Eastbank Riverfront (Phase I) Floating Walkway

Fish Predation Study

Final Report and
Data Summary

1999 and 2000 Sampling Seasons

Prepared for:

Michael McElwee
Portland Development Commission
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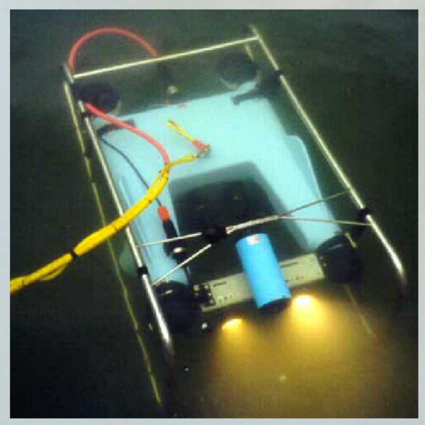

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FES Project 98102
October 30, 2001

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

REPORT SUMMARY

This report presents the goals, methods, results and conclusions of a study conducted in 1999 and 2000 on the potential relationship between the existence of a newly constructed floating walkway and the presence, abundance and relative level of predation on juvenile salmonids by fish-eating (piscivorous) fishes. The study was added as a condition of the federal permit authorizing construction of the floating walkway after the Nation Marine Fisheries Service expressed concern that the structure might attract predatory fishes. The floating walkway was completed in 1999 on the Willamette River in Portland, Oregon as part of the East Bank Riverfront Park project. A variety of sampling methods were used to document fish presence and abundance around the floating walkway, the adjacent shoreline, and at a reference site nearby that contained no structures. Electrofishing proved to be the most effective sampling method. The stomachs of potential piscivores were examined to determine what organisms were consumed.

The study concluded that piscivorous fish were not found in greater abundance in association with the floating walkway than in other areas. Piscivorous fish were found to be associated with shallow water and shore. No juvenile salmonids were identified in the stomachs of piscivorous fish. The contents of the fish stomachs examined were dominated by a highly variable assortment of invertebrates (crawfish, amphipods, insects) and a small percentage of non-salmonid fishes (primarily sculpin).

Fish presence and abundance exhibited a high degree of spatial and temporal variability. Distribution of piscivorous fish in the study areas appeared to be related to water depth and flow velocity, rather than presence or absence of human-built structures.

Length data for un-marked (presumed to be wild, not hatchery) juvenile chinook salmon suggest that yearling (1-year old) fish moved through the study area earlier in the season (March-April), while sub-yearling may have remained in the area later (through June, perhaps later).

The biology of the most abundant potential piscivorous fish, smallmouth bass, is discussed. The study results, and results of other referenced studies suggest that smallmouth bass predation is not a major issue in the lower Willamette River for spring-migrating juvenile salmonids. This is a result of bass feeding behavior, juvenile salmonid migration timing, and habitat parameters. There are some suggestions in the scientific literature, however, that smallmouth bass might consume more sub-yearling chinook salmon during summer.

This study, and others in the lower Columbia and Willamette Rivers, suggests that the relationship between human-built structures and piscivores may not be a major factor limiting populations of outmigrating juvenile salmonids.

1 INTRODUCTION

The City of Portland completed in 1999 the installation of a floating walkway in the Willamette River as part of the East Bank Riverfront Park Project. Questions arose during the federal permitting process about the relationship between the floating walkway and possible predation on juvenile steelhead, a threatened species, by warmwater gamefish, particularly large- and smallmouth bass and crappie. As a result of discussions between the Portland Development Commission (PDC), National Marine Fisheries Service (NMFS), and the US Army Corps of Engineers (Corps), a condition was added to the federal fill permit to implement a two year data collection study of predation by warm water game fish on juvenile steelhead related to the presence of the floating walkway[1]. Since the initiation of this contract in 1998, three additional salmonid ESUs that may occur in the project vicinity were listed as threatened under the Endangered Species Act. These included the upper Willamette River steelhead and the lower Columbia River chinook and the upper Willamette River chinook ESUs, all listed as threatened in March 1999.

The goal of the predation study was to document the influence of the floating walkway, during the peak spring salmon and steelhead outmigration, on piscivorous (fish-eating) species presence and abundance, and the relative level of predation on juvenile salmonids between the walkway and a reference area located upstream of the site. If the study documents an unacceptable impact to listed salmonid ESUs from increased predation, the PDC will investigate and implement methods to reduce the level of impact.

Previous reports of project data include a Spring 1999 Sampling Season Data Summary (FES 1999) and a memo dated April 25, 2000 describing the results of a volunteer sampling event. Preliminary results from both study seasons were also presented at the poster session of the annual meeting of the Oregon Chapter of the American Fisheries Society on February 14, 2001.

2 BACKGROUND

The Eastside Riverfront project is being developed in stages, beginning in 1986 and scheduled for completion in 2005-2006. The project is part of the Central City Plan adopted in the mid-1980s by the Portland City Council. A Master Plan for the Eastbank Riverfront was adopted by the Council in 1994, establishing goals to: connect the east and west sides of the river physically and visually; create significant public attractions in the Central East Side, and linking them with a linear park along the river; develop connections to the natural and cultural history of the east side; provide access to the river and strengthen awareness of the riparian edge; and develop bicycle and pedestrian links to other city and regional paths, parks and open spaces.

