (paved road, building, etc.) at each percentile.
Shoreline substrate type	None	1	Measured as the percentage of each substrate in a 1-m^2 area, 1 m above the waterline, at each percentile. Substrate classifications are: beach (0-64 mm); rock / small riprap (65-256 mm); large riprap (257-512 mm); bedrock; seawall; artificial fill.

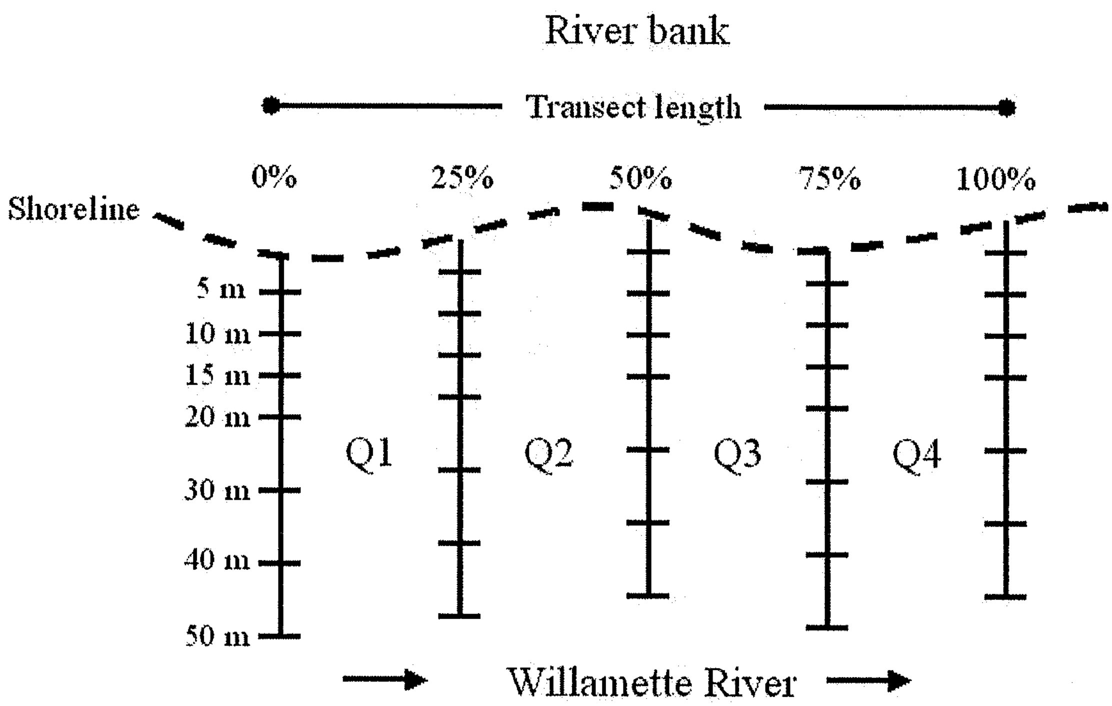

Figure 2. Schematic of sampling transects for habitat and water quality measurements in the lower Willamette River. Vertical bars perpendicular to the shoreline (at 25% increments) are percentiles; spaces between percentiles (Q1 – Q4) are quartiles.

Substrate Grain Size

In spring 2003, we used a standard ponar dredge (525 cm^2) to characterize sediment size (percent sand, silt, and clay) within the nearshore area. Using GIS, a polygon grid was created to randomly select sample locations within the nearshore habitat area of each sample transect. A GPS unit was used to navigate to the coordinates and a single grab sample was collected, placed in a plastic bag, and frozen for laboratory analysis. We collected samples from the 6 alcove sites and 15 standard sites; riprap, rock outcrop, and hardpan substrates at several standard sites precluded the collection of a substrate sample. The size-frequency distribution of sediment particles was analyzed at the U.S. Environmental Protection Agency field office Newport, Oregon. A Coulter LS 100Q laser diffraction particle size analyzer was used to measure the size distribution of particles in the range of 0.4 to 948 μm.

Distance to Thalweg

Using GIS, we made a series of 3 to 5 measurements along the percentile transect of each site. Distances were calculated by measuring the shortest distance from the water-shoreline interface to the thalweg for each site. A shapefile containing the lower Willamette River thalweg was provided by the City of Portland.

Seasonal Analysis of Habitat Groups

To provide a more quantitative approach to categorizing habitat types, we analyzed habitats based on surveyed parameters; the objective of this analysis was to group sample sites by season according to their physical and chemical attributes. Two multivariate techniques were used to analyze habitat data: cluster analysis and principal components analysis (PCA). Cluster analysis groups treatments (the sample sites) into clusters according to similarities in parameter measurements (the habitat parameters). The Ward hierarchal cluster analysis is commonly used and appeared to be the most appropriate data classification method for this study. Like other clustering techniques, Ward's method follows a series of clustering steps that begins with many clusters, each containing one object (e.g. a sampling site) and ends with one cluster containing all of the objects. The method successively merges clusters with the smallest variance, producing closely related groups of objects (Romesburg 1984).

We then applied PCA using SYSTAT software (SSI 2003) to determine which instream and onshore parameters were important in grouping sample sites and explaining variation among sites. Prior to this analysis, the data were separated by season and transformed to achieve a more normal distribution (Romesburg 1984; Neill et al. 1995; Goldstein et al. 1996).

As nearshore habitat use by fish is the focus of the study, we used only nearshore surface water quality measurements in the multivariate investigation, thus eliminating redundant parameters (Goldstein et al. 2002). River bottom slope was calculated using only nearshore depths (5, 10, and 20 m from shore) and the depth 20 m from shore was selected as the single nearshore depth included in multivariate analyses. Habitat data measured as percentages were arcsine transformed, the number of nearshore pilings, nearshore slope, and total outfalls categories were log $(x + 1)$ transformed, and the remaining instream habitat parameters were log transformed. Data were then standardized to a mean of 0 and a standard deviation of 1 prior to cluster analysis and PCA (Zitko 1995; Goldstein et al. 2002; SSI 2003).

Data for each season were also separated into instream and onshore measurements to determine which parameters from each set of measurements explained the majority of the variation among clusters. As a result of similar measurements among sites, buffer width was not included in PCA for any season. Using the methods described by Jolliffe (1972), we selected the variable with the highest absolute value loading from each successive axis until 75% of the overall variance was explained (Goldstein et al. 2002).

RESULTS

Study Area Habitat Evaluation

The majority (59.2%) of the riverbank habitat available in the study area was classified as undeveloped, and had not been modified by an obvious treatment or nearshore development (Table 8, Figure 3). Beach was the most abundant habitat type in both the upper (above Ross Island Bridge) and lower (below Ross Island Bridge) sections of the study area, but the

Table 8. Summary of habitat types and nearshore structures by area in the lower Willamette River, January - August 2001.

	Habitat below Ross Island Bridge (rm 0.0-13.9)		Habitat above Ross Island Bridge (rm 14.0-26.5)		Total habitat (rm 0.0-26.5)		Total nearshore structures (rm 0.0-26.5)		Total habitat and nearshore structures (rm 0.0-26.5)	
Habitat and nearshore structure type	Length (m)	% of total	Length (m)	% of total	Length (m)	% of total	Length (m)	% of total	Length (m)	% of total
Beach	13,471	29.1	21,826	38.8	35,297	34.4	0	0.0	35,297	29.0
Rock outcrop	0	0.0	14,763	26.3	14,763	14.4	0	0.0	14,763	12.1
Rock	1,687	3.7	8,974	16.0	10,661	10.4	0	0.0	10,661	8.7
Seawall	3,036	6.6	467	0.8	3,503	3.4	0	0.0	3,503	2.9
Vegetated riprap	11,358	24.5	6,773	12.0	18,131	17.7	0	0.0	18,131	14.9
Non-vegetated riprap	3,482	7.5	445	0.8	3,927	3.8	0	0.0	3,927	3.2
Bio-engineered	389	0.8	0	0.0	389	0.4	0	0.0	389	0.3
Unclassified fill	9,421	20.4	2,980	5.3	12,401	12.1	0	0.0	12,401	10.2
Pilings-allowing light[a]	1,315	2.8	0	0.0	1,315	1.3	6,793	35.0	8,108	6.6
Pilings-limiting light[a]	2,127	4.6	0	0.0	2,127	2.1	2,734	14.1	4,861	4.0
Floating-allowing light	0	0.0	0	0.0	0	0.0	7,659	39.5	7,659	6.3
Floating- limiting light	0	0.0	0	0.0	0	0.0	2,202	11.4	2,202	1.8
Total	46,286	100	56,228	100	102,514	100	19,388	100	121,902	100

[a] Classified as bank habitat instead of a nearshore structure type when highly incorporated into the bank and no separate bank habitat classification could be determined.

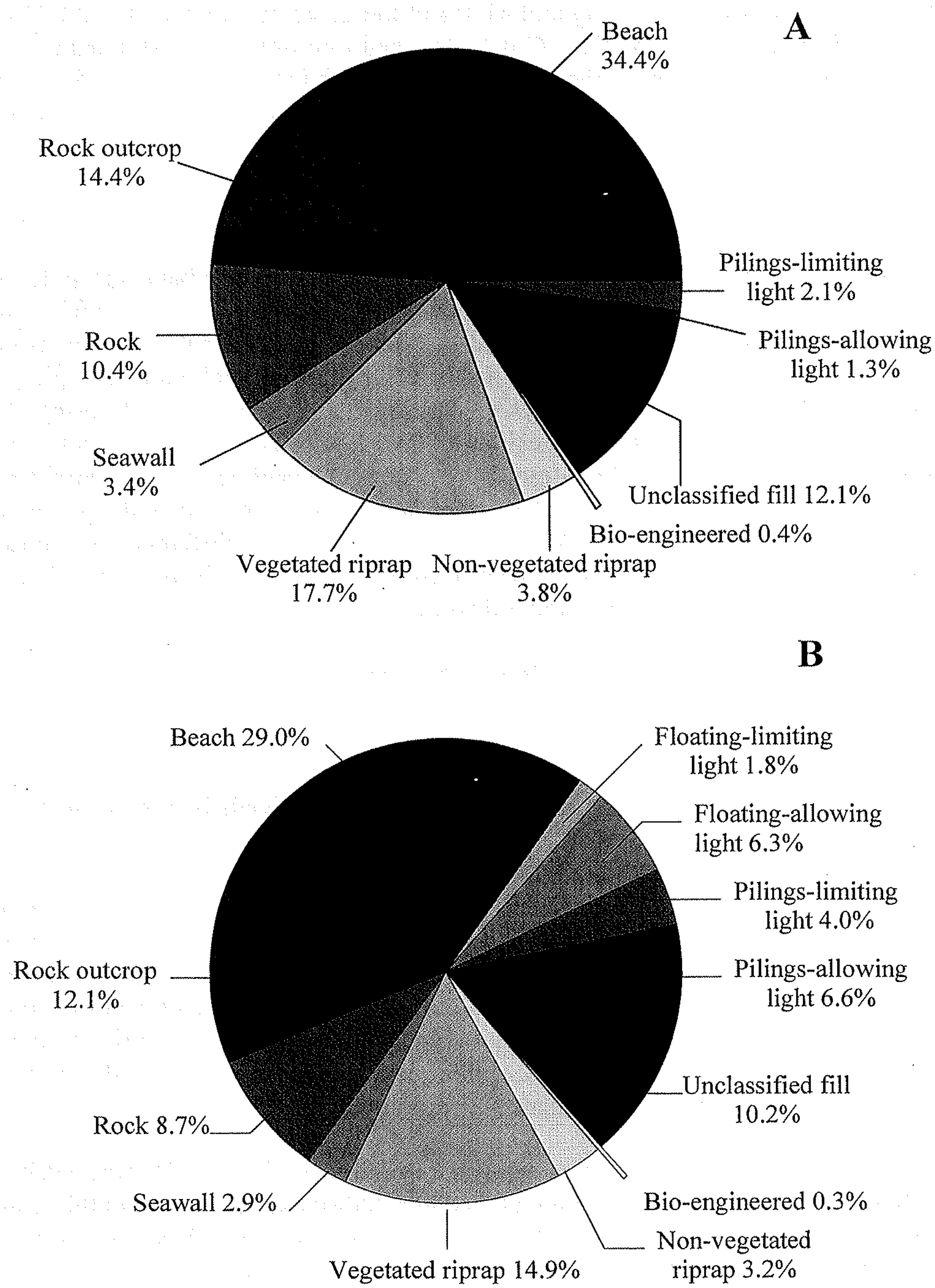

Figure 3. Percent of available (A) habitat types and (B) habitat and nearshore structure types in the lower Willamette River, January – August 2001. Piling structures in (A) were classified as bank habitat instead of a nearshore structure type because they were highly incorporated into the bank and no separate classification could be determined.

distribution of other habitat types was quite different (Table 8; Figure 4). Undeveloped or "natural" bank habitat occurred throughout 81.1% of the upper section but only 32.8 % of the lower section. Riprap and unclassified fill were two and four times more abundant in the lower section than the in upper section. Nearshore structures were found adjacent to 18.7% of the study area shoreline. About 75% of these structures were classified as allowing light and 25% limited light penetration.

Habitat Transition

During the three-year study period, several sites transitioned from one bank substrate to another or had mixed habitat (no predominant bank habitat). During year 1 (summer 2000-spring 2001), only three sites (051E, 064W and 079W) transitioned from one bank substrate (riprap) to another (sand)(Table 9). One additional site (112E) had mixed habitat throughout all sampling seasons and was not included in bank habitat analyses. During year 2 (summer 2001-spring 2002), four sites (012W, 051E, 064W and 079W) transitioned from one bank substrate to another (Table 10). Two additional sites (133W and 136E) transitioned from one bank substrate to mixed habitat. During year 3 (summer 2002-summer 2003), water levels were higher than the previous year and only three sites (051E, 064W and 079W) transitioned between two different bank substrates (Table 11). One additional site (133W) transitioned from beach to mixed habitat. Undeveloped sites and seawalls remained consistent regardless of river stage.

Habitat Surveys

Field Measurements

Physical and chemical parameters are summarized for quantitative habitat types in Table 12 and are described below.

Beach: Eight sampling sites were characterized as beach treatments (006E, 010E, 031W, 040W, 069W, 097E, 167W, 243W). These sites tended to have a shallow shelving shoreline consisting mainly of sand, silt, or fine gravel, and had few pilings or outfalls. Nearshore depths tended to be shallow, as 20 m (from shore) depths were significantly ($P<0.05$) shallower than rock outcrop, seawall, and riprap sites. Bank slopes were gentle and there was little vegetation on the first 10 m of shoreline. The buffers at beach sites generally extended a large distance from the shoreline and were significantly wider than seawall buffers ($P < 0.05$).

Alcove / off-channel: Six sampling sites were characterized as alcoves (067EA, 076WA, 107WA, 148WA, 232WA, 239EA). We included one additional site (148E) in this group because it likely provided off-channel habitat similar to the alcoves. These sites were often surrounded by river bank on three sides. Shoreline substrates were most often beach or a mix of beach and riprap or fill. The river bottom tended to be uniform and shallow; the average slope was significantly lower than rock outcrop and riprap sites ($P < 0.05$). There were also a large number of pilings associated with these sites.

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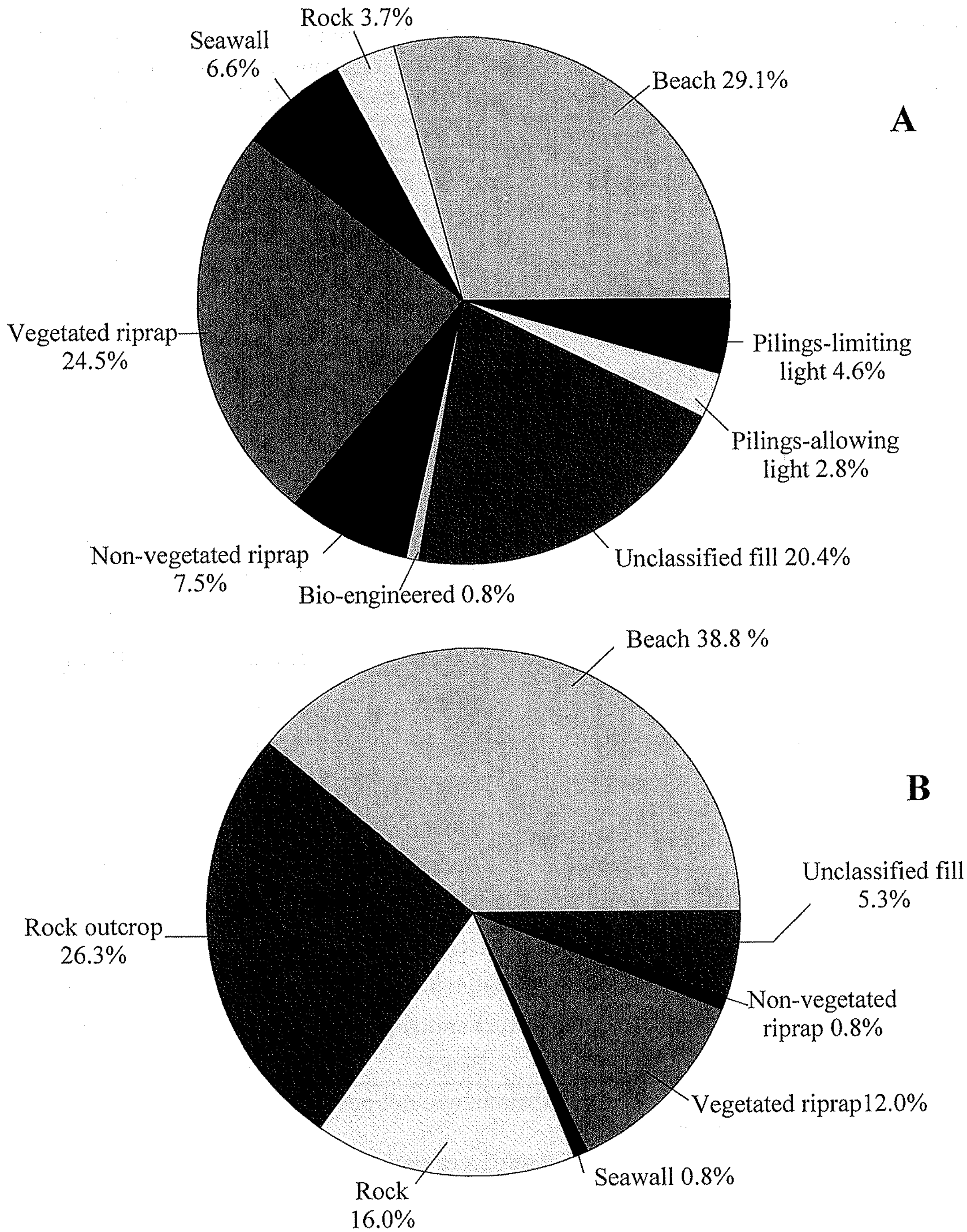

Figure 4. Percent of available habitat types downstream (A) and upstream (B) of Ross Island Bridge in the lower Willamette River, January – August 2001.

Table 9. Bank substrate of sampling sites in the lower Willamette River by season and year, May 2000 - June 2001. Classifications are based on a minimum of 80% similar substrate existing within –3 ft. of the sampling period mean river stage (MRS). N/A = not available.

	Sampling season and mean river stage				
Site	Spring 2000 MRS 6.2	Summer 2000 MRS 3.1	Autumn 2000 MRS 3.2	Winter 2001 MRS 3.4	Spring 2001 MRS 3.5
006E	N/A	Beach	Beach	Beach	Beach
010E	Beach	Beach	Beach	Beach	Beach
012W	N/A	Beach	Beach	Beach	Beach
031W	Beach	Beach	Beach	Beach	Beach
040W	Beach	Beach	Beach	Beach	Beach
048E	Seawall	Seawall	Seawall	Seawall	Seawall
051E	Riprap	Beach	Beach	Beach	Beach
064W	Riprap	Beach	Beach	Beach	Beach
079W	Riprap	Beach	Beach	Beach	Beach
097E	Beach	Beach	Beach	Beach	Beach
100W[a]	Riprap	Riprap	Riprap	Riprap	Riprap
112E[b]	Mixed	Mixed	Mixed	Mixed	Mixed
118W	Riprap	Riprap	Riprap	Riprap	Riprap
121W	Seawall	Seawall	Seawall	Seawall	Seawall
133W	N/A	N/A	Beach	Beach	Beach
136E	Riprap	Riprap	Riprap	Riprap	Riprap
148E	Beach	Beach	Beach	Beach	Beach
167W	Beach	Beach	Beach	Beach	Beach
200E	Rock outcrop	Rock outcrop	Rock outcrop	Rock outcrop	Rock outcrop
219W	Rock outcrop	Rock outcrop	Rock outcrop	Rock outcrop	Rock outcrop
243W	Beach	Beach	Beach	Beach	Beach

[a] Site classified as riprap although bank substrate was not positively identified below MRS 3.0. Likely riprap or cement.

[b] No predominant bank substrate existed at any river stage.

Table 10. Bank substrate of sampling sites in the lower Willamette River by season and year, July 2001 through June 2002. Classifications are based on a minimum of 80% similar substrate existing within –3 ft. of the sampling period mean river stage (MRS).

	Sampling season and mean river stage			
Site	Summer 2001 MRS 2.3	Autumn 2001 MRS 3.8	Winter 2002 MRS 5.6	Spring 2002 MRS 7.0
006E	Beach	Beach	Beach	Beach
010E	Beach	Beach	Beach	Beach
012W	Beach	Riprap	Riprap	Riprap
048E	Seawall	Seawall	Seawall	Seawall
051E	Beach	Beach	Riprap	Riprap
064W	Beach	Beach	Mixed	Riprap
079W	Beach	Mixed	Riprap	Riprap
100W[a]	Riprap	Riprap	Riprap	Riprap
116E	Riprap	Riprap	Riprap	Riprap
121W	Seawall	Seawall	Seawall	Seawall
133W	Beach	Beach	Mixed	Mixed
136E	Mixed	Riprap	Riprap	Riprap
148E	Beach	Beach	Beach	Beach
167W	Beach	Beach	Beach	Beach
200E	Rock outcrop	Rock outcrop	Rock outcrop	Rock outcrop
219W	Rock outcrop	Rock outcrop	Rock outcrop	Rock outcrop

[a] Site classified as riprap although bank substrate was not positively identified below MRS 3.0.

Riprap: Six sampling sites were characterized as riprap (012W, 079W, 100W, 116E, 118W, and 136E). Continuous stone revetments mechanically placed to curtail erosion and prevent alterations to the main channel characterized these sites. The river bottom was relatively steep, resulting in a significantly greater slope than at alcove sites ($P < 0.05$). In addition, depths at 5, 10, and 20 m from shore were significantly greater than those at beach sites ($P < 0.05$).

Mixed (riprap/beach/unclassified fill): Four sampling sites were characterized as a mixture of riprap, beach, or unclassified fill depending on river levels (051E, 064W, 112E, and 133W). These sites typically contained stone revetments down to the water line, which then transitioned to beach or fill. Mixed sites had an intermediate bottom slope and bank slope and a narrow buffer width (mean 22.7 m).

Table 11. Bank substrate of sampling sites in the lower Willamette River by season and year, July 2002 through September 2003. Classifications are based on a minimum of 80% similar substrate existing within –3 ft. of the sampling period mean river stage (MRS).

	Sampling season and mean river stage				
Site	Summer 2002 MRS 4.8	Autumn 2002 MRS 3.2	Winter 2003 MRS 5.6	Spring 2003 MRS 7.2	Summer 2003 MRS 3.2
006E	Beach	Beach	Beach	Beach	Beach
010E	Beach	Beach	Beach	Beach	Beach
012W	Riprap	Riprap	Riprap	Riprap	Riprap
048E	Seawall	Seawall	Seawall	Seawall	Seawall
051E	Mixed	Beach	Riprap	Riprap	Beach
064W	Mixed	Beach	Mixed	Riprap	Beach
079W	Mixed	Beach	Riprap	Riprap	Beach
100W[a]	Riprap	Riprap	Riprap	Riprap	Riprap
116E	Riprap	Riprap	Riprap	Riprap	Riprap
121W	Seawall	Seawall	Seawall	Seawall	Seawall
133W	Beach	Beach	Mixed	Mixed	Beach
136E	Riprap	Riprap	Riprap	Riprap	Riprap
148E	Beach	Beach	Beach	Beach	Beach
167W	Beach	Beach	Beach	Beach	Beach
200E	Rock outcrop	Rock outcrop	Rock outcrop	Rock outcrop	Rock outcrop
219W	Rock outcrop	Rock outcrop	Rock outcrop	Rock outcrop	Rock outcrop

[a] Site classified as riprap although bank substrate was not positively identified below MRS 3.0.

Seawall: There were two seawall sites (048E, 121W). These treatments are impervious vertical retaining walls, generally composed of concrete or sheet pile, that extend beyond ordinary low water. These habitats were uniformly deep and homogenous with a bottom slope significantly less than rock outcrop sites ($P < 0.05$). Because the bank is a vertical wall, the bank slope was 90°, and there was no buffer. These treatments contained large numbers of pilings and outfalls.

Rock Outcrop: There were two rock outcrop sites (200E, 219W), which both were found in the upper portion of the study area. This habitat contains natural bedrock formations consisting of angular ledges, protrusions, and sheer rock faces. Bank slopes were steep and buffer distances were large. The bottom slope was significantly steeper than beach, seawall, and alcove sites ($P < 0.05$). These were the deepest sites sampled with a mean depth of 21 m at a distance of 50 m from shore and were significantly deeper at 50 m from shore than all other habitat types except

Table 12. Mean measurements of instream and onshore parameters for each habitat type in the lower Willamette River, 2000 – 2003. Values differed significantly among types where $P \leq 0.05$.

Parameter	Beach	Riprap	Mixed	Alcove	Seawall	Rock outcrop	*P*
Depth 5m from shore (m)	0.5	1.9	1.3	1.1	11.4	3.8	<0.05
Depth 10m from shore (m)	1.1	3.9	2.7	2.4	12.1	9.0	<0.05
Depth 20m from shore (m)	2.3	7.5	6.0	3.6	13.7	15.2	<0.05
Depth 30m from shore (m)	3.4	9.9	7.9	4.2	15.0	18.8	<0.05
Depth 40m from shore (m)	4.6	11.4	9.5	4.6	15.8	21.0	<0.05
Depth 50 m from shore (m)	6.1	12.1	10.9	5.0	16.6	21.0	<0.05
Bottom slope (degrees)	0.1	0.2	0.2	0.1	0.1	0.4	<0.05
% Overhead cover	1.5	9.9	6.8	1.2	3.7	0.0	0.31
% No vegetation –10 m	9.7	24.3	10.5	17.6	100.0	29.0	0.07
% No vegetation – 20 m	36.8	46.5	41.5	38.7	100.0	60.5	0.17
Bank slope (degrees)	8.9	21.2	22.5	12.5	90.0	23.4	<0.05
Buffer width (m)	159.3	53.9	22.7	100.9	0.0	141.0	<0.05
Water temperature (°C)	12.2	11.3	11.6	12.3	12.7	13.7	0.82
Conductivity (μS)	84.4	74.8	78.4	69.1	74.6	69.2	0.05
Dissolved O_2 (mg/L)	9.9	10.2	10.1	10.0	9.8	9.6	0.84
Transparency-nearshore	94.5	97.2	105.4	82.9	100.4	131.4	0.40
Transparency-offshore	109.9	99.2	111.1	86.3	104.8	141.0	0.06
Number of pilings	17.0	54.7	68.4	94.0	100.0	2.0	0.41
Number of outfalls	1.0	7.8	4.2	0.0	70.0	1.0	<0.05

the two seawall sites ($P < 0.05$). Although these sites have substantial ground vegetation up to 20 m from the waterline, there was no overhanging cover. Transparency values were higher at rock outcrop habitats than at any other habitat type.

Substrate Grain Size

Several sites (100W, 116E, 121W, 200E, and 219W) had riprap, rock, or hardpan substrates and could not be sampled for sediment size. Mean sediment size among sites sampled ranged from 26.2 to 437.5 μm (Table 13). Fine sediments (silt and clay) dominated 12 of 21 sites and site 232WA had the highest composition (92%) of fine sediments. Most (5 of 6) off-channel sites had substrates comprised mainly of silt or clay. Eight sites had substrates dominated by sand; sites classified as beach typically had the highest composition of sand and the largest mean grain size.

Table 13. Sediment size and percent composition of bottom substrates from sampling sites in the lower Willamette River, spring 2003.

Transect	Mean substrate size (μm)	% Sand	% Silt	% Clay
006E	201.33	82.78	14.84	2.38
010E	95.39	49.86	41.38	8.77
012W	65.53	39.80	50.23	9.97
040W	98.07	42.95	47.22	9.83
048E	44.28	16.20	71.81	11.99
051E	65.57	28.60	56.60	14.80
064W	88.70	35.01	53.51	11.49
067EA	38.60	16.21	72.92	10.87
069W	437.53	98.24	1.56	0.20
076WA	50.31	15.95	72.33	11.72
079W	152.34	46.22	44.68	9.10
097E	60.79	32.72	56.50	10.78
107WA	398.54	89.51	8.25	2.24
133W	94.41	50.47	40.38	9.15
136E	129.33	63.01	31.03	5.96
148E	136.65	82.53	13.84	3.62
148WA	76.84	41.31	51.61	7.08
167W	119.58	51.40	41.25	7.35
232WA	26.22	7.88	77.00	15.12
239EA	77.03	39.05	52.02	8.93
243W	206.97	83.02	14.12	2.85

Distance to Thalweg

Standard transects in the lower portion of the river, below rm 14.0, had a lower mean distance to the thalweg (223 m) than standard sites in the upper portion of the river (325 m) (Table 14). Off-channel sites were a mean distance of 277 m from the thalweg and distances among sites were comparable to those of standard transects. The beach transect 148E, located on the east of Ross Island, was the farthest site from the thalweg at a mean distance of 1,094 m, and was therefore grouped as an off-channel site. The rock outcrop site (219W) on Hog Island was closer to the

Table 25. Summary of principal components analysis of instream habitat in the lower Willamette River, autumn 2001-2002. Shaded numbers indicate the highest eigenvalue in each axis.

Variable	Axis 1	2	3	4
%SAND	-0.990	0.009	0.020	0.043
%SILT	0.971	-0.012	0.144	0.000
SUBSIZE	-0.951	0.022	-0.006	-0.035
%CLAY	0.943	-0.013	0.016	-0.038
SURFO_2N	0.568	-0.428	-0.596	-0.074
PILINGN	0.543	0.054	0.353	0.450
DEPTH20M	0.516	0.779	0.110	0.060
TRANSPN	0.075	0.889	-0.271	0.262
STEMPN	-0.450	0.687	0.510	0.007
SLOPEN	0.099	0.686	-0.294	-0.313
PORTGAGE	-0.337	0.161	-0.704	-0.053
SCONDN	0.012	-0.232	0.572	-0.544
DISTHAL	-0.274	-0.359	0.057	0.678
% Total variance explained	38.5	21.0	13.5	8.8

any parameter in any season. Nearshore transparency had the highest eigenvalue in the second axis. The third and fourth axes were related to river hydrology; mean river level and mean distance to the thalweg were the most important parameters in these axes.

The first five axes of the onshore PCA explained over 76% of the variability (Table 26). Vegetative ground cover 10 m from the waterline was important in describing axis 1 and 3; percent no vegetation and percent grass at 10 m from the waterline had the highest loadings. Bank slope was selected from the second axis, and the fourth and fifth axes described bank composition (seawall and rock).

DISCUSSION

Identifying habitat parameters that influence fish abundance and diversity can be important in guiding future restoration and management efforts, but is often complex. Juvenile salmonid habitat preferences change throughout the year as environmental conditions fluctuate (Allen 2000; Orsi et al. 2000). Habitat use may also change with other factors, such as growth. Chinook salmon fry in the Wenatchee River, for example, occupied slow-moving, shallow stream margins whereas larger subyearling fish used faster, deeper water (Hillman et al. 1989). In addition, physical habitat attributes are rarely static, changing throughout the year as environmental conditions fluctuate.

Table 26. Summary of principal components analysis of onshore habitat in the lower Willamette River, autumn 2001-2002. Shaded numbers indicate the highest eigenvalue in each axis.

Variable	Axis 1	2	3	4	5
%10MNOVEG	-0.950	-0.032	-0.088	-0.002	-0.031
%10MFORB	0.825	0.296	-0.287	0.141	-0.105
%20MFORB	0.746	0.132	-0.364	0.168	-0.249
%LGRIPRAP	0.703	0.381	-0.296	-0.059	0.196
%10MTREES	0.687	0.047	-0.581	0.203	0.254
%20MNOVEG	-0.620	0.110	-0.286	0.475	-0.231
BANKSLOPE	0.210	0.782	0.339	0.431	0.005
OUTFALLS	-0.449	0.700	0.080	0.418	0.005
%BEACH	-0.388	-0.690	-0.533	-0.128	0.007
%SEAWALL	-0.428	0.606	0.000	0.568	-0.052
%10MGRASS	0.228	-0.389	0.696	0.271	0.395
%BEDROCK	0.213	-0.255	0.602	0.402	0.196
%20MGRASS	0.218	-0.412	0.595	0.379	0.376
DENSITOM	-0.103	0.387	0.118	-0.526	0.268
%10MSHRUBS	0.299	0.235	0.500	-0.522	-0.305
%ARTFILL	0.102	0.257	0.293	-0.517	-0.019
%ROCK	0.283	-0.310	0.210	0.146	-0.740
%20MSHRUBS	0.341	-0.275	0.340	0.179	-0.674
%SMRIPRAP	0.034	0.409	0.233	-0.469	0.060
%20MTREES	0.414	-0.287	-0.372	0.196	0.273
% Total variance explained	23.5	16.4	15.2	12.6	9.1

Waite and Carpenter (2003) indicated fish assemblages were greatly influenced by physical habitat diversity and quality in Willamette basin streams. Critical fish habitat parameters such as habitat complexity, vegetative cover, and large woody debris are severely limited in the lower Willamette River, especially near Portland, making the recognition of important habitat types essential for the protection of listed species. Much of the natural bank habitat below the Ross Island Bridge has been replaced by artificial habitats, which previous studies have shown to decrease aquatic species richness and diversity in the middle Willamette River (Hjort et al. 1984). In addition, Li et al. (1984) concluded larval and juvenile salmonid densities were lower at some sites in the Willamette River as a result of unfavorable conditions created by riprapped banks.

In our study, data reduction procedures and PCA reduced the number of habitat parameters from 60 to just 9 or 10 measurements for each season, eliminating redundant and homogeneous data. Vegetation (or lack of vegetation), substrate type, hydrology, and bank substrate explained the majority of the variation in our habitat data. Similar PCA results were noted for several rivers in British Columbia; water velocity, substrate size, water depth, and distance to cover explained most of variation in habitats (Taylor 1991). In our study, percent sand composition in bottom substrates was identified by PCA as an important source of variation among habitat types in every season. This parameter was always present in the first PCA axis and had very high eigenvalues (0.96 - 0.99). Onshore vegetation also appeared to be an important explanatory variable. The proportion of the riverbank that lacked vegetation at 10 m (summer and autumn) and 20 m (winter and spring) from the waterline also had high eigenvalues in the first PCA axis during every season. Other parameters identified in at least two seasons included: river level (gauge height), water depth 20 m from shore, distance to the thalweg, nearshore transparency, % beach, % small riprap, % bedrock, and bank slope. Bank substrates appeared to be especially important during spring. Additional surveys of bottom substrates should be conducted, as we were able to collect samples only during one season of one year. Percent sand appeared to be a highly important variable in explaining variation among sites, and is likely related to other parameters (e.g. bottom slope, % beach, depth).

Instream habitat measurements were more important in explaining variation among sites than onshore parameters, as eigenvalues were typically higher for these variables in each season. Water quality data indicated river chemistry varied little among sites; nearshore transparency was the only water quality measurement identified as an important component by PCA in more than one season.

Artificial and natural habitats tended to segregate, and although the upper portion of the study area (above Ross Island) contained more natural habitat, there was little evidence to suggest separation of upstream and downstream sites. Summer 2003 was the only period in which sites separated longitudinally; cluster group 1 consisted of natural habitats in the upper river (rkm 15.6 and above), whereas cluster group 2 consisted largely of natural habitats in the lower portion of the river (rkm 12.2 and below). Groups of sites identified with cluster analysis tended to correspond with the subjective (qualitative) habitat categories defined early in the study. For example, sites subjectively labeled as seawall and rock outcrop segregated into distinct groups during every season. Similar results were observed for beach sites, which were often grouped together. Riprap, rock, and mixed habitat types often appeared in multiple groups. These patterns increased our confidence that qualitative descriptions of habitats based on appearance were not wholly inaccurate, and the multivariate analyses were reliable in determining differences among habitats based on measured parameters.

Analyses conducted in the early years of this study identified little variation in fish community structure and abundance among habitats, particularly for ESA-listed salmonids (North et al. 2002; Friesen et al. 2002). However, the analyses were based solely on the subjective habitat classifications. We expect the habitat groups and variables identified in this report will be useful in further characterizing habitat use by fishes of the lower Willamette River, and may result in the development of scientifically valid management recommendations (see Friesen et al. 2004 and Pribyl et al. 2004).

Biology, Behavior, and Resources of Resident and Anadromous Fish in the Lower Willamette River

Final Report of Research, 2000-2004

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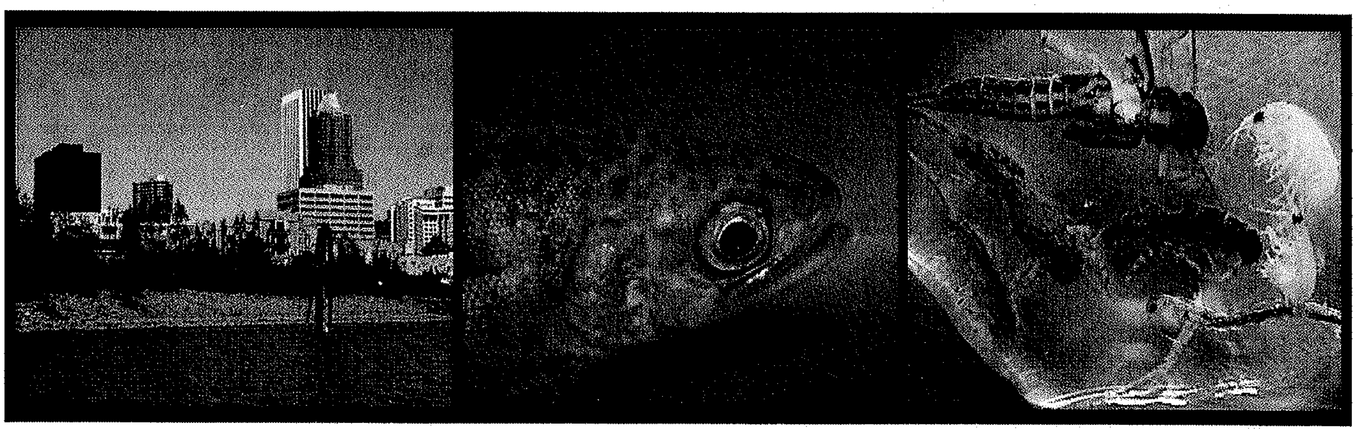

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To retain a manageable length of the comment submittal, only a representative sample of this references pages are included.

PREFACE

This document is the final report of research for a project funded by the City of Portland (COP) and conducted by the Oregon Department of Fish and Wildlife (ODFW). The general objective was to evaluate aquatic habitat and biotic communities in the lower Willamette River, and provide guidance for protecting species of threatened and endangered salmonids. Our report includes five research papers that describe how we addressed project hypotheses and objectives, how we reached our conclusions, and why we made our recommendations. The papers are listed and numbered in the Table of Contents, and the numbers are used to reference each paper in the Summary. The Summary integrates the results, conclusions, and recommendations, and provides the best overall picture of the status of aquatic resources in the lower Willamette River. The recommendations presented here were developed by the principal investigators, and will not necessarily be adopted as policies or guidelines by the Oregon Department of Fish and Wildlife.

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Many thanks to all the people who helped us accomplish our objectives over the past four years. The Portland Development Commission, the Portland Bureau of Environmental Services, the Portland Bureau of Development Services, and the Lower Willamette Group each contributed financial support for the project. Josh Allen, Chris Burnside, Sarah Courbis, Travis Eoff, Erin Phillips-Fincher, Ben Galuardi, Alex Gonyaw, J. T. Hesse, Michele Hughes, Jenny Kauffman, Jim Koloszar, Kathy Lisa, Casey Myers, Jodene Summers, Jason Vassar, Brian Vaughn, Mike Wallace, and Virgil Lee Watts of ODFW conducted much of the field sampling. Lisa Burner, Bonnie Cunningham, Ruth Farr, Jennifer Graham, and Howard Takata of ODFW co-authored annual reports and conducted field work. Matthew Powell and Joshua Tompkins of ODFW and Chad Smith of COP also assisted with field sampling. George Reed of ODFW purchased and maintained project equipment. Dave Ward of ODFW administered the project and provided expertise and guidance. John North of ODFW was instrumental in implementing the project, and served as project leader through 2001. Jim Middaugh, Mike Reed, and Chris Prescott of COP were project partners and provided detailed reviews of project design. Noah Adams, Scott Evans, John Plumb, Dennis Rondorf, Jamie Sprando, and Kenneth Tiffan of the U.S. Geological Survey provided expertise on radio telemetry design and techniques. Rick Boatner, Ken Bourne, Dick Caldwell, Milton Hill, Chris Kern, and Tom Rien of ODFW contributed time, supplies, equipment, and expertise. LTJG Katie Blanchard, CWO Robert Coster, and Captain G. F. Greene (U. S. Coast Guard); Karen Guntly (H. Naito Properties); Tony Lester, Brenda Strombo, and Alan Young (Multnomah County Department of Environmental Services-Transportation Division); Gene Loffler (Cargill Inc.); Jennifer Martinez (COP); and Mac Robinson (U. S. Army Corps of Engineers) provided facility access for radio telemetry fixed site locations; Skip and Joann White provided access at their residence for a radio telemetry fixed site. Dan Domina and Howard Bess (Portland General Electric); Captain Glenn Eisner (COP Fire Bureau); Jeff Jennings (Staff Jennings); and Sergeant Paul Steigleder (Clackamas County Sheriff Department) provided facility access for collection and holding of juvenile salmonids. Neil Bower, Terry Key, and Mike van den Tillaart of Lotek Engineering provided valuable assistance with radio telemetry. Mike Reed of COP, Dave Ward of ODFW, and Roger Peters of the U.S. Fish and Wildlife Service provided many helpful comments on earlier drafts of this report.

SUMMARY

Paper 1 - Description and Categorization of Nearshore Habitat in the Lower Willamette River

Our objective in this paper was to define and catalog existing nearshore fish habitat. We also identified habitat categories for subsequent analyses of fish use (Papers 2 and 3). Habitats were initially separated into six categories (beach, alcove, riprap, seawall, rock outcrop, and mixed) and 12 sub-categories based on their appearance and function. The majority (59.2%) of riverbank habitat in the study area (mouth to Willamette Falls) was undeveloped ("natural"), with no obvious modifications such as seawalls, riprap, or piers. Beaches were the most prevalent habitat type in the upper (above Ross Island Bridge; 38.8%) and lower (29.1%) sections of the study area, but the distribution of other types was considerably different. Undeveloped habitats composed 81.1% of the habitat in the upper section, but only 32.8% in the lower section. Nearshore structures (e.g., piers, docks, pilings) were associated with 18.7% of the total shoreline area.

To provide a more quantitative approach to habitat categorization, we intensively surveyed 27 sites during spring, summer, autumn, and winter. We measured 60 physical or chemical parameters at each site, both instream and onshore. We then used cluster analysis and principal components analysis to group habitats and identify the parameters that contributed most to their separation. Sampling sites separated into five or six clusters in each season. Sites initially classified as seawall or rock outcrop always segregated into distinct groups. Sites described as beaches often occurred together in a group; riprap, rock, and mixed habitat types often appeared in multiple groups. These patterns increased our confidence that the initial groupings based on appearance were relatively accurate, and the multivariate analyses were useful in determining categories based on measured parameters.

Bank vegetation, bottom substrate type, hydrology, and bank substrate type explained the majority of the variation in habitat data, and contributed most to the separation of sites into clusters. The percent of the bottom substrate composed of sand and onshore vegetation were important explanatory variables in every season; parameters important in at least two seasons included: river level, water depth, distance to the thalweg, transparency, bank slope, percent beach, percent small riprap, and percent bedrock. River chemistry (temperature, dissolved oxygen, and conductivity) varied little among sites during individual seasons, and did not contribute appreciably to site groupings.

Paper 2 - Migratory Behavior, Timing, Rearing, and Habitat Use of Juvenile Salmonids in the Lower Willamette River

Using electrofishing, beach seines, and radio telemetry, we assessed components of juvenile salmonid biology that would lead to a better understanding of their behavior in the lower Willamette River. We focused largely on nearshore habitat use, but also explored outmigration timing, size structure, growth, migration rate, and residence time.

Most (87%) juvenile salmonids we captured were Chinook salmon. Coho salmon and steelhead composed relatively small proportions of the catch (9% and 3%), and we occasionally observed mountain whitefish, sockeye salmon, and cutthroat trout. Hatchery-produced fish dominated the catch, composing 54% of the Chinook salmon, 66% of the coho salmon, and 91% of the steelhead. The electrofishing catch was dominated by large (>100 mm fork length) hatchery Chinook salmon; beach seines captured mostly small (≤100 mm fork length) Chinook salmon. Based on this gear selectivity and natural breaks in length frequencies, we assumed that Chinook salmon >100 mm fork length were yearlings (age 1) and smaller fish were subyearlings (age 0). Because we observed a large number of subyearling fish, and the abundance of fall Chinook salmon in the Willamette Basin is low, we concluded most small Chinook salmon in the lower Willamette River are spring-run fish that outmigrate as subyearlings.

The outmigration period for Chinook salmon, both hatchery and unmarked, was surprisingly long. The presence of juvenile fish often increased in late autumn and persisted into the next summer, and juvenile salmonids were present in every month we sampled from May 2000 to July 2003. Winter and spring were clearly the periods of greatest abundance, though the presence of different races (spring and fall), size classes, and stocks undoubtedly confounded our ability to completely assess timing. Coho salmon and steelhead were generally present only during winter and spring.

Median fork lengths and weights of hatchery and unmarked Chinook salmon were often significantly greater at downstream sampling sites than at upstream sites during winter and spring, suggesting these fish grow as they migrate through the study area. Observed changes in fork length ranged from 1-14 mm and equated to growth rates that were somewhat higher than described in the literature. Considering the large sample size, consistent pattern, and statistical strength of our analyses, we concluded that Chinook salmon exhibit changes in size during their migration through the lower Willamette River. Because these fish feed extensively (see Paper 4), the size changes we observed are likely a product of growth. Differential mortality among size classes of salmonids is a potential confounding factor that needs to be fully assessed.

We radio-tagged 186 juvenile salmonids from 2001 to 2003, including 95 Chinook salmon, 63 coho salmon, and 28 steelhead. All were >100 mm fork length. These fish moved relatively quickly through the study area, though the median migration rate for coho salmon (4.6 km/d) was significantly slower than for Chinook salmon (11.3 km/d) or steelhead (12.5 km/d). Median residence times in the study area were 8.7 days for coho salmon, 3.4 days for Chinook salmon, and 2.5 days for steelhead. We identified several variables that were related to migration rate. River flow explained much of the variation in migration rate for both Chinook ($r^2 = 0.385$) and coho ($r^2 = 0.476$) salmon, and fork length had a strong positive relationship with migration rate for Chinook salmon. Combined in multiple linear regressions, river flow and fork length were positively related to migration rate for Chinook salmon, and explained a considerable amount of the variation ($r^2 = 0.445$). Release day and river flow explained 67% of the variation in coho salmon migration rates. No significant relationships were observed for steelhead. The implications of migration rate, residence time, and factors affecting them are uncertain. Rapid travel through degraded habitats presumably improves survival, but elements of our study (e.g., feeding, growth, and low predation on salmonids) suggest the lower Willamette River has value as rearing habitat. Exposure to toxins and other poor water conditions (especially in the Portland Harbor area) is a concern, and has not been completely evaluated.

Radio-tagged Chinook salmon were not highly associated with nearshore areas; about 76% of the recoveries occurred offshore (>10% of the channel width). Fish that were recovered near shore were distributed unevenly with respect to the proportional availability of different habitat types; however, they did not show clear selection for (or avoidance of) particular habitats. Coho salmon behaved differently; they were found near shore more often (43%), appeared to prefer beaches, and avoided riprap and artificial fill. Steelhead were rarely (25%) associated with nearshore areas.

To further assess habitat selectivity, we compared electrofishing catch among habitat types. Sampling sites were grouped into generalized habitat categories (e.g., beach, riprap, rock outcrop) and into clustered groups based on similarities in physical and chemical parameters (see Paper 1). Results for these analyses were generally similar, regardless of how habitat groups were defined. Electrofishing catch per unit effort (CPUE) of juvenile salmonids >100 mm fork length varied significantly among habitat types, but differences were almost always associated with low catches of fish at seawall sites. We suspect sampling efficiency was reduced at these sites due to their greater depth relative to other habitats; unlike shallower sites, we did not sample the entire water column. We concluded juvenile salmonids did not use the upper portion of the water column at seawall sites, or tended to avoid them altogether. Other differences in CPUE among habitats were rare; we found no indication that yearling salmonids were associated with specific habitats or groups of habitats, with one exception. Median electrofishing CPUE for coho salmon in spring was significantly higher at rock outcrops than at other habitats, suggesting these areas have a particular value. High catches sometimes occurred more frequently in off-channel areas (alcoves, backwaters, side channels), but were not significantly different from those in the main river channel.