[1]Department of the Army permit #97-00914, Special Condition F: "Monitoring shall be conducted following project completion to determine actual impacts on juvenile salmonids. The monitoring plan shall be approved by the National Marine Fisheries Service. Results of the monitoring efforts shall be provided to the National Marine Fisheries Service and Corps of Engineers."

Phase I of the Eastbank Riverfront project is between the Burnside and Steel Bridges (Figure 1). Included in Phase I is a floating walkway that is 1,200 ft (365.8 m) long and 17.5 ft (5.3 m) wide. Construction of the floating walkway was begun in September 1998 and essentially completed in mid-1999; it was opened for public use during the summer of 2001. This section of the Eastside Riverfront trail was designed as a floating structure because there is no room for a land-based trail due to the interstate freeway being over the river and riverbank at this location.

The floating walkway is connected to the shore-based trail by ramps and two elevated fixed platforms at each end. An Americans with Disabilities Act (ADA) accessible system consisting of six 12 ft (3.7 m) wide by 60 ft (18.3 m) long aluminum gangways provides access over a river level of 20 ft (6.1 m) while the system is designed to accommodate a maximum river variation of 30 ft (9.1 m). Two additional sections of pile supported fixed pier provide transition points from the gangway to shore on each end of the walkway. The floating section consists of 17.5 ft (5.33 m) wide by 10.0 ft (3.05 m) long by 4.0 ft (1.22 m) deep concrete float pods connected so there are no gaps. Interior pile loops occur in every fourth pod. The downstream end of the floating walkway is over river bottom elevations of 0 ft to -16.4 ft (0 m to -5 m (City of Portland datum)); the upstream end is over bottom elevations of -9.8 ft to -32.8 ft (-3 m to -10 m). The lowest elevation under the walkway is just downstream of the Burnside Bridge where the river bottom is -62.3 ft (-19 m).

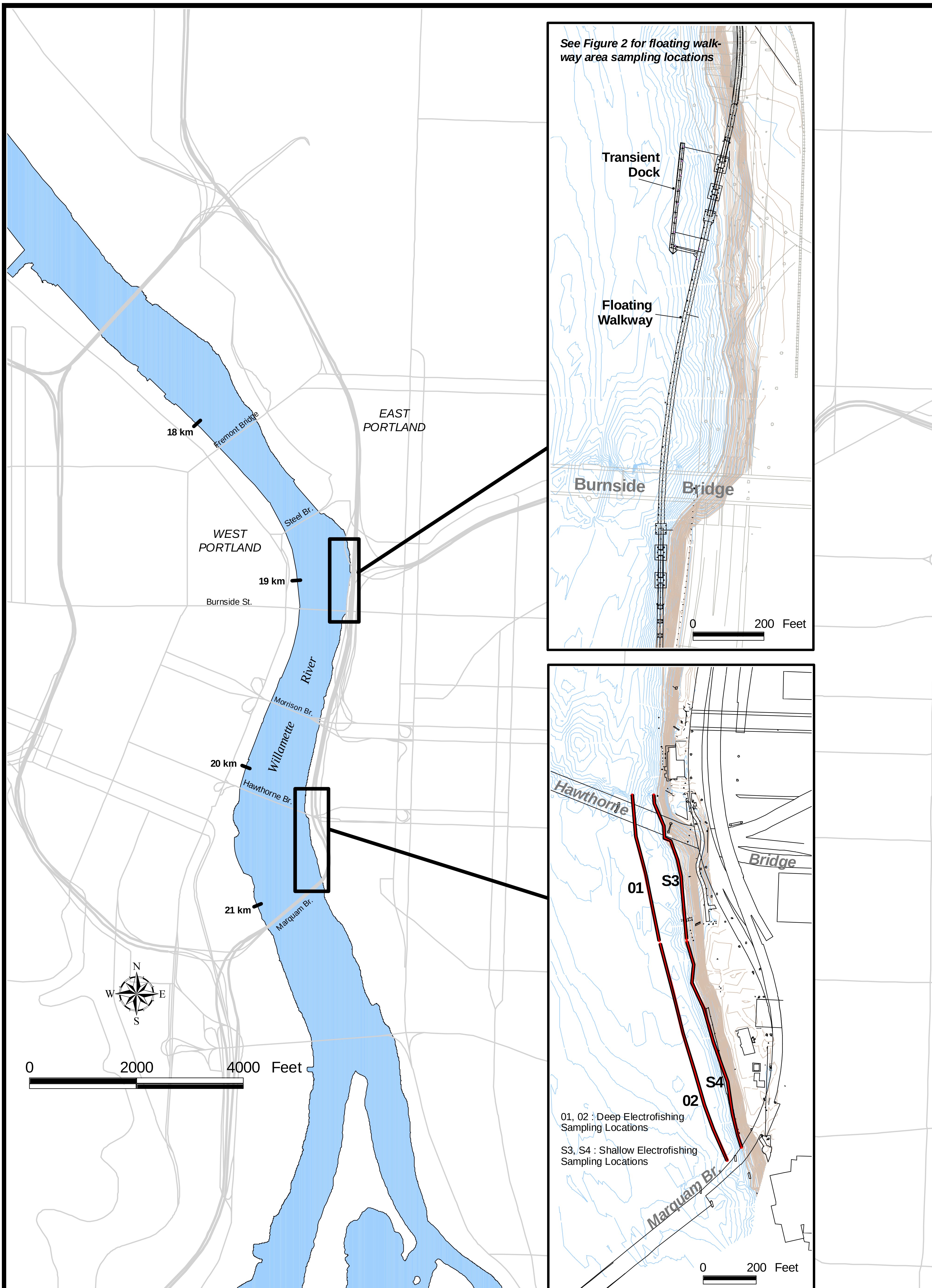
Oregon and federal fish resource agencies have long been concerned about predation on juvenile salmonids by introduced and native fish around fixed and floating human-made structures in the lower Willamette and Columbia Rivers. The concern appears to be based on the hypothesis that piscivorous fishes may lurk in the shade produced by these structures, and dart out to capture passing juvenile salmonids.

3 METHODS

3.1 Fish Sampling

Fish were collected from the Willamette River near river mile 12 (kilometer 19.3) in the vicinity of the floating walkway and further upstream at a reference site near the Hawthorne Bridge at river mile 13 (kilometer 20.9, Figure 1). The Hawthorne Bridge reference site was selected for its general similarity in depth profile, water velocity, substrate type, and proximity to the walkway site. Sampling locations for all gear types included near/under the floating walkway, along the shoreline, and in deeper offshore water where there was no over-water structure (Figure 2). Sampling was restricted to areas along the east bank of the river. Fish sampling was authorized by Scientific Taking Permits issued by the Oregon Department of Fish and Wildlife (permit numbers 9902 and 00-56).

Sampling was conducted between 6:30 am and 3:00 pm. Sampling frequency was bi-weekly from April 13 to July 9, 1999 and was increased to weekly intervals from March 30 to June 22, 2000 by NMFS staff request. Sampling dates were chosen to cover the peak juvenile salmonid migration period and to avoid periods of high recreational river traffic (e.g. Spring chinook fishing days, Portland Rose Festival, 4th of July).



Key to Features

Scale as shown
Contour Interval: 1 meter

Electrofishing sampling routes

Streets

Open water

Contours

Bathymetric Contours

 # km **River kilometers from Clolumbia River**

Source:
Streets and shoreline - METRO RLIS
KPFF Consulting Engineers and Minister-Glaeser Surveying, Inc. (project details and hydrographic survey.)

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Study Area and Sampling Locations

Figure 1	August 2001	Project #98102

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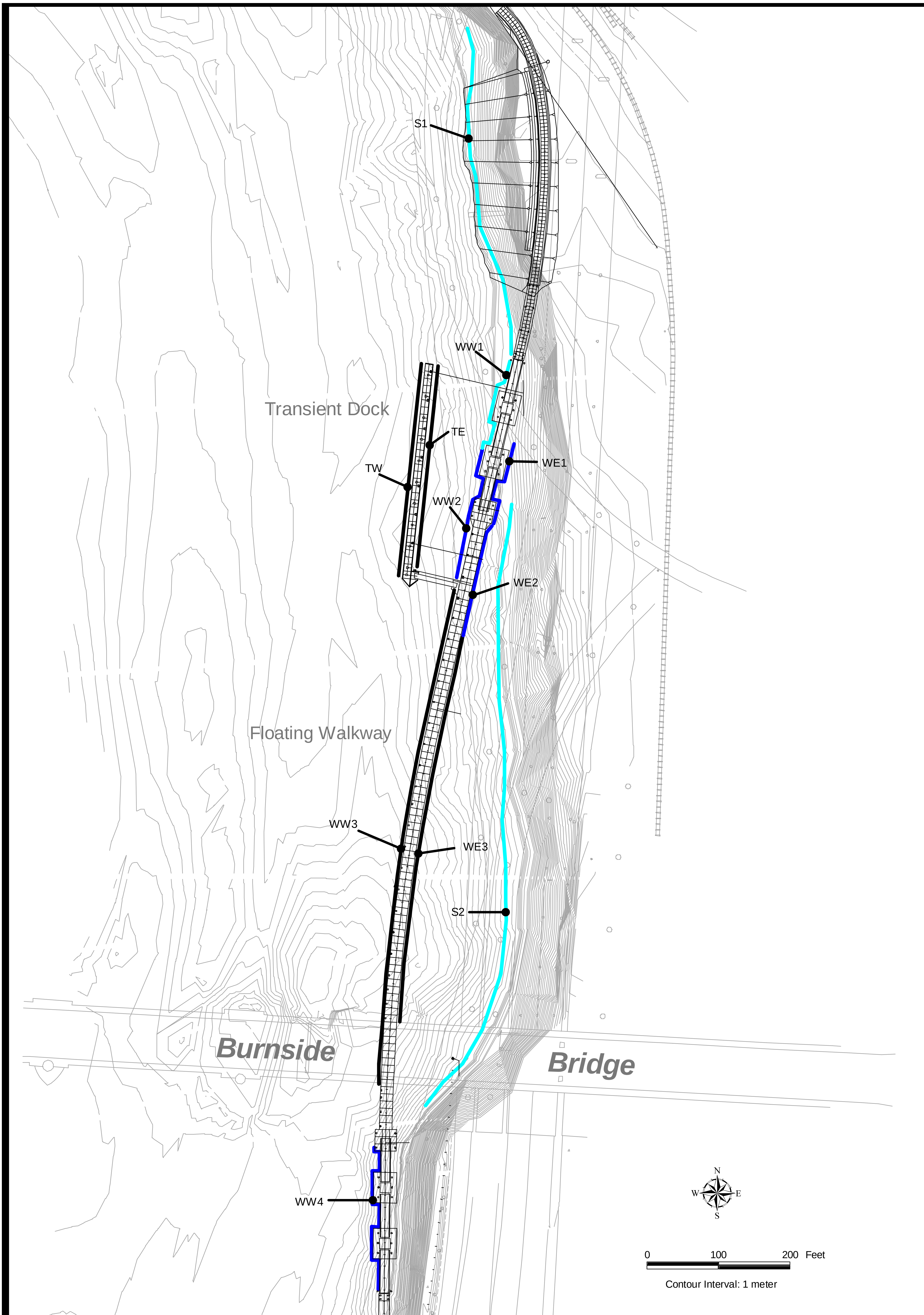