We also analyzed catch rates of juvenile Chinook salmon among individual habitat parameters; we selected those that contributed most to the separation of clustered habitat groups (see Paper 1). With the exception of bank vegetation (catches were lowest at sites with 0-10% vegetative cover), none of the parameters were related to median CPUE during spring. However, higher catches were often associated with sand substrates, shallow water, and moderate amounts of bank vegetation during winter. Some relationships were confused, and we recommended a more rigorous statistical approach for future work.

A final important observation in our study was the large number of subyearling Chinook salmon present in beach seine catches. Nearly all were naturally produced, and therefore protected under the federal Endangered Species Act (ESA). We could not analyze habitat preferences for these fish because seining efforts occurred at a single habitat type, but based on the high numbers of fish and their extended temporal distribution (November to July), we hypothesized that beaches are particularly important habitats for these fish.

Overall, we found little evidence to suggest that nearshore habitat as it currently exists is a critical factor affecting yearling salmonids, and we generally agree with prior studies, which concluded waterway developments in the lower Willamette River present few risks to juvenile salmonids. However, we believe the effects of development are incompletely explored, especially with respect to subyearling fish. Clearly, the lower Willamette River is more than a simple migration corridor. Juvenile Chinook salmon feed (see Paper 4) and apparently grow during their outmigration, and unaltered nearshore habitats appear to be important to smaller fish. Coho salmon also feed extensively on aquatic invertebrates, were associated with nearshore areas, exhibited selection for specific habitat types, and spent relatively long periods in the study area. All off-channel habitats were utilized by juvenile salmonids, and these fish were present for extended periods in all years. While current conditions appear to adequately support fish populations, future development should be planned carefully to avoid detrimental impacts.

Paper 3 - Population Structure, Movement, Habitat Use, and Diet of Resident Piscivorous Fishes in the Lower Willamette River

We investigated several species of piscivorous fish (northern pikeminnow, walleye, smallmouth bass, and largemouth bass) to determine if they pose a risk to threatened and endangered salmonids in the lower Willamette River. We used radio telemetry to examine movement patterns and habitat associations, and electrofishing, gillnetting, and beach seining to evaluate diets and compare catch rates among habitat types.

We radio-tagged and tracked 73 predator-sized fish (those capable of consuming juvenile salmonids) from 2000 to 2003. In general, we found these fish did not travel far from their initial release points, particularly largemouth and smallmouth bass. Walleye traveled a median distance of 9.0 km during the study and appeared to be the most active species. Relocations of radio-tagged fish tended to be close to shore (within 20% of the total river width), and were often associated with pilings and rocky banks. Densities of large predator fishes (from electrofishing catches) were generally low, but consistently higher at sites characterized by riprap, mixed rock, and rock outcrops. We observed very little evidence of predation on juvenile salmonids. By weight, the diets of northern pikeminnow and largemouth bass were dominated by crayfish; the diets of walleye and smallmouth bass consisted primarily of fish. Large predators often had empty stomachs (62%), and identifiable fish in their diets were usually sculpins.

We concluded that walleye are probably too rare in the lower Willamette River to have an effect on salmonid survival, and neither northern pikeminnow nor largemouth bass appeared to prey on salmonids. Considering their relative abundance (all size classes), diet, and ubiquity, smallmouth bass probably pose the most significant potential threat to juvenile salmonids in the lower Willamette River. Currently, densities of all large predator fishes are low, and their effects on juvenile salmonids are likely negligible.

Paper 4 – Diets of Juvenile Salmonids and Introduced Fishes of the Lower Willamette River

In this paper, our primary objectives were to characterize the diets of introduced and anadromous fish, and determine if dietary overlap occurs between naturally propagated ("unmarked") salmonids and either introduced species or hatchery salmonids. Diet similarities could suggest competition for food resources and have management implications for threatened and endangered species. We used boat electrofishing to collect fish and gastric lavage to obtain diet samples. We collected samples from juvenile salmonids and introduced fish (primarily smallmouth bass and yellow perch) of similar size, and used a variety of indices to characterize and compare diets.

Daphnia were the most important prey item for Chinook and coho salmon, occurring in 65% of the samples and composing >80% of their diets by weight. The amphipod *Corophium* spp. and insects (both aquatic and terrestrial) were also common in salmonid diets. We found no significant diet overlap between juvenile salmonids and introduced species. Daphnia were important prey for smallmouth bass (46% of all prey items), but fish and crayfish composed nearly all (97%) of their diet by weight. Yellow perch, bass, and sunfish generally had more diverse diets than juvenile salmonids, and unlike salmonids, did not specialize on particular taxa. Diets of unmarked and hatchery Chinook salmon did overlap significantly, though unmarked fish exhibited a more selective feeding behavior and consumed larger amounts of prey. Neither Chinook nor coho salmon consumed major food items at the same proportion at which they were present in the environment; both selected daphnia and avoided chironomids, indicating specialized, selective feeding behaviors. Yellow perch and smallmouth bass tended to be generalists, though a few smallmouth bass specialized on daphnia and baetid mayflies.

In terms of food resources, introduced resident fishes do not appear to adversely affect juvenile salmonids in the lower Willamette River. The current high abundance of prey items, especially daphnia, would probably preclude competition even if the diets of the various species did overlap. In a resource-limited environment, smallmouth bass and hatchery salmonids would be most likely to compete with naturally produced salmonids.

Paper 5 – A Brief Survey of Aquatic Invertebrates in the Lower Willamette River

We surveyed macroinvertebrates and zooplankton at 26 sites during spring 2003 using a variety of gears (drift nets, Hester-Dendy multiple-plate samplers, and ponar dredges). Our primary objectives were to inventory the invertebrate biota, provide baseline data on the community structure, and compare assemblages among nearshore habitat types.

We identified approximately 38,000 organisms from 44 taxa. Cladocerans (bosminids and daphnia), copepods, and aquatic insects dominated the drift net samples. Multiple-plate arrays were colonized primarily by daphnia and chironomids (95% of all organisms); oligochaetes and chironomids composed the majority (83%) of the taxa in ponar samples. Density and community metrics varied among gear and habitat types. Beaches tended to have relatively high species diversity, taxa richness, and sensitive taxa richness; seawalls had comparatively low densities and taxa richness. Rock outcrops and floating structures appeared to be preferred habitats for aquatic insects. Riprapped sites had very high densities of invertebrates, and except for multiple-plate samples, relatively high taxa richness.

We noted few differences in the proportional distribution of major taxa groups among habitats, suggesting a generally homogenous community structure. Bosminids and copepods were largely absent in drift samples from rock outcrops and floating structures, but dominated the drift at riprapped sites. Colonization of multiple-plate samplers was similar among habitats, except for riprapped sites, which had much higher densities of daphnia. Densities of *Corophium* spp. in ponar samples also varied somewhat among habitats.

Biotic integrity scores based on the proportion and tolerance of taxa indicated moderate to fairly significant levels of organic pollution, though the taxa we observed were typical of most large rivers. Index scores very consistent among habitats, though the infaunal community (ponar samples) indicated better water quality than the epibenthic community (multiple-plate samplers). The moderate levels of impairment suggest biotic communities in the lower Willamette River may respond well to habitat and water quality improvements.

RECOMMENDATIONS

Recommendations by the principal investigators fall into three categories: (1) primary recommendations, which are recommendations regarding in-water or shoreline activities that are supported directly by study findings, (2) secondary recommendations, which are recommendations regarding in-water or shoreline activities that are supported in part by study findings, but may rely in part on general ecological principles and ecosystem functions, and (3) recommendations for additional studies.

Primary Recommendations

1. **The in-water work period for activities such as dredging, bank stabilization, etc., should be restricted to July 1 – October 31.** Primary considerations for recommending in-water work periods are given to important fish species, including anadromous fish and those receiving protection under federal or state ESAs. The existing work period for the lower Willamette River and Multnomah Channel is July 1 – October 31 and December 1 – January 31 (ODFW 2000). Our findings indicate Chinook salmon, coho salmon, and steelhead (including a large number of unmarked fish) are present during December 1 – January 31, and are often abundant during this period; in-water work should be avoided to prevent harming listed stocks.

   This recommendation does not necessarily reflect policy of ODFW or the COP. ODFW is responsible for providing guidelines for in-water work periods to minimize impacts to fish, wildlife, and habitat. It is likely that ODFW will recommend the winter work period remain open, but that strict criteria be met to ensure impacts to fish, wildlife, and habitat resources are negligible.

2. **Protect existing beach habitat.** Natural beaches appeared to be an important habitat for younger age classes of salmonids (particularly Chinook salmon), were selected by radio-tagged coho salmon, and were not a preferred habitat of large predator fishes; enhancements directed at creating beaches will likely provide a benefit to salmonids. It is unknown to what extent this habitat type can be enhanced by physical restoration efforts (see recommendation

5). Remaining beaches in the lower Willamette River represent relatively undisturbed habitats, and have important recreational and aesthetic value.

3. **Avoid construction of additional seawalls.** Seawalls represent a loss of natural shoreline conditions, provide little habitat for any fish species, and appeared to be under-utilized by juvenile salmonids. Electrofishing catches were low at seawalls; fish either avoid seawalls or change their behavior (move out of the range of electrofishing gear) upon encountering them. Because juvenile salmonids are generally associated with the upper portion of the water column, it is unlikely that low catches were due primarily to fish utilizing deep water along seawalls.

4. **Minimize the use of structures with pilings in the lower Willamette River.** Native and exotic piscivorous fishes were clearly associated with nearshore areas, and all species over-utilized pilings to some degree. We found little evidence of predation by exotic predators on juvenile salmonids; however, effect of exotic fishes extends beyond direct predation on juvenile salmonids. Minimizing the future use of pilings or a net reduction in the overall number of pilings will reduce the amount of habitat favored by exotic species.

Secondary Recommendations

5. **Determine if bio-engineering and other techniques can restore beach habitat functions and processes.** The City of Portland and ODFW should work with engineers and habitat specialists to determine the feasibility of restoring or creating beach habitats while considering other issues, such as commercial shipping, bank stabilization, and flood control. Though yearling Chinook salmon and other species did not exhibit clear preferences for any habitat type, beaches were clearly important to subyearling fish, and catches of larger fish were positively correlated with small substrates (sand), shallow water, and vegetated banks.

6. **Where possible, consider alternatives to riprap.** Densities of large predators were consistently highest at sampling sites dominated by rocky habitats (both natural and riprap), and radio-tagged predators over-utilized riprap in summer and autumn. We found little evidence of predation by exotic predators on juvenile salmonids; however, as noted previously, the effect of exotic fishes extends beyond direct predation on juvenile salmonids. Occurrence frequencies of fish and crayfish in predator diets were highest for samples collected from riprap, suggesting riprap provides good feeding habitat for predators. Radio-tagged coho salmon, and to a lesser extent Chinook salmon, underutilized riprap. Densities of invertebrates (including daphnia) were high at riprapped sites, adding uncertainty to the overall effects of riprap on ecosystem functions.

   The recommendation to consider alternatives to riprap is consistent with recommendations 2 (protect existing beach habitat) and 5 (determine if bio-engineering and other techniques can restore beach habitat functions and processes). Bio-engineered sites are more likely than riprap to facilitate normative ecosystem processes. It is not feasible nor do findings warrant removal of existing riprap; however, the COP and ODFW should work with engineers and habitat specialists to determine the feasibility of using alternatives to riprap in the future while considering other issues such as commercial shipping, bank stabilization, and flood control.

7. **Protect existing off-channel sites.** Many of these areas (alcoves, lagoons, backwaters, secondary channels) have been eliminated from the lower Willamette River; remaining areas are likely important for forage and refuge. All off-channel habitat types were used by migrating yearling salmonids, and at least 12% of our radio-tagged fish migrated through the Multnomah Channel. Habitat alterations should, at worst, not further eliminate habitat important to juvenile salmonids, and at best, provide additional habitat for juvenile salmonids while discouraging predators, potential competitors, and invasive species. The Multnomah Channel should be included in habitat conservation and enhancement activities.

Recommendations for Additional Studies

8. **Focus additional studies on subyearling Chinook and coho salmon.** Very little is known about the origin and race, habitat use, residence time, diet, and survival of age-0 Chinook salmon in the lower Willamette River. Our observations indicated these fish were abundant and used beach sites extensively; however, this study focused largely on yearling salmonids and did not answer critical questions pertaining to smaller age classes (especially habitat use and migration rates). Subyearling fish may be particularly important because nearly all are naturally produced (and therefore federally protected), and unlike older fish, may be associated with specific nearshore habitats (beaches). Investigating subyearling Chinook salmon in the lower Willamette River will greatly improve knowledge of their behavior and habitat requirements, and will enhance the ability of agencies to protect listed races. The habitat requirements of all ages should be considered when implementing fish management strategies.

   Small steelhead were rare in our surveys and probably do not use the lower Willamette River to a great degree; most outmigrate after rearing for two years in their natal streams. However, younger age classes of coho salmon were clearly present. Considering their status as a state-listed endangered species (they are also proposed for federal listing), and apparent behavioral differences compared to other salmonids, we recommend coho salmon be considered in future studies.

9. **Continue monitoring fish diets and macroinvertebrate communities in the lower Willamette River** (see recommendation 11). Daphnia and other invertebrates are clearly important food sources for fish in the lower Willamette River, and are likely a critical component for the survival and success of ESA-listed salmonids. The effects of historic river development on these communities are largely unknown, and the effects of future development may go undetected without some level of monitoring.

10. **Future studies in the lower Willamette River should assess the impacts of other introduced species in relation to resource use, especially Asian shrimp *Exopalaemon modestus* and American shad *Alosa sapidissima*.** Although we found no significant dietary overlap among juvenile salmonids and introduced fishes, we did not evaluate the diets of

some important species. Juvenile American shad, which feed heavily on zooplankton, were the most abundant species observed during the study. Juvenile American shad in the lower Willamette River exhibit overlaps in seasonal abundance and size with juvenile Chinook salmon, and could utilize the same food resources. We did not examine American shad diets because this analysis requires dissection and removal of the digestive tract, which would not have been comparable to our non-lethal sampling of juvenile salmonids.

In addition, we noted freshwater Asian shrimp *Exopalaemon modestus* are abundant at various times of the year in the lower Willamette River. Little information exists about these exotic decapods and potential impacts they pose to native species. Other researchers have raised concerns regarding Asian shrimp predation on *Corophium* spp. in the Columbia River and the potential for dietary overlap with juvenile salmonids.

11. **Continue to monitor invertebrate populations in the lower Willamette River using standardized protocols** (see recommendation 9). Our survey of invertebrates in the lower Willamette River, while similar to previous studies, was largely cursory and emphasizes the need for a coordinated effort. Standardized procedures (sampling gears, locations, timing, level of taxonomic identification, and biotic indices) would be particularly useful for identifying changes in macroinvertebrate communities as anthropogenic development of the lower Willamette River continues. Biomonitoring could also aid in prioritizing habitat restoration projects and documenting the success of these efforts.

12. **Assess factors affecting macroinvertebrate communities in the lower Willamette River.** Water depth, sediment composition, sediment grain size, and percent volatile solids were significantly related to macroinvertebrate density in the lower Columbia River. Identifying similar factors in the Willamette River may help direct habitat restoration efforts and provide benefits for fish populations.

13. **Focus taxa-specific studies on daphnia.** Daphnia were very common in our study, dominating the taxa collected in both multi-plate samplers (which are generally not considered to be effective zooplankton sampling devices) and drift nets. Daphnia are a primary food source for juvenile salmon and other fish in the lower Willamette River, but little is known about their populations and factors affecting them.

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Description and Categorization of Nearshore Habitat in the Lower Willamette River

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INTRODUCTION

The loss of natural habitat is one of the most important factors leading to the decline of native fish stocks in rivers and streams (Behnke 1992). Fish depend on natural habitat complexity for feeding, rearing, and spawning. Habitat complexity in lotic systems is a result of a combination of factors, including: 1) riparian vegetation that provides complex root systems and woody vegetation that help stabilize stream banks and provide stream cover, 2) large woody debris that creates important instream habitat for salmonids, 3) undercut banks that provide cover for fish, and 4) off-channel stream habitat that provides rearing areas (Hicken 1984; Meehan 1991). When riparian habitat is removed, many of the factors that contribute to habitat complexity are lost, bank erosion occurs, and sediment loads can increase.

Rock revetment (riprap) is often used to stabilize banks after riparian habitat is removed; however, this solution can result in a reduction of fish habitat and cause channelization (Hjort et al. 1984; Schmetterling et al. 2001). Riprap is often unvegetated, which results in a loss of large woody debris recruitment and stream cover (Dykaar and Wigington 2000). Riprap also prevents any lateral movement or erosion of the stream channel, which causes reductions in secondary channel habitat and undercut bank habitat (Hjort et al. 1984; Schmetterling et al. 2001). Knudsen and Dilley (1987) documented short-term detrimental effects on juvenile salmonids *Oncorhynchus* spp. during construction of bank reinforcements, and Garland et al. (2002) reported Chinook salmon *O. tshawytscha* densities were significantly lower at riprapped sites than at sites consisting of smaller substrates.

The development of the lower Willamette River has transformed much of the natural bank habitat into riprap and seawalls to stabilize banks and control flooding. In addition, commercial shipping has altered the natural landscape and river bottom of the lower reach through construction of docks and channel dredging.

The Willamette River is also used by several evolutionarily significant units (ESUs) of anadromous salmonids listed as threatened under the federal Endangered Species Act (ESA). These include: upper Willamette River spring Chinook salmon (NOAA 1999a) and winter steelhead *O. mykiss* (NOAA 1999b), and lower Columbia River winter steelhead (NOAA 1998) and Chinook salmon (NOAA 1999a). In addition, naturally propagating coho salmon *O. kisutch* in the lower Columbia River ESU are listed as endangered by the State of Oregon (Chilcote 1999). The lower Columbia River ESU includes the Willamette River up to Willamette Falls.

Following a workshop conducted by the City of Portland's ESA Program with regional scientists and fisheries agencies, the decision was made to study habitat use and rearing by these stocks in the lower Willamette River. In May 2000, the Oregon Department of Fish and Wildlife (ODFW), funded by the City of Portland, implemented a four-year study of aquatic habitat and nearshore developments in the lower Willamette River with respect to their use by resident and anadromous fish species. The study was intended to assist the City with permitting, planning, and enforcement, and to maximize the protection of listed species.

The objective of this portion of the study was to describe and categorize nearshore habitats and development types in the lower Willamette River. The identification of habitat categories was intended specifically to help characterize habitat use by resident and anadromous fishes and to develop management recommendations for protecting listed species (see Friesen et al. 2004 and Pribyl et al. 2004). In addition, we identified parameters that contributed most to the separation of habitat groups; these are likely to have the greatest effect on fish use, and may provide managers with specific recommendations pertaining to habitat protection.

A list of abbreviations and acronyms used in this report is provided in Table 1. We refer to habitats and structures constructed by people (e.g. riprap, seawall, pilings) as "artificial"; all others are referred to as "natural."

METHODS

Selection of Sampling Sites

We conducted the study from Willamette Falls at river mile (rm) 26.5, river kilometer (rkm) 42.6, downstream to the confluence with the Columbia River (rm 0.0, rkm 0.0; Figure 1). A list of potential sampling sites was developed based on bank qualification data modified slightly from Greenworks et al. (2000). Each site was identified by a location code consisting of the river mile and bank designation (east or west). For example, 012W denotes a site with a lower bound at rm 1.2 located on the west bank. Alcove sites, which consisted of mixed habitat (no predominant habitat; usually a mixture of beach and riprap) and provided natural or artificial refugia in off-channel areas, were identified by an additional "A" in the location code (e.g. 148WA). Some sites (048E, 051E, 100W) were considered for inclusion because they had been used in a previous study (Ward et al. 1994) or were specifically identified by the City of Portland (006E, 136E). From this list, we randomly selected at least two replicate sites of each habitat type. Several sites were replaced based on reconnaissance surveys during May 2000 or eliminated (031W, 118W, 126E, and 203W) when factors such as distribution within the study area, proximity to nearby sites, consistency of bank habitat, access, and navigational hazards were considered. When differences existed between sites of a general habitat type, they were assigned to subcategories. Selection of subcategory replicates was attempted but was not always possible due to the criteria identified above and a limitation on the overall number of sites that could be sampled. This process resulted in the selection of 19 sites distributed throughout the study area from rm 0.6 to 24.3 (rkm 1.0-39.1). A "bio-engineered" site (133W) and six alcove sites were added in October 2000, resulting in a total of 26 sites (20 "standard" sites and 6 alcove sites; Tables 2 and 3).

We initially segregated sampling sites qualitatively into 12 types based on physical appearance and functionality (Table 4). For most analyses, we combined similar habitat types to increase sample sizes and improve our ability to describe differences among types. These categories included: 1) alcoves, 2) beach, 3) riprap, 4) rock outcrop, 5) seawall, and 6) mixed habitat. The habitat at the bio-engineered site was primarily riprap and was categorized accordingly. We also combined vegetated and non-vegetated riprap sites. "Piling" and "floating" categories were reclassified based on their associated bank type (e.g., a site with a floating dock could also have a riprapped bank).

Table 1. List of abbreviations and acronyms used in this report.

Abbreviation	Description
%10MFORB	Percent ground cover consisting of forbs 10 m above the waterline
%10MGRASS	Percent ground cover consisting of grass 10 m above the waterline
%10MNOVEG	Percent of bank with no vegetative cover 10 m above the waterline
%10MSHRUB	Percent ground cover consisting of shrubs 10 m above the waterline
%10MTREES	Percent ground cover consisting of trees 10 m above the waterline
%20MFORB	Percent ground cover consisting of forbs 20 m above the waterline
%20MGRASS	Percent ground cover consisting of grass 20 m above the waterline
%20MNOVEG	Percent of bank with no vegetative cover 20 m above the waterline
%20MSHRUB	Percent ground cover consisting of shrubs 20 m above the waterline
%20MTREES	Percent ground cover consisting of trees 20 m above the waterline
%ARTFILL	Percent bank substrate consisting of artificial fill
%BEACH	Percent bank substrate consisting of beach
%BEDROCK	Percent bank substrate consisting of bedrock
%CLAY	Percent clay composition (substrate samples)
%LGRIPRAP	Percent bank substrate consisting of large riprap
%ROCK	Percent bank substrate consisting of rock
%SAND	Percent sand composition (substrate samples)
%SEAWALL	Percent bank substrate consisting of seawall
%SILT	Percent silt composition (substrate samples)
%SMRIPRAP	Percent bank substrate consisting of small riprap
BANKSLOPE	Mean bank slope (degrees)
DENSITOM	Densitometer (overhead cover)
DEPTH20M	Depth 20 meters from shore (m)
DISTHAL	Mean distance to thalweg (m)
GIS	Geographic Information System
GPS	Global Positioning System
MRS	Mean river stage (ft)
OUTFALLS	Total number of outfalls
PCA	Principal components analysis
PILINGN	Mean number of nearshore pilings
PORTGAGE	River gauge height at Morrison Bridge (ft)
SCONDN	Mean nearshore surface conductivity (mS/cm)
SLOPEN	Mean nearshore river bottom slope (degrees)
STEMPN	Mean nearshore surface water temperature (^oC)
SUBSIZE	Mean substrate size (µm)
$SURF0_2N$	Mean nearshore surface dissolved oxygen concentration (mg/l)
TRANSPN	Mean nearshore transparency (cm)

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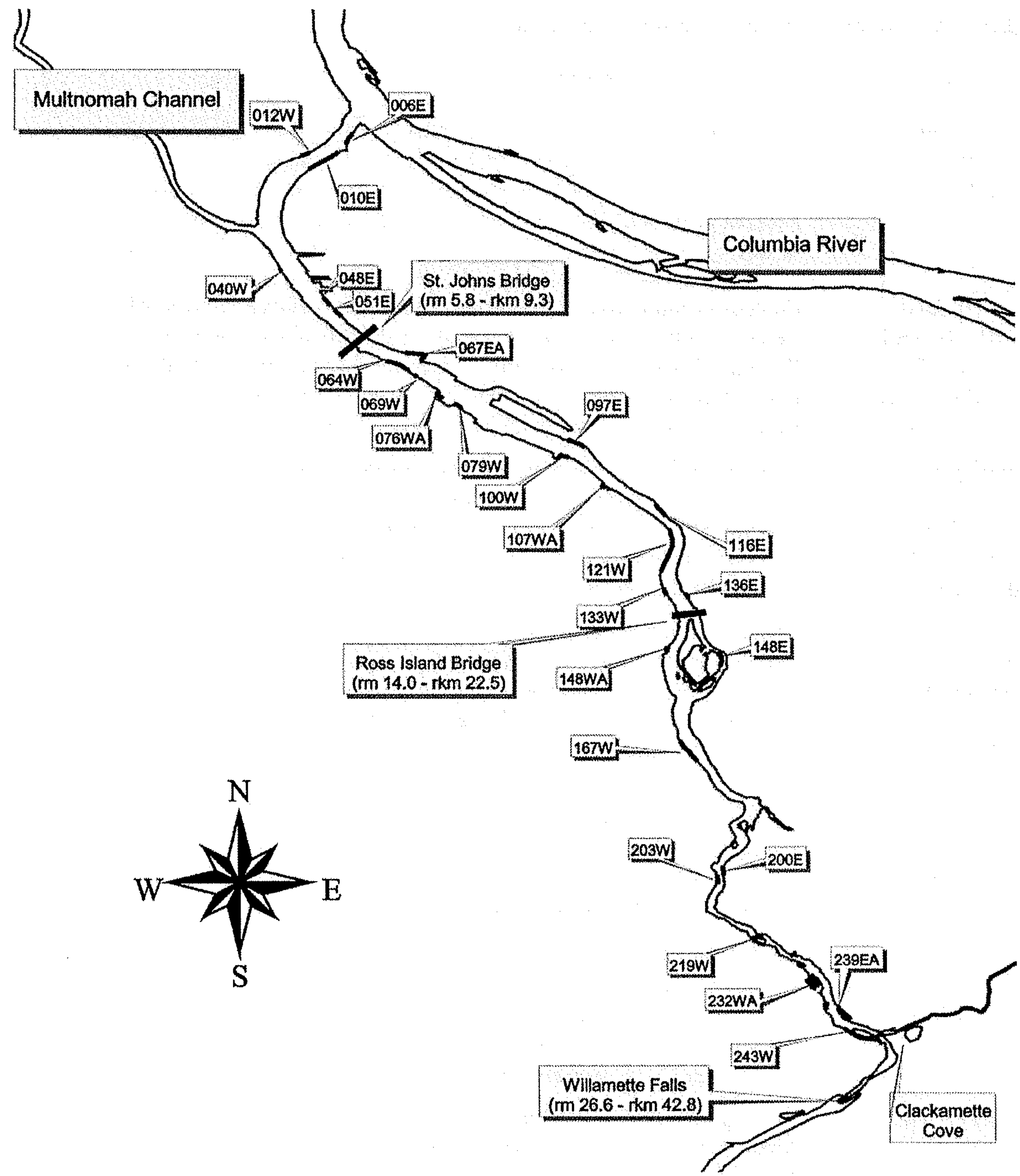

Figure 1. The lower Willamette River and associated features. Sampling site labels denote river mile (rm; xx.x) and east (E) or west (W) shore. A = alcove site; rkm = river kilometer.

Table 2. Description of standard sampling sites in the lower Willamette River, May 2000 - June 2003.

Habitat classification	Site[a]	River kilometer	Length (m)	General bank type[b]	Location / description
Undeveloped					
Beach (7)	006E	1.0-1.3	364	B	Kelley Point
	040W	6.4-6.5	64	B	Across from Terminal 4
	069W	11.1-11.3	--	B	Upstream from Doan Point
	097E	15.6-16.1	456	B	Across from Terminal 2
	148E	23.8-25.0	526	B	Behind Ross Island
	167W	26.9-27.8	804	B	Powers Marine Park
	243W	39.1-39.4	264	B	Downstream of Goat Island
Rock outcrop (2)	200E	32.2-32.6	333	RO	Lake Oswego Railroad Bridge
	219W	35.2-35.6	328	RO	Hog Island
Riprap (5)					
Vegetated (2)	012W	2.0-2.3	240	RR	Between day markers #6 and #10
	136E	21.9-22.0	183	RR	OMSI
Non-vegetated (2)	064W	10.3-11.0	564	Mixed (RR/B)	Doane Point
Bio-engineered (1)	133W	21.4-21.6	186	Mixed (RR/B)	Downstream of Marquam Bridge
Seawall					
Concrete wall (1)	121W	19.5-21.0	1,542	SW	Waterfront Park seawall
Metal sheetpile (1)	048E	7.7-8.0	286	SW	Terminal 4
Pilings					
Allowing light (3)	010E	1.6-2.4	905	Mixed (B/RR)	3 T-docks above Columbia Slough
	079W	12.7-13.0	255	RR	Olympic Tug T-dock
	116E	18.0-18.2	141	Mixed (RR/UNC)	T-dock above Fremont Bridge
Limiting light (1)	100W	16.1-16.2	78	RR	Terminal 2
Floating					
Limiting light (1)	051E	8.2-8.7	310	Mixed (RR/B)	Terminal 4 ship hull

[a] The first two digits represent river mile; the third digit represents river mile tenth. W=West bank, E=East bank

[b] B=beach; RO=rock outcrop; RR=riprap; SW=seawall; UNC=unclassified fill

Table 3. Description of alcove sites in the lower Willamette River, May 2000 - September 2003.

Category	Site[a]	River kilometer	Length (m)	General bank type[b]	Location / description
Natural	067EA	10.8-11.1	577	Mixed (RR/B)	Downstream of Doane Point
	148WA	23.8-24.0	206	Mixed (B/UNC)	Above Spaghetti Factory
	232WA	37.3-37.7	1029	B	Upstream of Cedar Oak boat ramp
	239EA	38.5-38.9	580	B	East side of Meldrum Bar
Artificial	076WA	12.2-12.4	317	Mixed (B/PAL)	Downstream of Chevron piers
	107WA	17.2-17.4	396	Mixed (PAL/UNC)	Below Fremont Bridge

[a] First two digits = river mile, third digit = river mile tenth; W=West bank, E=East bank, A=alcove.

[b] B=Beach; RR=riprap; UNC=Unclassified fill; PAL=Pilings-allowing light. For sites with mixed bank substrates, the predominant type appearing above normal low water is listed first.

Table 4. Definitions of bank nearshore habitat types in the lower Willamette River, May 2000 - March 2003.

Habitat type	Description
Beach	Shallow, shelving shorelines consisting of sand, silt, or gravel up to 64 mm diameter. This may also include native bank materials in their natural position and undisturbed by humans (e.g. clay bank). Vegetation cover varies but may include canopy, understory, and ground cover.
Rock outcrop	Natural bedrock formations consisting of angular ledges, protrusions, and sheer rock faces. May include some associated boulders.
Rock	Natural, round river rock >64 mm that does not fit into the riprap categories.
Seawall	Impervious vertical retaining walls generally composed of concrete, timber, or sheet pile, extending beyond ordinary low water. These habitats are uniformly deep and homogenous (e.g. house foundations in the water, bulkheads).
Vegetated riprap	Continuous stone revetments mechanically placed to curtail erosion and prevent alterations to the main channel. Vegetative cover varies but may include canopy, understory, and groundcover that occupy a minimum of 20% of the active bank below flood state (lower shore zone).
Non-vegetated riprap	Continuous stone revetment devoid (<20%) of vegetation.
Bio-engineered	Engineered banks that incorporate vegetation as a visible component of riprapped banks, but inert and artificial materials provide the physical structure that ensures bank stability. Bio-engineered banks rely on vegetation and natural fabric materials for banks stability (e.g. site 133W).
Unclassified fill	These areas appear to have been filled over time with miscellaneous unconsolidated materials (e.g. cement slabs). The surfaces of banks composed of unclassified fill have not been covered with engineered riprap or structures. Such banks generally contain debris of various types and may have become unstable because of erosion by river forces.
Pilings-allowing light	Stationary support structures consisting of concrete, metal, or timber used to elevate docks, buildings, etc. above the water. Elements of construction allow varying amounts of light to penetrate to the underlying habitat (e.g. T-docks)
Pilings-limiting light	Stationary support structures used to elevate docks, buildings, etc. above water. Construction is such that underlying habitat is not directly exposed to ambient light (e.g. site 100W).

Migratory Behavior, Timing, Rearing, and Habitat Use of Juvenile Salmonids in the Lower Willamette River

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INTRODUCTION

The lower Willamette River, Oregon, is unique in providing a major fishery for Pacific salmon *Oncorhynchus* spp. near a large metropolitan area, Portland (Figure 1). In 2001, anglers harvested approximately 47,600 salmon from the Willamette River and its tributaries (Oregon Department of Fish and Wildlife, unpublished data). Salmonids produced in the Willamette basin are also caught by commercial fishers in the Pacific Ocean and the nearby Columbia River, provide ceremonial and consumptive fisheries to Northwest Indian tribes, and contribute to the identity of the region.

In the late 90s, four evolutionarily significant units (ESUs) of naturally propagated anadromous salmonids were listed as threatened species under the federal Endangered Species Act (ESA): lower Columbia River and upper Willamette River Chinook salmon *O. tshawytscha* (NOAA 1999a), upper Willamette River steelhead *O. mykiss* (NOAA 1999b), and lower Columbia River steelhead (NOAA 1998). Lower Columbia River coho salmon *O. kisutch* were also listed as endangered under the Oregon Endangered Species Act (Chilcote 1999). The lower Columbia River ESU includes the Willamette River from the mouth to Willamette Falls at river kilometer (rkm) 42.6.

The lower Willamette River has been heavily modified, especially near Portland. The channel has been dredged to accommodate commercial shipping, and docks, piers, bulkheads (seawalls), and rock revetment (riprap) have replaced much of the natural bank habitat. Pollution from industrial sources, especially in the river sediments, is a serious concern. A section of the reach, from rkm 5.6 to 15.3, was added to the U. S. Environmental Protection Agency (USEPA) "Superfund" list in December 2000. Primary contaminants include mercury, polychlorinated biphenyls, polynuclear aromatic hydrocarbons, dioxins, furans, and pesticides (USEPA 2000).

In the mid-1980s, concerns about the effects of waterway development on juvenile salmonids led to a cooperative study between the Port of Portland and the Oregon Department of Fish and Wildlife (ODFW; ODFW 1992). The study focused primarily on the Portland Harbor area (rkm 0.0 – 19.0) and concluded that (1) with the exception of habitat losses caused by seawall construction, development posed little risk to salmonids; (2) the location of developments in the harbor area did not need to be weighed heavily when considering risks to salmonids; and (3) predation on juvenile salmonids by northern pikeminnow *Ptychocheilus oregonensis* was not enhanced by development (Ward et al. 1994). The study also recommended further research to better characterize fish-habitat relationships.

In 2000, following the ESA listings and consultations with regional fisheries managers, the City of Portland funded a new study directed at describing the relationships of nearshore development and bank treatments on both resident and anadromous fish species. The study was intended specifically to help the City of Portland protect listed species and support their recovery.

In this report, we examine in detail the migratory characteristics of juvenile Chinook salmon, coho salmon, and steelhead in relation to nearshore habitat in the lower Willamette River. Where possible, we assessed both hatchery and naturally propagated (unmarked) groups of all three species.

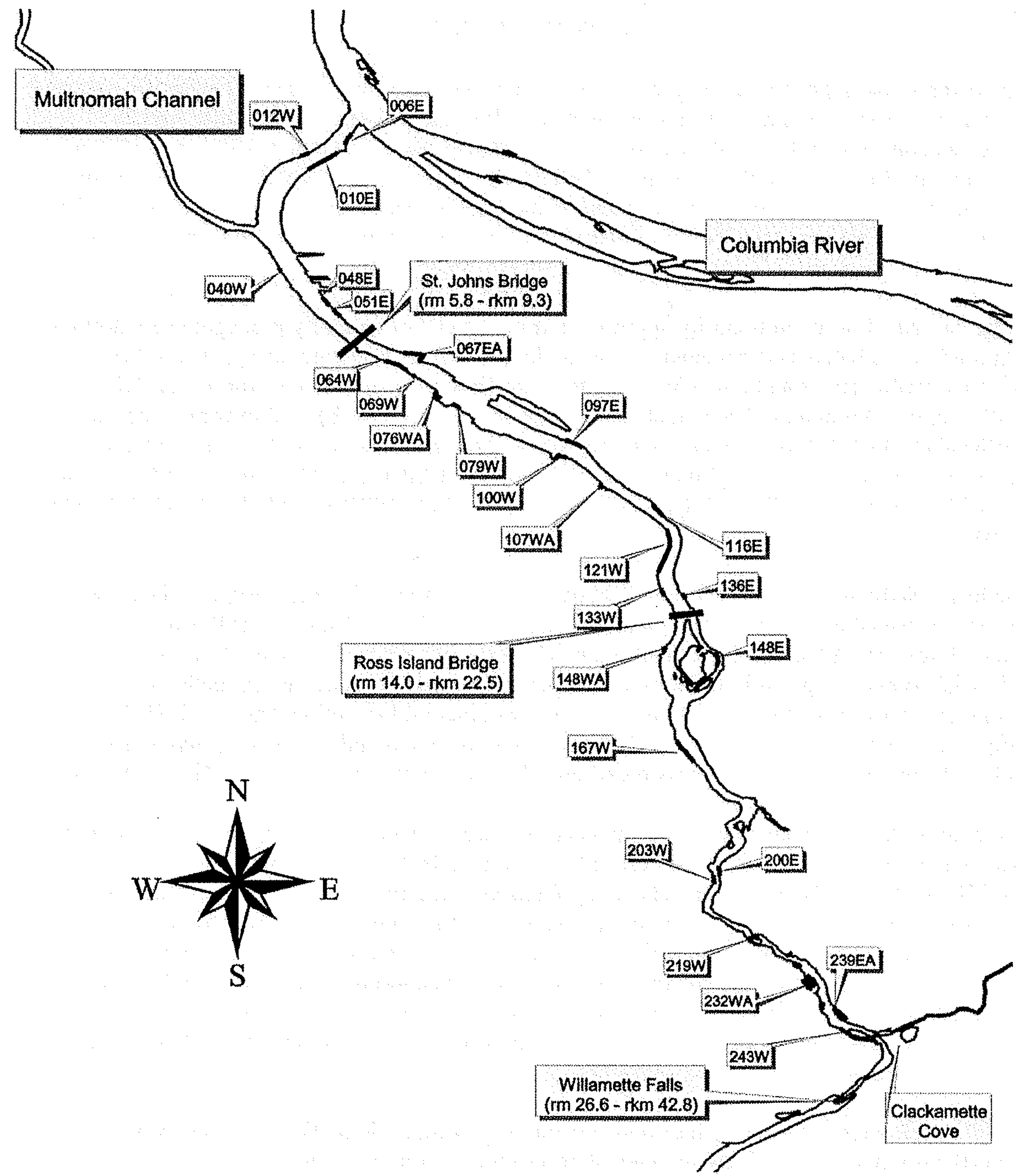

Figure 1. The lower Willamette River study area and associated features. Sampling site labels denote river mile (rm; xx.x) and east (E) or west (W) shore. A = alcove site; rkm = river kilometer.

We tested three null hypotheses:

1) *The density of juvenile salmonids does not vary among bank treatment and nearshore development types.*

2) *Juvenile salmonids do not exhibit changes in size (length or weight) during migration through the study area.*

3) *The distribution of radio-tagged juvenile salmonids among nearshore habitat types does not differ from the distribution of habitat types.*

We also documented other facets of juvenile salmonid biology that would lead to a better understanding of their behavior in the lower Willamette River. These included: species composition, outmigration timing, size structure, growth, migration rate, and residence time. We provided general comments on resident salmonids but focused our efforts on ESA-listed species and races.

METHODS

Field Sampling

Electrofishing and Beach Seining

We used beach seining and electrofishing to determine species composition, origin, size, run timing, and growth of juvenile salmonids. Repeated sampling was conducted at 27 sampling stations. Of these, 21 were sampled with electrofishing, 4 were sampled with beach seines, and 2 were sampled using both gears. Sampling sites are described in Vile and Friesen (2004). Prior to winter 2001, sampling was conducted during a 4-6 week period in each season (spring, summer, autumn, and winter), resulting in some temporal gaps (i.e., sampling did not occur in some months). We corrected this by redesigning the sampling scheme so all months were sampled equally. Beginning in December 2001, electrofishing was conducted four days per month (each site sampled twice), and beach seining was performed once per week (each site sampled once). Our level of effort varied somewhat due to other priorities (primarily radio telemetry) and weather conditions.

Boat electrofishing was conducted after sunset. Because the primary goal of the study was to characterize the effects of nearshore development on juvenile salmonids, we sampled as close to shore as possible. Navigation was difficult in water < 1 m deep, and sampling effectiveness was probably reduced at depths of > 3 m. We therefore adopted a target depth of 1-3 m, though some sites (loading docks, seawalls) were considerably deeper even very close to shore. We sampled for a maximum of 750 s (continuous energized direct current) at each sample site. Voltage regulator settings were changed frequently early in the study to avoid harming ESA-listed salmonids. Beginning in December 2000, we used 30 pulses/s at 50-100% of the low range, which appeared to maximize taxis (involuntary attraction to the anodes) and minimize tetany (immobilization). These settings resulted in an electrofisher output of <1.0 – 2.0 amperes, depending on conductivity. The conservative settings we used sometimes prevented us from collecting all observed juvenile salmonids when densities were highest. We counted juvenile salmonids we did not collect (± 10 fish) and identified individuals to species when possible.

We conducted daytime beach seining at five sites; a sixth was added in spring 2002. While shoreline habitat varied greatly for electrofishing efforts, beach seine sites were relatively consistent, defined by shallow areas with gentle slope, little or no structure, and small substrate (fines, sand, or gravel). We used a 2.4 x 45.7 m straight-wall, buntless net constructed of 4.8-mm Delta-style nylon mesh with a weighted line at the bottom and a floating line at the top. The seines were deployed from a boat in a semi-circular fashion and pulled to shore.

Juvenile salmonids collected by electrofishing and beach seining were identified to species when possible; small individuals could not always be identified readily and were recorded as unidentified salmonids. We examined all salmonids for the presence of clipped fins, indicating they were of hatchery origin. Non-finmarked fish were assumed to be naturally propagated and are hereafter referred to as "unmarked". We measured fork length (FL) to the nearest mm and weighed (g) a maximum of 30 individuals of each species and origin during each sampling effort.

Radio Telemetry

Radio telemetry was used to monitor actively migrating juvenile salmonids. We used telemetry data to calculate migration rates and residence times, describe the distribution of fish across the river channel, and explore habitat associations.

We collected juvenile Chinook salmon, coho salmon, and steelhead each spring (2001-2003) for radio tagging. Salmonids were collected by beach seining or electrofishing within the study area, or were obtained from the juvenile fish trap at the Portland General Electric Sullivan Plant at Willamette Falls. Fish between 100 and 230 mm FL were kept for tagging if they were in good physical condition.

We held salmonids for 16-48 hours following collection to allow for the evacuation of stomach contents. During 2001 and 2002, the fish were held in 125-L containers suspended by floating frames in Clackamette Cove, located near the confluence of the Clackamas and Willamette Rivers (Figure 1). The containers were perforated to allow water to circulate freely. Due to poor conditions (stagnant water and high temperatures) in this area during 2003, the fish were held at the ODFW Clackamas Regional office in large spring-fed tanks with continuous water circulation.

Radio tags were coded microprocessor transmitters (NTC-2-1 NanoTags®) manufactured by Lotek Engineering. We programmed all tags with a continuous 4 s burst rate, and the minimum estimated battery life was 11 d. Tag size was 4.5 x 6.3 x 14.5 mm and averaged 0.8 g (air weight) including antennae. During 2001, some fish were also tagged with MCFT-3KM tags measuring 7.3 x 18 mm with an air weight of 1.4 g. Adams et al. (1998a) and Brown et al. (1999) recommended tag weight should not exceed 5.0% of the weight of the fish. Due to difficulties in obtaining fish of the proper weight, our tags occasionally composed up to 6.5% of the weight of the fish during 2001 and 2002.

Prior to implantation, each tag was activated and checked with a receiver to ensure proper working condition. We surgically implanted the tags into the ventral body cavity following techniques described in Adams et al. (1998b). Following the procedure, we retained the fish for 12-36 hours to ensure complete recovery.

We released radio-tagged fish between 14 April and 27 June of each year. Releases occurred pre-dawn in the upper portion of the study area; between rkm 27.0 and 39.1 in 2001, rkm 32.5 and 39.6 in 2002, and rkm 39.4 and 39.6 in 2003. Only fish that appeared to be in good physical condition were released. We matched water temperatures in the holding containers as closely as possible to river temperatures, and released the fish via a water-to-water transfer.

We tracked radio-tagged fish in 5.5 - 6.7 m boats, traveling at approximately 8.0 km/h, using a six-element yagi-style antenna and Lotek receiver. Tracking was conducted in an upstream to downstream direction. Upstream of Elk Rock Island (rkm 30.6) we tracked mid-channel because signals from either shore could be detected. A zigzag tracking pattern was used downstream of Elk Rock Island, where the river becomes wider, to maximize the amount of surface area covered and to ensure random recoveries of fish between nearshore and offshore habitats. Total tracking time conducted offshore and nearshore was recorded for each shift to maintain an approximate 50:50 ratio.

We began tracking the fish about one hour after their release, 1.6 km above the release site. On non-release days, tracking began near the mid-point of fish relocations from the previous shift. If no fish were located after two hours of tracking, we employed a search pattern until signals were detected. Tracking was conducted twice per day (day and night) for eight to ten hours per shift, and for at least five consecutive days following a release.

Once a signal was audible on the receiver, we discontinued the tracking pattern and directed the boat towards the signal. The location of the fish was determined by lowering the gain and using the aerial antenna to locate the direction of the strongest power signal. When the power signal was sufficiently strong, a coaxial antenna was lowered 1 – 2 m underwater to pinpoint the location of the fish. Whether we pinpointed the fish or not, we stopped the boat where the signal was strongest and recorded the tag channel and code, time, latitude and longitude, river mile, distance to shore, channel width, final gain and signal power readings, and the quality of the signal. We defined nearshore recoveries as those occurring within 10% of the measured channel width of either shore. We recorded general habitat types for all nearshore recoveries; categories included beach, riprap, rock outcrop, other natural rock, seawall, artificial fill, and pilings (North et al. 2002; Friesen et al. 2003; Vile and Friesen 2004).

We also employed a number of fixed telemetry sites to monitor fish passage through the study area. These included a six-element yagi-style antenna attached to a fixed object, a Lotek receiver, and a power supply. The receiver was programmed to continuously monitor the tag frequencies and to record the date, time, tag code, and signal strength of passing tagged fish. Each week, data was downloaded to a laptop computer and the battery was replaced.

We employed eight fixed telemetry sites in 2001. At several locations, a station was set up on both sides of the river to ensure coverage of the entire channel. These included: 1) Sellwood Bridge (rkm 26.7), 2) Albers Mill Building (rkm 18.7), 3) Cargill Inc. Irving Elevator (rkm 18.7), 4) City of Portland Water Pollution Control Laboratory (rkm 9.5), 5) U. S. Army Corp of Engineers Portland District (rkm 9.5), 6) U. S. Coast Guard (USCG) navigation aid for Multnomah Channel (rkm 4.8), 7) USCG navigation aid #3 (rkm 1.1), and 8) USCG navigation aid #4 (rkm 1.1). In 2002 the number of fixed telemetry sites was reduced to four because of USCG restrictions on navigation aids and difficulties in setting up and maintaining the station on the Sellwood Bridge. Stations for 2002 included 1) the Albers Mill Building, 2) the Cargill Inc. Irving Elevator, 3) the City of Portland Water Pollution Control Laboratory, and 4) a private residence in Multnomah Channel 2.4 rkm downstream from the head of the channel. In 2003 the number of fixed telemetry sites was reduced to one because of difficulties in obtaining valid data from several of the receivers, due primarily to interference from automobile traffic. The remaining site was located at the private residence in Multnomah Channel.

Data Analysis

Density and timing

To assess run timing, we calculated the relative density of juvenile salmonids using an index based on the proportion of zero-fish catches. Although catch per unit effort (CPUE) is the most commonly used index of fish density, Bannerot and Austin (1983) recommended the use of the square root of the relative frequency of zero-fish catches. Zimmerman and Parker (1995) modified the index by using its reciprocal (1/square root of the proportion of zero catches) so the index value would be directly proportional to density.

For both electrofishing and beach seining, we calculated monthly density index values for Chinook salmon, coho salmon, and steelhead to provide information on their relative temporal distribution. Separate indices were calculated for unmarked and hatchery-origin Chinook salmon. Because the catch and relative density of both coho salmon and steelhead was low, we combined hatchery and unmarked fish to provide indices for these species.

Growth

Growth of juvenile salmonids implies active feeding and the existence of suitable rearing habitat. We used the Mann-Whitney rank sum test (a nonparametric equivalent of the T-test; Jandel Scientific Corporation 1995) to compare fork length and body weight of juvenile salmonids among sampling sites in the upstream and downstream portions of the study area (null hypothesis 2). As with other analyses, we examined only Chinook salmon because sample sizes of coho salmon and steelhead were small. Catches varied substantially with gear type; we divided this analysis into two components to maximize statistical power: hatchery fish captured by electrofishing and unmarked fish captured in beach seines. For beach seine catches, we compared downstream sites 006EN and 040WN to upstream sites 167WN and 243WN (Figure 1). Electrofishing sites were 006EN, 010EN, and 012WN (downstream) and 167WN, 200EN, and 219WN (upstream).

Habitat Use (electrofishing)

To supplement and verify radio telemetry results, we explored salmonid habitat associations using electrofishing data (null hypothesis #1). We used CPUE standardized to the mean electrofishing effort as our index of fish density among habitat types. Habitat use was evaluated among seasons, as bank habitats change throughout the year with fluctuations of river levels and other environmental conditions (Vile and Friesen 2004). Because electrofishing catches were biased towards larger fish, we restricted these analyses to individuals > 100 mm FL. We omitted analyses for some species and seasons where catches were very low (coho salmon in autumn and winter, and steelhead in summer and winter).