Key to Features

Depth Class

Deep

Mixed

Shallow

WW (1999, mixed depth class) = WW1, WW2, WW3, WW4 (2000)

WE (1999, mixed depth class) = WE1, WE2, WE3, (2000)

Source:
KPFF Consulting Engineers and Minister-Glaeser Surveying, Inc. (project details and hydrographic survey)

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Fish Predation Study

Spring 2000 Walkway Sampling Stations

Figure 2	August 2001	Project #98102

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Sampling gears tested in 1999 included boat electrofishing, gillnets, a remotely operated submersible with video camera (ROV) baited trot lines, and hook and line (specifications in Appendix).

Electrofishing provided 98 percent of the catch during the 1999 sampling season. Sampling gear during 2000 was therefore limited to electrofishing and hook and line. Gill nets, trot lines, and the ROV were not used in 2000.

Electrofishing effort was based on standard length transects established during the 1999 sampling season. Due to differences observed in capture data within samples in 1999, electrofishing stations were further subdivided in 2000 to better reflect differences in depth and distance from shore. Figure 2 shows these divisions, which where based on the -7 meter (COP datum) elevation contour. Table 1 shows depth class, structure presence, and year sampled for each sampling site. Depth classification was based on actual water depths during sampling. Linear distance of sampled habitat was used as the unit of effort for all electrofishing samples. Catch per unit effort (CPUE) is therefore expressed as number of fish per 10,000 linear feet of habitat in all comparisons.

Catch data for all fish species exhibited highly positively skewed distributions. This high degree of skewedness and other measures such as kurtosis indicated that samples were not normally distributed, even after logarithmic and 4^{th}-root transformations. The application of many classical statistical methods to these data would therefore have been invalid, as they are based on the normal (Gaussian) distribution. Statistical analysis was therefore restricted to nonparametric hypothesis testing methods based on ranked data such as One-Way Kruskal-Wallis ANOVA.

Sampling was conducted under a variety of river conditions. Water quality data (temperature, conductivity, dissolved oxygen, pH, turbidity, and clarity) were collected on sampling days throughout each study season (specifications in Appendix). River stage data were compiled from a U.S. Army Corps of Engineers database.

On May 7, 2000, thirteen members of the Oregon Bass and Panfish Club participated in a volunteer hook-and-line sampling event organized by Fishman Environmental Services. Participants fished from boats along the floating walkway and at the reference site. Their catches were kept alive in live wells on their boats and turned over to FES staff for measuring, tagging, and digestive tract sampling. Piscivorous fishes large enough to consume juvenile salmonid fish were measured and their digestive tracts were pumped before being tagged and released. Participants in the volunteer event logged a total of 52 angler-hours. In addition, anecdotal information on fish use of local habitat areas was collected from several experienced warmwater anglers.

3.2 Piscivore Diet Analysis

The digestive tracts of all bass, panfish, yellow perch, and northern pikeminnow larger than 100 mm were flushed (“lavaged”) with a stream of river water delivered by a 12-volt peristaltic pump. Fishes smaller than 100 mm generally did not possess large enough jaw gapes to prey on most juvenile salmonids, or to accommodate the diameter (5 mm) of the pump’s tube. Lavaged fishes were returned alive to the river after recovery. The structure of northern pikeminnow intestines prevented effective pumping, necessitating sacrificing and evisceration of these fish.

Table 1. Sampling Site Information

Sampling Site Code	Depth Class[1]	Over-water Structure Presence2	Sampling Year	
			1999	2000
O1	Deep	N	x	x
O2	Deep	N		x
S1	Shallow	N	x	x
S2	Shallow	N	x	x
S3	Shallow	N	x	x
S4	Shallow	N	x	4
TE	Deep	Y	x	x
TW	Deep	Y	x	x
WE[3]	Mixed	Y	x	x[3]
WE1	Mixed	Y	3	x
WE2	Mixed	Y	3	x
WE3	Deep	Y	3	x
WW[3]	Mixed	Y	x	x[3]
WW1	Shallow	Y	3	x
WW2	Mixed	Y	3	x
WW3	Deep	Y	3	x
WW4	Mixed	Y	3	x

1 Deep=25-75 ft.; Shallow=1-15 ft.; Mixed=25-75 ft.

2 Presence or absence of piles and over-water structures. "Y" includes walkway, but not high structures such as freeway ramps. N= control group sites.
3 Sites WE and WW were divided into smaller electrofishing zones in 2000.
4 Not accessible in 2000 due to construction activities.

Gut contents were preserved and identified to the lowest possible taxon. Many prey invertebrate items were only identifiable to order or family due to their highly digested state.

3.3 Fish Tagging

A number of piscivorous fishes were marked with streamer-type Floy tags during the 2000 sampling season. Project staff looked for tags on all piscivores subsequently captured. The tags had a phone number for anglers to call. The tagging was intended to help estimate piscivore population size based on mark-recapture methods, and to determine if these species were maintaining home areas. In addition, for the 2000 sampling season, all captured juvenile chinook were scanned with a PIT tag reader to aid ODFW tracking studies.

4 RESULTS

All water quality, fish sampling and digestive tract sampling data are contained in an electronic file. A CD containing this file is provided to the client with this report. The full report and data files, as .pdf files, are also posted in the research section of the Fishman Environmental Services website at: http://www.fishenserv.com/.

4.1 River Conditions and Tides

Sampling was conducted during a wide variety of tide and river stages. For example, river stages at the Morrison Bridge gage ranged from 4.56 to 10.32 feet above NGVD during the 2000 sampling season. Tidal back-watering of the Willamette exerts considerable influence on local flow velocities at sampling sites and can change river stage by several feet. Measured velocities near the floating structure ranged from 2.0 feet per second (fps) at low tide to less than 0.1 fps at high tide. Due to meteorological conditions and upstream flow regulation, neither sampling season included a Spring freshet.

4.2 Water Quality

Water temperature, dissolved oxygen, and pH data ranges for both sampling seasons are shown in Table 2. Water temperatures increased 8-10°C over the course of both seasons. Conductivity measurements ranged from 48.0 to 67.5 microSiemens/cc. Conductivities in this range are considered relatively low, but within the effective range of the electrofishing equipment used.

Meteorological conditions throughout both sampling seasons were responsible for excellent river conditions for electrofishing. Secchi depth measurements yielded visibilities of 4.3 to 6.5 feet during the 2000 sampling season. Turbidity levels stayed low throughout both sampling periods. FES water samples showed a range from 1.62 to 5.43 nephelometric turbidity units (NTU). Turbidities as high as 100 NTU were measured by FES in the Willamette River for comparative purposes during the winter of 1998/99.

Table 2. Summary of water quality data collected on fish sampling days during the springs of 1999 and 2000.

		temperature (°C)	dissolved oxygen (ppm)	pH	turbidity (NTU)	Secchi depth (ft)
1999	Minimum	10.2	9.5	7.0	1.62	nd*
	Maximum	18.8	10.0	7.2	5.43	nd*
2000	Minimum	9.4	8.3	7.1	1.93	4.3
	Maximum	19.7	11.0	7.6	nd*	6.5

*nd = no data

4.3 Electrofishing Samples

In 139 samples, 1089 total fish were captured by electrofishing in the course of the 1999 and 2000 sampling seasons (319 and 770, respectively). In addition, several hundred fish were observed reacting to the electrofisher current but evaded capture. Most of these uncaptured fish were cottids (sculpins) and small juvenile salmonids. Overall electrofishing mortality of captured fishes was 3 percent. Electrofishing results are summarized in Table 3. Catch data for all fish species exhibited highly positively skewed distributions. One-Way Kruskal-Wallis ANOVA was therefore used to test hypotheses.

Fish species captured over the course of the two sampling seasons are listed in Table 3. Eighteen species of fish were captured in the course of the project. Eight of these species are not native to the Columbia basin. Although species composition varied throughout both sampling years, largescale suckers *(Catostomus macrocheilus)* dominated most samples.

Most piscivorous fishes were captured near shore in slow water habitats with no floating structure or piles. Offshore samples were dominated by hatchery-marked juvenile chinook salmon *(Oncorhynchus tshawytscha)*.

Of piscivore species, only smallmouth bass were found in large enough numbers to compare CPUEs. No smallmouth bass, largemouth bass, or black crappie were captured at deep-water sampling locations near the floating structure (Table 3). Only one northern pikeminnow (345 mm long) was caught near the walkway in deep (53 ft) water at slack tide. All other potential piscivores caught near the floating structure were captured in shallow water (1-25 ft deep) near the ends of the structure. Most of the 1200-foot long floating structure is over deep (>20 ft) and relatively fast-flowing water.

Comparisons of smallmouth bass catch per unit effort (CPUE), expressed as individuals captured per 10,000 linear sampling feet, are shown in Figures 3 and 4. Significantly more smallmouth bass were captured at shallow shoreline (1-15 ft) sites than at deep or offshore (25-75 ft) and mixed depth (5-75 ft) sites (Figure 3; Kruskall-Wallis: $p<0.01$). Figure 4 shows a significant difference between smallmouth bass CPUE at sites with and without piles and over-water structure (Kruskall-Wallis: $p<0.01$). The difference, however, in smallmouth bass CPUE between shallow-water samples near the structure (sites WW1 and WE1) and shallow-water sites without piles and floating over-water structures (sites S1 through S4) was not statistically significant (Kruskall-Wallis: $p=0.0542$; means are shown in Table 3).[2] Smallmouth bass catches within habitat categories showed no significant differences between years (Kruskall-Wallis: p=0.22-0.53).

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2 Non-parametric tests are more robust, but have lower statistical power than parametric equivalents. Therefore failure to disprove the null hypothesis when it is false for a given difference is more likely.