The electrofishing data included a large number of zero catches, resulting in a non-normal distribution; we therefore used median values and nonparametric statistical tests. Box plots represented the data and provided the median CPUE for each habitat classification, 25th and 75th percentiles, and 10th and 90th percentiles (Figure 2). The Mann-Whitney rank sum test, the Kruskal-Wallis one-way analysis of variance (ANOVA) and Dunn's multiple comparison test were used to identify significant differences among habitats. For all analyses, comparisons were considered significant where $P<0.05$.

Generalized Habitat Categories

We compared mean standardized CPUE of juvenile salmonids among generalized habitat categories. To increase sample sizes and improve our ability to describe differences among types, we combined similar habitat types (Vile and Friesen 2004). In addition, habitat types initially categorized in North et al. (2002) often did not accurately describe the actual riverbank treatment. For example, a site classified as "floating structure" could also have a riprap bank treatment. Our final categories included beach, riprap, rock outcrop, seawall, and mixed habitats.

Clustered Habitat Categories

Vile and Friesen (2004) reported bank habitats in the lower Willamette River clustered into groups based on physical and chemical parameters, and subjective characterizations of habitat types (i.e., the general habitat categories) often accurately described differences in bank treatments. Therefore, we also compared median standardized CPUE to habitat clusters identified by Vile and Friesen (2004). For clarity, we identified the corresponding general habitat types (e.g., beach, riprap, seawall) in each analysis.

Off-channel Habitats

To assess the use of refuge-type habitats away from the main river channel, we compared the median CPUE for all species between off-channel (alcove, backwater, or secondary channel) and "main-channel" sites. Off-channel sites included 067EA, 076WA, 107WA, 148WA, 148EN,

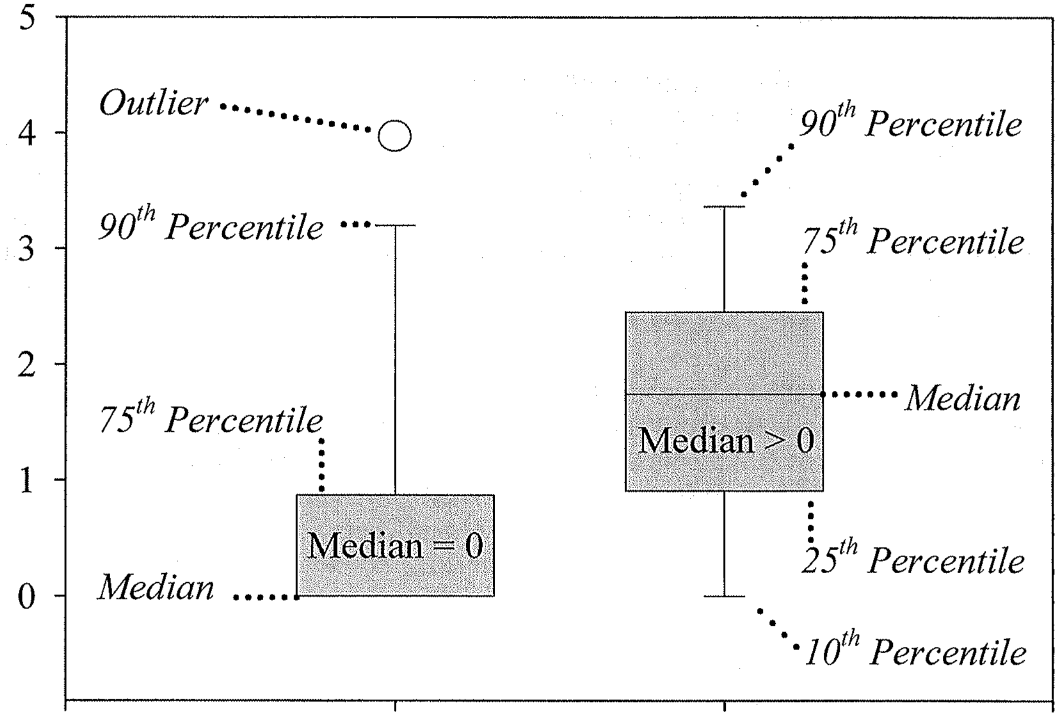

Figure 2. Key to box-and-whisker plots used in this report.

232WA, and 239EA (Figure 1). We used the Mann-Whitney rank sum test to determine if catches at off-channel and main-channel habitats differed significantly, and omitted species-specific results for some seasons with very low catches.

Habitat Parameters

Vile and Friesen (2004) also identified the onshore and instream parameters that contributed most to the separation of sampling sites into clusters. To provide information on the importance of individual habitat parameters, we compared median CPUE of juvenile Chinook salmon (hatchery, unmarked, and combined) to categorized values from the parameters using the Kruskal-Wallis one-way ANOVA and the Mann-Whitney rank sum test. Dunn's pairwise multiple comparison method was used to determine where differences occurred. We restricted the analysis to winter and spring, when most salmonids were captured, and again included only fish > 100 mm FL. Because habitat and fish surveys did not occur simultaneously, we eliminated parameters likely to change appreciably within a season (river level, transparency, conductivity). Winter habitat measurements included: (1) percent of the bottom substrate consisting of fines, sand, rock, and bedrock, (2) water depth 20 m from shore, (3) percent vegetative cover on the bank 10 and 20 m from the waterline, (4) percent vegetation composed of grass 10 and 20 m from the waterline, and (5) percent of the bank habitat consisting of beach.

Spring habitat parameters were: (1) percent of the bottom substrate consisting of fines, sand, rock, and bedrock, (2) slope of the river bottom 0-50 m from shore, (3) nearshore transparency (cm), (4) percent vegetative cover on the bank 10 and 20 m from the waterline, (5) percent of the bank habitat consisting of bedrock, (6) percent of the bank habitat consisting of large riprap, and (7) percent of the bank habitat consisting of beach (Vile and Friesen 2004).

Radio Telemetry

Migration rates and residence times

We calculated migration rates (km/d) of juvenile salmonids based on travel time from the initial release point to subsequent downstream relocation points. Mobile telemetry and fixed telemetry data were combined into one dataset and sorted by tag channel and code, allowing us to examine the data for individual fish and identify peculiarities that required editing. Criteria we established for radio telemetry data included: 1) fish that were pinpointed multiple times in the same location for over 24 hours were presumed dead and were not included in subsequent analyses; 2) fish that moved upstream with no subsequent downstream movement were not actively migrating, or may have been a victim of predation; migration rates were calculated using only downstream movements of the fish to the point at which the fish began to move upstream; 3) if the signal strength was of low quality (unable to obtain good signal strength on the aerial antenna and/or unable to pinpoint the fish using the underwater antenna), the data was not included in calculations of migration rate. In addition, we verified river mile estimates for relocations by plotting the GPS waypoints onto an Oregon Lambert-projected ortho-photo (2' resolution) using ArcView 3.2a.

To calculate residence time, we multiplied the overall migration rate for each fish by the study area distance (42.6 rkm). We compared migration rates and residence times among species using the Kruskal-Wallis one-way ANOVA on ranks and Dunn's nonparametric multiple comparison test. Migration rates and residence times between unmarked and hatchery fish, and the upper study area (rkm 22.6 – 42.6) and the lower study area (rkm 0.0 – 22.5) were compared for each species using the Mann-Whitney rank sum test. Factors that could influence migration rates, including river flow, temperature, release day, and fish size (fork length) were assessed using simple and multiple linear regressions.

Habitat use

We used distributions of radio telemetry relocations across the river channel to determine if salmonids were closely associated with nearshore areas, and are therefore likely to encounter different bank habitats. For each relocation, we divided the measured river width into 10% increments and assigned the relocation a category (e.g., 0-10%, 11-20%). We analyzed distributions using the chi-square test; samples with expected values of < 5 for a single category were not included (Zar 1999).

We used the same analysis to determine if nearshore relocations among general habitat types were distributed differently than the habitat types (null hypothesis #3), which could indicate selection or avoidance of specific habitats. Survey data from North et al. (2002) were used to determine proportions of each habitat type present throughout the study area (rkm 0.0 to 42.6). Because the release timing of radio-tagged fish varied from year to year, there was some potential for environmental conditions, primarily river flow, to affect telemetry results. To explore this factor, we plotted hydrographs of daily flow values for spring (April – June) and for periods we were tracking radio-tagged fish. Differences among years were identified using the Kruskal-Wallis one-way ANOVA on ranks and Dunn's nonparametric multiple comparison test. We also calculated median, minimum, and maximum flow values for each period, and qualitatively characterized differences among years. We used U. S. Geological Survey (USGS) river flow data collected at the Morrison Bridge gauging station (USGS 2004; Suzanne Miller, USGS, personal communication).

RESULTS

We collected 5,030 juvenile salmonids identifiable to species (Figure 3). Over 87% were Chinook salmon, 9% were coho salmon, and 3% were steelhead. A small number of other salmonids were collected, including 40 mountain whitefish *Prosopium transmontanus*, five sockeye salmon *O. nerka*, and two cutthroat trout *O. clarki*. Hatchery fish predominated, comprising 54% of the Chinook salmon, 66% of the coho salmon, and 91% of the steelhead. Differences in catch between gears were pronounced. The electrofishing catch consisted primarily (68%) of hatchery Chinook salmon, while unmarked Chinook salmon dominated (85%) the beach seine catch. The majority of steelhead (91%) and coho salmon (81%) were captured by electrofishing.

The mean fork length of hatchery Chinook salmon captured by electrofishing (155 mm) was considerably greater than that of unmarked fish (115 mm), though the unmarked component exhibited greater variance (Figure 4). Few hatchery Chinook salmon were captured with beach seines, and were similar in size to those captured with electrofishing gear. Unmarked fish observed in beach seine catches were generally much smaller than those captured by electrofishing, and exhibited a bimodal length distribution, with peak numbers of fish occurring at about 45 and 75 mm FL.

Steelhead, observed infrequently in both beach seine and electrofishing catches, were usually larger (>150 mm FL) than Chinook or coho salmon, and ranged from 58-250 mm FL (Figure 5). Coho salmon captured by electrofishing were slightly larger than those observed in beach seine catches, and had a bimodal length distribution, with peaks occurring at about 75 and 150 mm FL (Figure 5).

Density and Timing

From May 2000 to July 2003, density values of both hatchery and unmarked juvenile Chinook salmon captured by electrofishing generally increased beginning in November and declined to near zero by June (Figure 6). Peak densities varied, occurring between January and April. Hatchery Chinook salmon were present at higher densities than unmarked fish during most months, and both hatchery and unmarked fish were present at low densities in August, September, and October of some years.

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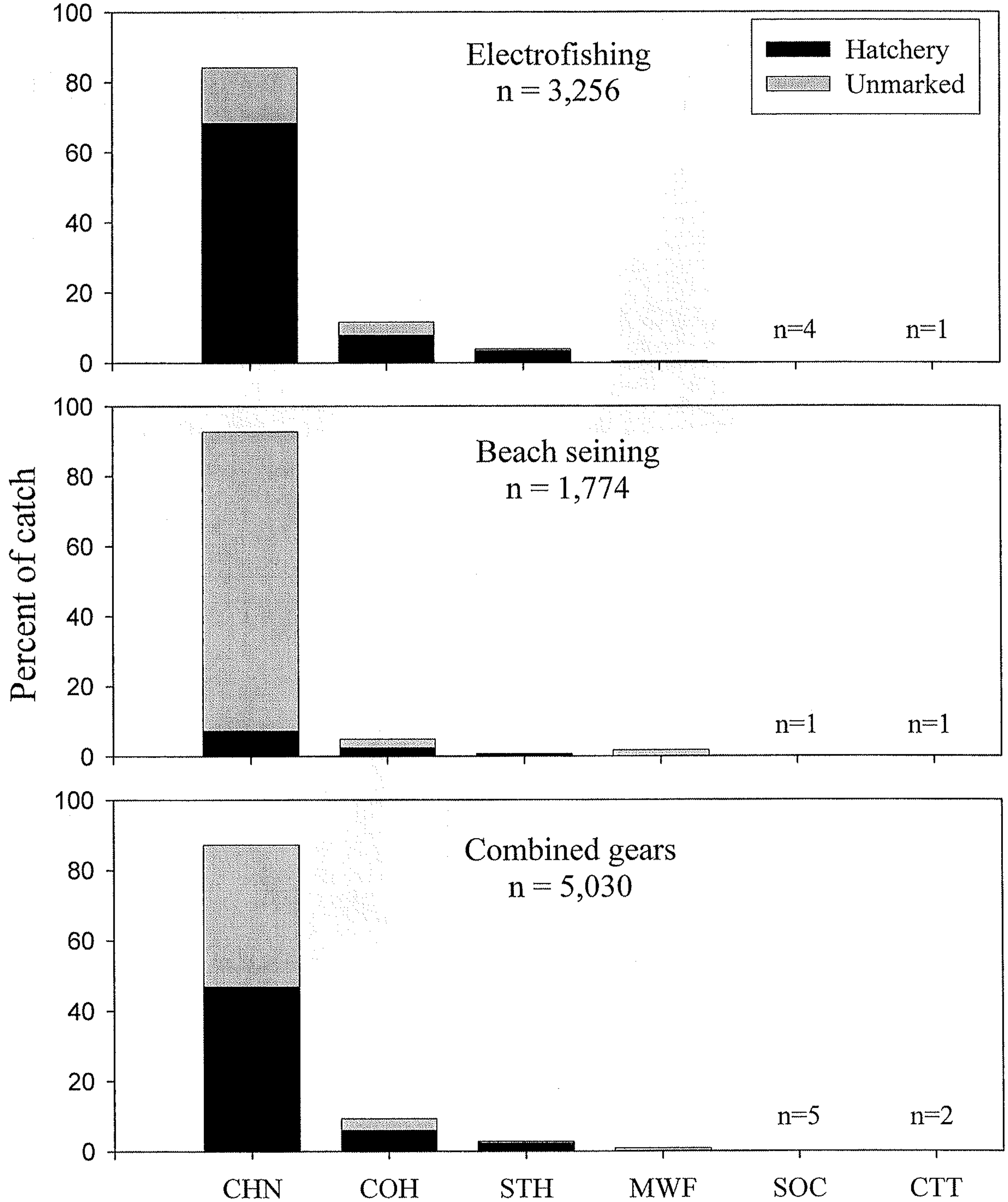

Figure 3. Juvenile salmonids captured by electrofishing and beach seining in the lower Willamette River, 2000-2003. CHN = Chinook salmon, COH = coho salmon, STH = steelhead, MWF = mountain whitefish, SOC = sockeye salmon, CTT = cutthroat trout.

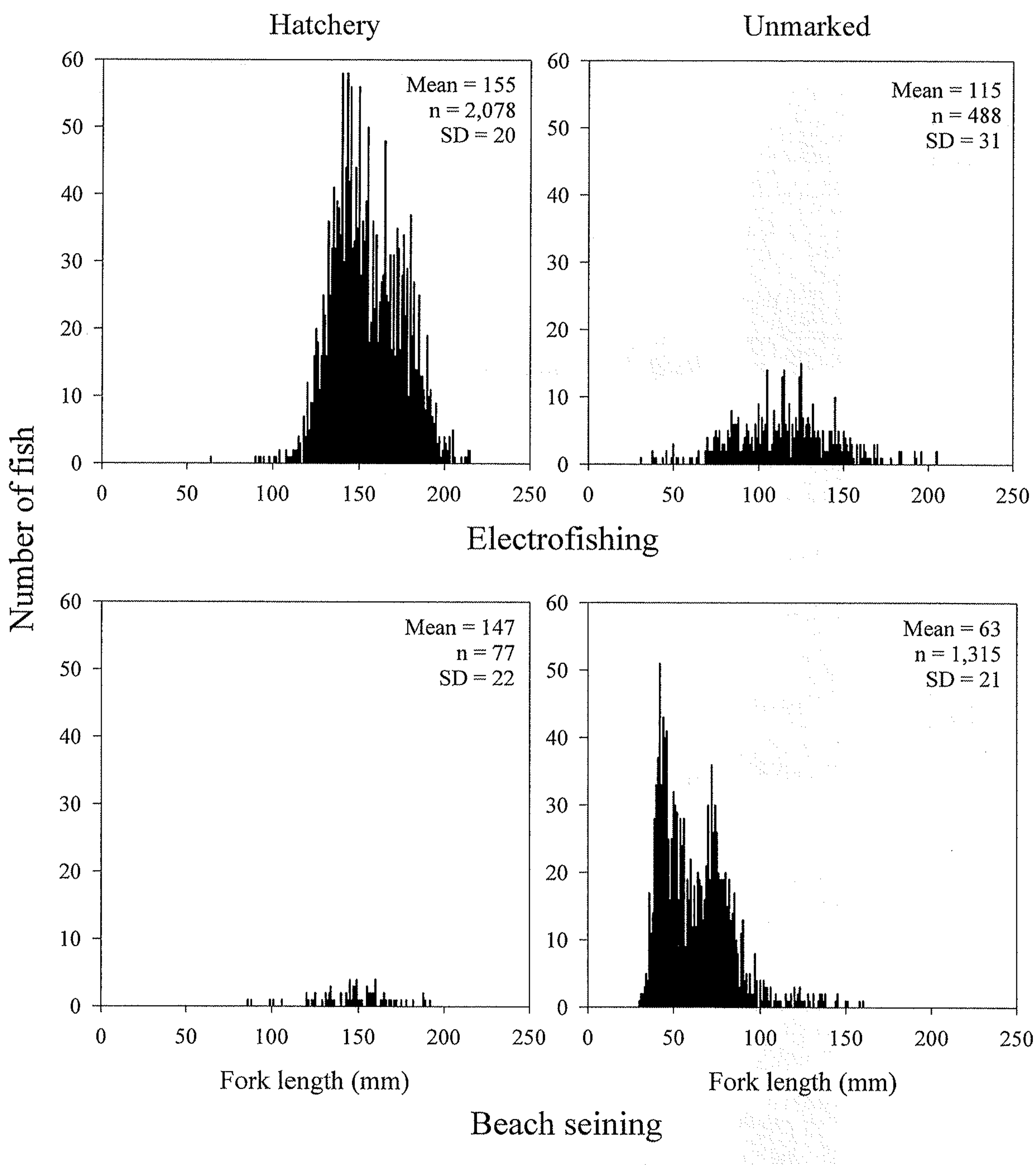

Figure 4. Fork length distributions for hatchery and unmarked juvenile Chinook salmon captured by electrofishing (top panels) and beach seining (lower panels) in the lower Willamette River, 2000-2003. SD = standard deviation.

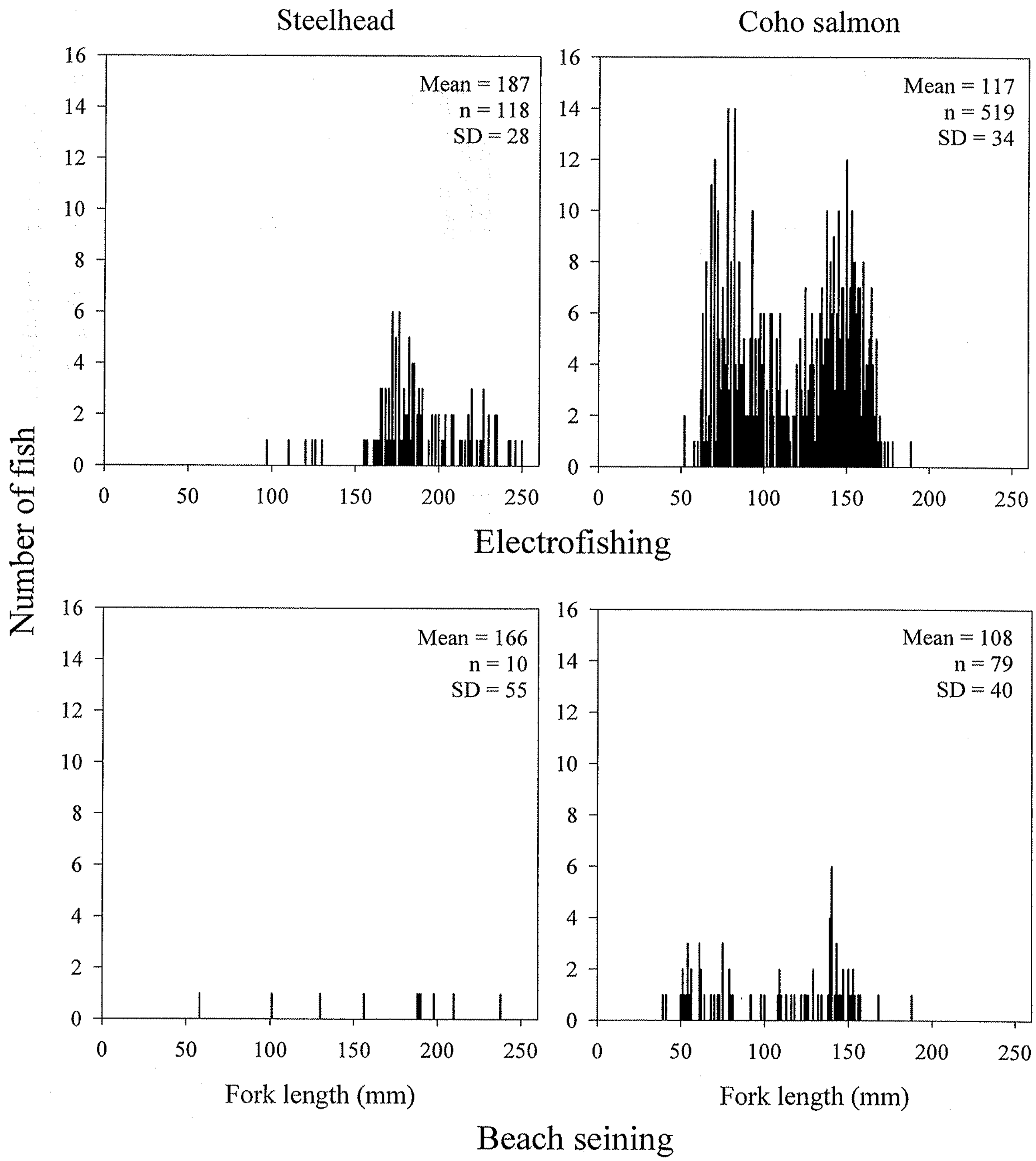

Figure 5. Fork length distributions for juvenile steelhead and juvenile coho salmon captured by electrofishing (top panels) and beach seining (bottom panels) in the lower Willamette River, 2000-2003. SD = standard deviation.

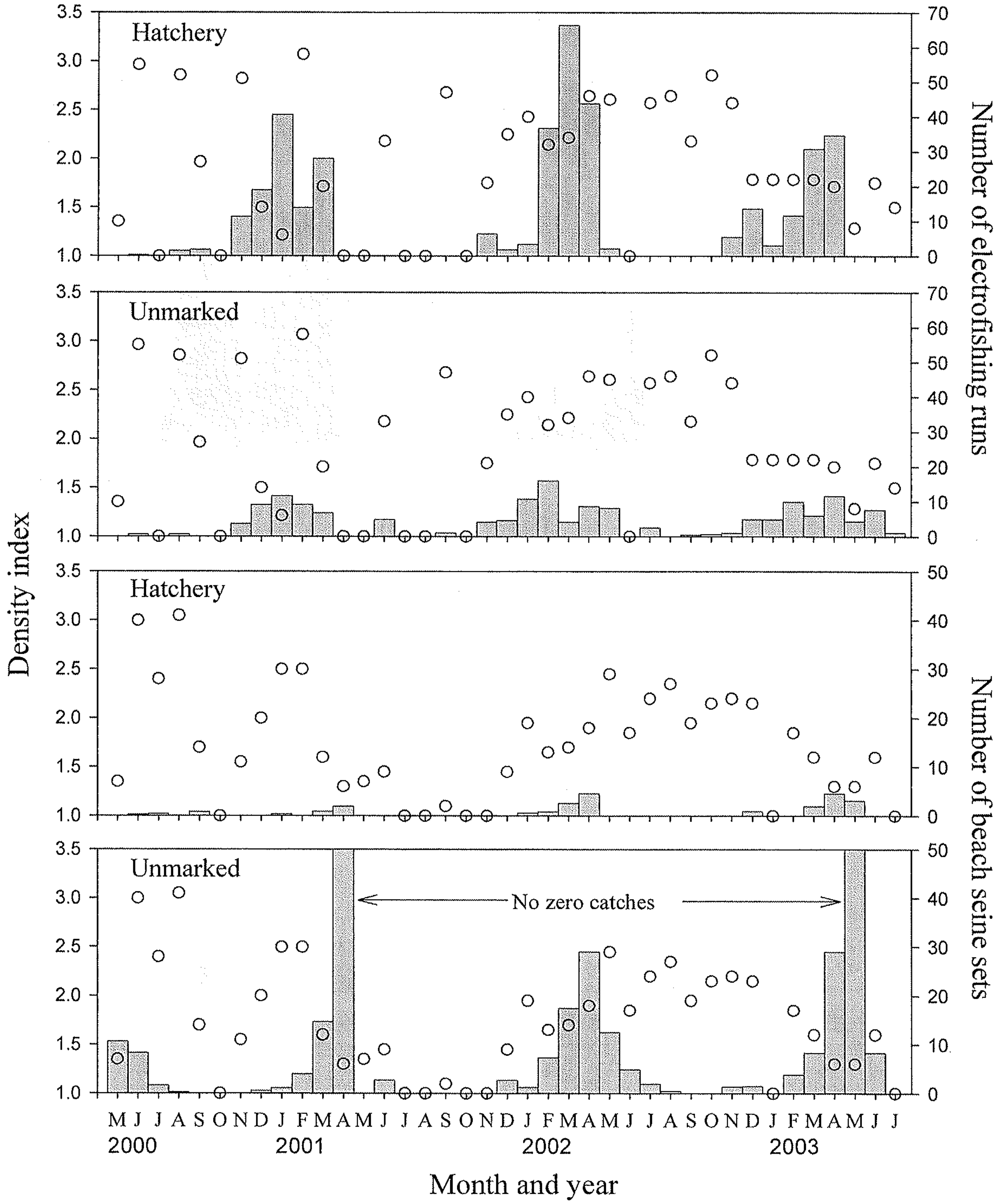

Figure 6. Monthly relative density for juvenile Chinook salmon (hatchery and unmarked) captured by electrofishing (top panels) and beach seining (lower panels) in the lower Willamette River, 2000-2003. Open circles indicate sampling effort (Z-axis).

Juvenile Chinook salmon observed in beach seine catches exhibited similar timing, except peak catches of both hatchery and unmarked fish occurred later (usually one month) than those from electrofishing (Figure 6). Densities of unmarked fish increased sharply in February and declined to near zero in July. Densities of unmarked fish were much higher than those of hatchery fish, and peak catches of unmarked fish occurred in April or May. We captured unmarked juvenile Chinook salmon in every beach seine set in April 2001 and May 2003, resulting in infinite density index values.

Due to the small number of coho salmon and steelhead collected, we did not separate these species into hatchery and unmarked groups. Relative densities for both species, derived from the electrofishing catch, were generally lower than those of Chinook salmon, and their temporal distribution varied widely (Figure 7). Densities of coho salmon in electrofishing surveys peaked during spring (April or May) in 2000, 2002, and 2003. Electrofishing effort was greatly reduced in 2001, and we observed coho salmon only during June. We captured coho salmon in every month except October. Juvenile steelhead were observed from November through June; peak densities occurred in November (2000) or May (2002 and 2003).

Densities of juvenile coho salmon and steelhead from beach seine catches were relatively low, with variable timing (Figure 7). No juvenile coho salmon were observed in 2000, but were present at low densities in December or January and May-June during 2001-2003. Steelhead were absent from beach seine catches in 2000 and 2001, but were present at low densities in 2002 (April-July and December) and 2003 (March).

Growth

Median fork lengths of hatchery Chinook salmon were significantly greater at downstream sampling sites than at upstream sites during winter, spring, and for both seasons combined (Figure 8). Differences were more pronounced during winter, when the median fork length was 14 mm greater at downstream sites than at upstream sites (compared to 9 mm greater during spring). Weight comparisons followed the same pattern; fish captured at downstream sites were significantly heavier ($P<0.01$) than those captured at upstream sites.

Length and weight differences for unmarked subyearling Chinook salmon among upper and lower sampling sites were less distinct (Figure 9). Median fork lengths were always greater (1 – 6 mm) at downstream sites but significantly different ($P=0.01$) from upstream sites only where winter and spring data were combined. Median weights were significantly greater at downstream sites during spring and both seasons combined, but not during winter ($P=0.85$).

Habitat Use (electrofishing)

Generalized Habitat Categories

We completed 898 electrofishing runs to assess habitat use. Median electrofishing catch rates of juvenile salmonids >100 mm FL were often zero, and we identified few significant differences among generalized habitat types. For all juvenile Chinook salmon (hatchery and unmarked;

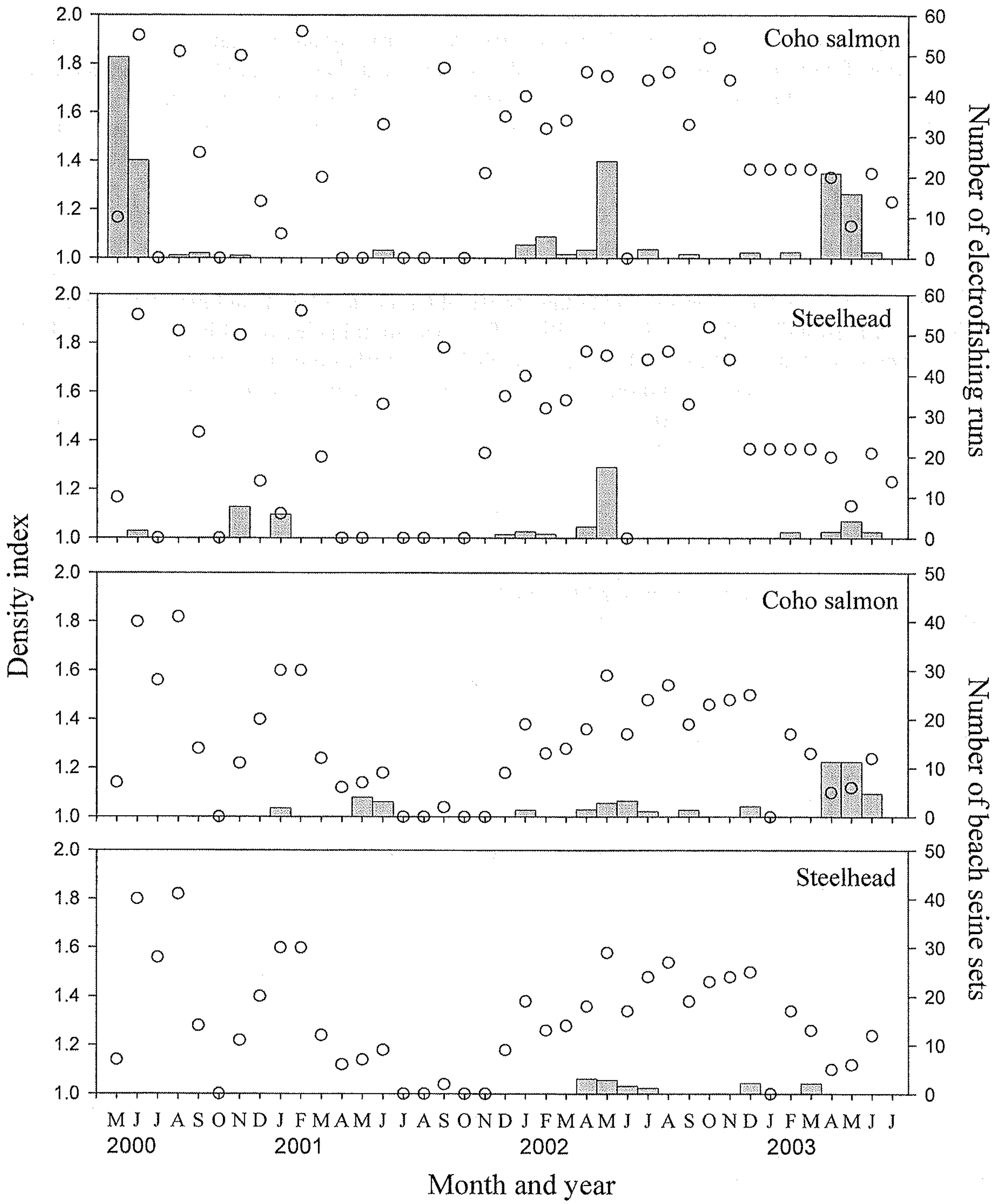

Figure 7. Monthly relative density for juvenile coho salmon and steelhead captured by electrofishing (top panels) and beach seining (lower panels) in the lower Willamette River, 2000-2003. Open circles indicate sampling effort (Z-axis).

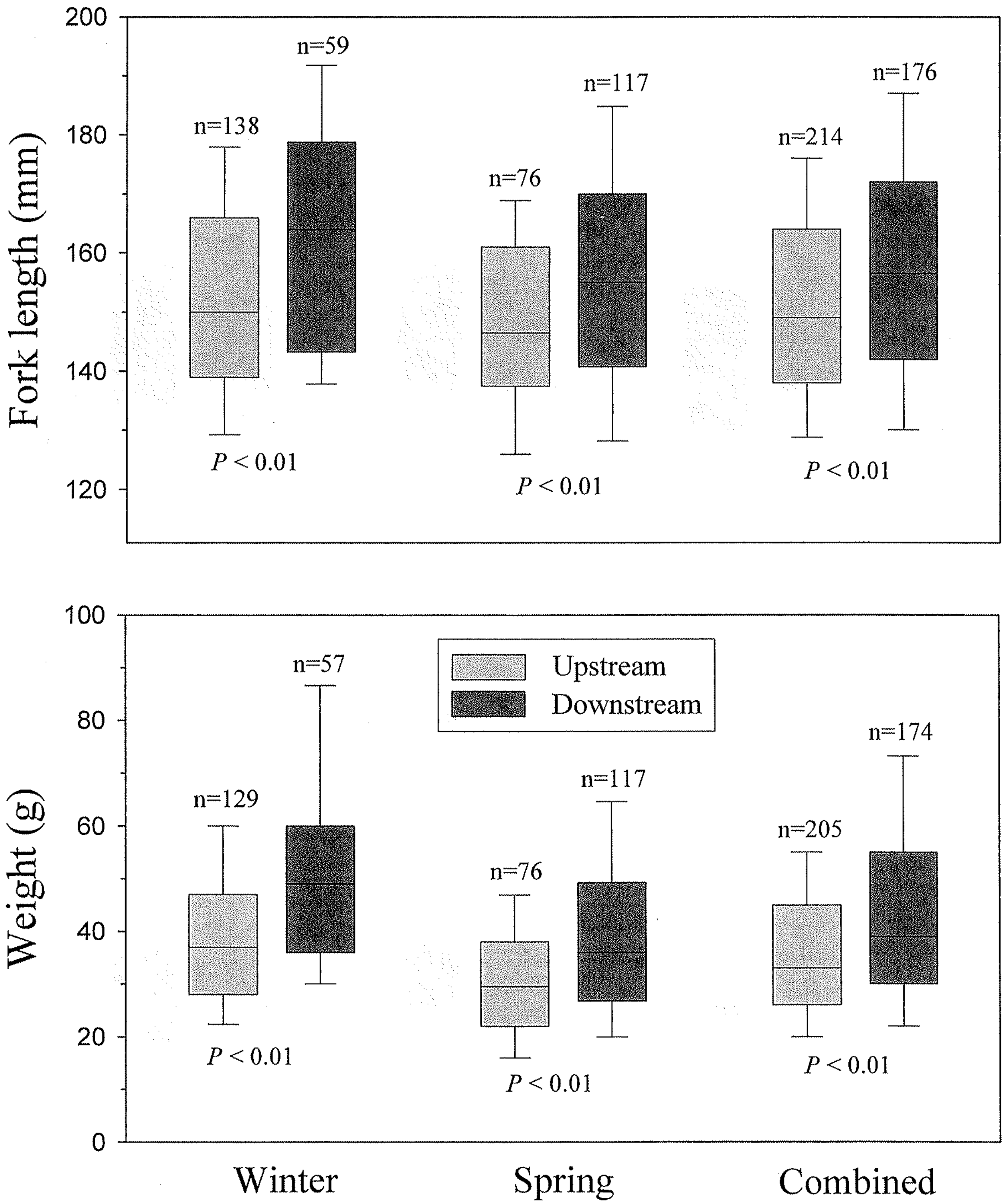

Figure 8. Seasonal fork length and weight of juvenile hatchery Chinook salmon at upstream (rkm 26.9, 32.2, and 35.2) and downstream (rkm 1.0, 1.6, and 1.9) sampling sites in the lower Willamette River, 2000 – 2003.

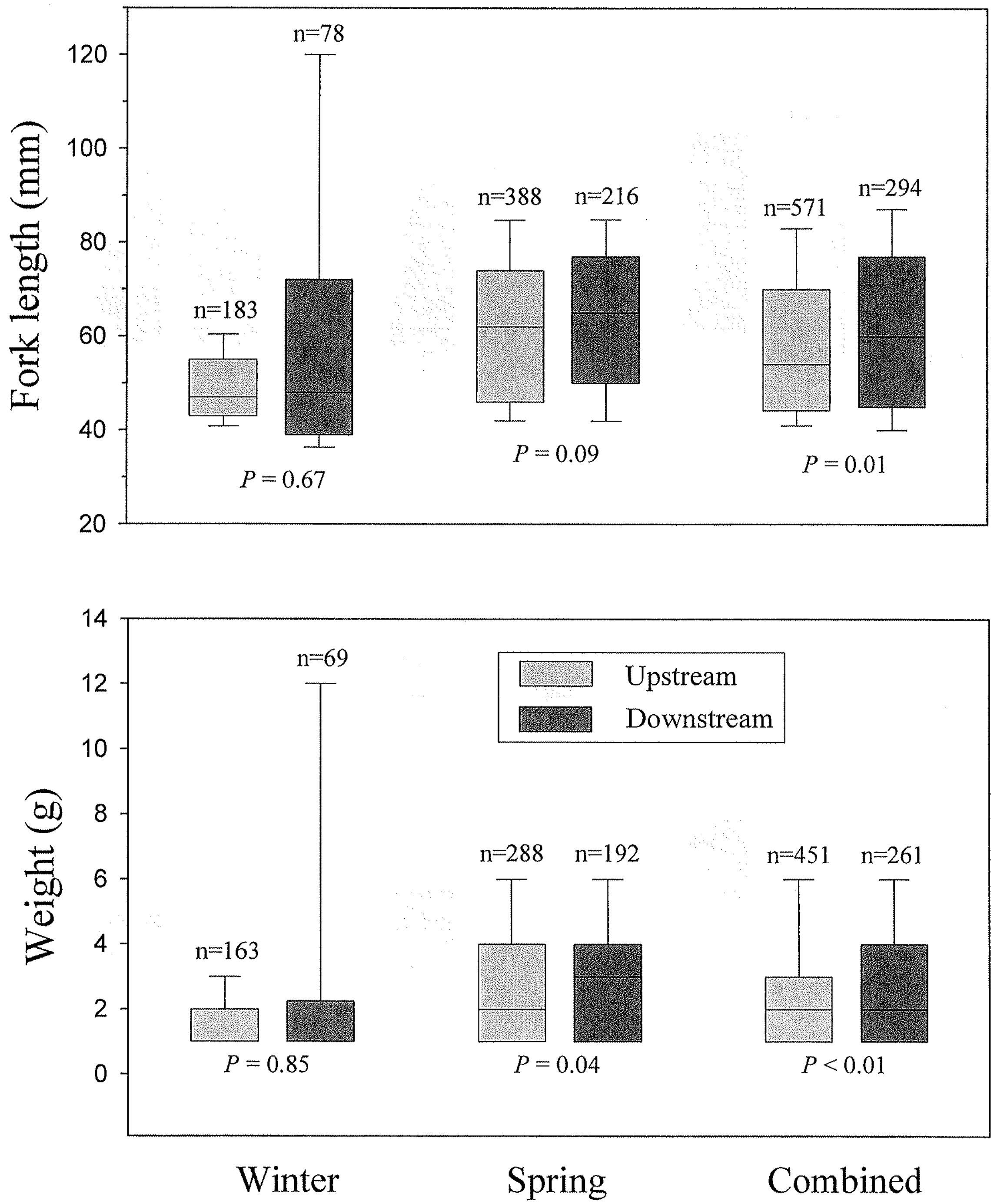

Figure 9. Seasonal fork length and weight of unmarked juvenile Chinook salmon at upstream (rkm 26.9 and 39.1) and downstream (rkm 1.0 and 6.4) sampling sites in the lower Willamette River, 2000 – 2003.

Figure 10), winter catch rates were significantly lower at seawall sites than at beach, mixed, and riprap habitats ($P<0.01$). In summer, catch rates were significantly ($P=0.04$) lower at seawall sites than at mixed-habitat sites. No significant differences were observed in spring or autumn.

We captured a relatively small number (n = 244) of unmarked Chinook salmon >100 mm FL, and observed few differences in median catch rates among habitat types (Figure 11). Catch rates were significantly higher at mixed-habitat sites than at seawalls in both winter and autumn ($P <$ 0.01 and $P = 0.04$).

Hatchery Chinook salmon >100 mm FL were far more numerous (n = 1,419), and differences among habitat types were significant only during winter ($P < 0.01$); median catch rates were significantly higher at riprap and mixed habitats than at seawalls (Figure 12). Though no significant differences were evident in spring, high catches tended to occur more frequently at mixed habitats than at other habitat types. Only 22 fish were captured during summer, and no differences among habitat types were evident. Autumn catch rates did not vary significantly among habitats, but some very high catches occurred at beaches.

Most coho salmon were captured in spring (n=347) and summer (n = 23). Median catch rates at rock outcrops during spring were significantly higher than at beach, riprap, and seawall sites ($P <$ 0.01; Figure 13). Catch rates at mixed habitats during spring were relatively high, but not significantly different from other habitats. No differences among habitat types were observed in summer.

Steelhead were present in low numbers, and catches were highest in spring (n = 54) and summer (n = 58). Differences in median CPUE for steelhead among habitat types were not significant in either season, though higher catches tended to occur more frequently at rock outcrops (spring and autumn) and mixed habitats (spring; Figure 13).

Clustered Habitat Categories

Differences in median catch rates among habitat groups defined by cluster analysis were similar to those of generalized habitat types. The median CPUE of juvenile Chinook salmon > 100 mm FL was significantly different among clustered groups during winter ($P < 0.01$; Figure 14). Group 3 (seawalls) catches were significantly lower than group 2 (riprap and mixed habitats) and group 5 (primarily off-channel habitats). Catch rates were significantly higher for group 2 than group 1 (rock outcrops). No significant differences among habitats were present in spring ($P =$ 0.09) or summer ($P = 0.51$). Though not significantly different ($P = 0.06$), autumn catch rates for groups dominated by riprap (4 and 6) were higher than other groups

The median catch of unmarked Chinook salmon >100 mm FL in winter was greater for group 2 (riprapped and mixed habitats) than any other group, but was significantly different ($P = 0.01$) only from group 3 (seawalls; Figure 15). Catch rates in autumn differed significantly ($P < 0.05$) among habitats, but the multiple comparison procedure (Dunn's test) could not identify which pairs differed. Low catches occurred more frequently at groups 1 (primarily beaches), 3 (beach and off-channel habitats) and 5 (rock outcrops). No significant differences existed among

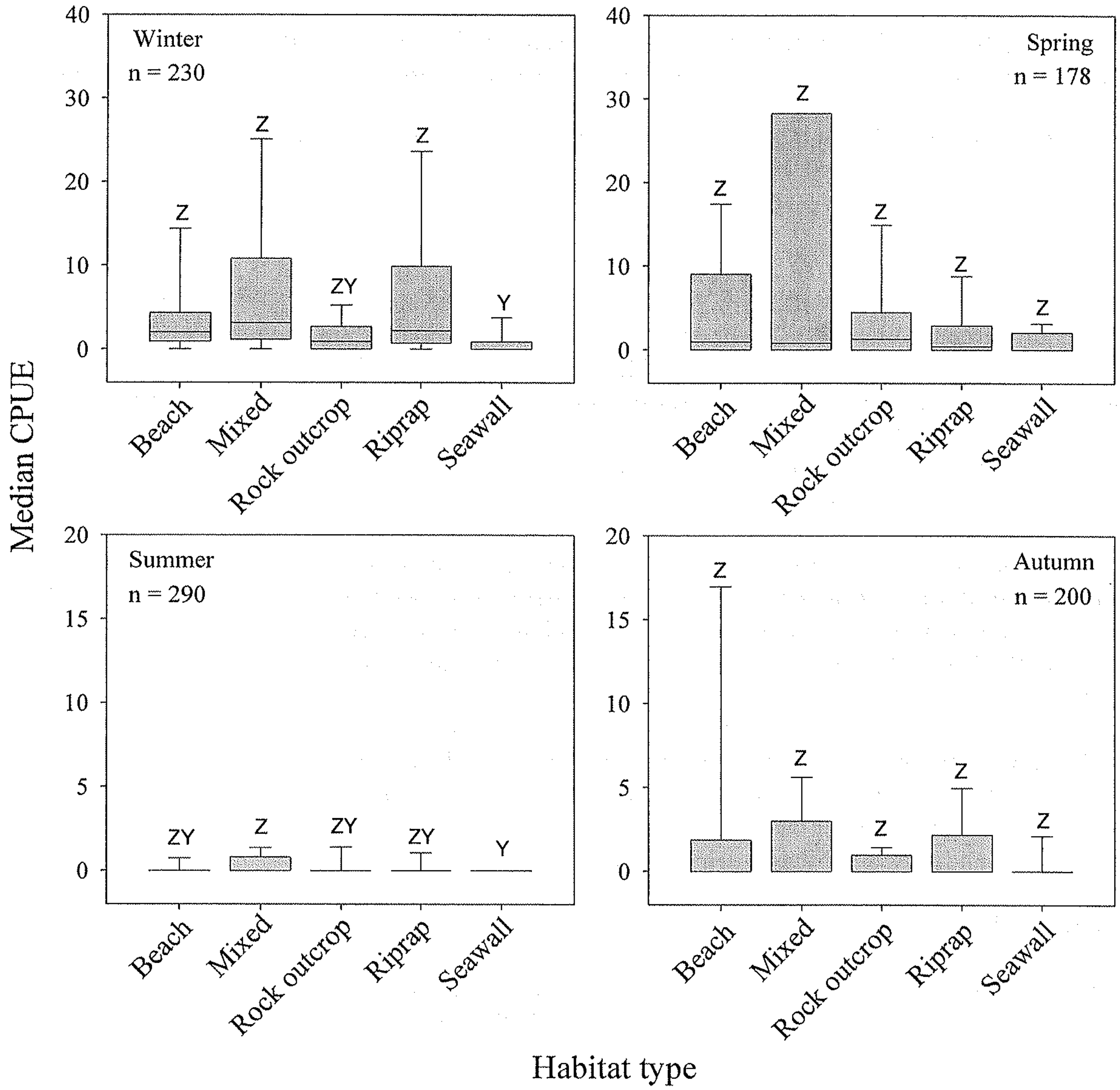

Figure 10. Median catch per unit effort (CPUE) of juvenile Chinook salmon >100 mm FL among seasons and generalized habitat types in the lower Willamette River, 2000-2003. In each chart, bars without a letter in common are significantly different (P<0.05). n = number of electrofishing runs.

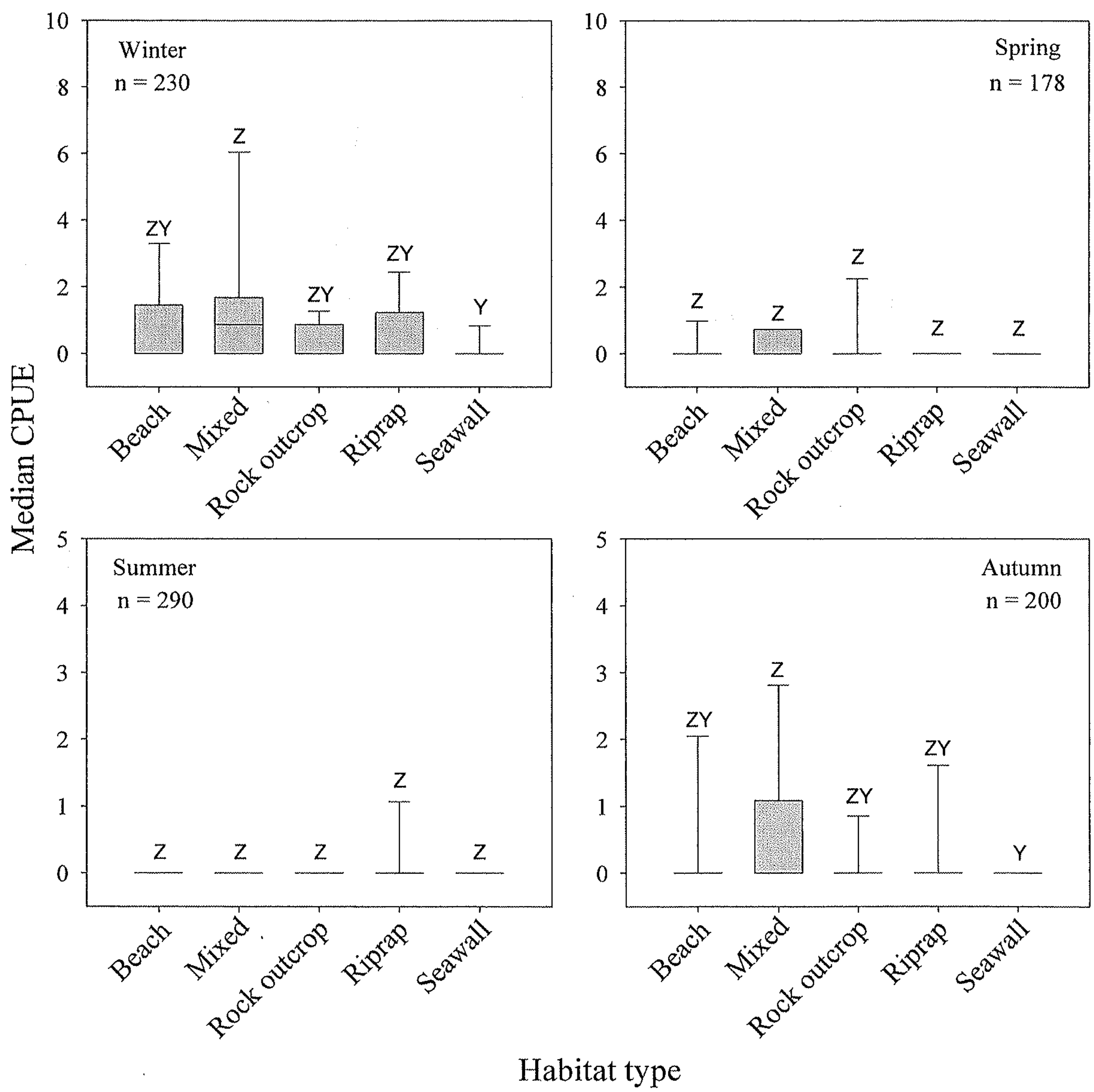

Figure 11. Median catch per unit effort (CPUE) of unmarked juvenile Chinook salmon >100 mm FL among seasons and generalized habitat types in the lower Willamette River, 2000-2003. In each chart, bars without a letter in common are significantly different (*P*<0.05). n = number of electrofishing runs.