Table 3.Fish species captured by electrofishing at floating walkway and reference sites (1999 and 2000 seasons).

Species		Origin	No. Captured	Structure-deep Mean CPUE (fish/10,000 ft.)	Structure-shallow Mean CPUE (fish/10,000 ft.)	Structure-mixed depth Mean CPUE (fish/10,000 ft.)	Control-deep Mean CPUE (fish/10,000 ft.)	Control-shallow Mean CPUE (fish/10,000 ft.)
				(41 samples)	(9 samples)	(39 samples)	(14 samples)	(36 samples)
largescale sucker	*Catostomus macrocheilus*	N	298	0.00	112.61	23.64	5.97	92.34
*prickly sculpin	*Cottus asper*	N	***168	3.21	7.51	18.91	0.00	49.54
peamouth	*Mylocheilus caurinus*	N	57	0.53	0.00	3.68	0.00	19.42
*northern pikeminnow	*Ptychocheilus oregonensis*	N	9	0.53	0.00	0.00	0.00	3.17
three-spined stickleback	*Gasterosteus aculeatus microcephalus*	N	**	**	**	**	**	**
sand roller	*Percopsis transmontana*	N	1	5.35×10^{-5}	0.00	0.00	0.00	0.00
lamprey ammocoete	*Lampetra* sp.	N	6	0.00	7.51	0.00	0.00	1.98
unmarked coho juvenile	*Oncorhynchus kisutch*	N	9	0.00	0.00	1.05	1.19	2.38
hatchery marked coho juvenile	*Oncorhynchus kisutch*	H	11	1.07	0.00	1.58	4.77	0.79
unmarked steelhead juvenile	*Oncorhynchus mykiss*	N	14	0.53	0.00	2.10	1.19	3.17
hatchery marked steelhead juvenile	*Oncorhynchus mykiss*	H	46	0.53	0.00	0.53	8.36	14.66
unmarked chinook juvenile	*Oncorhynchus tshawytscha*	N	***133	4.81	22.52	9.98	5.97	38.44
hatchery marked chinook juvenile	*Oncorhynchus tshawytscha*	H	196	18.18	105.11	22.07	8.36	39.24
bluegill	*Lepomis macrochirus*	I	5	0.00	0.00	0.53	0.00	1.59
*smallmouth bass >100mm	*Micropterus dolomieu*	I	67	0.00	30.03	3.15	1.19	22.19
smallmouth bass <100mm	*Micropterus dolomieu*	I	19	0.00	0.00	0.53	0.00	7.13
*largemouth bass >100mm	*Micropterus salmoides*	I	6	0.00	0.00	1.05	0.00	1.59
largemouth bass <100mm	*Micropterus salmoides*	I	4	0.00	0.00	0.00	0.00	1.59
*black crappie	*Pomoxis nigromaculatus*	I	3	0.00	0.00	0.00	0.00	1.19
goldfish	*Carassius auratus*	I	1	0.00	0.00	0.00	0.00	0.40
common carp	*Cyprinus carpio*	I	22	1.07	7.51	1.58	0.00	6.34
banded killifish	*Fundulus diaphanus*	I	1	0.00	0.00	0.00	0.00	3.96×10^{-5}
*yellow perch	*Perca flavescens*	I	13	0.00	0.00	3.15	0.00	2.77
Sum			*1089*					

Origin: I= introduced; N= native; H= hatchery.
* Denotes piscivorous species potentially capable of preying upon juvenile salmonids.
** Incidental sighting of schooling fish on July 9, 1999.
*** CPUE of cottids and subyearling unmarked chinook underestimate abundance relative to other fishes.

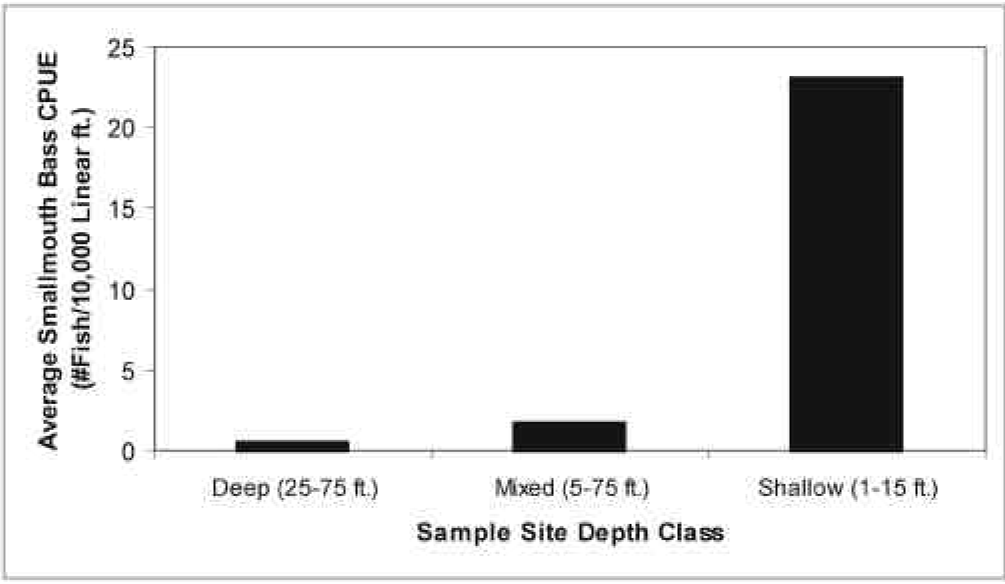

Figure 3. Average total smallmouth bass catch per unit effort (electrofishing) by sample site depth class. Differences between sample types are significant (Kruskall-Wallis: p<0.01) for all comparisons except between deep and mixed (p=0.265). All depth classes include both walkway structure and control samples.

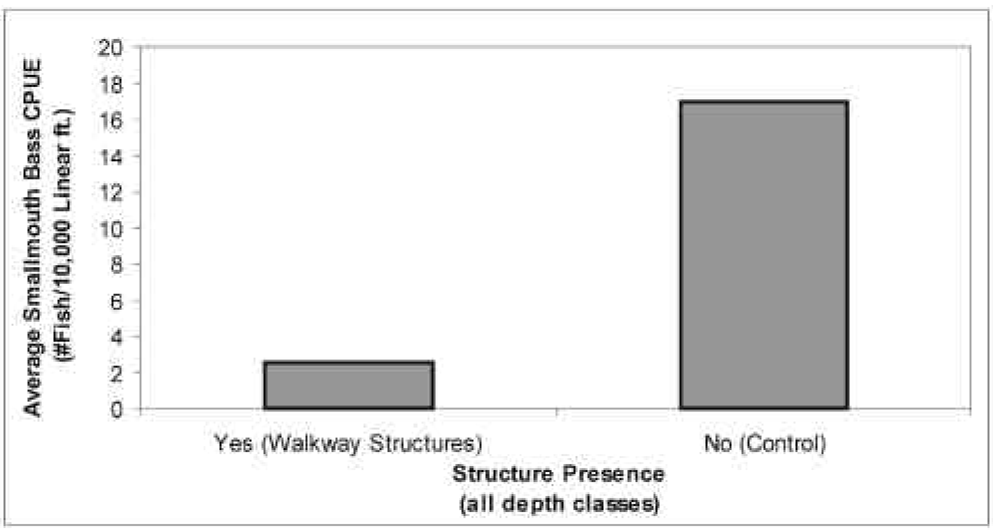

Figure 4. Average total smallmouth bass catch per unit effort (electrofishing) by presence or absence of pile and over-water structures. Difference between sample types is significant.
(Kruskall-Wallis: p<0.01)

Several hundred juvenile salmonids were captured incidentally while electrofishing. Most captured salmonids were hatchery-marked chinook (n=196), followed by unmarked chinook (n=133). Other species were found in smaller numbers and are listed in Table 3. Juvenile chinook catch was variable, with large peaks in adipose-clipped fish presumably due to hatchery releases. Substantial interannual variation in catch of unmarked chinook was also observed (Figure 5).

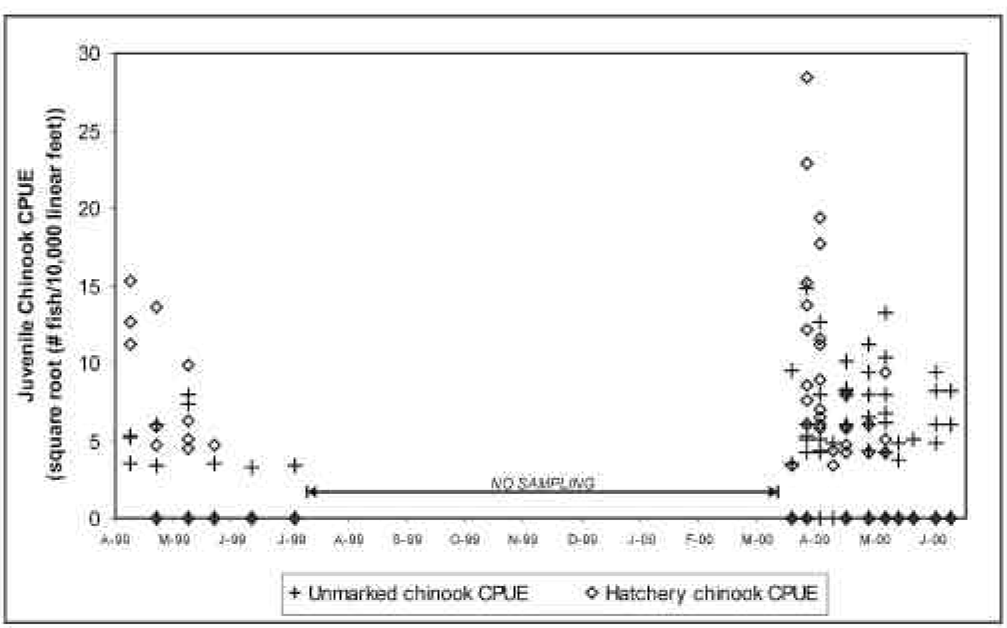

Figure 5. Juvenile unmarked and hatchery chinook catch per unit effort (individual sample CPUE) by sampling date (1999 and 2000 sampling seasons).