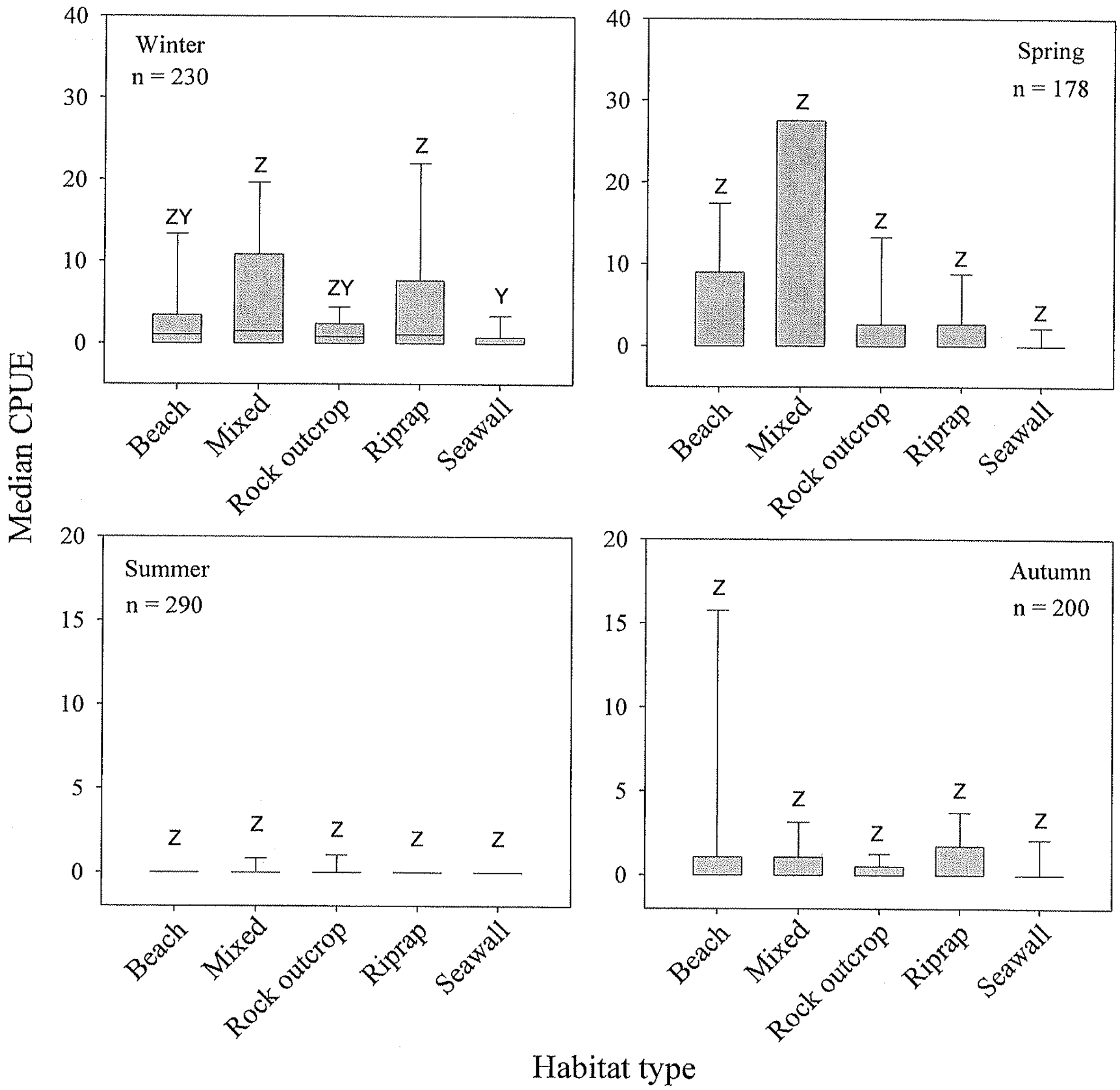

Figure 12. Median catch per unit effort (CPUE) of hatchery juvenile Chinook salmon >100 mm FL among seasons and generalized habitat types in the lower Willamette River, 2000-2003. In each chart, bars without a letter in common are significantly different ($P<0.05$). n = number of electrofishing runs.

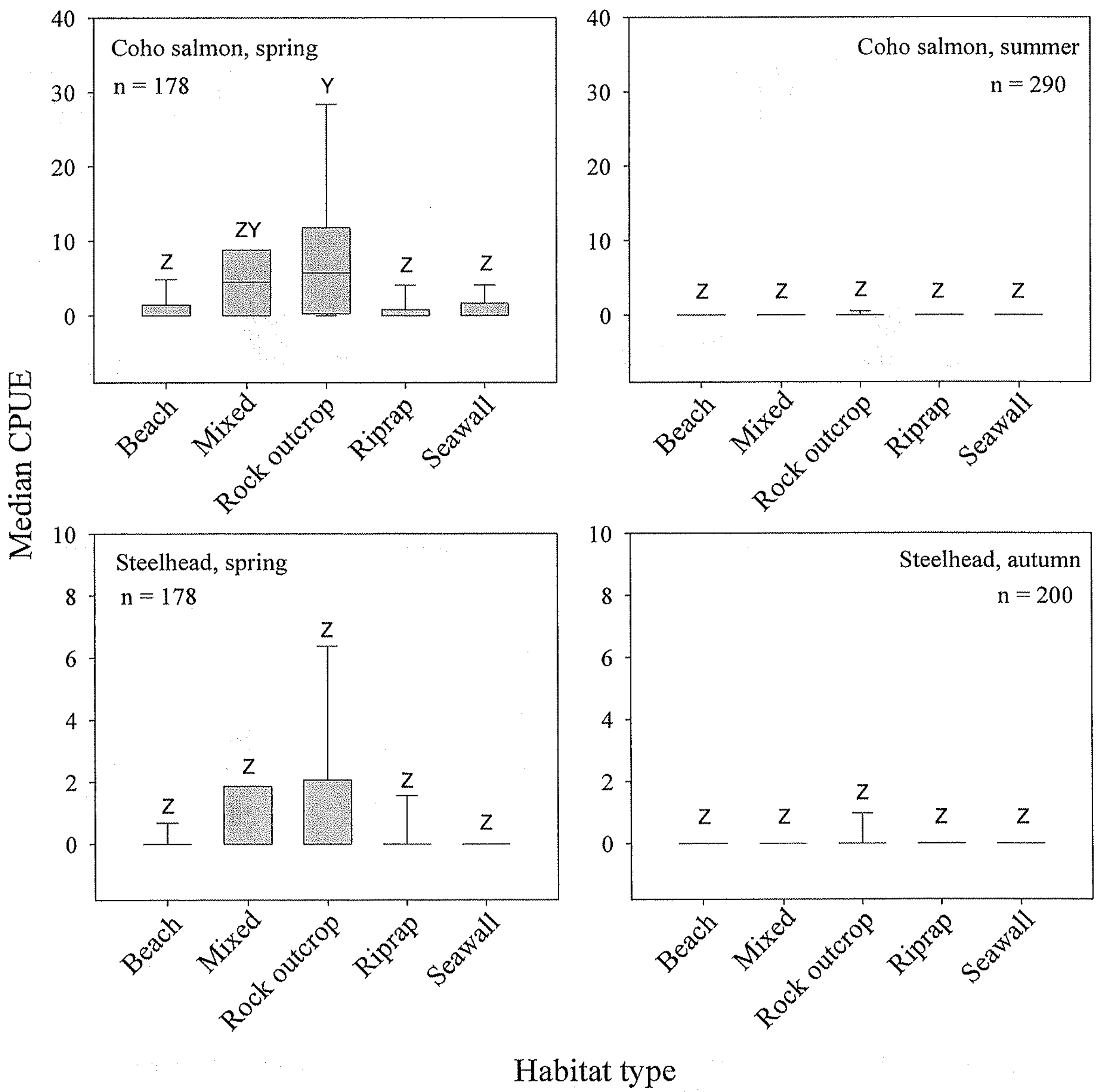

Figure 13. Median catch per unit effort (CPUE) of coho salmon and steelhead >100 mm FL among seasons and generalized habitat types in the lower Willamette River, 2000-2003. In each chart, bars without a letter in common are significantly different (*P*<0.05). n = number of electrofishing runs.

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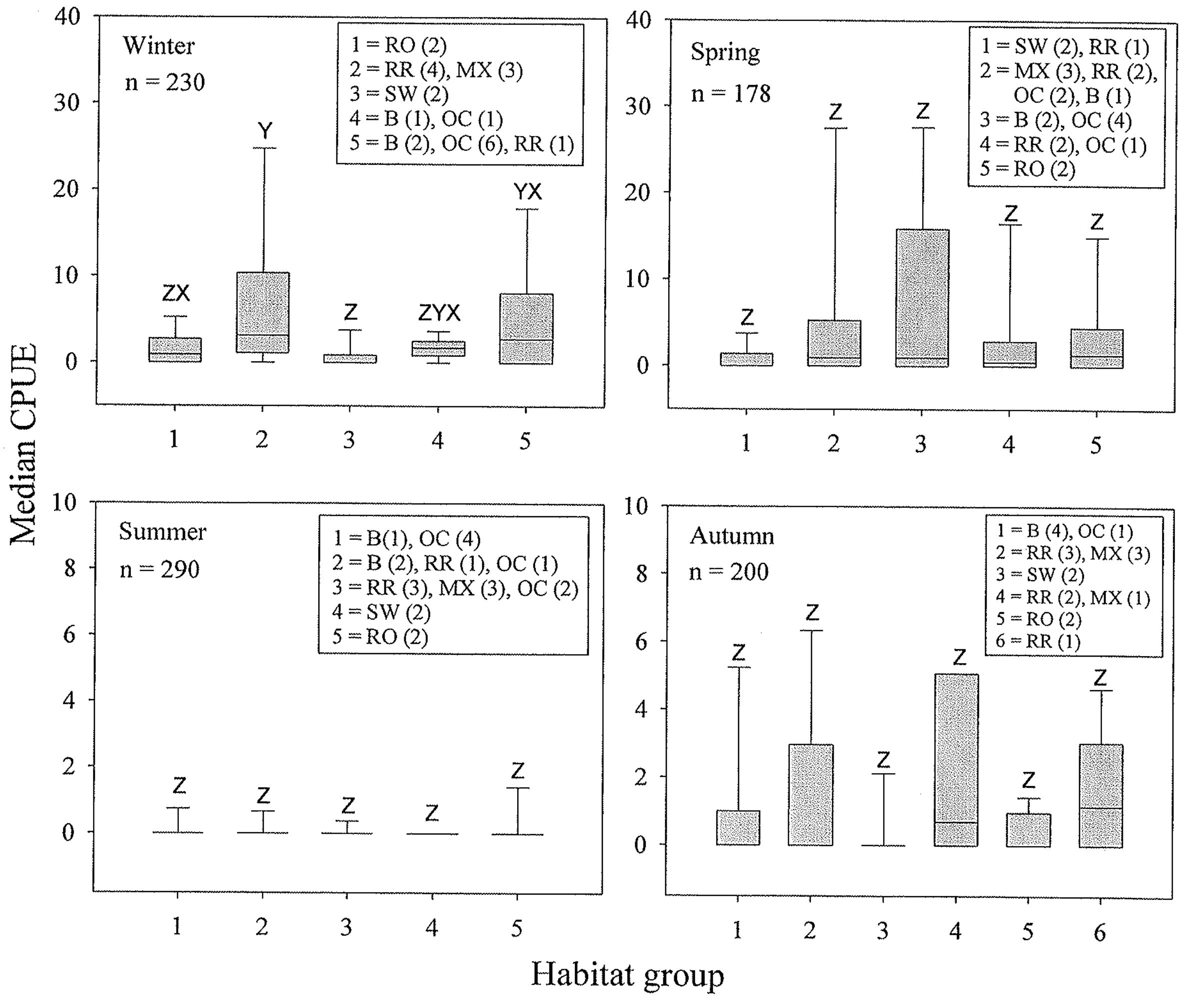

Figure 14. Median catch per unit effort (CPUE) of juvenile Chinook salmon >100 mm FL among seasons and habitat groups in the lower Willamette River, 2000-2003. Habitat groups represent sampling sites grouped by cluster analysis (Vile and Friesen 2004). Legends indicate generalized habitat types (number of sites in parentheses) present in each group: RO = rock outcrop, RR = riprap, B = beach, MX = mixed (usually RR and B), SW = seawall and OC = off channel. In each chart, habitat groups without a letter in common are significantly different ($P<0.05$). n = number of electrofishing runs.

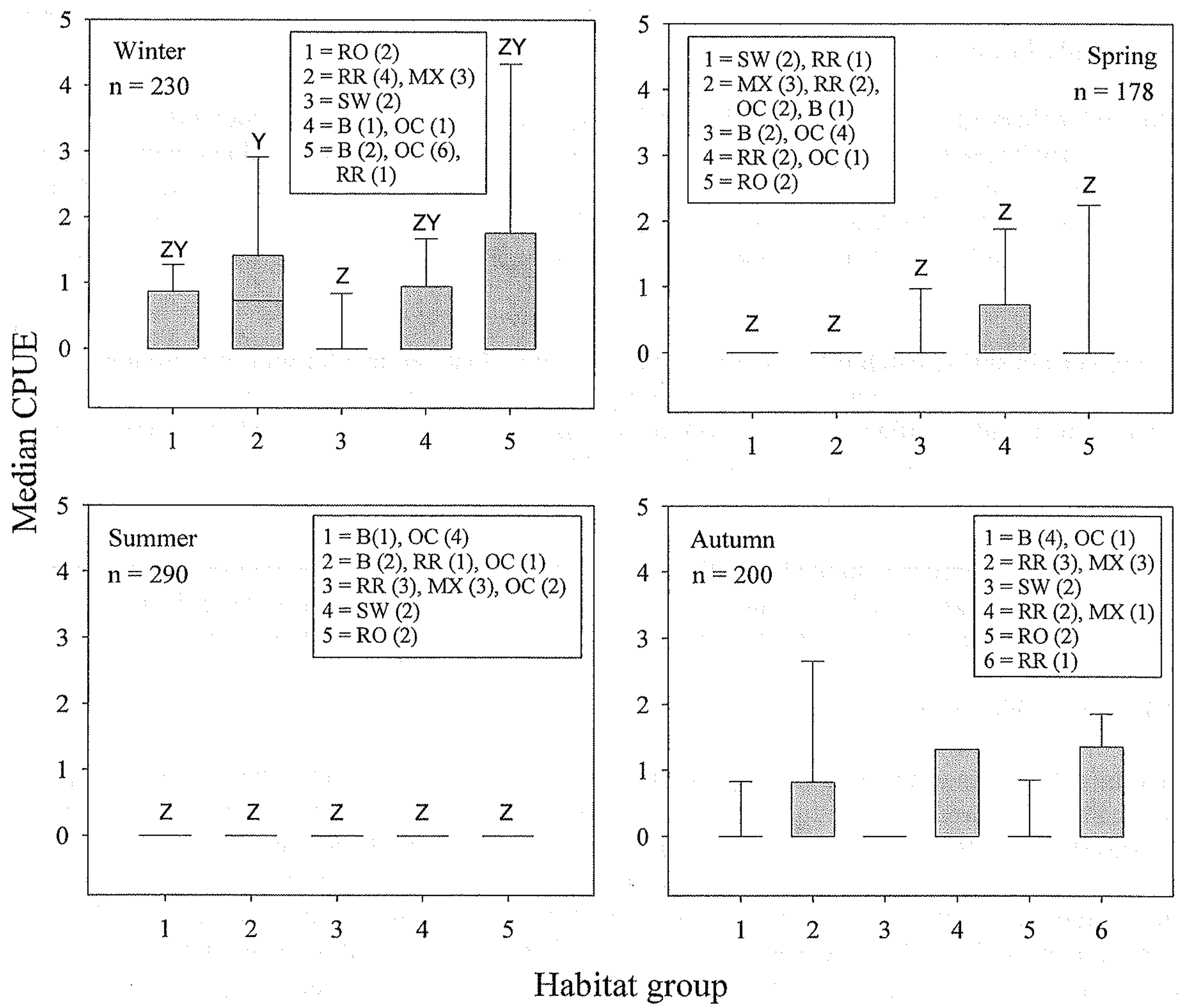

Figure 15. Median catch per unit effort (CPUE) of unmarked juvenile Chinook salmon >100 mm FL among seasons and habitat groups in the lower Willamette River, 2000-2003. Habitat groups represent sampling sites grouped by cluster analysis (Vile and Friesen 2004). Legends indicate generalized habitat types (number of sites in parentheses) present in each group: RO = rock outcrop, RR = riprap, B = beach, MX = mixed (usually RR and B), SW = seawall and OC = off channel. In each chart, habitat groups without a letter in common are significantly different ($P<0.05$). n = number of electrofishing runs.

groups in spring or summer. The median, 75th percentile, and 90th percentile of catch rates were consistently low at seawalls in all seasons.

Among hatchery Chinook salmon >100 mm FL captured in winter, median catch rates were significantly lower for group 3 (seawalls) than group 2 (riprap and mixed habitats) and group 5 (primarily off-channel habitats) ($P < 0.01$; Figure 16). Results for spring were similar; median CPUE was significantly lower for group 1 (seawalls) than group 2 (mixed, riprap, and off-channel sites) and group 3 (beach and off-channel sites; $P = 0.01$). Summer and autumn catch rates were not significantly different among groups.

Differences in spring catch rates of coho salmon among clustered habitat groups were nearly identical to those for generalized habitat types (Figure 17). Group 5, consisting of two rock outcrop sites, had significantly ($P < 0.01$) higher catches of coho salmon (median CPUE = 5.8) than the other four groups (all median CPUEs = 0.0). Catches of coho salmon during summer were sparse, and no differences among groups were apparent.

No significant differences in median CPUE for steelhead among clustered habitat groups were evident, though higher catches occurred frequently at group 5 (rock outcrop) sites during spring, and the relatively low P-value (0.06) may indicate some biological significance (Figure 17).

Off-channel Habitats

Median catch rates of juvenile Chinook salmon >100 mm FL tended to be slightly higher (and high catches occurred more frequently) at off-channel sites during winter and spring, but were not significantly different from main-channel sites. For all Chinook salmon combined (unmarked and hatchery), catches were significantly ($P = 0.04$) higher at main channel sites during autumn (Figure 18). Patterns for unmarked (Figure 19) and hatchery fish (Figure 20) were similar; high catches occurred more frequently at off-channel sites during winter and spring, and at main channel sites during autumn, though none of the relationships were statistically significant. Catches of coho salmon and steelhead were generally low and did not differ significantly between off-channel and main-channel sites, though higher catches of coho salmon occurred more frequently in off-channel areas (Figure 21).

Habitat Parameters

We observed few significant differences in median CPUE among categorical habitat parameter values during spring; catches of juvenile Chinook salmon did not vary with dominant substrate type, bottom slope, transparency, or the percent of bank habitat consisting of large riprap. (Appendix Tables 1-3). Catches among bank vegetation categories (the percent of onshore habitat covered by living plants within 20 m of the waterline) differed significantly.
The median catch rate for all Chinook salmon (hatchery and unmarked) was significantly higher at sites having 21-30% vegetative coverage than at sites with 0-10% ($P = 0.05$) (Appendix Table 1). Results for unmarked fish were similar; median CPUE was highest at sites with 71-80% coverage (Appendix Table 2). Catch rates for marked fish were relatively high at sites with both large (71 – 80%) and small (21 – 30%) amounts of vegetation, and the only pairwise significant

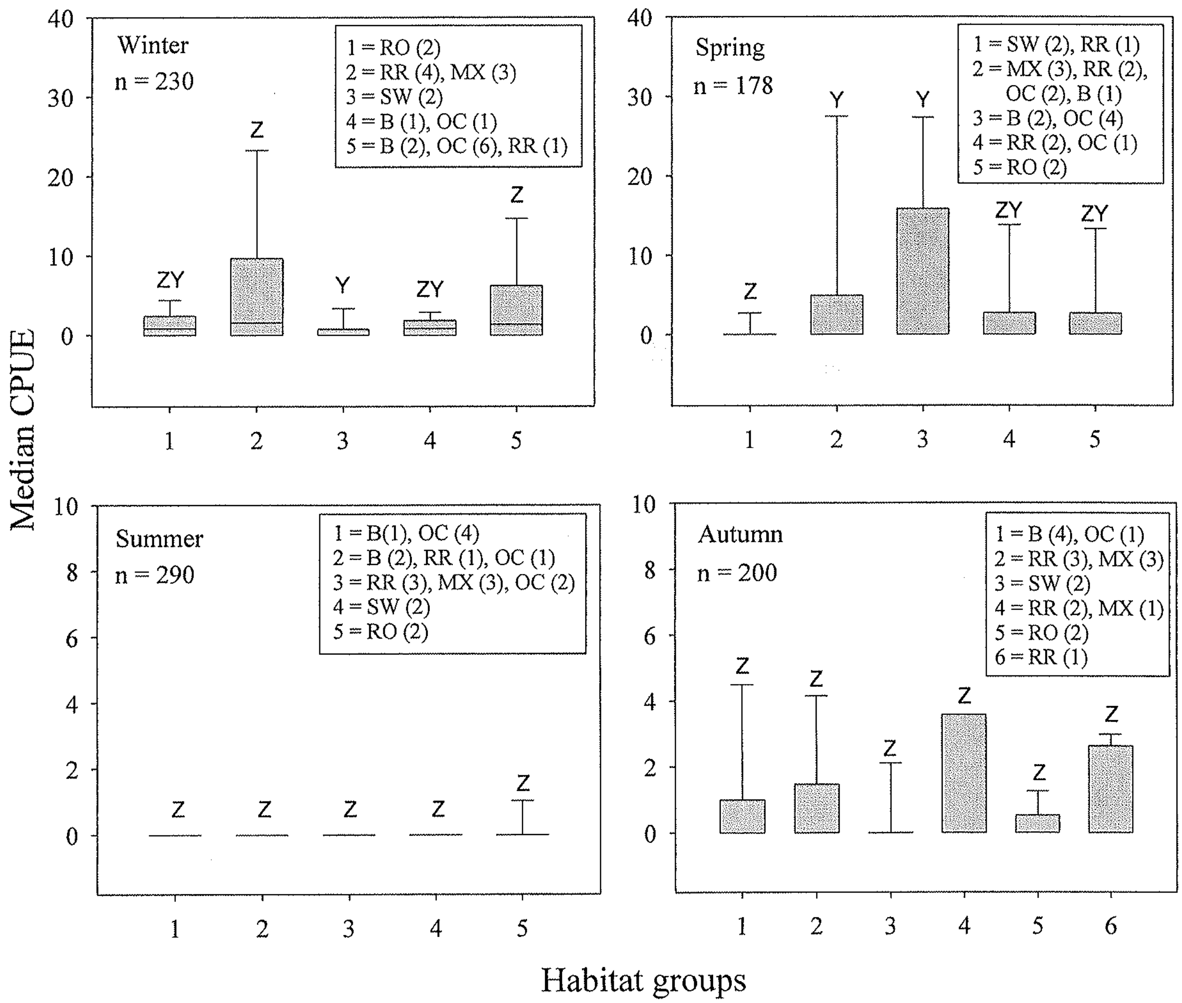

Figure 16. Median catch per unit effort (CPUE) of hatchery juvenile Chinook salmon >100 mm FL among seasons and habitat groups in the lower Willamette River, 2000-2003. Habitat groups represent sampling sites grouped by cluster analysis (Vile and Friesen 2004). Legends indicate generalized habitat types (number of sites in parentheses) present in each group: RO = rock outcrop, RR = riprap, B = beach, MX = mixed (usually RR and B), SW = seawall and OC = off channel. In each chart, habitat groups without a letter in common are significantly different ($P<0.05$). n = number of electrofishing runs.

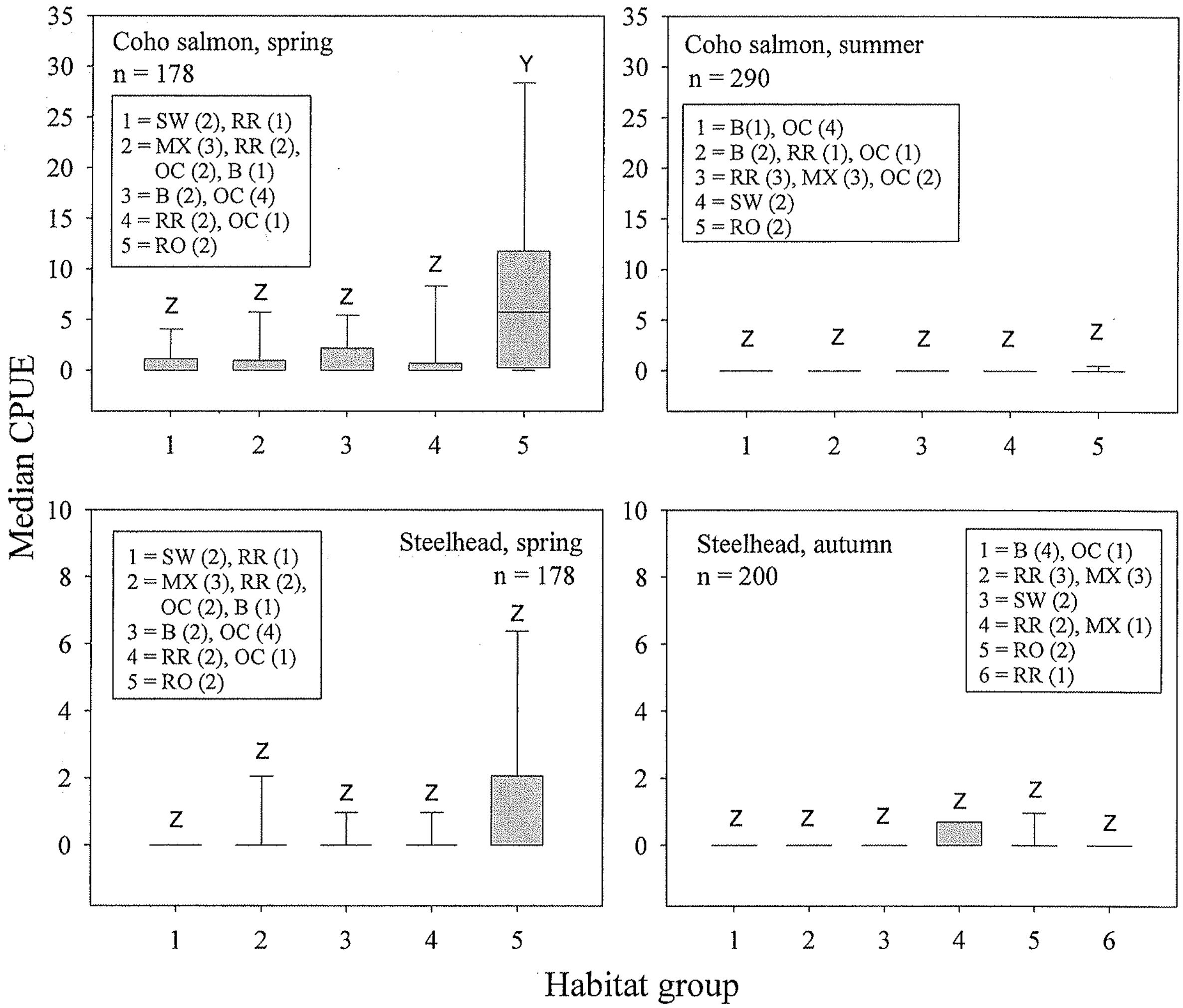

Figure 17. Median catch per unit effort (CPUE) of juvenile coho salmon and steelhead >100 mm FL among seasons and habitat groups in the lower Willamette River, 2000-2003. Habitat groups represent sampling sites grouped by cluster analysis (Vile and Friesen 2004). Legends indicate generalized habitat types (number of sites in parentheses) present in each group: RO = rock outcrop, RR = riprap, B = beach, MX = mixed (usually RR and B), SW = seawall and OC = off channel. In each chart, habitat groups without a letter in common are significantly different ($P<0.05$). n = number of electrofishing runs.

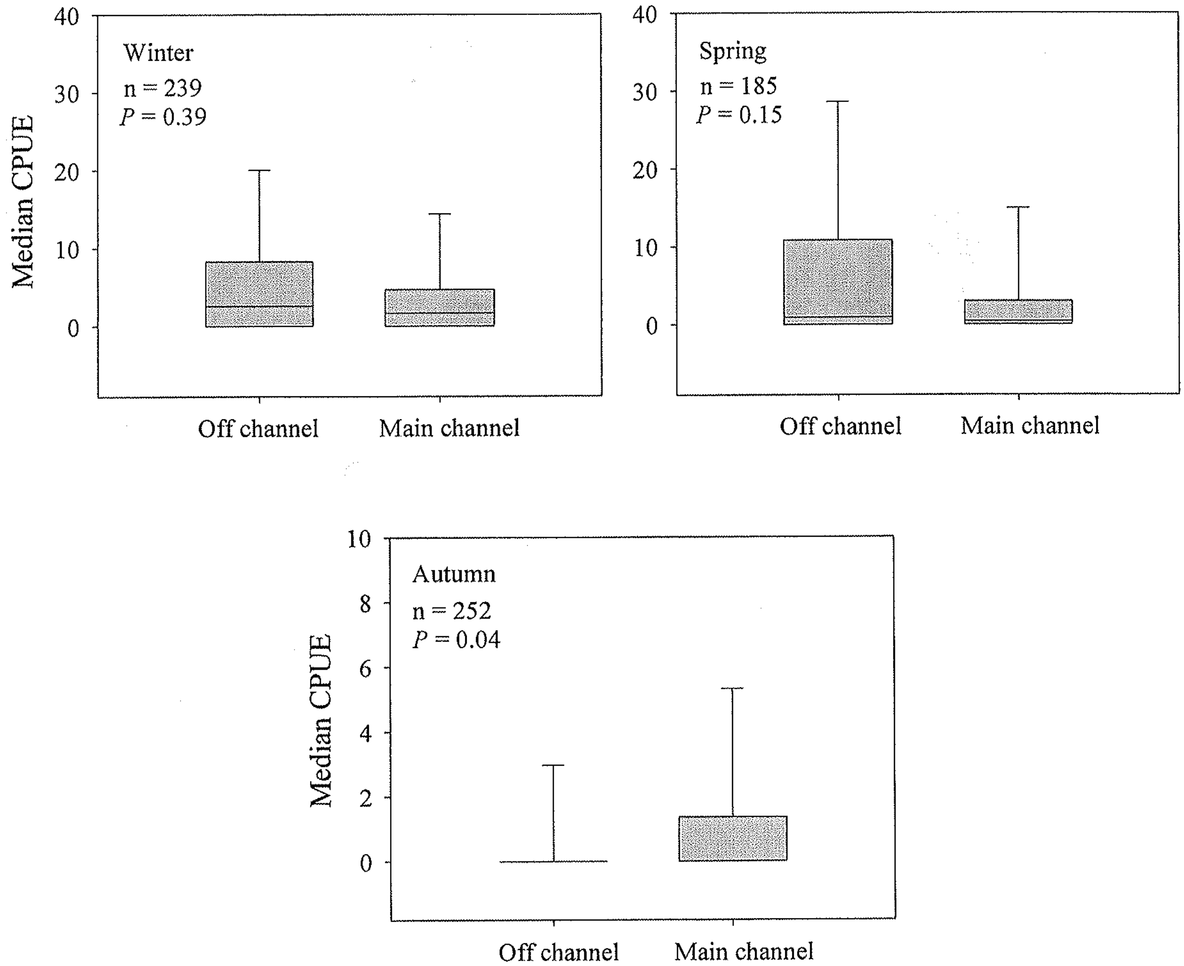

Figure 18. Median catch per unit effort (CPUE) of juvenile Chinook salmon >100 mm fork length at off-channel (alcoves, backwaters, and secondary channels) and main-channel sampling sites among seasons in the lower Willamette River, 2000-2003. n = number of electrofishing runs.

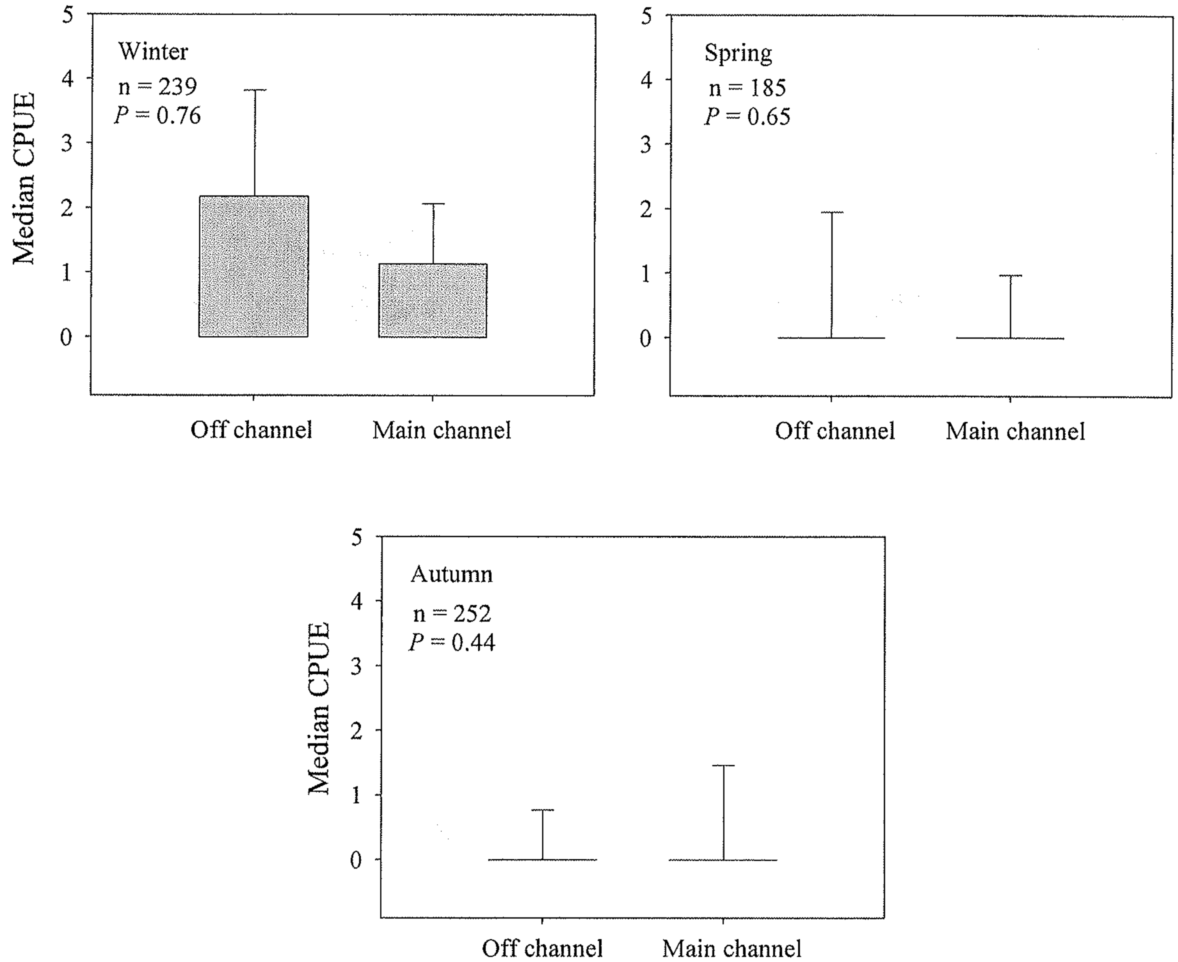

Figure 19. Median catch per unit effort (CPUE) of unmarked juvenile Chinook salmon >100 mm fork length at off-channel (alcoves, backwaters, and secondary channels) and main-channel sampling sites among seasons in the lower Willamette River, 2000-2003. n = number of electrofishing runs.

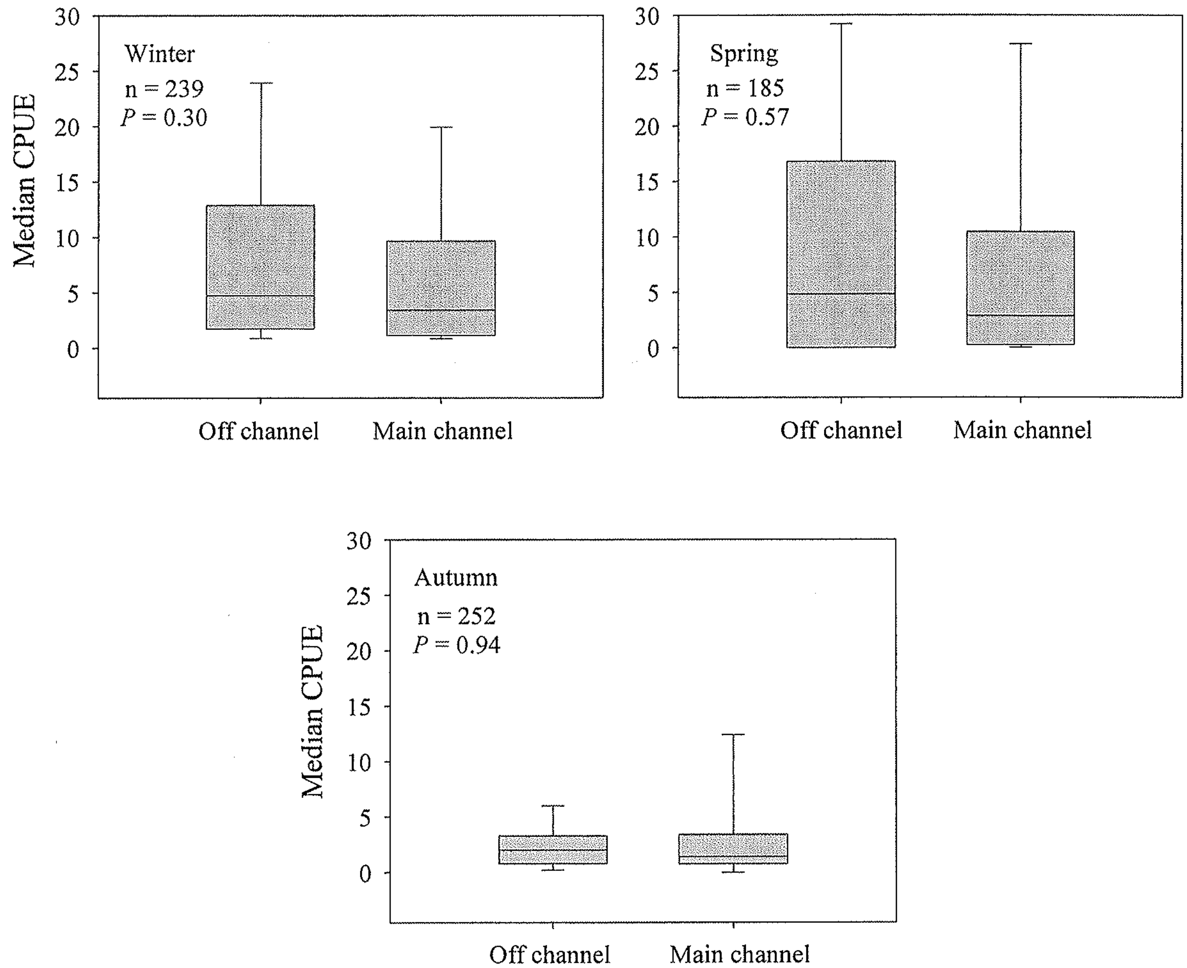

Figure 20. Median catch per unit effort (CPUE) of hatchery juvenile Chinook salmon >100 mm fork length at off-channel (alcoves, backwaters, and secondary channels) and main-channel sampling sites among seasons in the lower Willamette River, 2000-2003. n = number of electrofishing runs.

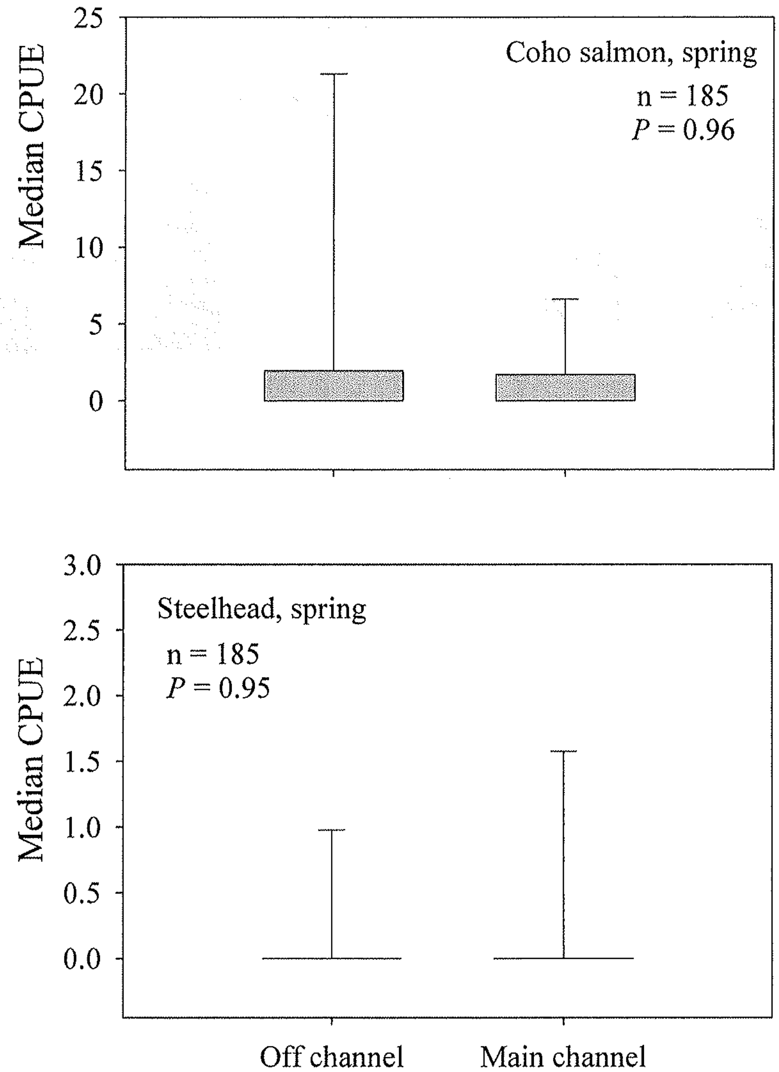

Figure 21. Median catch per unit effort (CPUE) of juvenile coho salmon and juvenile steelhead >100 mm fork length during spring at off-channel (alcoves, backwaters, and secondary channels) and main-channel sampling sites in the lower Willamette River, 2000-2003. n = number of electrofishing runs.

difference was between the 21-30% and 0 – 10% categories (Appendix Table 3). In all cases, catches were low when vegetation was sparse (<11% bank coverage). Catches did not vary significantly with the proportion of bank habitat composed of beach, except for unmarked fish during spring. Catches were significantly higher at sites consisting of 90-100% beach than at sites that were 80-89% beach (P=0.05; Appendix Table 2).

In contrast to spring, nearly every habitat parameter during winter had some statistically significant differences for catch rate among categories. For hatchery and unmarked fish combined (Appendix Table 4), median CPUE was highest at sites where sand was the major substrate type, and catches at sand-dominated sites differed significantly (P<0.01) from sites dominated by fines and bedrock. Catches were generally higher at sites having shallow depths (20 m from shore), and CPUE was significantly lower at depths of >10 m than at depths of 0.0 – 3.0 m (P<0.01). Sites that were 21-60% vegetated had significantly higher catches than sites with little or no bank vegetation (0-10%, P<0.01). Median CPUE tended to be higher where grass composed moderate proportions (11-40%) of the bank vegetation. Catches did not vary with the proportion of bank habitat consisting of beach, except the 11-20% category had the highest median CPUE and varied significantly (P<0.01) from sites consisting of 31-40% beach.

Patterns were similar for unmarked Chinook salmon captured in winter (Appendix Table 5). Catches of unmarked fish were significantly higher at sand-dominated sites than where riprap was the major substrate (P<0.01). Sites that were relatively deep (8.1->10 m) had a significantly lower median CPUE than sites where the average depth was 2.1-3.0 m. As with hatchery and unmarked fish combined, catches were lowest at sites with little or no bank vegetation (0-10%), and were significantly higher at sites that were 21-60% vegetated (P<0.01). Catches did not vary significantly with the proportion of bank vegetation composed of grass (P=0.11). Median CPUE was highest at sites composed of 51-60% beach habitat, but this category varied significantly only from sites with 31-40% beach habitat (P=0.01).

For hatchery Chinook salmon captured in winter (Appendix Table 6), variations among categories of dominant substrate, bank vegetation, and percent grass were nearly identical to those for hatchery and unmarked fish combined, and patterns for depth and percent beach followed those of unmarked fish.

Radio Telemetry

From 2001 to 2003, we released 186 radio-tagged juvenile salmonids, including 95 Chinook salmon, 63 coho salmon, and 28 steelhead (Table 1). No steelhead were tagged in 2003. More than half (57%) of all fish were of hatchery origin; the remainder were unmarked. Tagged steelhead were typically larger (mean FL 186 mm) than tagged Chinook or coho salmon (141 and 145 mm FL).

Tracking effort for the three years of telemetry totaled 401 hours (Table 2). Nearshore (53%) and offshore (47%) efforts were similar, and 66% of the effort occurred during daylight hours. We logged 591 total recoveries, and relocated 92% of the fish at least once, including 94% of the Chinook salmon, 86% of the coho salmon, and all of the steelhead (Table 1).

Table 1. Summary of radio-tagged juvenile salmonids released in the lower Willamette River, 2001-2003. H = hatchery; U = unmarked.

Species	Year	Number released	Number recovered	Number of relocations	Fork length (mm)			Weight (g)		
					Min.	Mean	Max.	Min.	Mean	Max.
Chinook salmon (U)	2001	14	13	61	108	115	125	13	15	19
Chinook salmon (H)	2001	18	18	67	118	140	150	17	25	32
Chinook salmon (U)	2002	14	12	36	112	125	166	15	22	51
Chinook salmon (H)	2002	4	3	0	160	178	186	52	63	77
Chinook salmon (U)	2003	13	13	38	123	141	156	16	27	33
Chinook salmon (H)	2003	32	30	77	131	154	180	21	35	55
Chinook salmon, total		95	89	279	108	141	186	13	28	77
Coho salmon (U)	2001	1	1	2	129	129	129	21	21	21
Coho salmon (H)	2001	17	9	18	132	144	153	21	28	34
Coho salmon (U)	2002	16	15	53	112	130	152	17	24	31
Coho salmon (H)	2002	5	5	10	140	153	161	28	39	48
Coho salmon (U)	2003	16	16	104	136	154	173	16	34	49
Coho salmon (H)	2003	8	8	60	146	157	180	27	33	41
Coho salmon, total		63	54	247	112	145	180	16	30	49
Steelhead (U)	2001	5	5	18	157	182	215	38	55	85
Steelhead (H)	2001	11	11	36	186	210	227	56	79	97
Steelhead (U)	2002	1	1	0	156	156	156	33	33	33
Steelhead (H)	2002	11	11	11	120	165	193	17	42	68
Steelhead (U)	2003	0	-	-	-	-	-	-	-	-
Steelhead (H)	2003	0	-	-	-	-	-	-	-	-
Steelhead, total		28	28	65	120	186	227	17	59	97
Total		186	171	591	108	149	227	13	33	97

Table 2. Tracking effort (h) for radio-tagged juvenile salmonids in the lower Willamette River, 2001-2003. Areas were considered nearshore if they were within 10% of the measured channel width of either riverbank. Off-channel habitats include alcoves, lagoons, side channels, and other areas not associated with the primary river channel.

Tracking category	2001	2002	2003	Total
Nearshore	54.3	57.1	75.9	187.3
Offshore	63.7	49.5	100.6	213.8
Off-channel	8.2	8.3	14.3	30.8
Day	84.8	72.4	106.2	263.4
Night	33.2	34.2	70.3	137.7
All locations	118.0	106.6	176.5	401.1

About 89% of the telemetry recoveries occurred in the main river channel. Off-channel recoveries occurred primarily in Multnomah Channel, the Swan Island lagoon, the east channel and lagoon at Ross Island, the alcove at Cedar Oak Island, and the west channel / alcove at Goat Island. Among fish we relocated, 23% were observed at an off-channel site at least once, including 29% of the Chinook salmon, 28% of the coho salmon, and 4% of the steelhead. Multnomah Channel was the most frequently used off-channel area (55% of off-channel recoveries), followed by the east channel and lagoon at Ross Island (21%).

Multnomah Channel terminates in the Columbia River, providing an alternative passage route for fish leaving the Willamette River. Overall, 12% of our radio-tagged fish used Multnomah Channel, including 16 of 89 (18%) Chinook salmon, 7 of 54 (13%) coho salmon, and 0 of 28 (0%) steelhead. However, many fish (71%) were never relocated downstream of the head of Multnomah Channel; their passage route remains undetermined.

River Flow

Flow regimes and the timing of radio telemetry efforts varied among years (Figure 22). In general, the timing of radio tracking corresponded to a period of moderate, relatively stable flows in 2001, relatively low, stable flows in 2002, and higher, more variable flows in 2003. Median daily April – June flows ranged from 21 kcfs (2001 and 2003) to 24 kcfs (2002), but differed significantly ($P < 0.01$) only between 2001 and 2002.

Statistical differences in river flow among years during the radio tracking periods were more pronounced. In 2001, median flow during the tracking period (April 25 – June 13) was 20 kcfs (range 13-34). Median flow during the 2002 tracking period (June 1 – June 27) was 17 kcfs (range 12–25) kcfs, and was 33 kcfs (range 18-63) during 2003 (April 14 – May 23). All pairwise comparisons differed significantly ($P<0.01$)

Migration Rates and Residence Times

Median migration rates were significantly higher for Chinook salmon (11.3 km/d) and steelhead (12.5 km/d) than for coho salmon (4.6 km/d; Figure 23). Hatchery Chinook salmon migrated

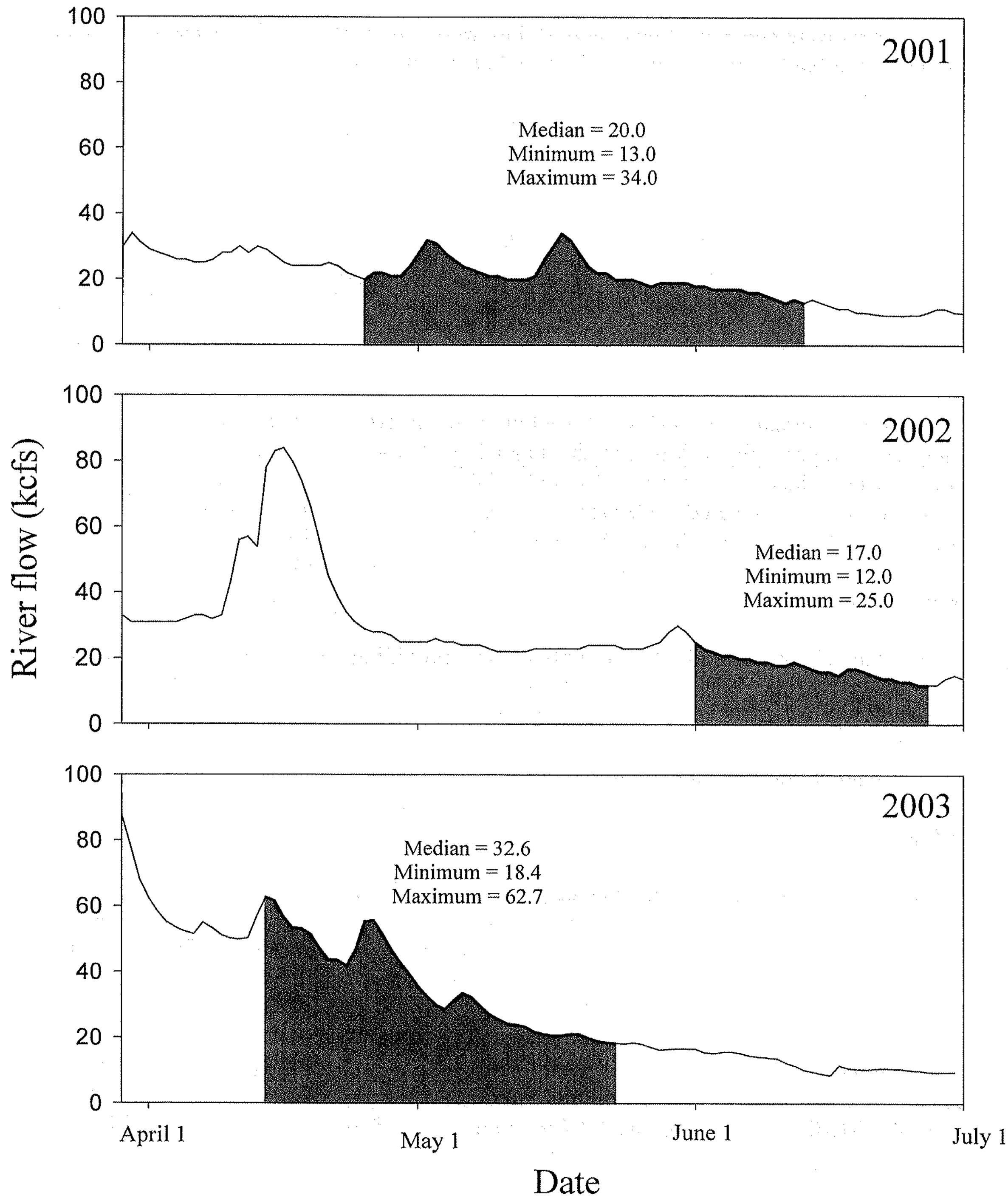

Figure 22. April – June hydrographs for the lower Willamette River, 2001 – 2003. Shaded areas represent the period of juvenile salmonid radio tracking efforts. Median, minimum, and maximum daily flows were calculated for the tracking period only.

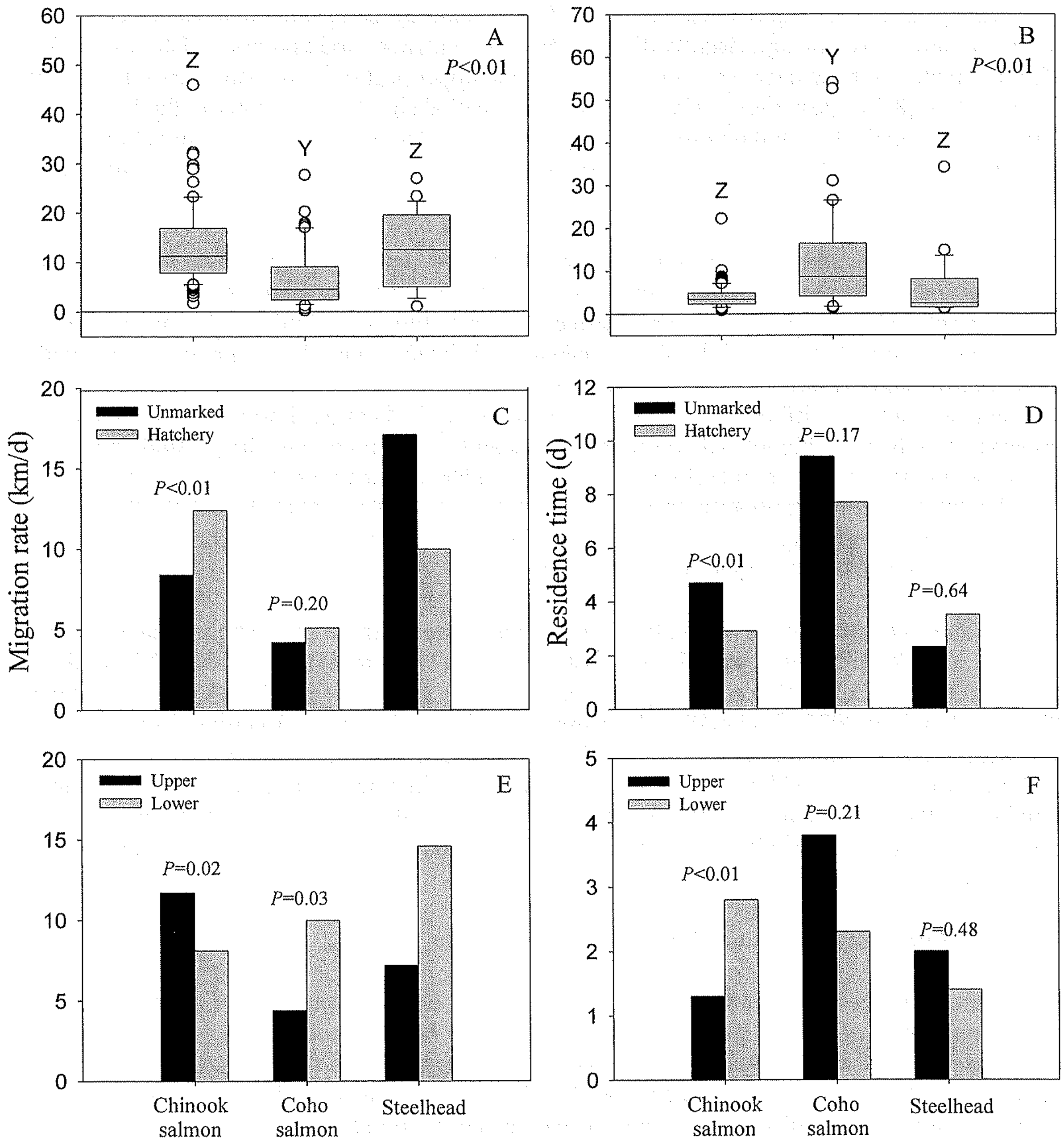

Figure 23. Median migration rates and residence times for juvenile Chinook salmon (n = 77), coho salmon (n = 46), and steelhead (n = 19) in the lower Willamette River, 2001 - 2003. Charts A-B are overall values, charts C-D compare unmarked vs. hatchery fish, and charts E-F compare upper (rkm 22.6 – 42.6) and lower (rkm 0.0 – 22.5) sections of the study area. In charts A and B, species without a letter in common are significantly different, and open circles denote outliers. *P*-values are not shown where the test power was low (<0.80).

significantly faster (12.4 km/d) than unmarked fish (8.4 km/d); coho salmon and steelhead migration rates were not significantly different between hatchery and unmarked fish. Chinook salmon traveled significantly faster (11.7 km/d) in the upper portion of the study area than in the lower portion (8.1 km/d); conversely, coho salmon traveled significantly faster in the lower portion (10.0 km/d) than in the upper portion (4.4 km/d). Steelhead appeared to travel faster in the lower portion than in the upper portion, but the sample size was small (n=19), and statistical power was low (<0.8).

Residence times, inversely related to migration rate, varied similarly (Figure 23). Coho salmon residence times were more variable (range 1.4 – 54.1 d) than those of Chinook salmon (0.9 – 22.3) or steelhead (1.2 – 34.2), and their median residence time was significantly longer (8.7 days) than Chinook salmon (3.4 days) or steelhead (2.5 days). Unmarked Chinook salmon had significantly longer residence times (4.7 days) than hatchery fish (2.9 days). Residence times were not significantly different between marked and unmarked coho salmon and marked and unmarked steelhead. Chinook salmon spent significantly more time in the lower study area (2.8 days) than in the upper portion (1.3 days). Median residence times for coho salmon were considerably longer in the upper portion (3.8 days) than in the lower portion (2.3 days), but did not differ significantly. Again, statistical power was low (<0.8) for steelhead comparisons (hatchery vs. unmarked and upper vs. lower study area).

Migration rates and residence times also varied among years (Figure 24). The median migration rate for Chinook salmon was significantly faster in 2003 (15.7 km/d) than in 2002 (7.3 km/d) or 2001 (8.6 km/d). Coho salmon migrated at a significantly faster rate in 2001 (17.1 km/d) than in 2002 (4.8 km/d) or 2003 (2.6 km/d). The sample size for steelhead was too small to analyze statistically, but median migration rates in 2001 (16.3 km/d) was considerably higher than in 2002 (4.7 km/d). Patterns for median residence time were identical but inverse; Chinook salmon remained in the study area for a significantly shorter period of time in 2003 (2.5 d) than in 2002 (5.4 d) or 2001 (4.5 d). Median residence time was significantly longer for coho salmon in 2003 (15 d) than in 2002 (8.3 d) or 2001 (1.7 d).

Factors Influencing Migration Rate

Simple linear regressions identified several variables that helped explain variation in migration rates, especially for Chinook salmon. Migration rates for both Chinook and coho salmon tended to increase linearly with flow (Figure 25), and these regressions had the highest r^2 values among any of the relationships we examined (0.385 for Chinook salmon and 0.476 for coho salmon). River flow was not a significant predictor of steelhead migration rates ($P = 0.23$).

Migration rate was positively related to fork length for Chinook salmon, and explained a considerable amount of the variation ($r^2 = 0.332$; Figure 26). For coho salmon, the relationship between fork length and migration rate was weak ($r^2 = 0.091$), and unlike Chinook salmon, migration rate tended to decrease with increasing fork length. In addition, the power of this regression was low (0.53). There was no significant relationship between migration rate and fork length for steelhead.

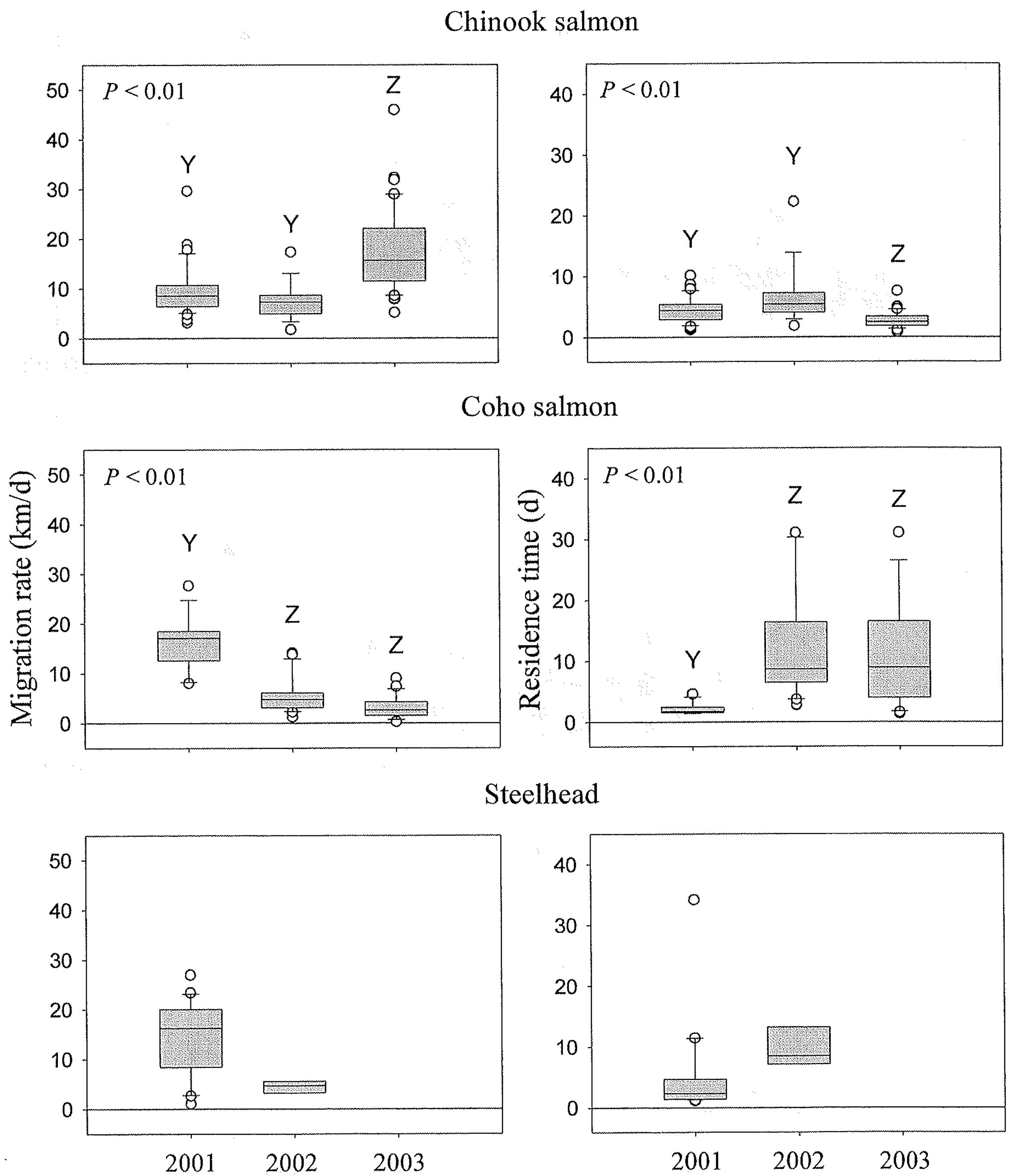

Figure 24. Migration rates and residence times by year (2001-2003) for radio tagged juvenile Chinook salmon, coho salmon, and steelhead in the lower Willamette River. No steelhead were tagged in 2003. In each chart, bars without a letter in common are significantly different (P<0.05); open circles denote outliers.

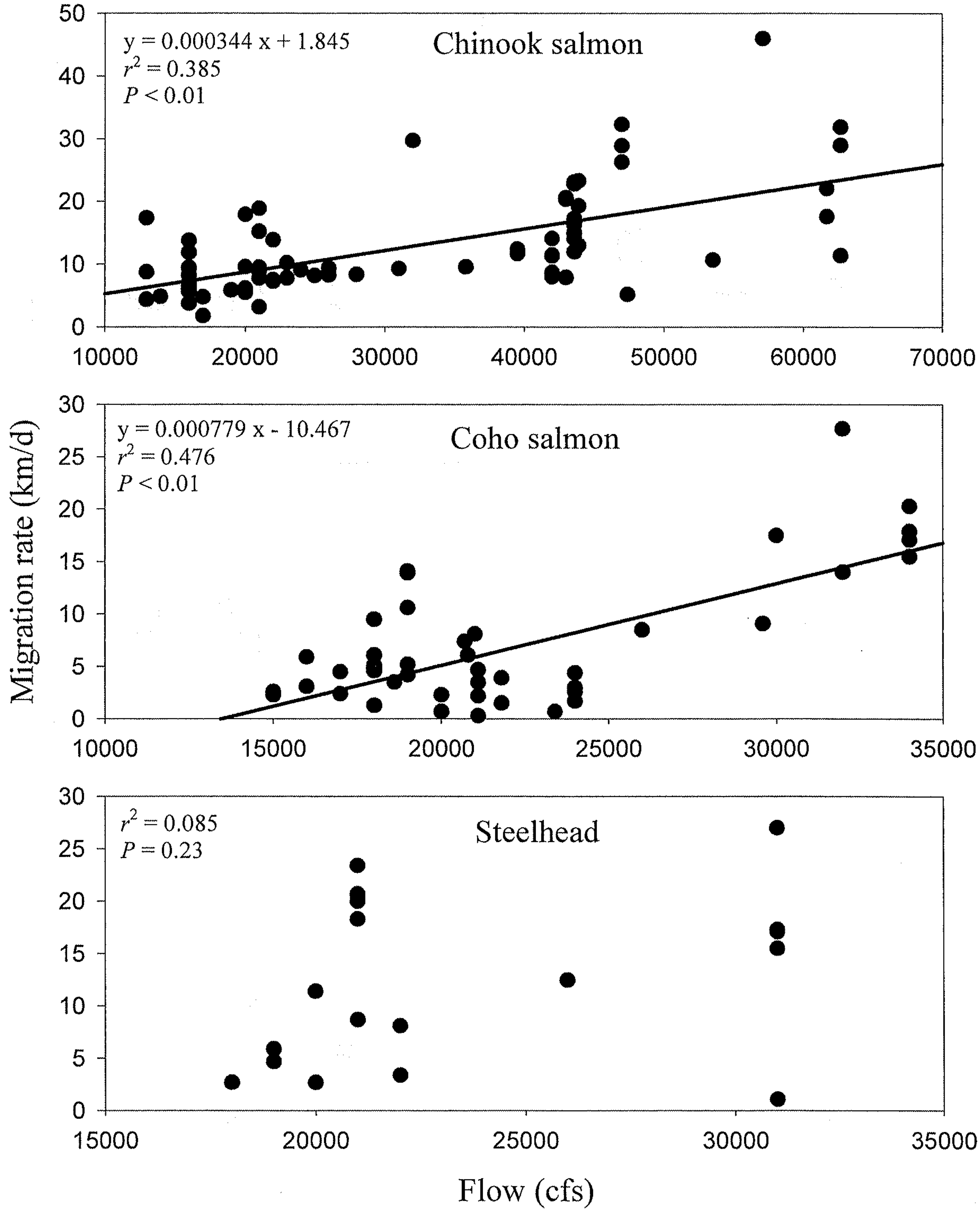

Figure 25. Linear regressions of migration rate on river flow (on last recovery date) for juvenile Chinook salmon, coho salmon, and steelhead in the lower Willamette River, 2001-2003.

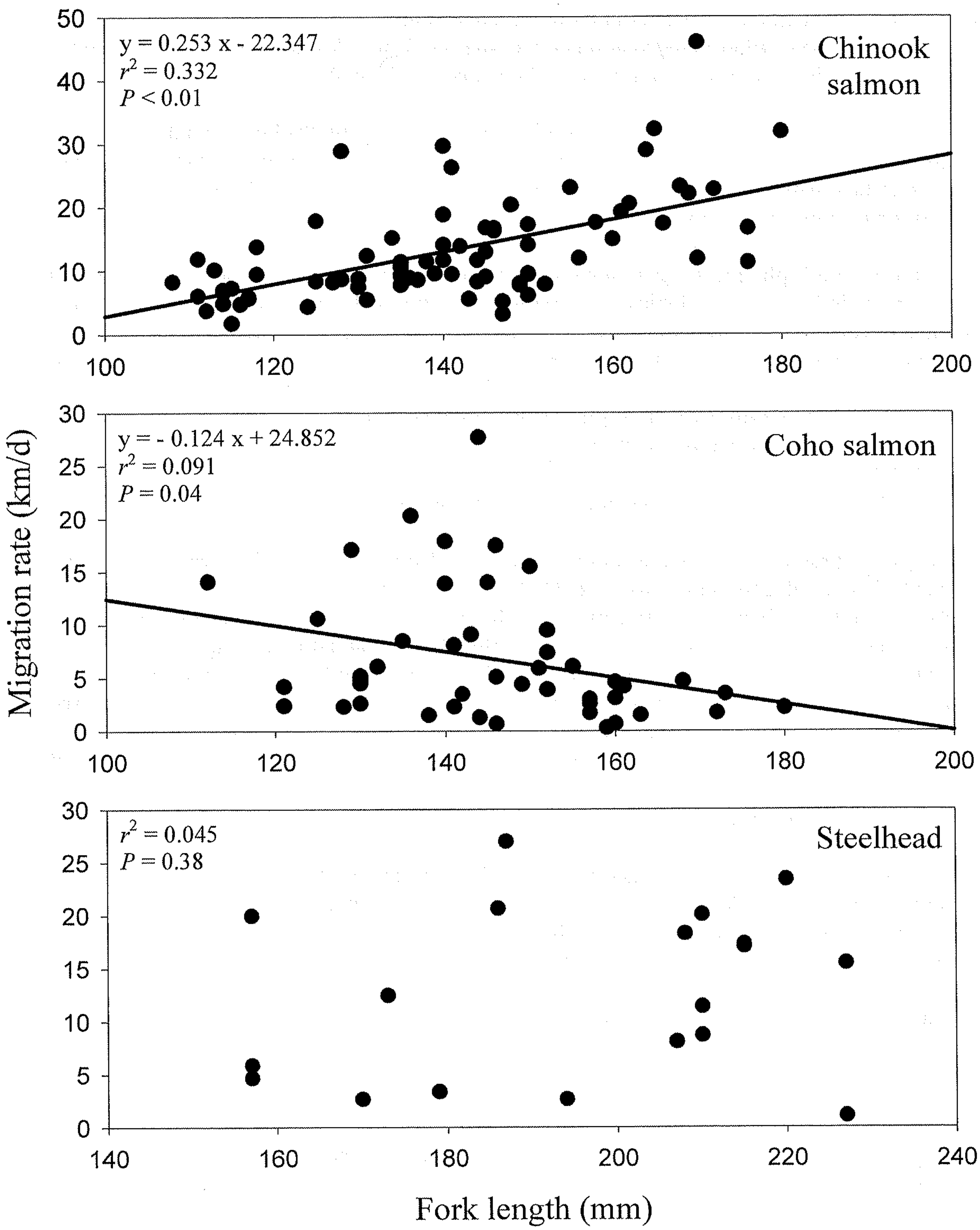

Figure 26. Linear regressions of migration rate on fork length for juvenile Chinook salmon, coho salmon, and steelhead in the lower Willamette River, 2001 – 2003.

Release day was negatively related to migration rate (Figure 27) for Chinook salmon (r^2 = 0.232); fish released earlier in the year tended to migrate faster. We detected no relationship between release day and migration rates of coho salmon and steelhead.

Temperature was a significant predictor of migration rates (Figure 28) for Chinook salmon but explained a relatively small amount of variation ($r^2 = 0.159$). Temperature and migration rate appeared to be positively related to coho salmon migration rates, though the test power (0.50) and r^2 (0.088) values were low.

We performed multiple linear regression on migration rate data, with river flow, fork length and release day as independent variables. Temperature was not included because it was a strong covariate of release day. For Chinook salmon, the three variables explained 44.5% of the variation in migration rate, though only river flow and fork length were statistically significant (Table 3). For coho salmon, river flow, fork length, and release day explained 67% of the variation in migration rate; river flow and release day were significant variables. No significant relationships were observed for steelhead.

Habitat Use (radio telemetry)

The majority of radio telemetry relocations occurred offshore (>10% of the measured channel width). Offshore relocation rates were 76.3% for Chinook salmon, 57.1% for coho salmon, and 75.4% for steelhead. Nearshore relocations of Chinook salmon (P=0.01) and coho salmon (P<0.01) varied significantly with the relative availability of habitat types (Figure 29). Radio-tagged Chinook salmon were recovered at lower-than-expected rates at rock and riprap habitats and at a slightly higher-than-expected rate near pilings. Juvenile coho salmon were recovered at a much higher rate than expected at beaches and appeared to under-utilize artificial habitats such as riprap and fill. We relocated a small number of steelhead (n=16) near shore; these were often associated with beaches and rock outcrops, but the sample size was too small to discern differences among habitats.

Relocation frequencies of radio tagged juvenile salmonids across the river channel indicated Chinook salmon and steelhead were distributed relatively evenly from the west bank to the east bank (Figure 30). Coho salmon were not distributed evenly across the river channel ($P < 0.01$) and showed an affinity for areas close to shore.

Day and night channel distributions were similar for Chinook salmon and coho salmon, but steelhead appeared to move closer to shore (especially the west bank) at night (Figure 31). Again, the sample size of steelhead was too small to determine if this pattern was statistically significant.

In the upper portion of the study area, Chinook salmon and steelhead were evenly distributed across the river channel, but coho salmon appeared to favor nearshore areas ($P < 0.01$; Figure 31). Relocations in the lower portion of the study area were evenly distributed across the river channel for all three species.

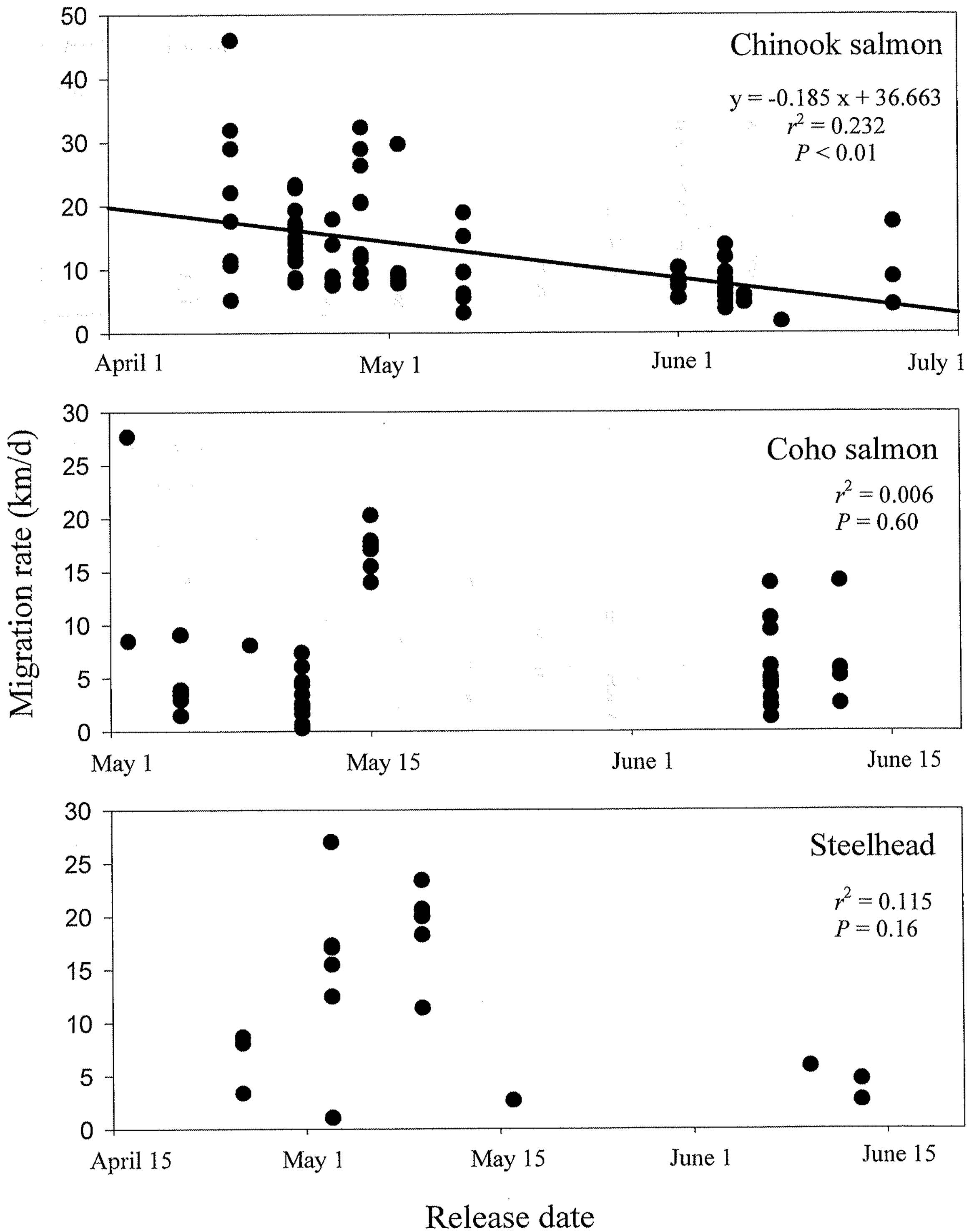

Figure 27. Linear regressions of migration rate on release date for juvenile Chinook salmon, coho salmon, and steelhead in the lower Willamette River, 2001-2003.

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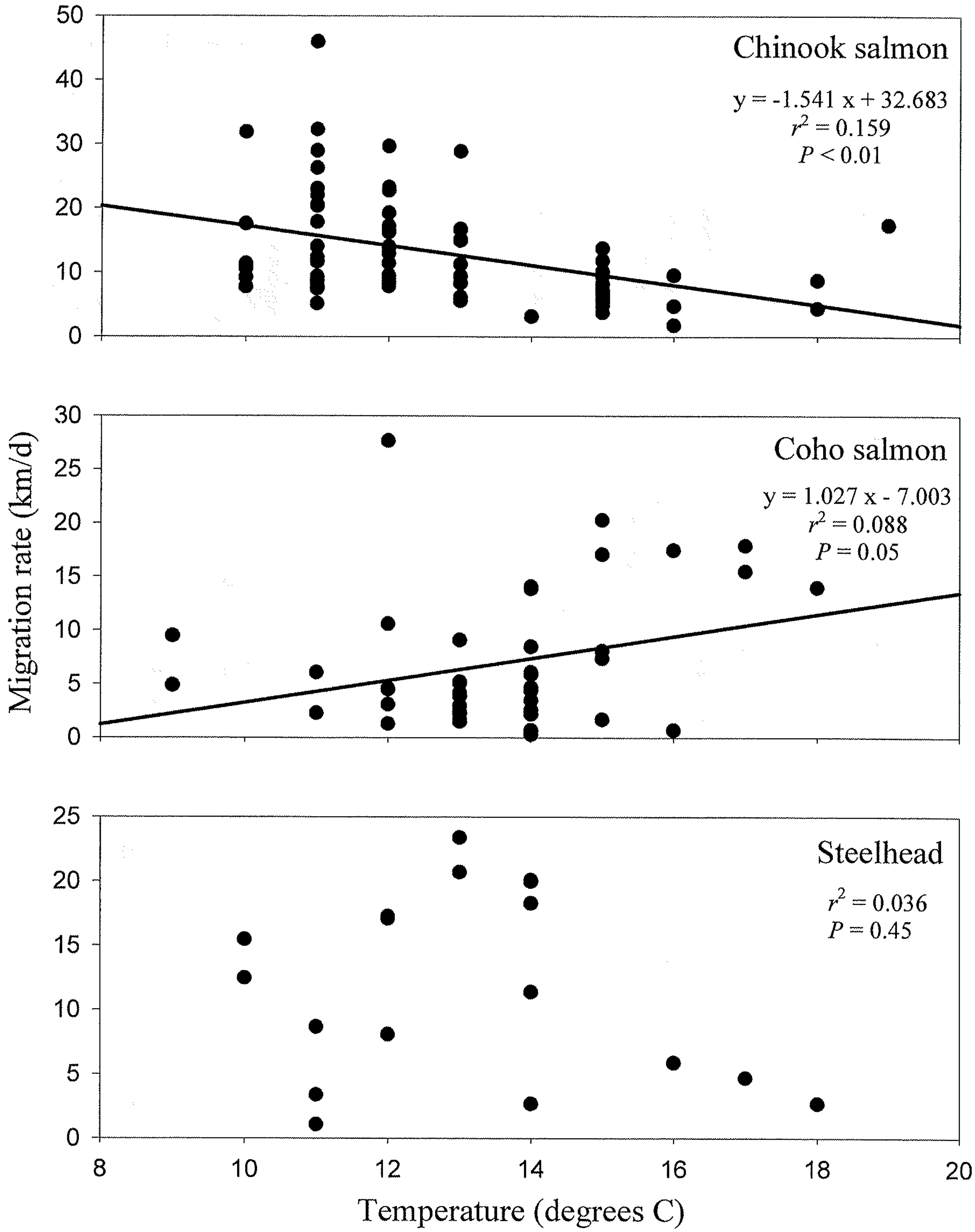

Figure 28. Linear regressions of migration rate on river temperature (on last recovery date) for juvenile Chinook salmon, coho salmon, and steelhead in the lower Willamette River, 2001 – 2003.

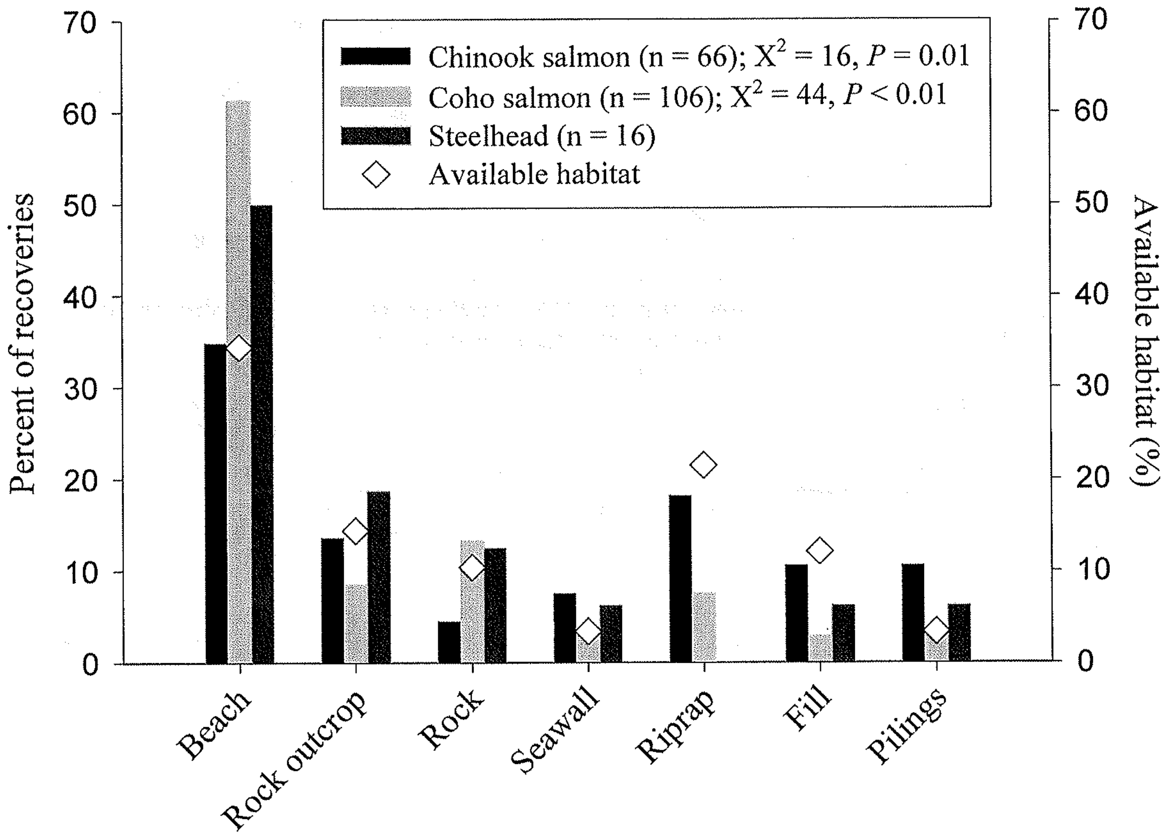

Figure 29. Proportional distribution of radio telemetry recoveries for juvenile Chinook salmon, coho salmon, and steelhead among nearshore habitat types in the lower Willamette River, 2001-2003. Chi-square statistics are included where the expected n (number of recoveries) was ≥ 5 for each habitat type (Zar 1999).

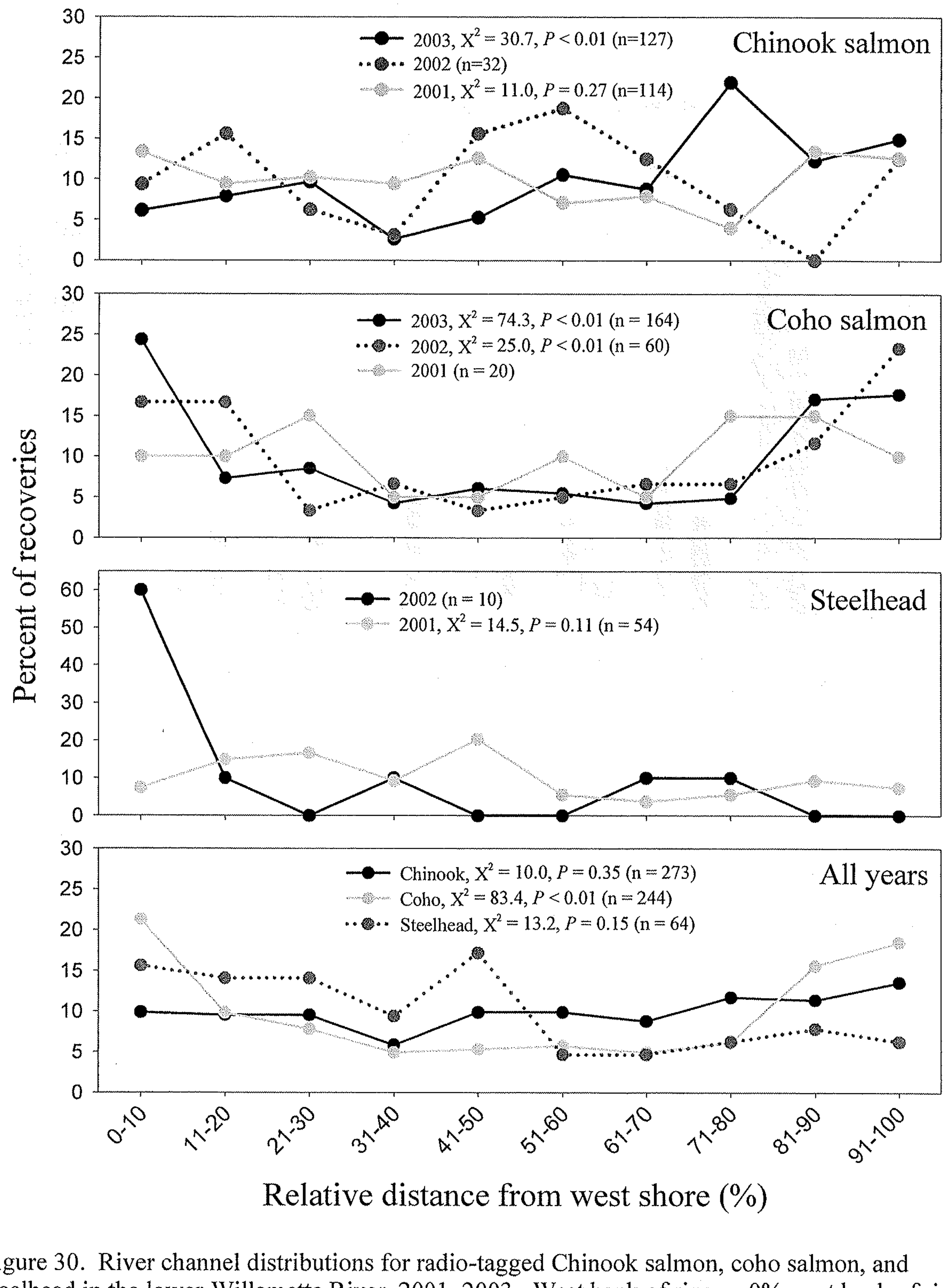

Figure 30. River channel distributions for radio-tagged Chinook salmon, coho salmon, and steelhead in the lower Willamette River, 2001–2003. West bank of river = 0%, east bank of river = 100% (X axis). Chi square statistics are included where expected n ≥ 5 for each category.

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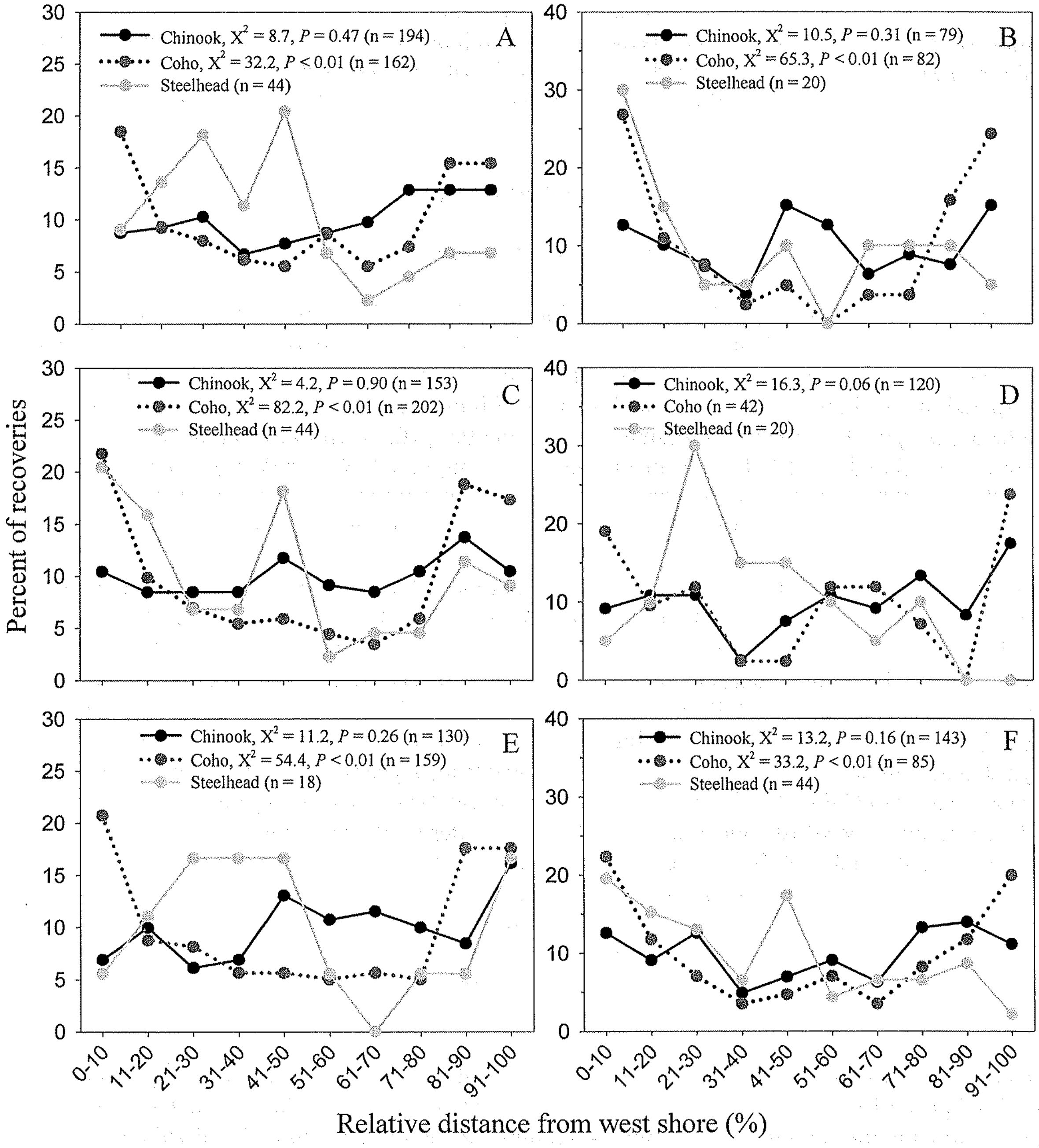

Figure 31. River channel distributions of radio-tagged Chinook salmon, coho salmon, and steelhead in the lower Willamette River, 2001 – 2003. West bank of river = 0%, east bank of river = 100% (X axis). Chart categories are: A) day, B) night, C) upper study area (rkm 22.6-42.6), D) lower study area (rkm 0.0-22.5), E) unmarked salmonids, and F) hatchery salmonids. Chi-square statistics are included where expected n ≥ 5 for each category.

We detected no differences in channel distribution patterns between hatchery and unmarked groups for any species (Figure 31). Relocations of both unmarked and hatchery Chinook salmon and unmarked and hatchery steelhead were evenly distributed across the river channel, while unmarked and hatchery coho salmon both appeared to prefer areas close to shore ($P < 0.01$).

DISCUSSION

Population Structure

Most juvenile salmonids we collected were Chinook salmon. We assumed these were largely spring-run stocks, as fall Chinook salmon are not indigenous to the upper Willamette River basin and wild fall Chinook in the lower Willamette River (primarily from the Clackamas River) were extirpated by 1934 (WRI 2004). A small number of introduced fall Chinook salmon persist; adults are observed annually at Willamette Falls. In 2002, 763 adult fall Chinook salmon were counted, compared to 82,111 adult spring Chinook salmon (ODFW 2002). Some production of fall Chinook salmon occurs in the upper watershed; Schroeder et al. (2003) estimated 6% of subyearling Chinook salmon seined in the Willamette River during 2002 were fall-run fish.

Chinook salmon captured in our study were approximately half hatchery fish and half unmarked fish, though there was a clear dichotomy between gear types. Large (>100 mm FL) hatchery fish dominated the electrofishing catch; small (<100 mm FL) unmarked fish were prevalent in beach seine catches. Lacking a means to accurately age these fish (most are intrusive and would have resulted in unacceptable mortality), we assumed that fish >100 mm FL were generally yearlings (age 1) and smaller fish were subyearlings (age 0). Spring Chinook salmon are generally regarded as "stream type" fish; they rear in fresh water for a year or more before migrating to the ocean, where fall Chinook salmon are considered "ocean type", rearing for only a few months before migrating (Wydoski and Whitney 2003). Considering the large number of small Chinook salmon we collected, and the apparent low abundance of fall Chinook salmon, we concluded that most small Chinook salmon in the lower Willamette River are spring-run fish that outmigrate as subyearlings. The bimodal distribution of length frequencies in beach seine catches also suggested several age-classes were present; these could include older subyearlings from upper basin tributaries (e.g., Santiam River) and younger subyearlings from lower basin tributaries (e.g., Clackamas River). Future studies should address the origin and race of these fish.

Hatchery coho salmon are no longer stocked above Willamette Falls, and remaining runs are confined primarily to the Clackamas River, helping explain their low abundance in our surveys relative to Chinook salmon. Like Chinook salmon, they exhibited a bimodal distribution of length frequencies (in the electrofishing catch) with a natural break at about 100 mm FL. This again suggested several age classes were present; the habitat requirements of all ages should be considered when implementing fish management strategies.

Juvenile steelhead were quite rare; we captured less than 150 over four years of intensive sampling in the lower Willamette River, and most were large (>150 mm FL). As steelhead spend one to three (usually two) years in fresh water (Wydoski and Whitney 2003), and we observed relatively rapid migration rates for our radio-tagged steelhead, we concluded these fish reared primarily in their natal streams and larger tributaries, and passed quickly through our study area.

The relative abundance of other salmonids in the lower Willamette River is low; for example, we observed very few mountain whitefish in our study. Like most salmonids, they are considered to be intolerant of habitat and water quality perturbations (Zaroban et al. 1999), and are therefore an important species for assessing stream health.

Sockeye salmon are not indigenous to the Willamette basin, though the landlocked form (kokanee) are stocked at lakes in the upper watershed. A small number of large, mature fish are observed each year passing Willamette Falls; these are presumably kokanee that have escaped the reservoirs and residualized or reared in the ocean (C. Foster, ODFW, personal communication).

Cutthroat trout persist in many Willamette River tributaries (Friesen and Ward 1996; Friesen and Zimmerman 1999; Graham and Ward 2002) but are apparently very rare in nearshore areas of the lower mainstem.

Timing

The outmigration period for Chinook salmon, both hatchery and unmarked, was surprisingly long. The presence of juvenile fish often increased in late autumn and persisted into the next summer, and juvenile salmonids were present in every month we sampled from May 2000 to July 2003. Winter and spring were clearly the periods of greatest abundance, though the presence of different races (spring and fall), size classes, and stocks undoubtedly confounded our ability to completely assess timing. Coho salmon and steelhead were generally present only during winter and spring.

Growth

The increases in size we observed in juvenile Chinook salmon from upper to lower sampling sites were generally greater than the range described in the literature, especially for hatchery fish. For example, we observed a median fork length increase of 9 mm for hatchery Chinook salmon from upper to lower sampling sites, where the mean distance between upper and lower sites was 29.9 km. Radio-tagged Chinook salmon traveled at a median rate of 12.4 km/d, so their residence time between the upper and lower sites was about 2.4 d. Fisher and Pearcy (1995) documented growth rates of 0.75 – 1.05 mm/d for juvenile (hatchery) Chinook salmon in the lower Columbia River; applying their results to our estimated residence time would result in observed growth of 1.8 – 2.5 mm. However, due to technical limitations (e.g., weight and battery life of radio transmitters) our telemetry efforts focused on larger, actively migrating fish, which may have biased our migration rate estimates (high). We eliminated some fish from migration rate calculations because they stopped moving or moved upstream. Even among fish that consistently moved downstream, we estimated individual migration rates as low as 1.8 km/d. Considering these factors, it is plausible that some juvenile Chinook salmon spend extended amounts of time in the study area, and the growth we observed is realistic.

Fork length and weight of small, unmarked juvenile salmonids, while not always statistically significant, were consistently larger at downstream sites, again suggesting growth occurs. We observed increases from one to six mm FL. As with hatchery fish, this amount of growth was generally greater than observed in other areas. Published growth rates for subyearling Chinook salmon (including ocean-type fish) range from 0.48 mm/d (Sommer et al. 2001) to 1.2 mm/d (Conner and Burge 2003). We did not radiotag subyearling juvenile Chinook salmon, but Giorgi et al. (1997) estimated age-0 Chinook salmon migrated at 15.6 km/d in the mid-Columbia River (Rock Island Dam to McNary Dam). Applying these figures to the mean distance between our upper and lower sites (29.3 km) yielded growth estimates of 0.9 – 2.3 mm from upper to lower sites. This calculation is largely speculative, lacking migration and growth studies specific to the Willamette or lower Columbia rivers, but provides a general reference. Future studies in the lower Willamette River should determine migration rates and residence times of age-0 fish.

Differential mortality resulting from size-selective predation or other factors may have contributed to the size changes we observed; higher mortality rates for smaller fish would result in larger observed sizes at downstream locations. In the Columbia River, smallmouth bass preyed on relatively small juvenile Chinook salmon, and consumed far more subyearling fish in spring than yearling fish in summer (Zimmerman 1999). However, predation on juvenile salmonids by resident fish in the lower Willamette River appears to be minimal (Pribyl et al. 2004), and we observed no other mechanisms for (or evidence of) differential mortality. Survival estimates for various size classes and life stages of juvenile salmonids in our area would help clarify this issue and improve analyses of growth.

Other fish entering the study area (from a tributary or the Columbia River) could have biased the observed lengths and weights of fish in our study. However, no major streams enter the Willamette River below rkm 39.9 (the Clackamas River; Figure 1). All of the sampling sites used in the analysis were downstream of this point, though one (rkm 39.1, site 243W) was relatively close and on the opposite shore, so some influence from the Clackamas River is possible. Fish entering from the Columbia River would have to exhibit an odd behavior – migrating about 2-10 km in an upstream direction. Considering also the large sample size, consistent pattern, and statistical strength of the length and weight analyses, we felt there was sufficient evidence to reject the null hypothesis that juvenile salmonids do not exhibit changes in size during migration through the lower Willamette River. Some amount of growth undoubtedly occurs, as Vile et al. (2004) documented extensive feeding by juvenile salmonids on *Daphnia* spp. and other invertebrates in our study area. Schreck et al. (1994) also documented feeding by hatchery Chinook salmon in the Willamette River above Willamette Falls.

Migration Rates and Residence Times

Our observed migration rates for juvenile Chinook salmon >100 mm FL (presumably yearlings) were very similar to those reported in the Port of Portland study (ODFW 1992, Ward et al. 1994). Ward et al. (1994) documented median migration rates of 9.8 (1990), 8.7 (1989), and 11.0 km/d (1988) during spring in the lower Willamette River; we estimated a median rate of 11.3 km/d from 2001-2003. Similarly, our estimate of median migration rate for steelhead was 12.5 km/d over the course of the study, compared to 17.9 km/d (1989) and 11.9 km/d (1990) in Ward et al. (1994).

In general, spring migration rates for juvenile Chinook salmon are generally higher (19.6 – 43.0 km/d) in Columbia and Snake river impoundments (Giorgi et al. 1997; Adams et al. 1998c; Hockersmith et al. 2003; Smith et al. 2003) and lower (4.1 km/d) in the Columbia River below rkm 75.0 (Fisher and Pearcy 1995). Juvenile steelhead also tend to move slowly in impoundments (30.4 km/d; Giorgi et al. 1997), and Dawley et al. (1986) observed that tagged coho salmon in the Columbia River traveled faster when they were released farther upstream. This pattern of slower migration rates as juvenile salmonids move downstream in the Columbia basin suggests the lower Willamette River may play a role in rearing as the fish prepare to transition to salt water.

In a pattern repeated over several of our analyses, coho salmon behaved differently than Chinook salmon or steelhead, exhibiting much slower migration rates and longer residence times. Conditions and resources in the lower Willamette River may therefore be of particular importance to coho salmon.

The implications of migration rates and residence times are uncertain. Delayed migration due to dams, low river flows, and other factors have been cited as causing serious impacts to salmonids in the Columbia and Snake rivers (Bentley and Raymond 1976; Raymond 1979). Rapid travel through watersheds altered by human activity presumably increases survival, as juvenile salmonids spend less time exposed to degraded or sub-optimal habitat, predation, poor water conditions, and toxins. Schreck et al. (1994), noting many resting and feeding areas in the Willamette River have been eliminated by channelization, speculated that quick downstream movement is the most successful evolutionary strategy for juvenile Chinook salmon. However, observations from our study, including the growth of juvenile salmonids, their presence throughout much of the year, extensive feeding (Vile et al. 2004), and low predation rates and predator densities (Pribyl et al. 2004) suggest the lower Willamette River has value as rearing habitat and does not present a particular danger to juvenile salmonids. If this is the case, the importance of rapid migration rates may be negligible. However, uptake of contaminants remains a potential risk for juvenile salmonids in the lower Willamette River, and a full assessment is planned (Windward Environmental 2004).

Factors Influencing Migration Rate

Recent evidence strongly suggests river flow and migration rate are positively correlated. Schreck et al. (1994) showed migration rates of hatchery Chinook salmon that traveled 280 km from the upper Willamette basin to Willamette Falls were strongly correlated ($r^2 = 0.66$) with river flow. Dawley et al. (1986) observed migration rates for both juvenile Chinook and coho salmon in the Columbia River estuary increased with river flow, and Giorgi et al. (1997) found that flow in the mid-Columbia River basin explained 42, 36, and 31% of the variation in migration rates of sockeye salmon, hatchery steelhead, and wild steelhead. In our study, positive significant relationships were observed for both juvenile Chinook salmon and juvenile coho salmon.

We also observed a relatively strong linear relationship between fish size (fork length) and migration rate. The relationship was relatively strong and positive for Chinook salmon, weaker and negative for coho salmon. Our results were similar to those of Giorgi et al. (1997), who noted a positive relationship between migration rate and fish length for ocean-type Chinook salmon juveniles (r^2=0.59). We also observed that hatchery Chinook salmon migrated significantly faster than unmarked fish. This was undoubtedly an effect of the size of the fish, as migration rate increased with size and the hatchery fish we radio tagged were significantly larger than unmarked fish.

Temperature (Chinook and coho salmon) and release date (Chinook salmon only) were weakly related to migration rate, and both are related to river flow. Combining river flow, fork length, and release day as independent variables in multiple linear regressions generally helped explain more of the variation in migration rates than the simple univariate regressions. River flow and release day accounted for 67% of the variation in coho salmon migration rate; river flow and fork length explained 45% of the variation in Chinook salmon migration rate.

Management implications of migration rates and factors affecting them are uncertain. The ability of the City of Portland to affect migration through manipulations of river flow and temperature is obviously quite limited, and the benefits of more rapid passage are uncertain. Flow in the Willamette River is controlled largely by reservoirs in the middle and upper watershed; managers should cooperate to maintain flows approaching historic levels and reduce temperatures during outmigrations of juvenile salmonids.

Habitat Use (telemetry)

Radio-tagged Chinook salmon were not highly associated with nearshore areas; they were distributed evenly across the river channel regardless of year, time of day (day or night), origin (hatchery or unmarked), or area (upper or lower study area). Very few studies have addressed the cross-sectional distribution of juvenile salmonids in lotic systems. Dauble et al. (1989) examined spatial distributions in the Hanford Reach of the Columbia River and reached conclusions similar to ours: yearling spring Chinook salmon (and steelhead) were found primarily in mid-channel areas; smaller fish (age-0 Chinook salmon) were most abundant at nearshore sites.

Chinook salmon located near shore were distributed unevenly with respect to the availability of different habitat types; we rejected the null hypothesis (*the distribution of radio-tagged juvenile salmonids among nearshore habitat types does not differ from the distribution of habitat types*). However, these fish did not show clear selection for, or avoidance of, particular habitat types. Associations with specific habitats (e.g., pilings) were weak, and the distribution of telemetry recoveries appeared to closely follow the proportional availability of habitat types. Also, a relatively small proportion (about 24%) of radio-tagged Chinook salmon were recovered near shore; the influences of different habitat types are likely minimal. We also rejected the null hypothesis for coho salmon. These fish were often located near shore and showed a clear preference for beaches; they also appeared to avoid riprap and artificial fill. Steelhead were rarely associated with nearshore areas and the small number of fish located near shore was insufficient to address the null hypothesis.

Habitat Use (electrofishing)

Electrofishing CPUE varied significantly among habitat types; we rejected the null hypothesis *(the density of juvenile salmonids does not vary among bank treatment and nearshore development types*) on the basis of the statistical tests. However, these differences were almost always associated with low catches of fish at seawall habitats. Sampling efficiency was probably compromised in these areas, which were typically much deeper than other habitats. Our electrofishing gear did not sample the entire water column, likely contributing to the low catches relative to other sites. We concluded these fish did not use the upper portion of the water column at seawall sites, or tended to avoid them altogether.

Aside from seawalls, we found no indication that juvenile salmonids >100 mm FL were associated with specific habitats or groups of habitats, with one exception. During spring, electrofishing catches of coho salmon were significantly higher at the clustered group consisting of two rock outcrops (group 5) than at any other group. Similar results were observed for the qualitative habitat types; the catch was highest at rock outcrops and significantly greater than catches at beaches, seawalls, or riprapped habitats. However, the telemetry analyses did not indicate a preference for rock outcrops; radio-tagged coho salmon were recovered at somewhat lower-than-expected rates at this habitat type. Considering the magnitude of the relationship in the electrofishing data, and the relatively small number of nearshore telemetry relocations, we felt rock outcrops clearly have a particular value for coho salmon during spring. We were unable to find any citations documenting the use of habitats similar to our rock outcrops by coho salmon.

Electrofishing CPUE for juvenile salmonids in off-channel areas was not significantly greater than in main-channel areas. However, all off-channel types were clearly utilized, and some (Multnomah Channel and the east channel at Ross Island) provide alternative passage routes. Off-channel sites provide refuge from extremely high flow events, and may be important foraging areas.

Individual habitat parameters (those that contributed to the separation of clustered habitat groups; Vile and Friesen 2004) appeared to have little or no relationship to juvenile Chinook salmon density during spring, with the exception of bank vegetation. Habitat parameters appeared to be much more important during winter; higher catches were generally associated with sand substrates, shallow water, and moderate amounts of bank vegetation. Some relationships were confused; CPUE in similar parameter categories occasionally varied significantly (e.g., 11-20% and 21-30% bank vegetation). For other parameters, CPUE varied significantly only between the highest and lowest proportional categories. We suggest future studies use a more rigorous approach to identify important habitat variables, such as multivariate logistic regression modeling (e.g., Garland et al. 2002).

A final important observation in our study was the large number of subyearling Chinook salmon present. Because we did not often capture these fish with electrofishing gear, and beach seining efforts occurred at a single bank habitat type, we could not effectively analyze their habitat preferences. However, based on the high numbers of fish and their extended temporal distribution in seine catches, beaches were clearly an important habitat type for small Chinook salmon. These observations are supported by numerous citations, which are virtually unanimous in concluding that younger age classes of juvenile salmonids are highly associated with shallow, nearshore areas in both lotic and lentic environments (e.g., Lister and Genoe 1970, Johnson and Sims 1973, Dauble et al. 1989, Kahler 2000, Tabor and Pioskowski 2002). Recent work also suggests the quality and composition of nearshore habitat is important to subyearling salmonids. Garland et al. (2002), for example, concluded substrate size was the most important factor in determining the presence of subyearling fall Chinook salmon in the Columbia River above McNary Dam; fish were more likely to be present at unaltered shorelines than at riprapped sites.

Overall, we found little evidence to suggest that nearshore habitat as it currently exists is a critical factor affecting yearling salmonids, and we generally agree with Ward et al. (1994), who concluded waterway developments presented few risks to juvenile salmonids. However, we believe the effects of development are incompletely explored, especially with respect to subyearling fish. Clearly, the lower Willamette River is more than a simple migration corridor. Juvenile Chinook salmon feed (Vile et al. 2004) and apparently grow during their outmigration, and unaltered nearshore habitats appear to be important to smaller fish. Coho salmon also feed extensively on aquatic invertebrates (Vile et al. 2004), were associated with nearshore areas, exhibited selection for specific habitat types, and spent relatively long periods in the study area. All off-channel habitats were utilized by juvenile salmonids, and they were present for extended periods in all years. While current conditions appear to adequately support fish populations, future development should be planned carefully to avoid detrimental impacts.

RECOMMENDATIONS

We present several recommendations intended help protect ESA-listed species. These were developed by the principal investigators, and will not necessarily be adopted as policies or guidelines by the Oregon Department of Fish and Wildlife. Recommendations fall into three categories: (1) primary recommendations, which are recommendations regarding in-water or shoreline activities that are supported directly by study findings, (2) secondary recommendations, which are recommendations regarding in-water or shoreline activities that are supported in part by study findings, but may rely in part on general ecological principles and ecosystem functions, and (3) recommendations for additional studies.

Primary Recommendations

1. **The in-water work period for activities such as dredging, bank stabilization, etc., should be restricted to July 1 – October 31.** Primary considerations for recommending in-water work periods are given to important fish species, including anadromous fish and those receiving protection under federal or state ESAs. The existing work period for the lower Willamette River and Multnomah Channel is July 1 – October 31 and December 1 – January 31 (ODFW 2000). Our findings indicate Chinook salmon, coho salmon, and steelhead (including a large number of unmarked fish) are present during December 1 – January 31, and are often abundant during this period; in-water work should be avoided to prevent harming listed stocks.

This recommendation does not necessarily reflect policy of ODFW or the COP. ODFW is responsible for providing guidelines for in-water work periods to minimize impacts to fish, wildlife, and habitat. It is likely that ODFW will recommend the winter work period remain open, but that strict criteria be met to ensure impacts to fish, wildlife, and habitat resources are negligible.

2. **Protect existing beach habitat.** Natural beaches appeared to be an important habitat for younger age classes of salmonids (particularly Chinook salmon), were selected by radio-tagged coho salmon, and were not a preferred habitat of large predator fishes (Pribyl et al. 2004); enhancements directed at creating beaches will likely provide a benefit to salmonids. It is unknown to what extent this habitat type can be enhanced by physical restoration efforts (see recommendation 5). Remaining beaches in the lower Willamette River represent relatively undisturbed habitats, and have important recreational and aesthetic value.

3. **Avoid construction of additional seawalls.** Seawalls represent a loss of natural shoreline conditions, provide little habitat for any fish species, and appeared to be under-utilized by juvenile salmonids. Electrofishing catches were low at seawalls; fish either avoid seawalls or change their behavior (move out of the range of electrofishing gear) upon encountering them. Because juvenile salmonids are generally associated with the upper portion of the water column, it is unlikely that low catches were due primarily to fish utilizing deep water along seawalls.

Secondary Recommendations

4. **Protect existing off-channel sites.** Many of these areas (alcoves, lagoons, backwaters, secondary channels) have been eliminated from the lower Willamette River; remaining areas are likely important for forage and refuge. All off-channel types were used by migrating yearling salmonids, and a proportion of our radio-tagged fish migrated through the Multnomah Channel. Habitat alterations should, at worst, not further eliminate habitat important to juvenile salmonids, and at best, provide additional habitat for juvenile salmonids while discouraging predators, potential competitors, and invasive species. The Multnomah Channel should be included in habitat conservation and enhancement activities.

5. **Determine if bio-engineering and other techniques can restore beach habitat functions and processes.** The City of Portland and ODFW should work with engineers and habitat specialists to determine the feasibility of restoring or creating beach habitats while considering other issues, such as commercial shipping, bank stabilization, and flood control. Though yearling Chinook salmon and other species did not exhibit clear preferences for any habitat type, beaches were clearly important to subyearling fish, and catches of larger fish were sometimes correlated with small substrates (sand), shallow water, and vegetated banks.

Recommendations for Additional Studies

6. **Focus additional studies on subyearling Chinook and coho salmon**. Very little is known about the origin and race, habitat use, residence time, diet, and survival of age-0 Chinook salmon in the lower Willamette River. Our observations indicated these fish were abundant

and used beach sites extensively; however, this study focused largely on yearling salmonids and did not answer critical questions pertaining to smaller age classes (especially habitat use and migration rates). Subyearling fish may be particularly important because nearly all are naturally produced (and therefore federally protected), and unlike older fish, may be associated with specific nearshore habitats (beaches). Investigating subyearling Chinook salmon in the lower Willamette River will greatly improve knowledge of their behavior and habitat requirements, and will enhance the ability of agencies to protect listed races. The habitat requirements of all ages should be considered when implementing fish management strategies.

Small steelhead were rare in our surveys and probably do not use the lower Willamette River to a great degree; most appear to outmigrate quickly after rearing in their natal streams. However, younger age classes of coho salmon were clearly present. Considering the status of coho salmon as a state-listed endangered species (they are also a candidate for federal listing), and their apparent behavioral differences relative to Chinook salmon, we recommend they be considered as a focal species in future studies.

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Computer models are tools intended to inform inquiry. A model is a simplification or representation of reality, or our perceptions of reality, and thus does not reflect all of reality; "truth (full reality) in the biological sciences has essentially infinite dimensions and hence full reality cannot be revealed with only finite samples of data and a "model" of the information in the data." (White and Doherty).

Models can be ranked on a continuum of very useful to essentially useless. "In order to validate the usefulness of a model, it is important to determine whether things that are observed in reality also hold true in the model." (Ventana Systems, Inc.) It is important for policy makers and stakeholders to ask "how useful is the Portland NRI model?" Does the model, and its outputs, provide a good representation of real-world conditions? Do the outputs provide decision-makers with good information needed for planning and regulation? Does the model allow for testing, feedback, and inputting of new information?

The usefulness of a model also is dependent on the validity of the data fed into the model, and the validity of the calculations performed by the model. If either or both of these is faulty, the model is useless.

<u>Is the medium the message</u>?
Marshall McLuhan's groundbreaking work on "media," published in 1964, is as or more important today then it was then. McLuhan's book was written before the personal computer revolution, but his ideas on technology as media are critical reading for our times.

"The medium is the message" because it is the "medium that shapes and controls the scale and form of human association and action." According to McLuhan, any medium (i.e. any new technology) "amplifies or accelerates existing processes," introduces a "change of scale or place or shape or pattern into human association, affairs, and action," resulting in "psychic and social consequences" (Wikipedia). Thus, the real "meaning" or "message" of a medium depends solely on the medium itself, regardless of the "content."

To put this in the context of the present discussion, the GIS model is the medium, and the model itself is the message delivered to us. The content of the model – the actual reality that the model presumes to represent – is no longer important. The model produces maps, and the maps show us what reality is. All future actions, decisions, "psychic and social consequences" will be based on the model (the medium), not reality.

Science vs. Policy Advocacy
An on-going discussion among scientists is their role in policy making, and the application of science in this process. "One common concern about the science-policy interface is that some so-called science is imbued with policy preferences" (Trudgill 2001 in Lackey 2007). Lackey discusses the use of terminology, pointing out the difference between "is" and "ought" statements: "science deals with the "is" world (facts

about the past, present, or future)...whether [the documenting fact] warrants a change in policy would be an *ought* statement – a policy question." He uses as examples the words *degradation*, *improvement*, *good*, and *poor*. "Such value-laden words should not be used to convey scientific information because they imply a preferred ecological state, a desired condition, a benchmark, or a preferred class of policy options. Doing so is not science, it is policy advocacy. Subtle, perhaps unintentional, but it is still policy advocacy...the appropriate science words are ones such as *change*, *increase*, or *decrease.* These words describe the scientific information in ways that are usually considered policy neutral." (Lackey 2007)

The City NRI model assigns relative[1] rankings of "low," "medium" or "high" for riparian and wildlife functions to areas within the NRI study area. These rankings are based on a set of criteria related to riparian functions that measure the size, shape and distances from water bodies of "landscape features" such as woody vegetation and wetlands. The criteria designate landscape features as either "primary" or "secondary," which each are presumably assigned a different score. However, as Lackey points out, these rankings are not science – they advocate policy (i.e. "high" is better than "medium" is better than "low").

The result of the NRI is that some areas shown on the NRI maps are better than others, and they all have some inherent value as riparian corridor. This new reality, basically a policy statement, will become the basis for future policy intended to protect or manage natural resources. Unfortunately, the leap from "science" to "policy" is false, and this false step can be traced back to the Metro Goal 5 riparian corridor program.

Metro reviewed a large body of scientific literature on riparian corridors. Based on this review, Metro developed a table of numbers representing the range of "recommended minimum riparian area widths for fish and wildlife habitat" (Metro 2001, Table 5), and this table became the basis for the subsequent Metro Goal 5 program (and, now, the City of Portland Goal 5 NRI). As I pointed out in a technical review of the Metro work (Fishman 2001), Metro misinterpreted the scientific literature by substituting policy advocacy for science. The source literature reviewed by Metro does not conclude that a distance of X meters is the "minimum required" distance necessary to support a specific ecological function. The cited literature generally presents data on measurements of ecological functions showing how functional attributes vary related to some measured parameter, such as distance from a stream. Metro generally <u>selected</u> from the literature the measurement (i.e. distance) that resulted in the <u>maximum</u> value for the ecological function being studied. An example is the entry in the Metro Table 5 that 100 ft is the "minimum required width" of a forested riparian corridor for temperature regulation and shade. The cited literature actually concludes that the maximum amount of temperature lowering measured in the forest was at a distance of 100 ft from the studied streams. The selection of 100 ft as the "minimum riparian area width" is advocating a policy – forested areas along streams should provide the maximum amount of shade and temperature-lowering possible.

[1] The meaning of "relative" is not explained in the NRI documents.

Metro developed a GIS model using scoring or ranking criteria based on the information in their Table 5. The City of Portland used this same model, with some modifications to certain criteria, to produce the NRI relative rankings and maps. The City GIS model is complex, and we are presently (August 2007) going through the model code (provided by the City) to determine how site rankings are assigned. A couple of things are apparent, however, about the scoring or ranking method, as discussed below.

Riparian Corridor Model – the Low, Medium and High ranks are based on the number of primary features identified by the model, as tabulated below. It appears that secondary features do not figure into the ranking, begging the question of why secondary features are identified. The reasoning behind assignment of rank to each number of primary features is not explained – for example, why are 1 and 2 "medium," while 3-6 constitute "high?" Without a scientific explanation of this ranking scheme, we can only assume that it is arbitrary, and therefore a policy decision.

Primary Features	Secondary Features	Riparian Rank
0	any number	LOW
1	any number	MEDIUM
2	any number	MEDIUM
3 - 6	any number	HIGH

Combined Relative Rank (Riparian plus Wildlife ranks) – the assignment of combined relative rank, shown below, appears to be based on the highest of the two ranks (riparian or wildlife). There are no intermediate ranks, such as "high" plus "low" equals "medium," or "medium" plus "high" equals "medium-high." Differences between sites are thus hidden. And again, this ranking system is not science-based, it is arbitrary.

Riparian Rank	Wildlife Rank	Combined Relative Rank
HIGH	HIGH	HIGH
HIGH	MEDIUM	HIGH
HIGH	LOW	HIGH
MEDIUM	HIGH	HIGH
MEDIUM	MEDIUM	MEDIUM
MEDIUM	LOW	MEDIUM
LOW	HIGH	HIGH
LOW	MEDIUM	MEDIUM
LOW	LOW	LOW
LOW, MEDIUM or HIGH	Null	LOW, MEDIUM or HIGH
any rank	any rank	if SHA* = HIGH

*SHA = Special Habitat Areas

Oregon Statewide Goal 5 Process and Policy

The City NRI update is based on requirements of Metro and Oregon Statewide Planning Goal 5. The Goal 5 process requires local jurisdictions to conduct an inventory of natural resources; the steps in the inventory process are: a) collect information about Goal 5 resource sites, b) determine the adequacy of the information, c) determine the significance of resource sites, and d) adopt a list of significant sites. The City NRI Update being reviewed here represents step (a) in this process. The result of step (a), collection of information, is represented by the vegetation and water body information in the City NRI, including location and quantity; this appears to be high quality information based on field data collection and aerial photo interpretation. The determination of information adequacy (step b) under Goal 5 is based on location, quality and quantity of resource information. Location and quantity are straight-forward mapping and tabulation tasks, and these appear to be adequate.

The information on quality, however, is the main question raised in this review. Goal 5 requires that "information on quality shall indicate a resource site's value relative to other known examples of the same resource" (OAR 660-023-0030(3)(b). The City NRI update ranks sites with a "relative ranking;" however, there is no explanation of how the rankings are "relative" to other known examples of the same resource within the City (or region). In fact, the assignment of rank (high, medium, low) appears to be arbitrary and subjective, as discussed above.

Specific Inventory Issues: Riparian Corridor Criteria
The following comments are specific to the application of the City NRI riparian corridor criteria to the Willamette River in Portland.

"Water bodies" map features. The City NRI has automatically rated all water bodies as primary features for all 6 riparian corridor functions (microclimate and shade; stream flow moderation and water storage; bank stability, and sediment, pollution and nutrient control; large wood and channel dynamics; organic inputs, food web and nutrient cycling; and riparian wildlife movement corridor). Although the river itself is an important feature (there are no riparian areas without a water body), it is difficult to understand how the water body provides most of these 6 functions. This is not explained well in the City NRI documents.

There is no information about location and condition of habitat in the river. The City includes the river as part of the riparian corridor, but does not provide any inventory information about habitat characteristics and fish and wildlife use. Fish habitat data are available from a variety of sources, and should be incorporated in the City NRI. There is also a lack of wildlife habitat information for the river (i.e. the water body) itself. This is an important but missing component – there are numerous wildlife species that are aquatic, semi-aquatic or water dependent. The use of human-made structures, as well as more "nature" habitat elements by these wildlife species cannot be overlooked.

River/floodplain ecosystems. The City NRI incorrectly applies stream/riparian ecosystem concepts to the lower Willamette River, an altered river/floodplain ecosystem. The six riparian corridor functions, and the model criteria for each, are more appropriate for streams with associated riparian forests than for large, low-gradient rivers, such as the lower Willamette, and their associated floodplains.

River/floodplain ecosystems, in their unaltered state, have a complex set of physical, chemical and biological relationships between the river channel and the active floodplain (annually inundated floodplain) that are very different from stream/riparian systems (Bayley 1995). In the City NRI, the lower Willamette is assumed to be the equivalent of any small tributary stream, in terms of ecosystem functions; this is not a correct assumption.

Altered and managed water body. The City NRI does not consider the altered state of the lower Willamette River in the riparian model criteria. This altered state is mentioned in the NRI discussion draft:

- *Flow levels are managed through the operation of dams in the upper basin;*
- *The Willamette River has been substantially altered in Portland;*
- *the river bottom is dredged to improve navigation;*
- *substantial portions of the river banks have been hardened with rip-rap, seawalls and docks;*
- *the banks…throughout most of Portland, have been filled and hardened to minimize flooding and erosion (p. 24).*

Some of the criteria in the Metro riparian corridor model were modified by the City to take into account the managed nature of waterways in drainage districts. Drainage districts are not included in criteria for stream flow moderation and water storage; bank stability, and sediment, pollution and nutrient control; and large wood and channel dynamics. The lower Willamette River should also be exempted from application of these criteria because of its altered and managed condition.

Incorrect use of the 100-year floodplain. The City NRI incorrectly uses the 100-year floodplain (and the area of inundation during the large 1996 flood event) as a functional component of the riparian corridor. The 100-year floodplain is a designation used for city planning and flood insurance purposes, and has "limited practical relevance to riparian workers" (Nelle 2007). The ecologically functional floodplain in both stream/riparian and river/floodplain ecosystems is frequently inundated, typically every 1-3 years, or having a 1.5 year return interval (Nelle 2007). This active floodplain provides the important functions, such as those listed in the City NRI model.

Incorrect Application of Ecosystem Function Concepts. The basic issue I have with the City NRI is related to the criteria used in the GIS models. The criteria are based on interpretations of scientific literature that are used out of context. I summarize some of these issues below.

The City NRI report states: "Riparian corridors are comprised of rivers and streams, riparian vegetation, and off-channel areas, including wetlands, side channels, and floodplains….Riparian corridors also include areas that provide the transition between the stream banks and upland areas" (pp. 17-18). These statements clearly make a distinction between riparian and upland areas. One distinguishing difference between riparian areas and upland areas is the vegetation; riparian areas can be delineated in the field based on the dominant plant species. The model criteria, however, ignore the differences between these two ecological units, and incorrectly use prescribed distances from water bodies to define riparian boundaries.

The City NRI further states: "Intact riparian corridors provide the following critical watershed functions:

- Microclimate and shade
- Bank stabilization and control of sediments, nutrients and pollutants
- Streamflow moderation and flood storage
- Organic inputs and food webs
- Large wood and channel dynamics
- Wildlife habitat/corridors" (p. 18).

It is clear from previous statements in the NRI that the Willamette River riparian corridors are not intact; therefore, it must follow that the Willamette River riparian corridors do not provide the listed watershed functions.

Further, the six listed "watershed functions" (riparian functions?) are not appropriate for the lower Willamette River because the functions are derived from stream/riparian ecosystem studies, and the managed and altered conditions of the Willamette River and associated corridor override the functions.

Microclimate and shade are riparian functions related to maintenance of cool in-stream water temperatures and cooler, more humid air in riparian forests. Shade along the lower Willamette River is irrelevant for maintenance of water temperature in the river because of the large water volume. Microclimate effects are potentially important parameters for certain native vegetation and wildlife species in large riparian or active floodplain forests along the lower Willamette; however, this concept is inappropriately applied by using distances, such as 780 feet, gleaned from published scientific literature on studies in very different settings than the lower Willamette River.

Bank stabilization and control of sediments, nutrients and pollutants are functions that can be provided by streamside, riparian vegetation in unaltered systems. In the altered lower Willamette River, however, these functions are often provided by the built environment, including armored banks and seawalls, fill material, and constructed stormwater facilities. The designation of non-vegetated land within 50 feet of the river as a primary feature for this function is not scientifically supported, particularly on developed lands. The inclusion of woody vegetation within the 100-year floodplain or areas of inundation during the 1996 flood as a primary feature for this function is also not scientifically supported.

Streamflow moderation and flood storage is not an appropriate criterion for the lower Willamette River as applied by the NRI model. The model criteria use the "flood area" consisting of the 100-year floodplain and area of 1996 flood inundation. However, during a flood event that inundates this "flood area" the volume of water "stored" in the "flood area" is insignificant in relation to the volume of water in the river. The effect of vegetation in the areas described by the model criteria, in terms of infiltrating precipitation, is also insignificant in relation to the volume of water in the Willamette River.

Organic inputs and food webs model criteria are based on the presence of woody vegetation within specified distances outside the "flood area." These areas are certainly upland, not riparian, and their relationship to aquatic food webs is unclear at best. Allochthonous organic material is potentially involved in limited food webs of the lower Willamette River; however, lower river food webs are primarily based on organic inputs from upstream and phytoplankton production.

Large wood and channel dynamics is a function that is not appropriately assigned to the lower Willamette River. In stream/riparian systems, large wood influences the characteristics of stream channels, such as location and complexity. Historically, immense log jams in the Willamette River affected channel characteristics; this function is gone today because of the alterations to the channel (dredging, straightening, narrowing) and the river banks (filling and armoring). Large wood is not important for channel dynamics in the altered river.

Wildlife movement corridor model criteria are based on vegetated width (100 and 300 feet) along the water. The model does not consider patchiness or lack of continuity of vegetation along the river; in other words, opportunities for wildlife to move from a vegetation patch to other patches. The result is that isolated patches of vegetation are assigned a "movement corridor" function, when no such function exists.

Recommendations

The Goal 5 process requires citizen and stakeholder participation: "the development of inventory data…must, under Statewide Planning Goals 1 and 2, provide opportunities for citizen involvement…" (OAR 660-016-0020 Landowner Involvement). The City has appropriately asked for comments on the draft NRI update. I recommend that the City engage in stakeholder discussions that focus separately on the topics of location, quantity and quality of the inventory information. There could be general agreement on the location and quantity information; however, the quality information, based on the GIS modeling, will likely generate considerable discussion and disagreement. The goal of these discussions should be to reach agreements on how the information will be used.

I also recommend that the City think about my comments concerning models and reality, and science and policy. In my opinion, science and policy must have clearly defined boundaries. Decisions about resource "value" have to be grounded in science. Rankings such as "high" and "low" are not appropriate unless specifically tied to scientific variables. It has often been stated in the Metro and City processes that the model criteria represent riparian and wildlife variables and that "high" wildlife values, for example, indicate values of native habitat for native species. The City NRI vegetation data, however, only indicate areas as either forest, woodland, shrubland or herbaceous; identification of native and non-native plant species are not part of the data. Some areas mapped as having "high" value for wildlife could therefore be dominated by non-native plants, and not have the assumed value for wildlife.

Under Goal 5, it is appropriate (required?) to involve stakeholders in decisions of policy. An appropriate public discussion would be around the topic of what types and locations and quality of resources have high value for Portlanders. These policy decisions can then be applied to the natural resource location and quantity information to identify the resources that should receive more attention under future resource protection decisions.

The City needs to consider the differences between stream/riparian ecosystems and river/floodplain ecosystems in order to correctly evaluate the quality of natural resources along the Willamette River in Portland. The realities of the river as an altered, managed water body must also be included in the criteria for evaluation of quality.

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October 12, 2007

Roberta Jortner
Portland Planning Bureau
1900 SW 4th Avenue, Suite 4000
Portland, OR 97201

Re: SWCA Technical Memorandum
Evaluation of the City of Portland's Draft Natural Resource Inventory Model Results for Port of Portland Willamette River North Reach Properties

Dear Roberta:

At the Port's request, SWCA Environmental Consultants has completed a thorough review of the Draft Natural Resource Inventory Update (NRIU). The review compared the City's findings for six Port properties with the Port's own data from our more detailed Natural Resource Assessment and Management Plan (NRAMP). The review found significant issues with the City's original source data, with the validity of the assumptions inherent in the model based on both the inputs and the criteria, and with the application of riparian corridor functions to Port properties.

Data

The comparative analysis of the NRIU and NRAMP data found a multitude of discrepancies at each of the five Port sites (NRAMP data for Willamette Cove is not available). The analysis found that at all but Terminal 5, over 60% of the acreage has been misclassified. In the case of Terminal 2, more than 80% of the acreage has been misclassified. These discrepancies underscore the need for flexibility in developing code language that implements the goals of Title 13 - Nature in the Neighborhood and other natural resource effected regulatory programs. For example, we support the idea that new Greenway code allowing applicant based inventories be used in place of the NRIU data. We also contend that the effectiveness of policy implementation will depend on allowing for the use of applicant natural resource data.

What is most important, of course, is the accuracy and function of the NRIU. We are concerned that this high percentage of misclassification is applicable throughout the resource area in the Lower Willamette. Beyond the serious implications of this to the program are the affects of the inaccuracies on all property owners in the North Reach. The inaccuracies in the NRIU will affect land use applicants and also the pursuit of mitigation or restoration sites. How do we judge potential sites with the greatest opportunity for enhancement if we can't depend on the City's basic inventory?

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Validity of Assumptions

SWCA's memorandum questions the approach of claiming intact riparian corridor functions in a non-intact Willamette River riparian corridor. While we understand that the City is striving toward better functionality, as an inventory, the NRIU must be an account of current functional conditions as explained in the discussion draft on page 24. A genuine recognition of the altered state of the Lower Willamette would take this into account in describing the current and potential conditions for:

- *Microclimate and shade;*
- *Bank stabilization and control of sediments, nutrients and pollutants;*
- *Streamflow moderation and flood storage;*
- *Organic inputs and food webs;*
- *Large wood and channel dynamics; and*
- *Wildlife habitat/corridors*

Related to the question concerning the riparian corridor functions is the foundation of the model criteria. The model criteria are based on measurements in relatively unaltered ecosystems unlike the conditions extant in the Lower Willamette River. The landscape features inventoried by the City for the NRIU do not provide the same ecological functions as unaltered landscape features. The outcome is model results that are not representative of on-the-ground conditions.

Riparian Corridor Functions

In their memorandum, SWCA explores each of the six riparian corridor functions subject to the City NRIU model and finds multiple issues with each function. While the details in the report are important to the future usefulness of the NRIU as a document that can shape natural resource policy in the North Reach and across the City, in general the functions as described are applied incorrectly or without scientific support. One example of this is the designation of non-vegetated, often impermeable land within 50 feet of the river as a primary feature for multiple functions. Another is the assigning of riparian function to the river itself (i.e. the water) when the primary and secondary function of the water is aquatic.

These issues with the data, assumptions and functions led us to examine and compare the NRIU inventory to our own NRAMP for each Port property in the study area for which data was available. The issues identified as a result of this analysis are numerous and complex, however they are similar for all Subject Areas and Port properties. SWCA's review concluded that, "in general, Port of Portland properties have been assigned higher riparian corridor values than warranted by conditions on the ground." There are also site by site issues with the habitat attributes related to shape, size and proximity that affect the quality or function of the patch based on the accuracy the underlying vegetation data. The issues with the habitat attributes affect their functional value and usefulness as tool for shaping policy.

Overall, the Port finds the NRIU to be of questionable value. Clearly, as evidenced by the maps and data presented by SWCA, our own inventory is much more accurate. We find that because of the way the model is run, the mapping inaccuracies have a cumulative effect in scoring and improperly classifying natural resource data. As has been stated, our concern would be focused on any land use program, policy or regulation using the NRIU as a proxy for existing conditions or functionality in the Lower Willamette. The Port finds the issues outlined here and detailed in the SWCA memorandum reinforce the need for flexibility in striving for compliance with Goal5/Nature in the Neighborhoods Title 13 and other regulatory programs.

We thank you for the opportunity to comment on the NRIU and are appreciative of all the challenging work completed by staff on this project. Responding to the NRIU has also been a challenge for us, yet we would be remiss in not performing a comprehensive analysis of the NRIU given its potential to shape policy across hundreds of acres of Port property, within the North Reach and across the City. As mentioned, the NRIU also has potential financial implications related to funding millions of dollars of possible mitigation work. It also has implications for the current and future inventory of buildable industrial lands.

We welcome additional interaction with yourself and other Planning Bureau staff over this draft. In particular we would appreciate a written response to our comments, as well as further conversation as we work toward a new greenway code and River Plan. Please let me know if you would like to meet for further discussion.

Sincerely

Greg Theisen
Port of Portland, Planner

Attachment – Technical Memorandum and Appendices

Cc: Susie Lahsene, Port
Dorothy Sperry, Port
Keith Leavitt, Port
Paul Fishman, SWCA
Sallie Edmunds, City of Portland
Brian Campbell, City of Portland
Deborah Stein, City of Portland

Memorandum

To: Tom Bouillion, AICP, Port of Portland

CC: Paul Fishman, Principal Ecologist

From: Rafael Gutierrez, GIS Analyst, SWCA, Inc.

Date: March 24, 2005

Re: METRO Riparian Corridor and Wildlife Habitat Inventory Assessment for Port of Portland: T4 Criteria Assessment Summary

---

At the request of the Port of Portland, staff at Fishman/SWCA, Inc. has assessed the Marine Terminal 4 (T4) site in relation to the available information on METRO's riparian corridor and wildlife habitat inventory modeling program. Criteria for the site have been assessed for classifications and contributing scores. A comparison of the METRO findings with the Port of Portland's natural resource inventory and 2004 aerial imagery has been made for further assessment of resources on the site.

Site Description

The Port of Portland's Marine Terminal 4 (T4) is located along the east bank of the Lower Willamette River in Portland, Oregon. The site functions primarily as a receiving yard for Toyota Car manufacturing. There are two main shipping docks along the north end of the site.

The site is nearly devoid of any natural resources. The riverbank consists mostly of riprap material covered in Himalayan blackberry. The inland surface is impervious pavement and some gravel. There is a small herbaceous upland area on the southern property line. The terrain of the T4 sites reflects decades of human landform alterations, including large volumes of fill, riverbank armoring, grading, wharf and berth construction, and paving.

Summary Key Findings - Resource Values

The METRO Riparian and Habitat Model is based functions and values of variables that include, but are not limited to, vegetative cover, water features, floodplain features, topography, and wetlands. The METRO Riparian model looks at five ecological functions that determine primary and secondary significance that affect the overall score for its resource class designation. Similarly, the Wildlife Habitat value is determined by measurements of vegetated patches to other patches and water bodies. Summarized below are key findings determined by SWCA based on known ecological functions, knowledge of the site, previous natural resource determinations, and Port of Portland Natural Resource Inventory data.

Riparian Habitat

- Microclimate and Shade – There are no documented areas on the Terminal 4 site that fulfill the microclimate and shade criteria.
- Streamflow Moderation and Water Storage - Impervious areas of the site do not provide the hydrologic functions described by METRO.
- Bank Stabilization, Sediment and Pollution Control – In areas where banks are armored, stabilization is a function of infrastructure rather than riparian width. Riparian areas at T4 have no opportunity to provide sediment and pollution control functions where they are bypassed by stormwater conveyance systems.
- Large Wood (LWD) and Channel Dynamics - LWD functions in the METRO model are specific to small streams, and are not fully applicable to the lower Willamette River at T4. This reach of the Willamette River has no channel migration zone (CMZ) due to human alterations, and therefore riparian areas cannot provide the channel dynamics functions described by METRO. Many of the areas mapped by METRO at T4 for this criterion do not have the potential of supporting trees and have been modified specifically to prevent the river from meandering outside its defined channel.
- Organic Material Sources – Like the LWD functions above, the METRO model criteria are designed for small streams. However, organic material origins are considerably different in lower reaches of large rivers such as the Willamette River. Areas of the T4 site that are not in the frequently inundated active floodplain, even if vegetated, contribute little to no organic materials to Willamette River food webs.

Wildlife Habitat

- Wildlife habitat present at T4 is limited to a strip of undeveloped herbaceous upland vegetation along the southern property boundary
- No unique or sensitive habitats or species are present

The following details existing conditions and scoring for criteria that contribute to the resource class assignments for the features that are within the site.

T4 Riparian Criteria Assessment Summary

METRO's riparian corridor inventory consists of five criteria:

1. microclimate and shade
2. streamflow moderation and water storage
3. bank stabilization, sediment and pollution control
4. large wood and channel dynamics
5. organic material sources

According to METRO's riparian corridor model, the T4 site contains four of the METRO criteria, which were scored differently throughout the site. The site is situated along the eastern edge of the Willamette River, with some areas affected by floods. Mapped flood areas include the FEMA 100-year floodplain and areas inundated in the 1996 flood. Inundated areas do not necessarily indicate a floodplain and have therefore been subject to corrections and omissions from the flood area variable. The T4 site is also largely developed, with parking lots and berth areas occupying a significant portion of the site. The portions of the site that satisfied the METRO criteria are discussed below. Appendix A illustrates mapping criteria for riparian corridor functional values.

Microclimate and Shade

According to METRO, no part of the T4 site satisfied the microclimate and shade criteria.

Streamflow Moderation and Water Storage

Along the Willamette River side of the T4 site, the METRO criteria for streamflow moderation and water storage are satisfied due to coincidence with floodplain areas and wetlands. Where floodplains are developed, the areas have been assigned secondary functional value. Floodplain include 1996 flood inundation levels.

With the exception of small, narrow sections of vegetation near the river, most of the areas mapped for this criterion are paved or otherwise developed. Although subject to occasional inundation, these impervious areas do not provide the hydrologic functions described by METRO for this criterion[1].

Bank Stabilization, Sediment and Pollution Control

Along the Willamette River side of the T4 site, the METRO criteria for bank stabilization, sediment and pollution control apply to all areas within 50 feet of surface streams (the Willamette River), including wharfs. In addition, one small vegetated area was also assigned primary functional value for this criterion. No steep slopes within the required distance exist on the site.

Portions of the riverbank at T4 are armored or covered by large wharfs. In these areas, especially where stormwater from paved surfaces is piped to the river, bank stabilization and sediment and pollution control functions are provided by infrastructure. Where water bypasses the riparian zone, there is no opportunity for the designated 50-foot width to act as a filter. Riparian areas at T4 have no opportunity to provide sediment and pollution control functions where they are bypassed by stormwater conveyance systems.

Large Wood and Channel Dynamics

Although there are few trees on the T4 site, all areas along the riverbanks were mapped by METRO as primary due to the FEMA or 1996 flood elevation or because it was within the default 50 feet of a surface stream.

Areas mapped at T4 for these criteria include armored shorelines and wharfs. Many of these areas do not have the potential of supporting trees and have been modified specifically to prevent the river from meandering outside its defined channel.

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[1] METRO, Preliminary Draft – <u>METRO's Riparian Corridor and Wildlife Habitat Inventories</u>, August 8, 2002, Exhibit A, Appendix A, Resolution 01-3141C, pg. 2.

In addition, large woody debris (LWD) plays a distinctively different role in large river channels than in small streams, where LWD is generally local in origin and plays an important role in habitat formation. In the lower portions of a watershed, the majority of LWD originates upstream and the width of the river precludes the influence of LWD on the formation of pools, riffles, and meanders. LWD does play a role in the ecology and morphology of large rivers, but riparian width standards from small streams, with their emphasis on local recruitment and pool/riffle habitat formation, do not properly acknowledge the distinct role and origins of LWD in large rivers.

As stated in Resolution 01-3141C, streams and rivers altered by human development may not have a channel migration zone (CMZ). Much of the area of the site that is mapped by METRO as having primary functional value appears to be mapped for CMZ functions that do not exist at T4.

Organic Material Sources

A small area on the south end of the T4 site and was mapped as primary based on the METRO criterion of forested and woody vegetation within 100 feet of a stream or wetland.

The area mapped for this criterion is not forested and appears to have been mapped in error. Most nutrients in a large river originate from upstream sources or in-stream production, and frequently inundated (i.e. every 1-5 years) active floodplains are the main pathway for local terrestrial nutrients to enter the aquatic ecosystem. Areas of the T4 site that are not in the active floodplain, even if vegetated, contribute little to no organic materials to aquatic food webs.

T4 Wildlife Habitat Inventory Assessment Summary

Wildlife habitat present at T4 is limited to a small patch of herbaceous upland along the southern property boundary (METRO No. 421); this area was mapped as "pervious wasteland/barren/weedy fill" in the Port's Natural Resource Inventory. The following evaluates the herbaceous upland according to METRO's mapping. Appendix A illustrates the Wildlife Habitat mapping criteria.

Patch Size

A patch is defined as any wetland or upland forest greater than 2 acres. Large habitat patches are better than small patches because they frequently retain more functions and values by providing greater food resources and reduced predation. There are no wetlands or upland forest habitat resources on T4; therefore, the herbaceous upland received no points.

Interior Habitat

The shape of a patch influences species richness and diversity; increased edge habitat favors common urban species (e.g. opportunists, predators) and reduces habitat for less common habitat specialists. A patch with more interior habitat has a higher value for wildlife habitat because it reduces competition from non-native and generalist species, provides better food and cover, and increases avian nest success for native species. According to the METRO model, interior habitat is calculated by drawing internal 200-foot buffers within each patch and calculating the acreage of the new interior patch; the greater the new acreage the greater the habitat value. Undeveloped areas on T4 have internal buffers less than 200 feet wide and do not qualify as having significant interior habitat.

Connectivity to Water

Patches that are closer to water/wetland resources have higher wildlife values than areas further from water/wetland resources. The herbaceous upland is located within 300 feet of the Willamette River and score 2 points.

Connectivity and Proximity to Other Patches

The number and proximity of patches increases the wildlife habitat value because it enables wildlife a greater ability to disperse. The herbaceous upland receives a score of 1 because it has low proximity to other patches nearby.

Habitat of Concern

Soils and native vegetation at T4 have been disturbed by past fill and land development. No unique or sensitive habitats or species are present.

T4 Resource Classification and Port of Portland Natural Resource Classification Comparison

The Port of Portland has conducted a Natural Resource Inventory (NRI) of all Port of Portland properties that provides a detailed and valuable tool in which to compare METRO Resource mapping. The NRI mapping was an extensive, ground-truthed inventory of resource features using the Johnson and O'Neill[2] classification schema and a local classification. Although the NRI does not describe delineated wetlands or other surveyed hydrology, it still offers an accurate depiction of real ground conditions.

Findings for the T4 site suggest discrepancies with METRO's significant resource features and POP NRI data. Table 1 describes a cross tabulation of METRO's resource classes and POP's NRI in acreages. The comparison indicates that 5 acres of the 254 acres on T4 are relevant resources and not the 47 acres proposed by METRO. See Appendix B for the Port's Natural Resource Inventory Mapping for T4.

As stated earlier, the criteria for the Port of Portland Marine Terminal 4 site have been assessed for classifications and contributing scores. Scores for riparian corridor functions do not reflect complete ground conditions. The influences of the built environment are inadequately accounted for (e.g. armored banks, paved surfaces, gravel lots, etc.). This is also true for wildlife habitat model scoring which is based on shape, size, and proximity to water and other resource patches, but does not include habitat quality. The METRO model assumes that all herbaceous patches near water are equal but they are not. The POP NRI illustrates a more accurate depiction of location and type of vegetation cover on the T4 site; the herbaceous upland mapped by METRO is mapped as wasteland/barren/weedy fill and not herbaceous upland. The T4 site functions primarily as an industrial terminal and provides little ecological function to fish and wildlife.

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[2] Johnson, David H. and O'Neill, Thomas A. 2001. *Wildlife-Habitat Relationships in Oregon and Washington.* Corvallis, Oregon State University Press.

Table 1. Comparison of METRO Goal 5 and POP Natural Resource Inventory - Marine Terminal 4. The Port's Local Classification is described in light gray on the left hand column. METRO's Resource Classes are described in black. Total acres for each POP NRI Local Class within a METRO Resource class are found with each cell. Dark gray cells indicate natural resources according to POP NRI model. The POP NRI model indicates a significantly smaller amount of natural resources on the T4 site.

Port of Portland's Local Classifications	**METRO's Goal 5 Resource Classes**	class 1 riparian, highest-value habitat	class 2 riparian, medium-value habitat	class 3 riparian, lower-value habitat	class A wildlife, highest-value habitat	impact areas, land next to regionally significant habitat that may have a significant affect on the condition of the habitat
	1.98	0.07	1.54	0.16	0.00	0.21
Blackberry Scrub-Shrub	2.14	0.03	0.92	0.98	0.00	0.21
Developed - Cultivated	0.11	0.00	0.00	0.00	0.03	0.09
Developed - Impervious	23.97	0.16	3.46	12.42	0.00	7.94
Developed - Pervious	3.09	0.00	0.03	1.17	0.00	1.89
Emergent Wetland	0.06	0.00	0.06	0.00	0.00	0.00
Hardwood (Planted)	0.08	0.00	0.00	0.08	0.00	0.00
Herbaceous Upland	0.61	0.00	0.17	0.32	0.00	0.12
Mixed Conifer-Hardwood (Planted)	0.50	0.00	0.00	0.02	0.00	0.48
Pervious Wasteland/Barren/Weedy Fill	0.59	0.00	0.00	0.59	0.00	0.00
Railroad - Crushed Rock	0.07	0.00	0.00	0.00	0.00	0.07
Railroad - Paved	1.58	0.00	0.88	0.14	0.00	0.55
River Beach (Modified/Protected)	4.15	0.00	2.87	0.13	0.00	1.16
River Beach (Natural)	0.60	0.00	0.36	0.24	0.00	0.00
Road - Paved	1.29	0.04	0.00	1.08	0.00	0.17
Scrub-Shrub	1.81	0.00	0.18	0.00	0.30	1.33
Scrub-Shrub (Planted)	1.65	0.00	0.19	0.32	0.00	1.14
Water Related Structure	2.50	0.18	1.70	0.00	0.00	0.62
	46.78	**0.48**	**12.34**	**17.67**	**0.33**	**15.96**
	100%	1%	26%	38%	1%	34%
Total Acres of Natural Resources According to POP NRI	4.70	0.00	0.60	0.74	0.30	3.06
	100%	0%	13%	16%	6%	65%
Total acreage of T4	**254.32**					
Percent Acreage of Natural Resources	18%	0%	5%	7%	0%	6%

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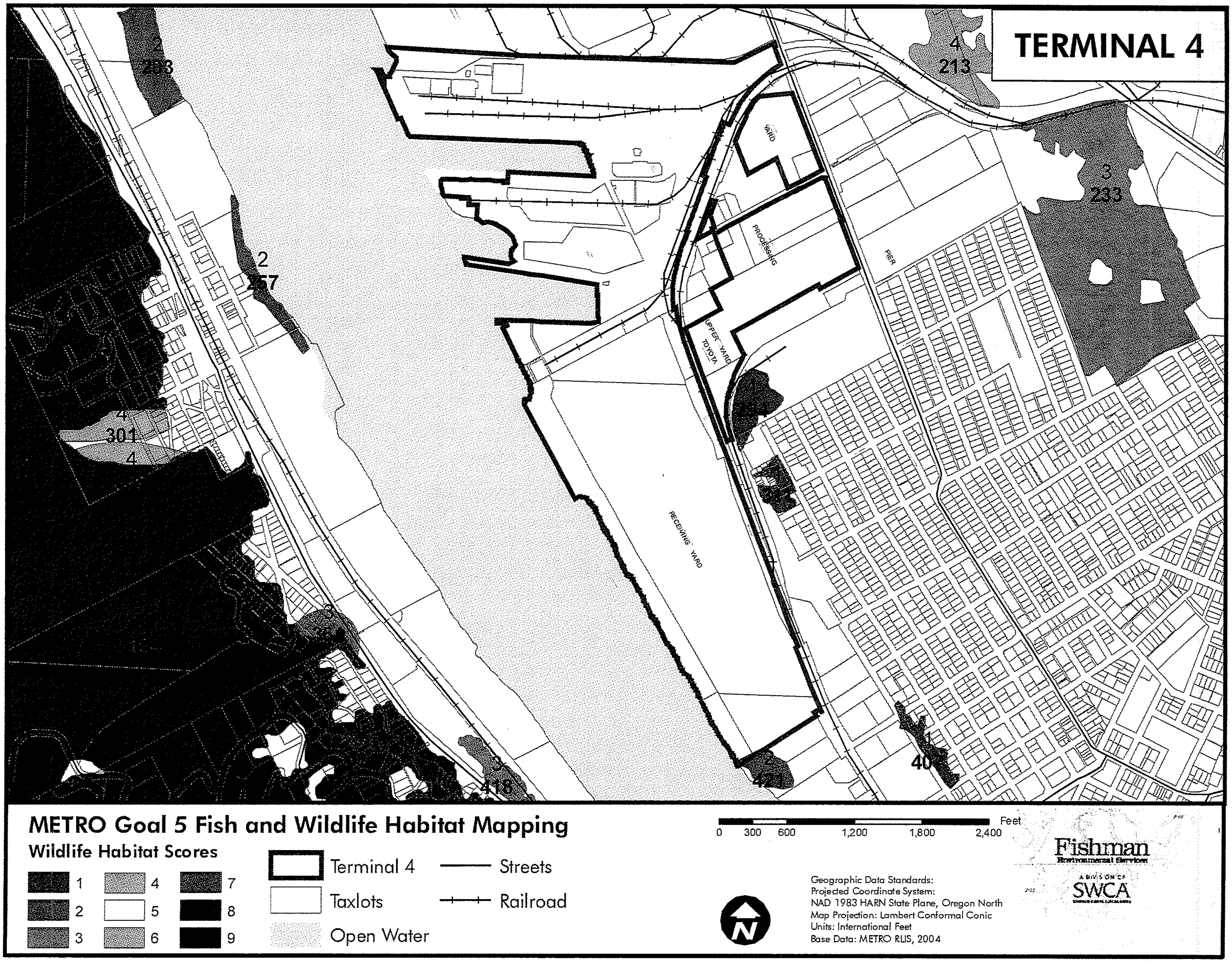
APPENDIX A

METRO Riparian Corridor and Wildlife Habitat Model Mapping


TERMINAL 4
YARD
PROCESSING
PIER
UPPER YARD
TOYOTA
RECEIVING YARD
METRO Goal 5 Fish and Wildlife Habitat Mapping
Wildlife Habitat Scores
1
2
3
4
5
6
7
8
9
Terminal 4
Taxlots
Open Water
Streets
Railroad
Feet
0 300 600 1,200 1,800 2,400
Geographic Data Standards:
Projected Coordinate System:
NAD 1983 HARN State Plane, Oregon North
Map Projection: Lambert Conformal Conic
Units: International Feet
Base Data: METRO RLIS, 2004
Fishman
Environmental Services
A DIVISION OF
SWCA

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METRO Goal 5 Fish and Wildlife Habitat Mapping

Streamflow Moderation & Water Storage

Primary (6)
Secondary (1)
Terminal 4
Taxlots
Open Water
Streets
Railroad

0 300 600 1,200 1,800 2,400 Feet

N

Geographic Data Standards:
Projected Coordinate System:
NAD 1983 HARN State Plane, Oregon North
Map Projection: Lambert Conformal Conic
Units: International Feet
Base Data: METRO RLIS, 2004

Fishman Environmental Services
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METRO Goal 5 Fish and Wildlife Habitat Mapping

Bank Stabilization, Sediment & Pollution Control

Primary (6)

Secondary (1)

Terminal 4

Taxlots

Open Water

Streets

Railroad

0 300 600 1,200 1,800 2,400 Feet

Geographic Data Standards:
Projected Coordinate System:
NAD 1983 HARN State Plane, Oregon North
Map Projection: Lambert Conformal Conic
Units: International Feet
Base Data: METRO RLIS, 2004

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METRO Goal 5 Fish and Wildlife Habitat Mapping

Microclimate and Shade

- Primary (6)
- Secondary (1)
- Terminal 4
- Taxlots
- Open Water
- Streets
- Railroad

0 300 600 1,200 1,800 2,400 Feet

Geographic Data Standards:
Projected Coordinate System:
NAD 1983 HARN State Plane, Oregon North
Map Projection: Lambert Conformal Conic
Units: International Feet
Base Data: METRO RLIS, 2004

Fishman Environmental Services
A DIVISION OF SWCA

METRO Goal 5 Fish and Wildlife Habitat Mapping

Large Wood and Channel Dynamics

- Primary (6)
- Secondary (1)
- Terminal 4
- Taxlots
- Open Water
- Streets
- Railroad

0 300 600 1,200 1,800 2,400 Feet

N

Geographic Data Standards:
Projected Coordinate System:
NAD 1983 HARN State Plane, Oregon North
Map Projection: Lambert Conformal Conic
Units: International Feet
Base Data: METRO RLIS, 2004

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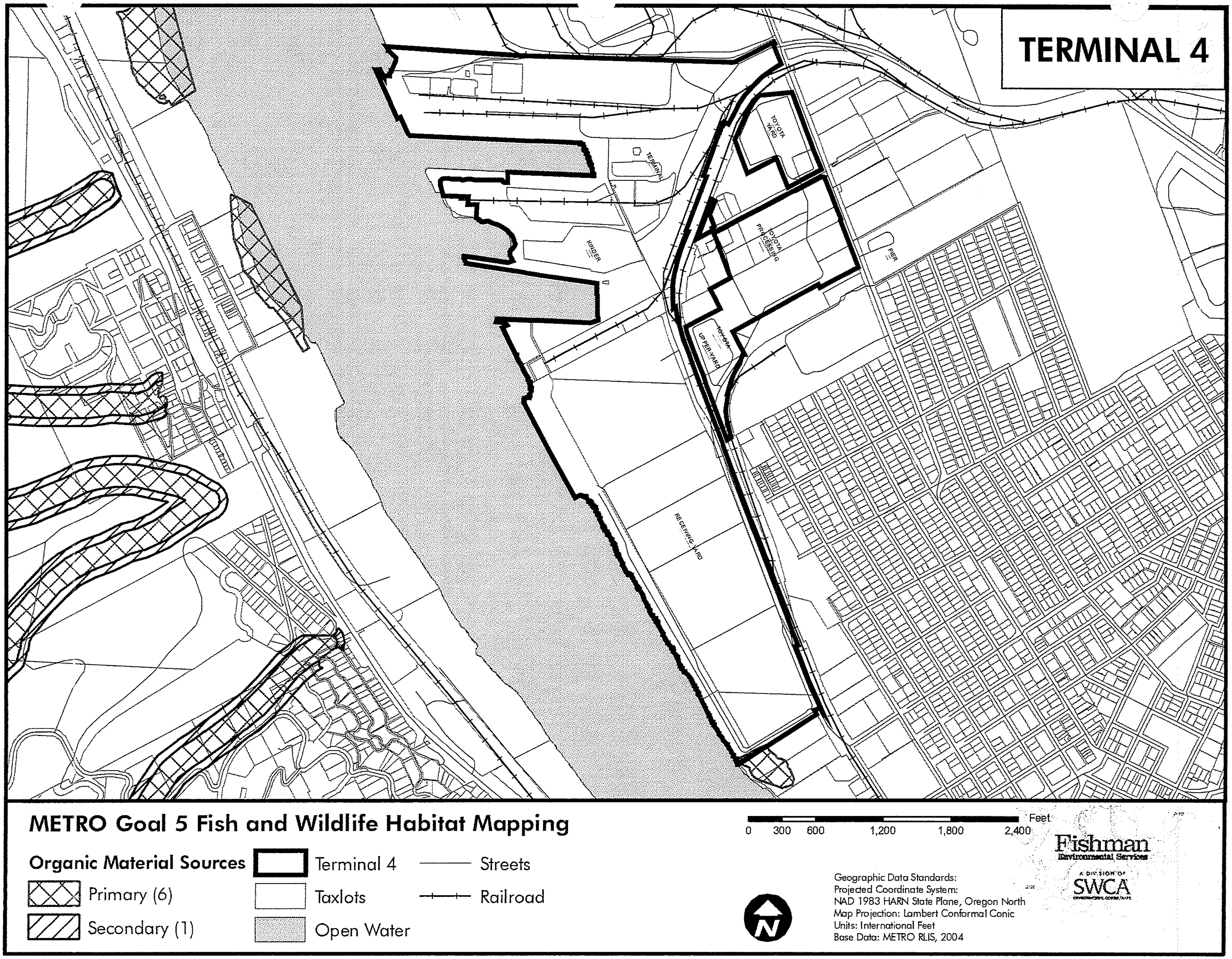
TERMINAL 4
TOYOTA YARD
TERMINAL
KINDER
TOYOTA PROCESSING
PIER
TOYOTA UPPER YARD
RECEIVING YARD
METRO Goal 5 Fish and Wildlife Habitat Mapping
Organic Material Sources
Primary (6)
Secondary (1)
Terminal 4
Taxlots
Open Water
Streets
Railroad
Feet
0 300 600 1,200 1,800 2,400
Geographic Data Standards:
Projected Coordinate System:
NAD 1983 HARN State Plane, Oregon North
Map Projection: Lambert Conformal Conic
Units: International Feet
Base Data: METRO RLIS, 2004
Fishman Environmental Services
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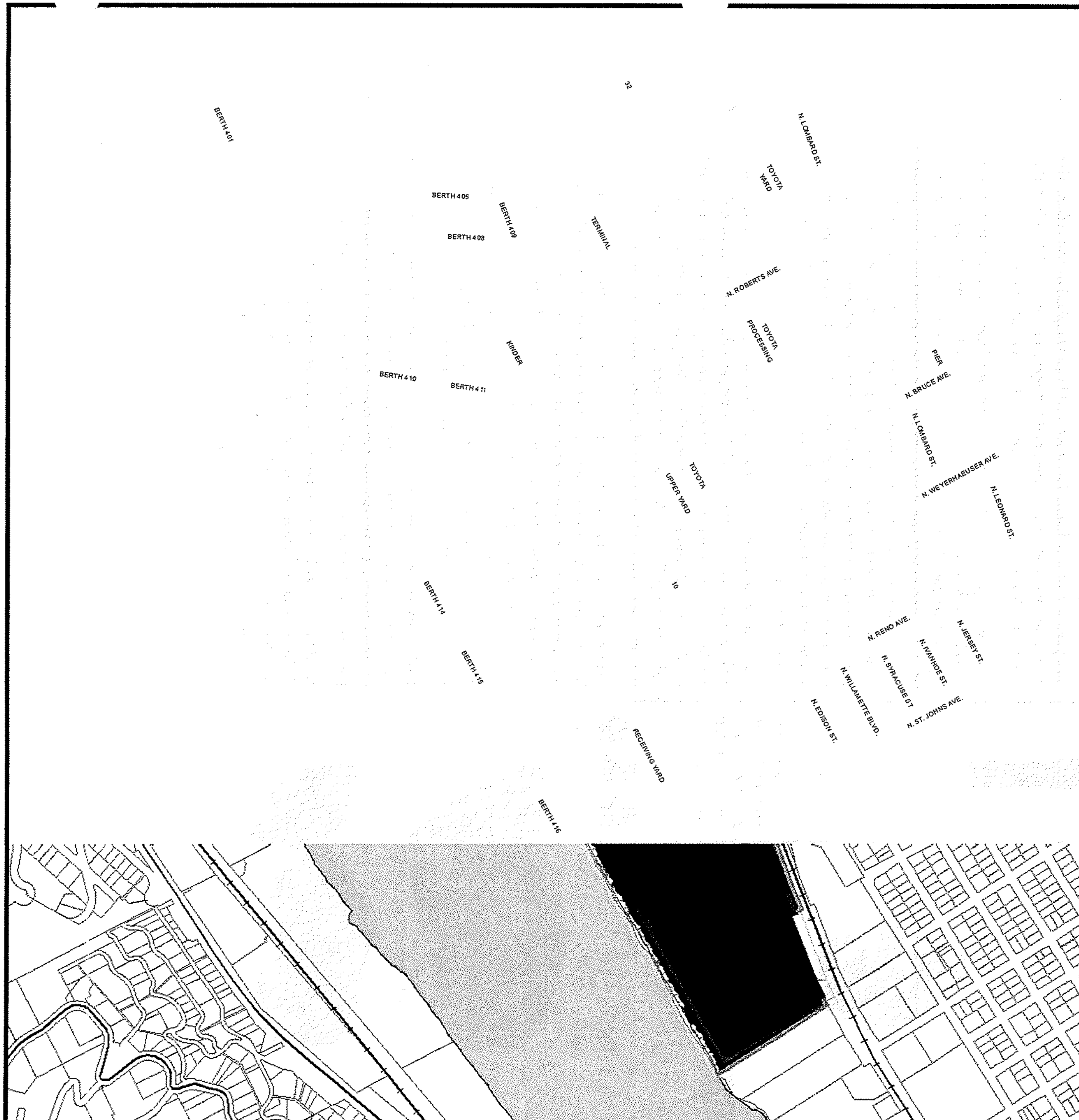
APPENDIX B

Port of Portland Natural Resource Inventory Mapping



Port of Portland
Natural Resource Inventory
TERMINAL 4

- Blackberry Scrub-Shrub
- Channel
- Cottonwood
- Cottonwood, Willow Scrub-Shrub
- Cottonwood, Willow Scrub-Shrub (Planted)
- Cottonwood, Willow, Ash Forest (Planted)
- Developed - Cultivated
- Developed - Impervious
- Developed - Pervious
- Ditch
- Emergent Wetland
- Grass/Forb - Mowed
- Hardwood (Planted)
- Herbaceous Upland
- Herbaceous Upland (Planted)
- Herbaceous Wetland
- Mixed Conifer-Hardwood
- Pervious Wasteland/Barren/Weedy Fill
- Railroad - Crushed Rock
- Railroad - Paved
- River
- River Beach (Modified/Protected)
- River Beach (Natural)
- Road - Crushed Rock
- Road - Dirt
- Road - Gravel
- Road - Paved
- Scrub-Shrub (Planted)
- Terminal 4
- Taxlots
- Streets

Geographic Data Standards:
Projected Coordinate System:
NAD 1983 HARN State Plane, Oregon North
Map Projection: Lambert Conformal Conic
Units: International Feet
Base Data: METRO RLIS, 2004

N

Feet
0 200 400 800 1,200 1,600

183694

ACTION 2

Plant trees, native vegetation and create buffers and shade along streams

Trees and native vegetation are the backbone of a healthy ecosystem. Before being developed, the City of Portland was a combination of wetland forested floodplain and conifer forest. The forest had huge Douglas Firs and cedars, with understory trees and shrubs. Trees and soil soaked up the rainfall, which then could flow slowly or seep into nearby wetlands and waterways.

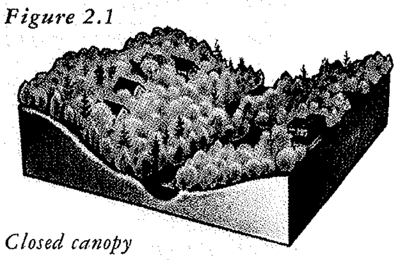
The tree canopy in these healthy "riparian areas" (lands adjacent to streams) provided shade and limited light that penetrated to the water, keeping stream temperatures cool. Streams running through the forest were full of salmon and steelhead. Historically, fish thrived because the streams were full of woody debris and side channels that provided places for fish to spawn, rest, feed and hide from predators. Healthy riparian areas help keep water temperature low by providing shade to the stream. Healthy riparian zones reduce erosion and sedimentation (and the associated pollutant loading) from entering a stream and help prevent streambank failures. They also provide habitat and encourage species diversity.

A single mature tree with a 30 foot crown can intercept 4,600 gallons of water per year.

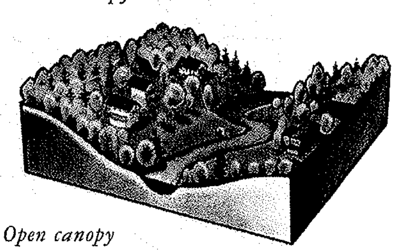
The urbanization of Portland dramatically reduced the forest ecosystem and riparian tree canopy. *(Figure 2.1)* Wetlands and flood channels were filled for development. Today, rainwater hits streets, roofs and driveways and is conveyed by pipes to local streams, creeks and rivers. Many streams are laden with sediment and pollutants. In addition, the rush of stormwater into our urban streams contributes to the erosion of stream channels and banks.

In many areas, trees, tree canopy and native vegetation are not sufficient to sustain healthy watersheds. Many stream corridors are virtually treeless. This allows direct sunlight and water from heated streets and rooftops to reach and warm streams and rivers to unhealthy temperatures. Most of Portland's streams and rivers do not meet temperature standards during summer months. Several species of fish are now listed as threatened under the federal Endangered Species Act. The habitat needed for their survival is seriously impaired or, in some instances, non-existent in the Portland metropolitan area.

Figure 2.1



Closed canopy



Open canopy

Under natural conditions, trees that grow along a stream corridor eventually fall into the stream, creating instream habitat for young fish. Woody debris and other structures, like boulders, force water to flow in intricate patterns, making pools where fish can hide and gravel pockets where they can lay their eggs.

In addition, invasive non-native plants, such as Himalayan Blackberry and English Ivy are crowding out native plants and overrunning many stream corridors. This reduces the overall number and kinds of plants and animals that would normally live in or visit these areas. The proliferation of invasive, non-native plant species can also increase the risk of erosion because the most dominant non-native plants have relatively shallow root systems.

Restoration Actions for Success

The City will develop partnerships for tree planting and streambank restoration projects. Plant trees and native vegetation, to increase Portland's tree canopy in partnership with agencies, neighborhoods, organizations, schools and businesses. Trees and native vegetation will be planted in the riparian areas, in urban yards and streets and in upland or wetland areas. *{Figure 2.3}*

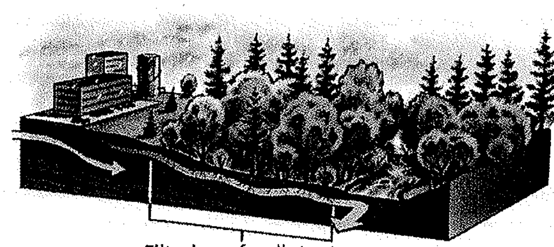
- The City will form partnerships with riparian owners to revegetate degraded areas. Riparian areas are the transition area between streams and the drier upland. This area influences the health of the entire stream ecosystem. Most of Portland's stream riparian properties are in private ownership. In many places the riparian areas are bare and in need of native vegetation or overrun by invasive non-native plants. The City will support and teach riparian landowners to preserve natural riparian vegetation, plant trees and native vegetation and remove invasive, non-native plants. The City, in—partnership with landowners, community groups and other agencies—will plant 24 miles of stream buffer (50 feet wide on both sides of the stream) with native trees and shrubs, for an additional 300 acres of tree canopy.

Figure 2.3

- The City will increase street trees and the urban tree canopy. Hundreds of miles of Portland streets lack shade cover provided by trees. Urban areas have a high percentage of pavement which creates heat islands. Stormwater flowing off hot pavement warms up, flows into creeks through pipes and increases the stream temperature. In addition to street trees, urban tree canopy is needed to shade neighborhoods, roofs and driveways.

Increasing the density of street trees will reduce stormwater inflow to Portland creeks and streams, and contribute to CSO control on the Willamette River. A single mature tree with a crown of 30 feet intercepts 4,600 gallons of rainwater a year.

{Figure 2.2} **Filter pollutants:** Typically, urban stormwater has been piped directly into creeks carrying fine suspended sediments laden with nutrients, metals, and toxics. When stormwater is managed on site and allowed to filter through riparian areas the results are much better. As it flows across the riparian area roots, branches, shrubs and leaves capture the sediment. Cleaner water then flows into the creek. As the sediment is left behind, so are nitrogen, phosphorus and other pollutants that are attached to the sediments. The trees and shrubs in the riparian area can use these excess nutrients for their growth. The same happens with metals and hydrocarbons. Metals and many toxics also attach to sediment particles and drop out in the riparian zone. They are retained in the soil and degraded through natural processes.



Filtering of pollutants

The rainwater held on leaves and branches evaporates, never reaching the ground. Each tree can also transpire up to 40 gallons of water in a day. *{Figure 2.4}*

The City will work with Friends of Trees and other groups to plant 63,000 trees along streets and in neighborhoods. This is equal to 350 miles of bare curbline and will increase the tree canopy by 1,000 acres. *{Figure 2.5}*

- Upland and wetland areas are also important because they provide large amounts of stormwater storage. These areas also provide habitat connections between riparian areas and uplands. An additional 2,700 acres of upland area will be restored. This will be accomplished by working with Portland Parks and Recreation to plant City parks and large tracts of land with trees and native vegetation. Additionally, large areas zoned as open space in subdivisions or purchased by Metro through the open space acquisition program will also be targeted for restoration. The City's Revegetation Program can efficiently reforest and maintain large tracts of planted land.

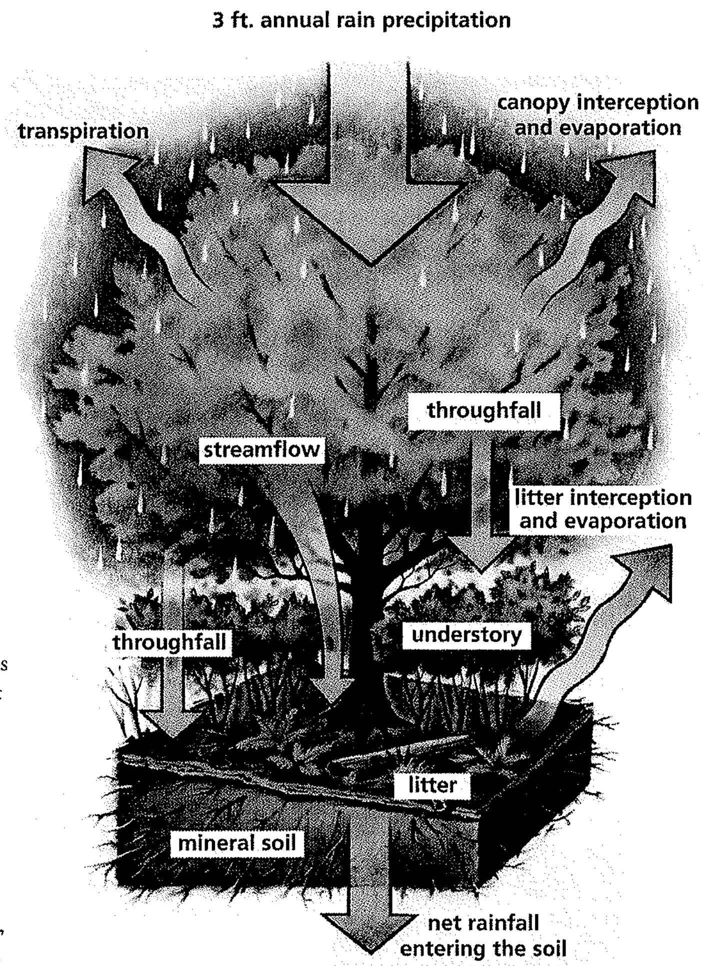
Increasing Portland's tree canopy will provide benefits to people and the natural environment. Portland will use partnerships with local schools, colleges, neighborhoods and businesses to plant trees and restore our watersheds. These partners share costs and resources to help plan, design, and implement tree planting and restoration programs.

Adopt and enforce existing and new development standards to protect existing stream buffers and city trees.

- Develop and refine City standards for landscaping, street design, and development patterns in riparian and upland areas of the City.

- Increase the number of acres covered by Environmental Protection Zones. Portland has an environmental overlay zone that is applied to areas of high environmental value. The environmental zones cover many of Portland's streams and forested areas, but there are some critical areas where this zone is not applied over a large enough area to protect the natural resources.

- Enforce new tree preservation and replacement ordinance.



{Figure 2.4} Typical pathways for forest rainfall. A portion of precipitation never reaches the ground because it's intercepted by vegetation and other surfaces.

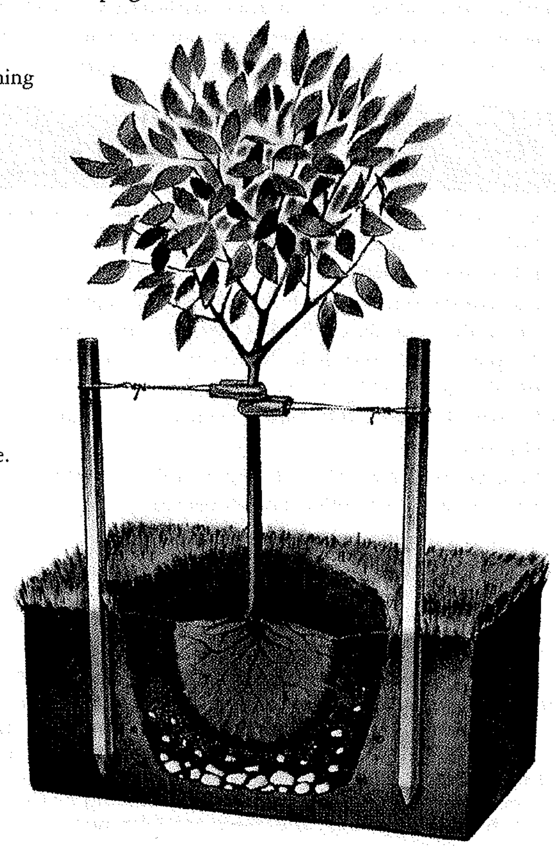
* Create development codes that promote and require native landscaping for newly developed and redeveloped land use. The City of Portland's Native Plant List will be used when mandatory native landscape is installed in riparian areas. This landscaping requirement will be for developments, redevelopment and public works projects. Lawns are often planted at the expense of habitat for wildlife. Native plants can create beautiful landscapes that increase stormwater and wildlife benefits.

* Increase inspection and enforcement of Environmental Zone protections and landscape standards by the City. Typically, enforcement happens only when someone notifies the City of a problem. Regular monitoring during and after construction can anticipate a problem before it occurs. This is a vital step in preventing inappropriate loss of native trees and ground cover and assures that required tree plantings and landscaping become established.

Respond to the requirements of the Endangered Species Act (ESA). Use the National Marine Fisheries Services "Properly Functioning Conditions Analysis" to:

* Define biological requirements of salmon and steelhead,
* Evaluate current environmental conditions,
* Determine the effects of City activities and public works projects, and
* Determine if fish can survive and recover.

Increase the amount of in-stream structure in creeks and streams. Placing woody debris in the stream provides areas where gravel can deposit for fish spawning. These structures also cause water to "fall over" the woody debris, aerating the water and increasing the oxygen content. Root wads can be strategically placed to protect the stream bank from eroding. This also provides small eddies for fish to hide. Woody debris can also account for some level of shading in a creek and lower water temperatures.



{Figure 2.5} In the Clean River Plan, over 63,000 new street trees will increase canopy cover by 1,000 acres. Much of the rain water that would have reached the street and gone directly to a stream, will be intercepted by leaves and needles.

Additionally, boulders and cobbles can also be added to the stream to create complexity and therefore a dynamic system. Leaving woody debris (from fallen trees) in a stream can make important contributions to fish habitat. The natural accumulation of woody debris in an urban setting needs to be assessed to determine if the materials pose potential flood problems downstream. *{Figure 2.6}*

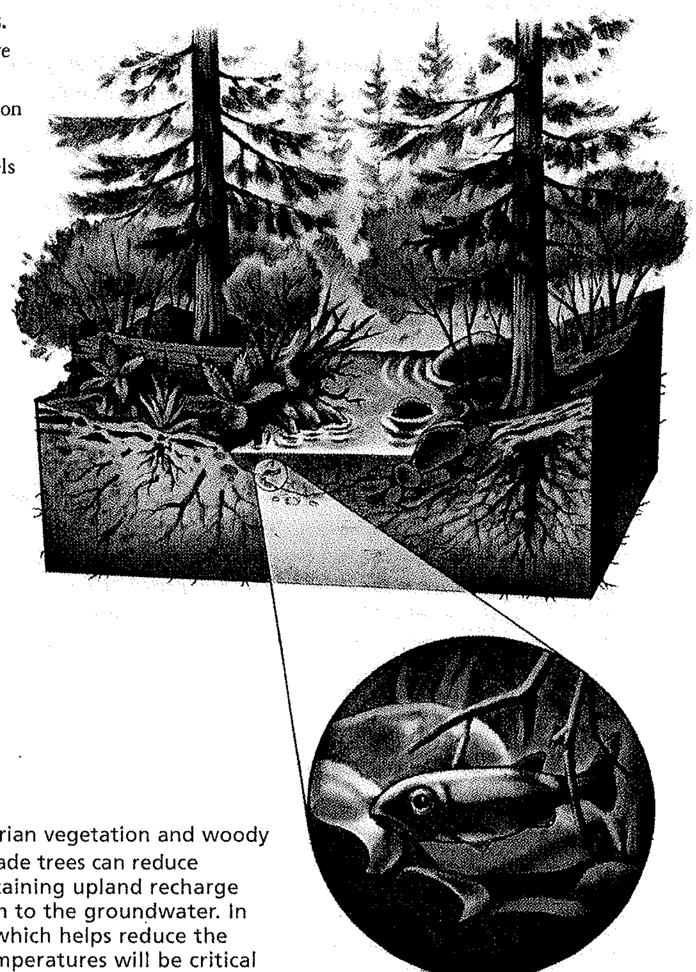
Create slow moving backwater areas and braided channels.
In many urban watersheds, backwater areas and creek channels have been filled in to accommodate development. Backwater areas and channels need to be re-created to assist with salmon recovery. Salmon can spend more than a year in a particular creek if they have slow moving water and abundance of food. Backwater areas and channels may also contain springs and seeps that are critical in providing clean, cool water during the summer months. *{Figure 2.6}*

Results

Adding 4,000 acres of trees, tree canopy, and native vegetation will:

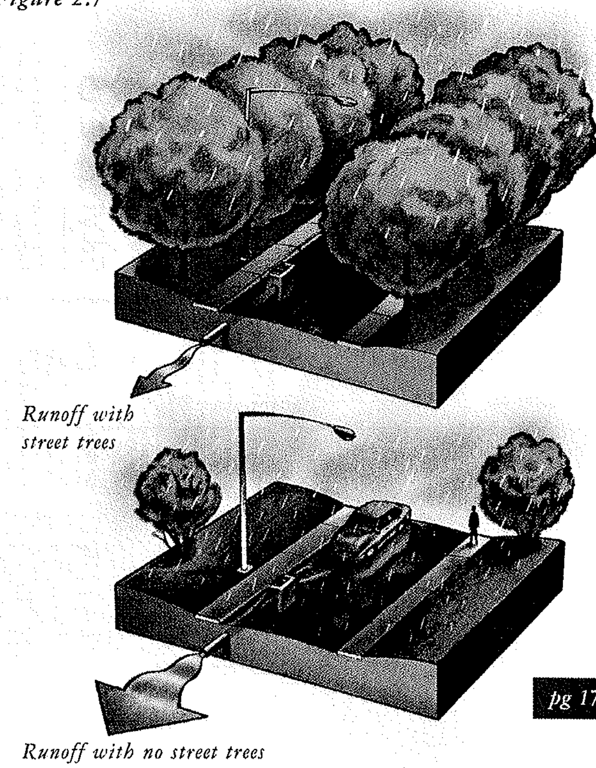
- Reduce the volume of stormwater runoff by about 495 million gallons per year. *{Figure 2.7}*
- Cool stream temperatures in the Columbia Slough, Johnson Creek, Fanno Creek, and Tryon Creek, by at least 5 degrees. Temperature reduction in the Willamette will reflect successful efforts upstream of Portland.
- Improve fish and wildlife habitat along at least 9 miles of streams.
- Improve water quality by reducing or avoiding total suspended solids by about 2.3 million pounds per year.

pg 16



{ Figure 2.6} **Riparian area and lower temperature:** Riparian vegetation and woody debris provide shade over the creeks. Maintaining mature shade trees can reduce stream temperature from 5 to 18 degrees Fahrenheit. Maintaining upland recharge areas and vegetated corridors also helps connect the stream to the groundwater. In summertime, cool groundwater slowly seeps into streams, which helps reduce the water temperature. Reducing and maintaining instream temperatures will be critical for fish survival, as well as compliance with water quality standards.

Figure 2.7



Timeframe • • •

By 2006, tree planting and native vegetation will be well underway. By 2020, 4,000 acres of native trees and vegetation will be planted.

Estimated Cost • • •

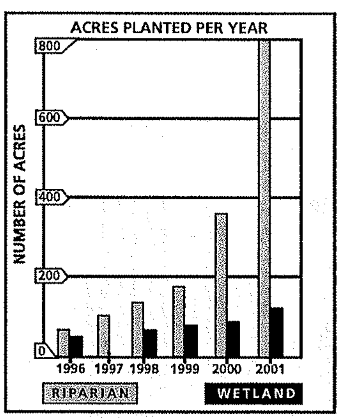
The City will invest $54 million over the next 20 years to plant trees and native vegetation.

Current Programs

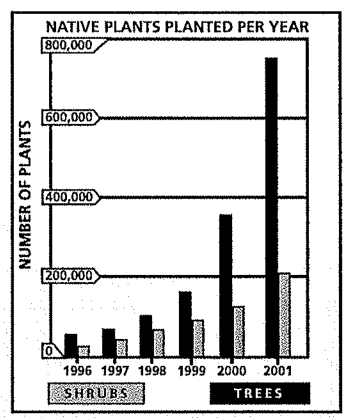
• The Watershed Revegetation Program plans, facilitates and implements watershed revegetation projects throughout Portland. Since 1996, the program has revegetated 371 riparian and 27 wetland acres with 298,000 trees, 144,491 shrubs and 365,560 wetland plants. *(Figure 2.8)*

• In partnership with the Friends of Trees and non-profit community groups, the City participated in several tree planting projects. 3,850 volunteers and 791 property owners joined this effort to plant 30,000 seedlings, 1,900 street trees, 2,226 fruit trees for low-income families and 437 trees in local school yards.

Figure 2.8



YEAR	Riparian Acres	Wetland Acres
1996	32.9	2.25
1997	45	0
1998	81.4	10.5
1999	212.4	15
2000	292.9	25
2001	560	40
TOTAL	1224.6	92.75



Year	Trees	Shrubs
1996	22,932	280
1997	43,049	6,225
1998	37,715	120,000
1999	100,271	137,800
2000	300,000	150,000
2001	726,000	216,000
TOTAL	1,324,770	510,491

If you like these coupons, you'll find these and more at **GreenPowerOregon.com** in the Benefits section.

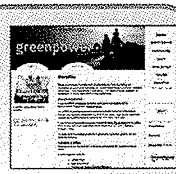
PGE

121 SW Salmon
Portland, Oregon 97204

Thanks for your support!

We thank the organizations shown at right for their support of renewable power. We welcome these customers to our Commercial/Industrial Renewable Power program, Clean Wind.

Coupons and discounts online



If you like the coupon you receive with this newsletter, you'll love what's available at **GreenPowerOregon.com.** As a renewable power customer, you will find coupons and special offers just for you from other PGE renewable-powered businesses.

Current coupons include Miller Paint, OMSI, Burgerville, Stash Tea and Kettleman Bagel Company. Simply register on **GreenPowerOregon.com** and print the coupons found in the "Benefits" section. It's our way of thanking you for your support of renewable energy and bringing together our growing green community.

For a full listing of our business customers who buy renewable power, please visit **GreenPowerOregon.com.**

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A newsletter for **PGE Renewable Power** customers.

Spring 2010

Renewable Report

A Quarterly Newsletter from **Portland General Electric**

Thank you for purchasing renewable energy from PGE.

By choosing these environmentally superior options, you're helping to avoid greenhouse gas emissions, restore our watersheds for wild salmon and create a more sustainable future for Oregon.

We know you care about these issues, so Portland General Electric is sharing updates on the projects funded with your support. We've also included other news you can use.

In this issue:

If you have questions about this newsletter, please contact:

Thor Hinckley, Manager,
PGE Renewable Power Program
at **renewables@pgn.com**

PGE
Portland General Electric

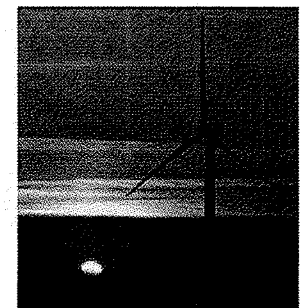
If you'd prefer to receive an electronic version of this newsletter, please send an e-mail with your name and address to: **renewables@pgn.com**

Growth in wind power skyrockets

Between 2001 and 2007, the United States' wind generating capacity expanded at a remarkable rate of 49 percent per year on average. By the end of 2007, the U.S. had more than 16,800 MW of wind capacity online, enough to power more than 1.5 million homes for the entire year! The Pacific Northwest is a leader in this wind development.

The Northwest has the potential to generate more than 137,000 average megawatts of electricity from wind power. In fact, Montana alone has enough potential wind resources to supply **one-quarter** of the electricity needs of the entire U.S., according to Renewable Northwest Project.

Wind farms and projects in development in the Northwest could triple the amount of wind currently generated in just three years. As a renewable power customer, you're doing your part to generate the demand for wind power that fuels the need for more wind projects. At PGE, we're also doing our part for Oregon's energy future by purchasing more renewable energy and beginning Phase III of our Biglow Canyon Wind Farm in Sherman County. Phase I of the project began producing power in late 2007 with 76 turbines and Phase II came online in August 2009 with 65 turbines. The Phase III addition of the final 76 turbines later this year will make Biglow Canyon one of the largest wind farms in the Pacific



Northwest with a generating capacity of 450 megawatts, enough to power about 125,000 Oregon homes.

Wind power is also a job-creating dynamo, infusing money into the local economy during construction phases and paying property taxes to the host county and royalties to local landowners during operation. On average, landowners make between $2,000 and $7,000 annually for each modern wind turbine located on their land, according to RNP.

Visit **GreenPowerOregon.com** to learn more about how wind energy works, and for a map of renewable projects in the Northwest.

Climb a wind turbine

Video shows a bird's-eye view from Biglow Canyon

Come along as a PGE wind technician, Adam Morse, climbs 262 feet up in a tower, showing you the view from the top of a wind turbine at PGE's Biglow Canyon Wind Farm. Start climbing at **youtube.com/watch?v=R_lrBEbI6Q.**

183694

A newsletter for **PGE Renewable Power** customers.

Little Butte Creek Watershed Council Coordinator Tim Weaver examines non-native Himalayan blackberry along the creek's bank in Southwest Oregon. Outcompeting native vegetation while failing to provide shade, shelter and protection from soil erosion, the weed is being removed to restore habitat critical for spawning salmon and other wildlife.

Blackberries be gone

Berries provide food for wildlife and people, but Himalayan blackberry is a thorny problem for salmon and other native fish.

Brought from Europe in the late 1800s, the noxious weed has since spread widely, displacing native vegetation while failing to provide the shade and shelter salmon need. Plus, the bushes' shallow roots don't hold soil well during floods and heavy rains, leading to reduced water quality.

In a nutshell, when restoring a stream, these tangled non-native thickets have to go.

The Nature Conservancy
Protecting nature. Preserving life.

That's exactly what's happening along Little Butte Creek, an important tributary to Southwest Oregon's Rogue River, where the Little Butte Creek Watershed Council is working with landowners to restore streamside habitats by removing blackberry.

Thanks to a $5,000 grant from Portland General Electric's Habitat Support customers, an extensive eradication project is under way at the Gadberry Ranch. Himalayan blackberry bushes — some 10 feet high and 50 feet wide — are being mowed along 3,360 feet of the creek.

"We're working our way up the creek," said Tim Weaver, watershed council coordinator, "with a goal of restoring all of it."

Once the bushes are removed, native trees and shrubs will be planted and fenced off to keep livestock away from the creek's sensitive bank. A solar-powered pump will deliver stream water to a watering trough instead.

"Little Butte Creek has been a significant tributary for salmon spawning," Weaver said. "By restoring it, we are making it valuable once again for the fish that come back."

For an additional $2.50 donation per month, renewable power customers can directly support projects like this by choosing the Habitat Support option. The funds are administered by The Nature Conservancy. To add Habitat Support to your renewable option, visit **GreenPowerOregon.com.**

Customer profile: **the Booth family**

In addition to purchasing renewable energy from PGE, Carey Booth and her daughters are going green at home in several ways.

Carey's main mode of transportation is riding her bike, but when it's raining or the family is going places together, they use their ZAP Xebra 3-wheel electric vehicle, painted like a zebra.

"Driving this is like being in your own parade," says Carey. "Everywhere we go, people point, shout, wave, take our picture and ask lots of questions about it, which was partly my point in being an early adopter."

The car has four doors, four seatbelts and a top speed of 40 mph. Carey says the car can go about 20 miles on an overnight charge, and that it costs only about 2 cents per mile for electricity.

"It plugs into a regular outlet in our garage or anywhere," Carey says. "PGE is installing free charging stations around town, and I can plug in at work. I see it as appropriate technology for around town errands."

In addition to driving green, Carey has made many energy-efficient updates to her home. She installed a new roof, solar hot-water panels, solar photovoltaic panels and a heat pump furnace, along with compact fluorescent light bulbs and more insulation and gap sealing.

Carey strives to garden green as well. She has one 55-gallon rain barrel in front of the house to water the front flower beds and a 550-gallon cistern in the backyard that collects water from the back half of the house roof plus the deck roof.

"Some of this 'going green frenzy' has been in the works since my teen years in the '70s, reading the *Whole Earth Catalogue*," Carey says. "Lately, it seemed like time to do something about global warming."

You can find out more about Carey's sustainable efforts and see photos of her home improvements at **http://people.reed.edu/~boothr/.**

Control costs with help from Energy Trust

Investing in energy efficiency is a smart move — even in a tight economy. To make energy improvement projects easier and more affordable, PGE wants to help you connect with Energy Trust of Oregon programs.

What is Energy Trust?

Energy Trust is an independent nonprofit organization dedicated to helping customers benefit from saving energy. They can help you determine the most beneficial projects for your home or business, and they offer cash incentives that can significantly reduce your costs.

Analysis and advice

To control energy bills, you need to first understand exactly how you're using energy and how you can save. Energy Trust offers several tools to help:

- **Online Home Energy Analyzer** — Energy Trust's do-it-yourself energy audit helps you calculate your carbon footprint and how you use energy.
- **Pencil It Out™** — This online tool for businesses helps you figure the costs and potential energy savings for a particular energy project. You can find this tool in the "Evaluate your Business" section.

Energy Trust representatives can also help answer questions and offer on-site assistance for qualifying projects. Need a contractor? They maintain a network of pre-approved trade allies who are well acquainted with the Energy Trust programs. Find out more at **EnergyTrust.org.**

EnergyTrust of Oregon

You can also find a wealth of energy-efficiency information at **PortlandGeneral.com/EE** for your home and **PortlandGeneral.com/SaveEnergy** for your business.

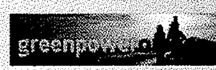
Going green? Go paperless.

If you're reading this, you've already made the choice to buy renewable energy and support our environment. You can go a step further by enrolling in PGE's Paperless Bill program. Our Paperless Bill program reduces paper, clutter and waste, and helps the environment. Instead of sending a paper bill, we'll notify you by e-mail each month when your bill is ready to view online. It's simple, secure and sustainable. We'll also send your PGE newsletters, including *Renewable Report*, via e-mail.

If 20 percent of U.S. households switched to electronic billing, statements and payments, the collective impact annually would:

- Save more than 150 million pounds of paper;
- Avoid creating more than 1.4 billion gallons of wastewater — enough water to fill 2,180 Olympic-size swimming pools;
- Avoid producing more than 3.9 billion pounds of greenhouse gas emissions — that's like taking 325,722 cars off the road!

PGE's Paperless Bill enrollment grew 60 percent in 2009. If you haven't already joined the paperless trend, you can enroll at **PortlandGeneral.com/Paperless.**



Volunteer connection

Resources for sustainable events and volunteer opportunities

You can find many organizations at **GreenPowerOregon.com** that offer educational events and volunteer opportunities, ranging from tree planting and habitat restoration to educational events. For more events, visit our calendar at **GreenPowerOregon.com.**

Find these coupons and more in the Benefits section of **GreenPowerOregon.com.** Thanks for supporting renewable energy!

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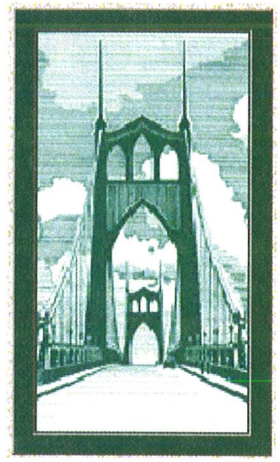
FRIENDS of CATHEDRAL PARK NEIGHBORHOOD ASSOCIATION



April 1, 2010
City Council
City Hall
1221 SW 4th Avenue,
Portland, OR 97204

Dear mayor and commissioners,

I would like to comment on the resolution directing the Bureau of Planning and Sustainability to negotiate a development agreement with the University of Portland for consideration by City Council. (Co-Sponsored by Mayor Adams and Commissioner Fish).

In talking with Jim Kuffner of the University of Portland recently, I expressed appreciation for the work the university has done on adjacent Waud's Bluff to preserve and maintain existing ecosystems. I would like to continue the conversation with the university on the importance of the bluff to north Portland biodiversity and connectivity. And I am shocked to see through this resolution, the university's Master Plan with a proposed parking structure that bisects the bluff completely from top to bottom.

Understanding the sensitive nature of the Willamette bluff as an ecosystem and advocating for its improved connectivity is crucial in the next 20-30 years to allow enough space for north Portland's remnant native plants & wildlife. In fact your own Watershed Task Group for the River Plan lists as the most important natural feature of Waud's Bluff that it "provides connectivity." As an important future action they list, "improving connectivity between oak habitats" primarily between the Decatur woods also known as Baltimore Woods and Waud's Bluff.

Bob Sallinger of Audubon makes the point that one of the primary challenges to protecting terrestrial biodiversity in the city is lack of connectivity and migratory corridors. The Willamette Bluffs represents the most intact north south corridor in East Portland. Losing any portion of this corridor, even degraded portions, would undermine the integrity of this corridor along its entire length.

The work we're doing through Friends of Baltimore Woods which is at the end of the bluff is only part of a larger picture in terms of north Portland connectivity. I am horrified that this proposal has been suggested and apparently is being considered by council. It goes against everything we are trying to do to preserve biodiversity and improve connectivity in the North Reach through the North Reach Plan and goes against your own task force, I respectfully urge you to and the university to seek other solutions.

Thanks sincerely,

Barbara Quinn

Barbara Quinn,
Chair, Friends of Cathedral Park Neighborhood Association
Friends of Baltimore Woods
7034 N. Charleston
Portland OR 97203
503 289-6112

183694

Mayor Adams and Commissioner's

Social Justice is the subject I would like to address. The summary of the NRP states the importance of economic prosperity, watershed health, access, riverfront communities and partners. If we use a scale with economic prosperity on one and all of the other topics on the other, this plan is much too heavily weighted on the side of economic prosperity; In particular big industry money and interest. A huge inequity exists, shouldn't all of the topics be considered equally?

We have major crises impending- Peak Oil, Climate Change, a major catastrophic earthquake, and our biggest challenge of the future, Water. None of these are clearly addressed in the NRP. These are an essential part of our now to 30 year future, for our economy, our river and our survival.

More specifically on the subject of social justice are the issues of public input, Linnton and the environmentalists. The public engagement of the community have been whittled away to near extinction. Since the 1960's, numerous times Linnton has asked, negotiated and been promised changes that would make their neighborhood a livable sustainable community. Linnton is down to asking for very little from their original vision. Grant us an access to the river and keep the entire Mill site out of industrial sanctuary and open to possibilities that would allow other uses including but not specifically only HI. Industry and the city readily granted to the Univ.of Portland this exclusion from "too valuable for anything but HI" but why not Linnton? Contrary to the stance that has been taken Heavy industry and environmental stewardship are not mutually exclusive. Environmentalists negotiated at the table for specific changes at the beginning of this plan. Those changes were reduced to less than half of what was called for to create mitigation for negative environmental impacts. Don't make a mockery of public input. If you didn't want to implement what we had to say then you shouldn't have asked and wasted our volunteered time. Why are all of the compromises made on the side of the public and none on the side of industry?

The very reasons that industry uses for keeping the Mill site only HI are reasons to open it for other possibilities.

- The Multi-modal Energy transportation cluster is located in an area that will have catastrophic effects from our impending earthquake or other disaster .
- Because of the relatively low amount of pollution the Mill site is "shovel ready" for environmental remediation and restoration by means of a fish refuge.

We are faced with major crises far more important than the pursuit of the almighty $, given these crises we need to tip the scale to the environment and the needs of the community. Our lives are more important than money.

Darise Weller
dweller972@comcast.net

Darise Weller

Audubon Society of Portland
Founded in 1902

April 1, 2010

Mayor Sam Adams
Commissioner Amanda Fritz
Commissioner Randy Leonard
Commissioner Nick Fish
Commissioner Dan Saltzman
City of Portland
1221 SW 4th Ave
Portland, OR 97204

Dear Mayor Adams and Portland City Council,

I am writing on behalf of Portland Audubon Society to urge you to adopt the North Reach River Plan. There are some who continue to suggest that the River Plan needs more time and more consideration. The fact is that the City of Portland has already spent more than nine years getting to this point--Audubon participated on its first River Renaissance Committee in 2001. The City has yet to begin work planning for the Central or the South Reaches. The time that the City has already taken to develop the North Reach Plan represents more than one third of 20-25 years that the plan will actually be in effect. Audubon supports strong, transparent and inclusive public processes. However, there comes a point where delay ceases to facilitate public input and rather serves to disenfranchise segments of the community that do not have unlimited resources to track and participate in hyper-extended public processes. After years of committee work and public meetings, six months of review before the Planning Commission, and eight months pending before the City Council, we believe that the community has produced a document which will achieve the city's environmental, economic and recreational objectives. We urge you to adopt the River Plan and to drop several proposed last minute amendments which we believe undermine the integrity of the plan.

We would begin by noting that Audubon has not raised a single issue since the River Plan was referred to council by the Planning Commission in June, 2009. While there were many specific aspects of the River Plan with which we disagreed, we also recognized that the Plan was the product of extended negotiation and compromise. We felt then as we do now that the community would best be served, not by perpetuating a process that had already extended over the better part of a decade, but rather by moving expeditiously to implementation and establishing a robust process to track and evaluate the plan as well as a time certain to bring the plan back for a comprehensive review. We believe that there is an unfortunate trend in Portland of spending too much time and resource trying to perfect plans in the development phase and too little time and resource actually implementing and evaluating plans after they are adopted. We are pleased to hear that the City is in fact recommending establishing an advisory committee to help evaluate that plan as it is implemented. We hope that the City will also allocate sufficient funding to ensure that the North Reach Plan is adequately staffed to allow for implementation of its ambitious agenda.

We would like to focus the remainder of our comments on several areas of the plan that have undergone major revision in recent weeks. We would urge Council to avoid eliminate several last minute amendments that significantly undermine the integrity of the plan and which fail to account for significant compromises that we made during the development of the plan.

Standards and Exemptions: Our area of greatest concern revolves around changes that have been made to the standards and exemptions section of the plan. We applaud the City for taking a strong stand to date regarding the importance of retaining its regulatory authority via the River Review Process. However, incremental expansion of the list of standards and exemptions is now being used by industry as a strategy to achieve their original objective of eliminating the city's oversight of projects that directly impact high value environmental zones. Standards and exemptions have traditionally been used to address actions in e-zones that are expected to have de minimus impacts or which were intended to actually enhance the e-zone. The packaged of standards and exemptions that was forwarded in the draft River Plan adopted by the Planning Commission was the product of extensive discussion, negotiation and compromise. Audubon believed that this original package was too broad but was willing to accept it because all impacts were to be mitigated either in or adjacent to the e-zone in which the development activity took place. In this way we believed that even if development impacts had significant impacts, they would at least be mitigated in the same area thus preventing loss of the ezone over time. The changes proposed in the amendment go much further and will lead to a situation where e-zones can be significantly eroded over time through a series of actions conducted under the standards provisions without any city review. This defeats the whole purpose of the ezone. We are not suggesting that there should never be significant impacts to the ezones. We are strongly asserting that when there are significant impacts, those impacts should be subject to river review. That in fact is a major part of the reason for having an ezone in the first place.

- We oppose the decision to allow industry to pay a fee in lieu rather than mitigating within or adjacent to the e-zone when they meet "standards" for projects. The planting requirement in the Draft River Plan was included after extensive discussion and was meant to ensure that the integrity and connectivity of the E-zone would be maintained while still allowing industry a fast track for development of certain types of projects. The amended standards give industry the assurance of a fast track, it gives the environmental community absolutely no assurance as to when or where the lost resources will ever be replaced. We would not have been able to support that standards approach at all if we had known that the compensation would result simply in a fee in lieu rather than immediate plantings within or adjacent to the impacted environmental zone. One can easily envision scenarios where high value ezones are lost entirely and unnecessarily over time by a succession of unreviewed actions conducted under the standards.
- We oppose the following last minute additions to the standards. None of these standards was specifically discussed during the multiyear committee process, before the Planning Commission or during multiple stakeholder meetings held with the mayor. It is disappointing to see these significant changes added at the last minute with no substantive discussion of their merits or impacts. We believe that each change has tremendous potential to impact the integrity of ezones and are exactly the types of activities that should be subject to River Review:
    - Outfalls: Property owners can place an unlimited number of outfalls in the ezones (the Planning Commission draft only allowed one)

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- Structures: Property owners can build a structure of any size on paved areas within the ezone (the Planning Commission draft only allowed structures that are up to 24x24 without review. This will lead to noise and light impacts, access impacts, construction impacts and vegetation impacts (since trees can be pruned within 10 feet of structures under another standard.)
- Utilities: Property owners can replace utilities within an ezone even regardless of whether the footprint is significantly larger than the original without review (In the Planning Commission draft, utilities had to have the same impact area in order to use the standards)

- We oppose the amendments on page 61 which would require increased mitigation for impacts under standards in sites used for previous mitigation or in situations where mitigation occurs offsite. It is standard practice to require elevated mitigation for impacts to sites that were used to meet prior mitigation obligations. This is done in recognition of the fact that it takes mitigation sites a significant amount of time to become established and reach their full potential. If they are continually replaced, they are never able to fully compensate for the impacts to occurred. The requirement that there be increased mitigation for situations where the mitigation occurs offsite was done in recognition of the fact that in most cases mitigation for activities done under standards are supposed to occur at the site of impact. The lower mitigation ratio for onsite versus offsite was meant to serve as an incentive to promote remediation impacts near where they occur. Again this is consistent with the fact that Standards are meant to have de minimus impacts . Despite our participating in multiple meeting in recent weeks and months, this change was never presented to us.

Siltronic Agreement: Audubon appreciates the work that the City and Siltronic have invested in developing a MOU to move forward with a development agreement. We also appreciate the time that Siltronic has invested in discussing this approach with Audubon and participating in our ecoroof charrette. However at this time we do not believe the terms of the MOU are sufficient to compensate the City for lifting the C-zones from the Siltronic Property. The Siltronic Property is highly significant from a wildlife perspective. It provides one of only a few connective corridors between Forest Park and the Willamette River. Doane Creek represents one of the most significant opportunities to daylight and restore a creek north of the Fremont Bridge. The mouth of Doane Creek could be laid back to provide critical shallow water habitat for migrating salmon. The grassy area along the top of the bank bordering the Willamette River offers significant opportunity for re-vegetation to provide structurally complex habitat for migrating songbirds. Finally the grasslands at the back of the property, while degraded, represent a rare and important habitat type within the City of Portland. A panel of experts recently convened by the Port and the City as part of the Airport Futures Process identified grasslands as being of critical importance for several species and specifically noted that their importance was heightened by the fact that they have virtually disappeared from our urban landscape. On the day that I visited the Siltronic site, the grassland area was teaming with deer and diverse species of songbirds. We would ask Siltronic and Council to consider the following areas in which believe the agreement could be improved:

- **Width of the easement**: We understand that this issue of width of the wildlife corridor has been the most difficult part of the negotiations to date and appreciate the conflict between maximizing the development potential of the site and allowing adequate area for a functional wildlife corridor. The agreement that has been negotiated would result in a corridor that would be at best severely compromised. There is extensive literature that suggests that wildlife corridors should be a minimum of 300 feet in width to support larger mammalian species as well as to provide protective interior habitat for migratory birds. A corridor of 100 feet or less would be considered almost entirely edge habitat which increases the frequency of predatory birds such as crows and scrub jays and invasive species such as starlings. The narrow width of the corridor also would restrict the City's ability to daylight and restore underground portions Doane Creek. It is debatable as to whether it would be worth the expense to do this type of restoration if in fact there is inadequate protected area adjacent to the creek to allow for meanders and protective vegetated buffers. We are pleased that the City would receive a 200-foot wide easement at mouth of the creek which is the most ecologically valuable part of the landscape, but most of the remainder of the easement is at high risk of failing to achieve desired ecological functions. Limited additional width could potentially be gained by moving the fence line and the dirt road so that they directly abut any new structures. Given the size of this parcel we also urge Siltronic and the City to continue to strive to find site designs that would increase the overall width of the corridor.

- **Setback Along the River Frontage**: The agreement calls for a 50-foot setback from top of bank. However it does not require that this setback be vegetated until some unspecified date in the futute. We urge the City and Siltronic to include in the agreement a provision that Siltronic will plant the setback within a time certain with native trees in shrubs in order to create structural complexity, food sources and nesting habitat for migratory songbirds that follow the river's edge. We believe that in addition to providing natural resource value, this would also significantly improve the aesthetic qualities of the property as viewed from the river, would be enjoyed by Siltronic employees and could serve as a showcase for river restoration efforts.
- **Ecoroof**: Section 7 of the agreement commits the city to paying the cost differential between a conventional roof and an ecoroof. It is uncertain from the agreement that an ecoroof will ever be constructed. In the agreement the ecoroof is considered "potential additional habitat." Audubon strongly believes that the ecoroof must be a legally binding part of the agreement and that Siltronic should bear the cost. The loss of grasslands on the property is significant. An ecoroof that incorporates habitat values could mitigate for some of that loss. Given that the wildlife corridor is severely compromised in this agreement, we believe that it is completely reasonable to require Siltronics to install an ecoroof with functional wildlife habitat value. This structure has the potential to serve as a local and national model for incorporating habitat into the rooftops of large structures.
- **Credit Toward NRDA**: Section 11 of the agreement allows Sitronic to seek credit for this agreement towards its Superfund obligations. Audubon strongly opposes this section of the agreement. The River Plan is supposed to provide restoration above and beyond NRDA. If property owners are allowed to count work done for th River Plan towards NRDA, it would render the River Plan functionally meaningless. . We would specifically cite a letter dated April 1, 2009 from NOAA Fisheries to the City of Portland in which the agency wrote:

  > *While we have worked to ensure that the River Plan and Superfund are complementary, it is important to note that they serve different functions and respond to different criteria. Superfund is not a substitute for a strong municipal program to restore fish and wildlife habitat in the North Reach.. The NRDA funds generated by Superfund will be used specifically to remediate natural resource damage caused by the discharge of contaminants into the environment. The funds generated through River Plan would restore habitat that is lost or affected by City-permitted development and re-development.*

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This term of the MOU also directly contradicts the text of the River Plan itself which reads:

> ***What is the relationship between Portland Harbor Superfund and the River Plan / North Reach?***
> *The Portland Harbor Superfund study area is within the boundaries of the River Plan / North Reach, but the two programs have different authorities, implementation approaches, and goals. Superfund implements federal law and focuses on cleaning up contamination resulting from past actions or operations. The River Plan / North Reach is the City's land use plan for a geographic area that includes, but is larger than, the Portland Harbor Superfund Site. The River Plan implements state land use law and City policy for a range of development activities. Both of the programs have a mitigation component but the mitigation is for different purposes. The Natural Resources Damages Assessment part of the Superfund process requires mitigation for natural resource damages caused by pollution. The River Plan / North Reach requires mitigation for development-related impacts to ensureno net loss of habitat and vegetation to improve future conditions in the Willamette River. Mitigation required for one program cannot be used to comply with the other program.*

University of Portland Agreement: (amendments to page 212) We oppose the decision to change the bluff at the University of Portland from a P-Zone to a C-Zone or to remove the environmental zoning altogether. The decision to put a P-Zone on the bluff was extensively reviewed and affirmed by staff, committees and the Planning Commission. We believe the importance of the bluff as a connective corridor as well as the hazards associated with building directly on a steep slope support the original ESEE analysis that resulted in a P-Zone. We would also note the tremendous community effort led by the Friends of Baltimore Woods and joined multiple conservation organizations to protect and restore the bluffs. We appreciate University of Portland's need to connect their upper and lower campuses, but the proposal that the University is putting forward goes far beyond connectivity and includes placement of not only an elevator, but also a parking garage and classrooms on the bluff. We believe that allowing this type of development to go forward in the middle of a high value wildlife corridor on steep slopes will become a highly visible embarrassment to the City and the University for decades to come. We urge the city to retain the P-zone on this site and to look for more environmentally sensitive strategies to connect the upper and lower campuses. We also urge the City to utilize the standard zoning mechanisms that it has in place to protect the environment rather than carving out a new exception to accommodate the University of Portland and allow it to skirt well considered environmental protections.

Items for further review containing in the Memorandum from the Mayor:

1. **HEP-HEA**: Audubon supports the continued work on HEP-HEA and look forward to participating in further development of this model. However we do not believe that it useful to develop thresholds below which HEP-HEA would not be triggered until the plan actually has a chance to be implemented on the ground. This type of refinement makes far more sense once we have real world experience with implementation rather than being debated in a speculative pre-implementation context. We would further note that we are disappointed by industries citing of the results of a case study in which all parties were repeatedly informed that the numbers being used were

purely hypothetical to demonstrate how HEP-HEA works and should not be used for the purpose projecting actual real costs for an given project.

2. **New Standards**: We strongly oppose the directive to continue considering new standards---As noted previously in this letter, we believe that expansion of standards are being used by industry to erode the City's ability to review projects in high value environmental zones. We also believe that amendments to the standards go to far already. Standards have been repeatedly discussed during the River Plan development process, by the Planning Commission and during review by the City Council. We do not believe that it is respectful of stakeholder time and resources to ask us to go back and spend another several months going over the same ground that has been repeatedly covered over literally the course of several years. We would respectfully ask that the City adopt the standards that were forwarded by the Planning Commission to Council without amendment and refrain from considering new standards until the plan can be evaluated on the ground during the implementation phase.
3. **Refinement of River Overlay Zones**: We support the ability of property owners (industrial or otherwise) to seek corrections to zoning that they believe was incorrectly applied. However, we believe that allowing industry to continue to challenge the NRI at City expense years after the draft NRI was presented is inappropriate and goes beyond accommodations that are afforded to any other property owner in the city. We further believe that any changes to the overlay zones should be subject to public notice and review.

Audubon appreciates all of the work that has gone into the River Renaissance/ River Plan effort to date. We especially appreciate the work of City staff, council staff and Mayor Adams all of whom have invested huge numbers of hours on this plan. We believe that further refinement of this long-term community effort, which has now spanned three mayoral administrations, should be left to the NoRAC once after on the ground implementation of the plan has commenced and the true merits and deficiencies of the plan can be assessed. Please adopt the River Plan and reject the last minute amendments that have been outlined above.

Thank you for your consideration of our comments.

Robert Sallinger

Bob Sallinger
Conservation Director
Audubon Society of Portland

Willamette RIVERKEEPER®

Testimony to the Portland City Council – April 1, 2010

Re: North Reach Plan

Travis Williams, Willamette Riverkeeper

Thank you for this opportunity to share Willamette Riverkeeper's views regarding the North Reach Plan. My name is Travis Williams, and I'm Riverkeeper and Executive Director of Willamette Riverkeeper. We are an organization that works to protect and restore clean water and healthy habitat throughout the Willamette Basin.

In our view, the Portland City Council should approve this plan. Willamette Riverkeeper believes that this plan can still provide meaningful improvements to river habitat along this stretch of the Willamette River. The plan has been years in the making, and has received significant evaluation and input from a wide range of interests.

Those who oppose this plan should consider carefully the consideration and changes they have been provided so far. Also, the present draft could merit the following questions.

- Does this plan provide options to landowners along this stretch that are quite flexible in some cases? The answer is yes.
- Does this plan require vigorous on-site habitat restoration where solid structures do not currently exist, such as along riprap or seawalls? The answer is no.
- Does this plan really capture the essence of the Willamette Greenway Program, and the original goal? One could argue that it doesn't come close.

What we do have today is a compromise that will result in better habitat than we have at present, and will *require action* where some landowners would not consider action to improve habitat.

On these grounds I urge you to adopt this plan at your earliest convenience. I also applaud the attention and consideration that Mayor Adams and other City Council members have provided to this issue.

Willamette Riverkeeper – 1515 SE Water Ave. – Portland. OR 97214 – www.willametteriverkeeper.org

This plan is part of a larger terrain for this industrialized part of the Willamette. This plan will support larger efforts related to the Superfund Cleanup and the Natural Resource Damages Process that will yield improved water quality and habitat in this stretch. This combined effort will help improve conditions for not only the people and species that use this stretch of river, but can help improve the entire river.

Thanks for your consideration.

URBAN
Greenspaces
INSTITUTE

183694

Mayor Sam Adams
Commissioners
1221 SW 4th Ave
Portland, OR 97204

April 1, 2010

Dear Mayor Adams and Commissioners,

I am writing on behalf of the Urban Greenspaces Institute to urge you to adopt the North Reach River Plan. It's been more than 26 years since I assisted the city in conducting a Willamette River Greenway, Goal 15 inventory. Today, we are still debating the protection and restoration of natural resources in the Portland harbor. Recently, I participated in one of the myriad workshops the city has hosted regarding the Portland Plan. One tenet of the Portland Plan, as I understand it, is to ascertain what we need to do differently to achieve a more sustainable and livable city. I recall testifying before city council in 1979, when the fate of Ross Island was still in doubt and the city planned to fill in what is now Oaks Bottom Wildlife Refuge to create a site for the Children's Museum, a yacht harbor, sports fields, and a motocross course. I'm pleased to say we've come a long way in the intervening thirty-one years with regard to our understanding of what we need to do differently to create a sustainable and livable city. But we have not yet put different policies into place that will take us to an ecologically sustainable or equitable future.

The North Reach River Plan presents Council with an opportunity to establish a new paradigm for how the city will do things differently. If Portland is serious about weaving nature into the city, greening the built environment, and advancing equity across the city's landscape we have to integrate the built and natural landscapes, in our residential, commercial-----and industrial----areas.

Finally, we have two specific concerns. We share concerns raised by the Audubon Society of Portland regarding eleventh hour changes to standards and exemptions which undermine those reviewed and adopted by the Planning Commission and are unacceptable. The University of Portland's request to remove environmental zoning on the Waud Bluff is also unacceptable. If they are genuine in their assertion they wish to protect natural resources they can do so under an Environmental Conservation Zone. I urge you to reject their request to remove the EC Zone.

Respectfully,

Mike Houck,
Executive Director

Post Office Box 6903, Portland, Oregon 97228 Phone: 503.319.7155 Fax: 503.725.3166 www.urbangreenspaces.org

183694
4-1-10

Mayor Adams and Commissioners

My name is Alan Sprott. I am vice president, Vigor Industries, LLC and chair of the Working Waterfront Coalition .

I have been here before to offer comments on the River Plan and return tonight with three short messages.

First, the River Plan is being adopted at a challenging time for Portland. While we see glimpses of an economic recovery, unemployment remains unacceptably high. Competition for investment dollars is stiff, and those few funds that are being deployed are going to places like Longview, Kelso and Vancouver. The Superfund designation has turned out to be an even bigger burden that we envisioned, and redevelopment of brownfield sites appears to be years away. Because the environmental improvements we all hope to see in the river are dependent upon private investment, please ensure that the River Plan as adopted stimulates business development.

Second, we support creation of the North Reach Advisory Committee. This is an opportunity to educate ourselves about the permitting process and to offer improvements to the Plan as we go along. Thank you for this opportunity. One suggestion we have is to encourage all members of the committee visit the working harbor and learn first hand about the economic and environmental investments we are making on behalf of this community. We would be delighted to welcome you all to the harbor.

Finally, I urge you to make one final amendment to the zoning code. As we have discussed with you, we are confident that the environment will receive more benefit if business is allowed to pay a fee in lieu in certain circumstances.

Our request is to amend the Zoning Code to allow the fee-in-lieu of River Review for those projects that will be subject to a Corps of Engineers and Division of State Lands permit AND are not one of the potential restoration sites identified on Map 6, Volume 1A: Policies, Objectives and Recommendations. Because these projects will be subject to the avoid, minimize and mitigate requirements of the Corps and DSL and because these projects will also contribute 1% to the restoration fee (going to 2% when the economy improves), we propose the fee in lieu be set at 1.5% of the permit cost, with no cap.

Please also accept this document for the record. It includes a number of technical studies and papers that address concerns that we have raised before either in public hearings or with staff.

183694

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PORT OF PORTLAND
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April 1, 2010

Mayor Sam Adams
City of Portland
1221 SW 4th Avenue
Portland, Oregon 97204

Dear Mayor Adams,

We appreciate your leadership in working through the complex issues of the River Plan/North Reach. This is a major land use action that deserves a thorough and thoughtful review and your attention has helped bring rigor to this effort. We also appreciate the efforts of Bureau of Planning and Sustainability staff in sorting through the details and evaluating the implications of the regulations as outlined in the code.

As you know, The Port of Portland is committed to helping American producers increase their exports to foreign markets. We recognize the higher value that exports generate for producers, their employees, and the communities in which they're located. The most significant constraint that seaports face in increasing U.S. exports is the capacity and efficiency of the infrastructure that transports exports to seaports and to overseas markets; that's why being able to improve and modify our facilities in the harbor is truly a competitiveness issue. From that standpoint, the decisions the City makes in the River Plan/North Reach set the tone for this community's economic future.

We have always been fully supportive of the basic premise of the North Reach Plan: New fees from business expansion or new business location should help fund watershed and natural resource improvements. We also know that in order for both jobs and environmental quality to benefit, these new fees must be reasonable, and the process navigable; otherwise, there will be neither adequate funds for restoration nor jobs to strengthen the city's economic base. Investment in the harbor is a business decision, not a political one, and I applaud your direction to staff to continue working on the four items of the plan outlined in your letter.

For this reason, I believe it is in the best interest of this effort to continue to work on the issues outlined before the entire plan is adopted. I urge you to adopt Policy 1A, Policies and Objectives document, and defer adoption of the other elements of the plan. Adoption of the entire plan while work still needs to be done, removes the incentive to continue to work out the important details in this effort.

Sincerely,

Bill Wyatt

Bill Wyatt
Executive Director

cc: City Council

121 NW Everett Portland OR 97209
Box 3529 Portland OR 97208
503 944 7000

33.865.025 Fee in Lieu of River Review

"At the applicant's option, the applicant may pay a fee in lieu of River Review if

A. Proposed development is subject to Corps of Engineers Section 10 and/or Division of State Lands 404 Permit and

B. The property is not identified as a potential restoration site on Map 6, Watershed Health, Volume 1A, River Plan.

The fee-in-lieu will be 1.5% of the project cost, to be paid at such time as construction commences on the project.

(commentary: Both the Corps of Engineers and Division of State Lands permits subject the project to the "avoid, minimize, mitigate" process.)

183694

Moore-Love, Karla

From: Jennifer G. Parks [jenniferparks@hevanet.com]

Sent: Thursday, April 01, 2010 1:20 PM

To: Moore-Love, Karla; Commissioner Fish; Commissioner Saltzman; Leonard, Randy; Commissioner Fritz; Adams, Sam

Subject: Please Adopt River Plan Now

Honorable Council Member:

I am writing to express my desire to get the Willamette River back on course towards good health and to ask that you PLEASE, adopt the River Plan. I have spent time attending the hearings and writing prior to today's hearing along with many others. We have put the effort into making this happen and would not appreciate council giving in to last minute pressure by industry, thereby ignoring the public process. Portland citizens have a right to have a voice over what happens on our river. Regulatory authority should stay in the hands of The City, otherwise the regulations we have in place today would be threatened and contribute to further degradation of this stretch of the river. I am also very much opposed to industry not paying their fair share to cover impacts they have made to the problems we are trying to repair. They should be held accountable.

I feel this is a very critical step in keeping Portland green and I am asking and urging you to please adopt the River Plan. Our lives and our futures depend on it. Thank you for adopting the River Plan now.

Sincerely,

Jennifer Parks

(7706 SW Barnes Rd., #C, Portland, OR 97225)

183694

Moore-Love, Karla

From: Steve Durrant [stevedurrant@altaplanning.com]
Sent: Thursday, April 01, 2010 10:44 AM
To: Moore-Love, Karla
Cc: Edmunds, Sallie
Subject: River Plan - North Reach comments - Trail alignments in and near railroads

My firm specializes in bicycle planning and design and authored the study: "Rails with Trails, Lessons Learned" for the USDOT and the Federal Rail Authority, we are contributors to federal and state highway and bicycle facility design guidelines and consult internationally on design for bicycle facilities, especially in proximity to freight and passenger rail and rail transit facilities. We contributed to the trail alignment and other aspects of the North Reach Plan.

Regarding proposed public access and trail alignment and crossings of the Pacific and Western Railroad: The proposed crossings or other passage through the rail right of way is completely consistent with best practices currently used or anticipated in the industry. The proposed crossings are within currently permitted public crossings of the right of way, and are located in areas with very slow rail and vehicular speeds. Safety in these areas will be improved through trail development.

Regarding site security: The proposed greenway trail is within public right of way and/or uses existing permitted rail crossings. No increase in security exposure is proposed. Research and observations nationally have established the understanding that trail development improves security by 1) displacing anti-social activities with legitimate users, "eyes on the street" in well design spaces, and 2) using Crime Prevention Through Environmental Design (CPTED) principals to channelize users, and establish clear expectations of publicly accessible territories. The greenway trail will improve security in the study area.

Regarding trail alignments in the public right of way in Linnton: Accommodating pedestrian and bicycle circulation in the public right of way is a rightful use that must be accommodated and planned for on all public roadways. The NW 107th Street alignment, currently a long-range line-on-a-map, would improve pedestrian and bicycle safety by delineating areas where bicycles and pedestrians are most appropriately accommodated, and marking where industrial and automobile traffic should pass and park. Detail design of this segment (and others in similar situations) will improve safety, reduce encroachments into the right-of-way and reduce unsafe practices in the public ROW. Maintaining status quo will promote continued unsafe situations.

Steve

...

Steve Durrant, ASLA :: Principal
Alta Planning + Design :: 711 SE Grand Avenue :: Portland, OR 97215
503 230 9862 :: stevedurrant@altaplanning.com

183694

Oregon
John A. Kitzhaber, M.D., Governor

Department of Land Conservation & Development
800 NE Oregon St. # 18
Portland, OR 97232
(503) 731-4065
FAX (503) 731-4068

April 1, 2010

Sallie Edmunds
City of Portland Bureau of Planning
1900 SW 4th Avenue
Portland, OR 97210

Subject: Portland North Reach Plan (DLCD file # PAPA 008-08)

Dear Ann,

The Department of Land Conservation and Development has reviewed the City of Portland's proposed North Reach Plan and commends the city for creating a plan that considers the unique qualities of land along the Willamette River and promotes future development that recognizes and integrates these qualities. The North Reach Plan is consistent with the intent of Statewide Land Use Goal 15, "To protect, conserve, enhance, and maintain the natural, scenic, historic, agricultural, economic, and recreational qualities of the lands along the Willamette River as the Willamette River Greenway."

Specifically the plan preserves and supports continued economic use of commercial and industrial lands along the river with particular attention to water-related and water-dependent activities. The plan also identifies opportunities for enhancement of recreation opportunities and natural habitat functions within the North Reach Planning area. These plan elements will serve to implement the Willamette Greenway Goal.

Department staff and city staff have discussed the review and process requirements for changes to a local Greenway plan and amendments to the state Greenway boundary. The department is confident that city understands these requirements and is taking the steps necessary to ensure compliance with state statute and administrative rules.

The department appreciates the opportunity to engage with the city at this stage of the planning process, and remains available to support the city in its efforts to adopt and implement the North Reach Plan.

Sincerely,

Amanda Punton
Natural Resources Specialist

cc: Darren Nichols, DLCD Community Services Division Manager
Rob Hallyburton, DLCD Planning Services Division Manager
Jennifer Donnelly, DLCD Metro Area Regional Representative

SCHNITZER STEEL INDUSTRIES INC.

3200 NW Yeon Avenue (97210)
PO Box 10047
Portland, Oregon 97296-0047
Phone 503.286.5771
Fax 503.286.6948

March 31, 2010

Mayor Sam Adams
City of Portland
1221 SW 4th Ave., Suite 340
Portland, Oregon 97204

Dear Mayor Adams,

As follow up to my letter dated February 17, 2010 with respect to prior submitted comments on the City's Natural Resource Inventory Update (NRIU), I submit the following updated comments and attached memo from Windward Environmental:

1. Some erroneous assumptions in the NRIU previously identified by Windward and Schnitzer have not yet been corrected. These assumptions are used to establish the ranking and classifications. It is assumed that some *features are de facto natural resources providing a* function. For example, the Willamette River is a *feature* that is assumed to provide a sediment/pollution/nutrient control *function.* Yet, clearly, a hardened bank does not provide pollution control. Conclusion: some of the report assumptions are incorrect and require further attention and correction prior to adoption by Council.

2. The rankings are not transparent and site attributes that resulted in a medium or high ranking are not easily knowable. By way of example, some sites have both wildlife habitat and riparian functions. If the rankings are not equal (one is low, another medium or high), the higher ranking trumps the lower ranking. Without significant research, it is not known which function triggered the higher designation. Recommendation: added symbology to indicate combined functions determining the rank of medium or high.

3. With respect to beaches, the assignment of Willamette Beach areas as SHAs based on the 2005 ODFW fish study is not appropriate. The study did not find statistically significant correlations for salmonids and beach habitat. Please delete any reference to this effect. (See Friesen, T.A. (ed). 2005. Biology, Behavior, and Resources of Resident and Anadromous Fish in the Lower Willamette River: Final Report of Research, 2000 – 2004. ODFW)

4. Map Corrections on Schnitzer property and property north of IT Slip: certain bank treatments are in error as noted in the attached memo. These bank types should be corrected prior to adoption of the finalized NRIU.

5. Flood Plain "function": the *de facto* baseline condition of “low” for developed flood areas should be reconsidered. Assignment of an ecological function for flood plain solely because it lies within the 100-year flood plain does not necessarily correspond to the capacity of the area to perform flood plain function.

We appreciate your thoughtful attention and consideration of our concerns over the River Plan.

Sincerely,

James H. Wilson
Regional Director

enclosure

183694

WindWard environmental LLC

200 West Mercer St. • Suite 401 • Seattle, WA 98119
Phone: 206.378.1364 • Fax: 206.217.0089 • www.windwardenv.com

MEMORANDUM

To: Jeff Swanson, Schnitzer Steel Industries
Subject: Updated review of Natural Resource Inventory Discussion Draft
Date: March 11, 2010

Schnitzer Steel Industries, Inc. requested an updated review of the "Natural Resource Inventory: Riparian Corridors and Wildlife Habitat, Willamette River, Portland, Oregon Recommended Draft Report November 2009" (NRIU) produced by the City of Portland Bureau of Planning. This most recent version of the NRIU updates Metro's inventory of regionally significant fish and wildlife habitat adopted in September 2005. The purpose of the document is to provide updated information on the location, extent, and relative condition of natural resources along the Willamette River in the North Reach. The NRIU has several purposes and potential uses including, but not limited to, inform the design of land use and zoning tools for the City's and Willamette Greenway zoning programs and to fulfill programs developed to meet statewide land use planning goals to protect significant natural resources and meet multiple objectives for the Willamette River Greenway. Since the publication of the draft NRIU in 2007, the City of Portland has further developed the River Plan for the North Reach related to habitat restoration, mitigation, and establishment of a habitat mitigation bank. In many instances, the NRIU will be used to determine baseline condition of a property parcel to evaluate a development's potential benefit or impact on natural resources.

August 2007 comment: *The intent of the NRIU is to document the current location, extent, and relative condition of natural resources along the Willamette River. The report divides the resource mapping of the river into three reaches, the North, Central, and South. At this time, only the results of habitat mapping for the North Reach, which includes the Portland Harbor Superfund site, are presented. While the intent of the report is to provide a "snapshot" of current natural resources, it is unclear throughout the report how the inventory will be used in development of regulation and potentially affect river-dependent industry within the highly developed North Reach of the Willamette River.*

Updated comment: The City website states that the NRIU does not propose any new regulations or programs, but that it will be used to update City regulations such as environmental zones and the Willamette Greenway program. Areas ranked in the NRIU as medium and high are the basis for a new River Environmental overlay zone, which will replace the existing Greenway overlay zone. Projects conducted in the River Environmental overlay zone will need to conform to specific standards, will require additional development fees, and will often require mitigation as specified in the River Plan/North Reach code amendment. The City could use the NRIU classifications as a basis from which to scale the potential benefit or impact of a development project within the North Reach. Additionally, the City developed plans for a habitat bank to provide on-site mitigation for development impacts. However, the selection of the restoration sites, according to Section 33.475.050 of Code Amendment and Zoning Maps volume of the River Plan (Vo. IB), "were identified based on input from River Plan stakeholders and refined by City staff with the help of staff from state and federal agencies."

August 2007 comment: *The updated NRIU maps wildlife habitat, riparian function, Special Habitat Areas (SHA), and combinations of the above components. The individual riparian function and wildlife habitat maps represent the results of a model that relatively ranked and summed criteria for each inventory site within the North Reach. The rationale for the development of the riparian rank based on primary and secondary features is not clear. How are secondary relative ranking incorporated into the ranking scheme? Furthermore, what are the "relative ranks" relative to? Summaries of the specific model input of riparian corridor model criteria and wildlife habitat ranking for each individual inventory site are not presented in the report. We recommend including summary tables of the model input for inventory sites to provide greater transparency and evaluation of site ecological function.*

Updated comment: The City has clarified how the secondary relative rankings are incorporated into the ranking scheme. However, concerns still remain regarding the assumptions behind the rankings and the resulting classifications. A table listing the riparian corridor GIS model criteria used in ranking riparian function has been added (Table 1 of the NRIU main report). The table lists primary features and secondary features of riparian areas organized by the watershed functions they are considered to provide. The features listed in Table 1 are considered to be natural resources and are also considered to provide significant functions and are subsequently referred to in the NRIU as primary and secondary functions. Riparian areas that have none of the primary features and between one and six secondary features are ranked "low"; areas that have between one and three primary features and zero and six secondary features are ranked "medium"; and areas that have four to six primary features and zero to six secondary features are ranked "high" (see Table 2 of the NRIU main report).

It is unclear how all of the riparian features listed in Table 1 perform riparian functions. For example, one of the secondary features in Table 1 is listed as "Willamette River North and Central Reach." This listing implies that all riparian areas within the North and Central Reach are performing a secondary riparian function in the category of bank function and sediment/pollution/nutrient control. Based on the way the rankings are calculated, all riparian areas in the North and Central Reach automatically receive at least a "low" riparian habitat rank and are considered to provide significant riparian corridor functions. This makes "low" ranking the baseline and gives only two indicators ("medium" and "high") with which to distinguish relative riparian quality. It is unclear how hardened bank areas devoid of vegetation provide significant riparian functions such as pollution control.

Information on inputs used in the wildlife habitat model has also been provided. Habitat patches were defined as areas of forest vegetation or wetlands at least two acres in size, plus the woodland vegetation adjacent to these areas. Table 3 of the NRIU main report lists the categories considered when evaluating habitat patches: patch size, interior habitat area, connectivity/proximity to other habitat patches, and connectivity/proximity to water. For each category, wildlife habitat areas received a "high" score (worth three points), a "medium" score (worth 2 points), or a "low" score (worth one point). Habitat patches that received a total of one to three points were ranked "low"; those that received four to eight points were ranked "medium"; and patches that received nine or more points were ranked "high."

When a wildlife habitat and a riparian function overlap or if either of these overlaps with a special habitat area (SHA), the higher ranking habitat value or the SHA "trumps" a lesser rank, thus masking the individual habitat rankings used to compile the summary figures. In our 2007 memo, we recommended the incorporation of map symbology on the combined riparian/wildlife relative ranking figures to clearly indicate the combination of functions overlain to create the summary figures (e.g. low wildlife ranking, high riparian, etc.). No symbology or indications of combined ranking have been added. We still feel that it would be more accurate and informative to include a scale that portrayed combined rankings. For example, an area that was ranked medium for riparian function and low for wildlife habitat would receive a unique ranking (with corresponding shading or other indication on the map) of med-low. This would allow managers and planners using the NRIU to understand, at least in a basic sense, the separate site features resulting in the ranking. In the example provided, the manager or planner would understand that a specific area provides moderate riparian function but only low wildlife habitat function, rather than just seeing that an area has a "medium" rank, without understanding the site conditions behind that ranking. Such a system would also allow for a more transparent evaluation of the habitat rankings. This level of detail in the figures will provide a more informative management tool.

August 2007 comment: *Special Habitat Areas (SHAs) were identified based on several attributes and designations. In general, the criteria for SHAs seem reasonable. However, the assignment of Willamette Beach areas as SHAs based on the 2005 ODFW fish study is generally not appropriate. The study did not find statistically significant correlations for salmonids and beach habitat. The report concludes that it "found little evidence to suggest that nearshore habitat as it currently exists is a critical factor affecting yearling salmonids" while suggesting* *nearshore habitats "appear to be important to smaller fish (Friesen 2005) [1]." As the study did not conclusively find (i.e. statistically significant results) it does not provide a substantive basis from which to designate SHAs for beach areas within the North Reach.*

Updated comment: Beaches are considered a scarce resource within the North Reach. Within Site WR5, the beach area within and adjacent to ITS is not identified correctly and the map should be updated. The NRIU still states that the beaches and near-shore shallow water areas in WR5 provide important ESA habitat (for salmonids and macroinvertebrates) citing the ODFW 2005 report. The City's statement regarding the beaches at Site WR5 is the following: "Although the vegetated banks reflect disturbance associated with development, they provide a connectivity corridor between Site WR4: South Rivergate Corridor to the north and Cathedral Park to the south." The City has since revised its rationale for identifying beaches as part of SHA in the North Reach based on the 2005 ODFW study to emphasizing their role in providing habitat connectivity.

The City responded to our previous comments regarding habitat function on specific hardened banks. The revised draft has downgraded bank habitat values in the North Reach, and in International Terminal Slip, on the riparian values map where there are hardened banks without vegetation, seawalls, pilings, manicured landscapes or cultivated vegetation (versus natural vegetation), and sediment contamination; the revised draft states that these downgrades will likely also apply to areas in the Central reach. The revised draft also recognizes that microclimate and shade functions should only be considered when the forest vegetation is contiguous to the river and that shrubland and cultivated woodland areas do not significantly contribute to the microclimate and shade functions. However, it is not clear if a site is bordered by shrubland and cultivated woodland areas, whether the score is zero or "low" for those functions. Additionally, more clarification is needed on river bank classification when the SHA areas interface a low-ranked upland. In response to this comment, most of the SSI property is now ranked "low" except for in-water area and some of the shoreline area.

In 2007, we suggested including information on current bank conditions, such as presented in the Willamette River Atlas, to provide a context for the riparian rankings. Information on current bank conditions is now provided on Site WR5- Maps 2 and 3 (water-related features map and vegetation features map, respectively,) but are not accurate for SSI and adjacent properties. Inaccuracies on the type of bank within ITS should be corrected. The shoreline in front of Burgard Yard, to the south of ITS, is currently classified as "unclassified fill bank" when this bank is primarily unvegetated rip rap. The north side of ITS at the mouth of the slip is currently classified as beach, when this portion is actually unvegetated riprap. The bank type layer should be verified for inconsistencies prior to finalizing the NRIU. Additionally, the details on

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[1] Friesen, T.A. (ed). 2005. Biology, Behavior, and Resources of Resident and Anadromous Fish in the Lower Willamette River: Final Report of Research, 2000 – 2004. ODFW.

bank type are lost on WR5- Maps 4 – 6 where habitat rankings are presented. It would be more informative to carry the bank type layer through on all figures.

Separate comment: On the Site WR5- Map 4 figure, there are a couple medium ranked slivers within ITS located in the middle near the northern shoreline. Please clarify the basis of this ranking in the slip.

August 2007 comment: *The upland area of the Schnitzer property is assigned a low riparian function as a result of being located within the 100-year flood plain. Developed floodplain areas, such as the 680 acres of non-vegetated flood plain within the Willamette River watershed, do not provide equivalent ecological functions, such as flood control, groundwater recharge or stormwater attenuation as undeveloped flood plains. As a developed site covered by impervious surfaces, the site lacks the vegetation and soils necessary for a functioning flood plain. Assignment of an ecological function for flood plain solely because it lies within the 100-year flood plain does not necessarily correspond to the capacity of the area to perform flood plain function. The City needs to consider current site conditions within each inventory area and their potential to fulfill the ecological function assigned.*

The *de facto* baseline condition of "low" for developed flood areas should be reconsidered. The upland area of the Schnitzer property is still assigned a "low" riparian function ranking. The NRIU states in the definition of the low riparian rank that it includes developed flood areas and hard, non-vegetated banks (see pg. 16 of the NRIU main report). The low ranking is considered to perform zero primary functions and one to six secondary functions (these are referred to as primary and secondary features in Table 1). See previous discussion in this document.

In order to effectively accomplish the goals of the Natural Resource Inventory update, we respectfully request the City consider these comments to better represent current resources in the highly developed industrial North Reach of the river.

183694

Moore-Love, Karla

From: michelle bickley [michellebickley@gmail.com]
Sent: Tuesday, March 30, 2010 3:54 PM
To: Moore-Love, Karla
Subject: North Reach River Plan

Dear Council Members:

I urge you to move boldly forward with the North Reach River Plan. All of the work and time spent on developing this fair and important plan for the future of the river should be considered well spent, but only if it is put into action. The time is now.

North Portland is home to many unique natural and residential areas. I live here, walk to the river under the St. Johns Bridge, spend time at Kelley Point Park, and enjoy our blossoming commercial district. I am fully aware that industry is vital to our growing city. But, as a city grows, a healthy and expanding population will demand more from the city, it's natural areas, and it's government. The pressure under which you debate the current North Reach Plan will only increase in the future. And, as time goes by, so increases the damage that will eventually need to be repaired. Again, now is the time. Industrial concerns will always present a strong voice to sway policy toward their increased profits. The arguments are certainly that industry will either move away, or never come to Portland if the city demands "too much" of it in clean-up costs. But, this rings false to me. I've heard experts tell of this tactic regarding industry paying higher taxes in Oregon. But, there is no significant movement away once the higher taxes take effect. I believe this to be the case in this debate. It is only right that any person or body cleans up after itself. Volunteers clean up litter along the riverbanks, but the filth that any industry in the North Reach produces, and has produced for many years, is beyond volunteer efforts. You must step in for us, as we cannot do it ourselves. Please look to the interests of everyone involved, not only prosperous industrial concerns.

Please do not diminish our rights to the health & vitality of our stretch of the beautiful Willamette River. Adopt the North Reach River Plan for Portland.

Thank you very much for your time,

Michelle Bickley
9847 N. Ivanhoe St.
Portland, OR 97203

183694

Moore-Love, Karla

From: Susan Prindle [daffydil@comcast.net]
Sent: Monday, March 29, 2010 5:10 PM
To: Moore-Love, Karla
Subject: River Plan

I moved up from CA about 12 years ago. My children had preceded me and I frequently drove up to see them. After many visits, I began to feel at home as soon as I got through the curves and had my first view of the bridges and the river. And so I left CA and came here.

The Willamette River ***is*** Portland and it is vitally important that we have a healthy river.

Many many people have attended meetings and hearings, written letters and it's imperative that their voices be heard. Please do not give in to industry, which ,in the end, is about money. The city should be the regulatory authority on what happens to our river. And the 1.5% fee is not enough to cover the damage that has already been done and will be done if you let industry have its way.

Please save the Willamette River and bring it back to health.

Thank you,

Susan Prindle

183694

npGREENWAY

friends of the north portland greenway trail

17 March 2010

Mayor Sam Adams
Commissioner Amanda Fritz
Commissioner Dan Saltzman
Commissioner Randy Leonard
Commissioner Nick Fish
c/o Council Clerk
1221 SW 4th Avenue, Room 140
Portland, Oregon 97204

Re: proposed River Plan North Reach

Dear Mayor and City Commissioners,

npGREENWAY is a group of citizens together with local interest groups, agencies and businesses that has been advocating for several years in the River Renaissance and River Plan process for a multiuse trail along the Willamette River from the Steel Bridge to Kelley Point Park. This will provide a vital transportation corridor for commuters as well as a great recreation link for Portland neighborhoods and their employment.

This process has been an open process for interested citizens and groups. We understand that there are several items that will require some additional time and should be completed by the end of this year. We also recognize that the large majority of the plan, including the Willamette River Greenway Trail (i.e. east bank of the river), along with rezonings, inventories etc. that are 'complete'. We ask that you adopt these portions that are ready now so that interested citizens, the City, Metro and groups can pursue funding and construction.

We again ask for your support of the highest possible priority for its funding and construction.

We thank you for your consideration of this request. npGreenway supports and strongly urges your immediate adoption and implementation.

Sincerely,

CURT SCHNEIDER

On behalf of npGREENWAY

Francie Royce, Co-Chair	Scott Mizee, Co-Chair
Pam Arden, Treasurer	Curt Schneider, Secretary
Joe Adamski	Lenny Anderson
Paul Maresh	Shelley Oylear
Mark Pickett	Jason Starman

Cc: Sallie Edmunds, Shannon Buono PBPS