Length frequency distribution of juvenile unmarked and hatchery chinook captured between March 30 and April 7, 2000 are shown in Figures 6 and 7. These figures suggest two distinct groups of chinook in the marked and unmarked populations. The grouping of larger unmarked chinook does not appear in later samples (Figure 8). This may indicate that the 40-90 mm and 130-170 mm groups represent subyearlings and yearlings, respectively. The presumed subyearlings were generally caught in shallow near-shore habitats and would often evade capture in rip-rap interstices. These smaller unmarked chinook are of unknown origin, but may be the progeny of natural production in the lower Clackamas River and/or the Willamette River below the falls at Oregon City.

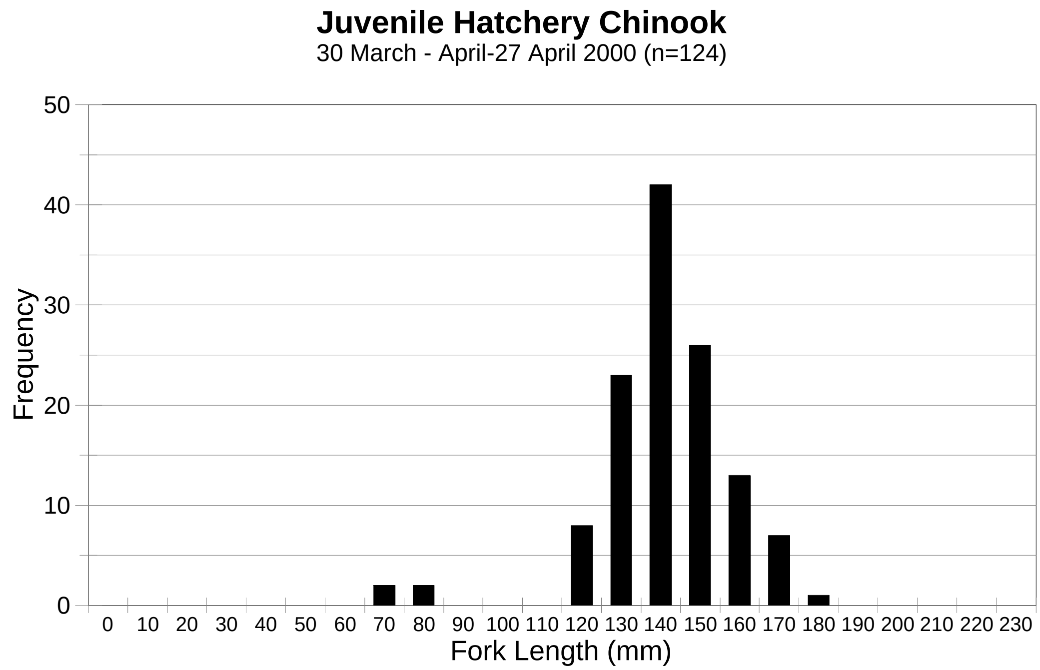

Figure 6. Length frequency distribution of juvenile hatchery chinook captured between March 30 and April 7, 2000.

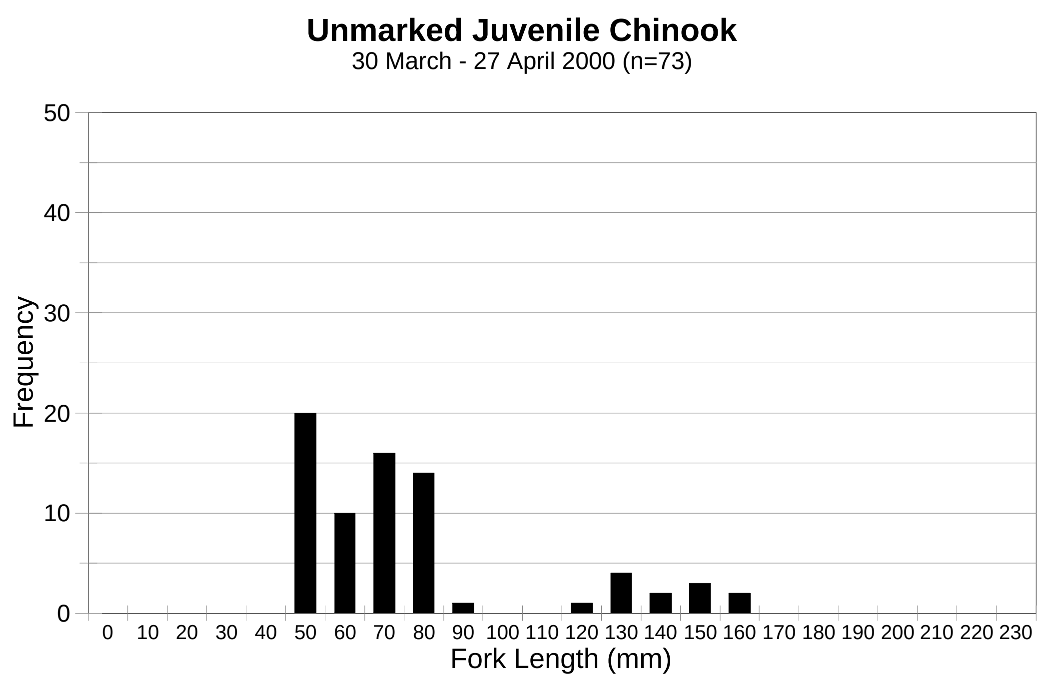

Figure 7. Length frequency distribution of unmarked juvenile chinook captured between March 30 and April 7, 2000. Fish in the 30-50 mm range are under-represented due to dipnet mesh size and evasion into interstitial spaces in rip-rap.

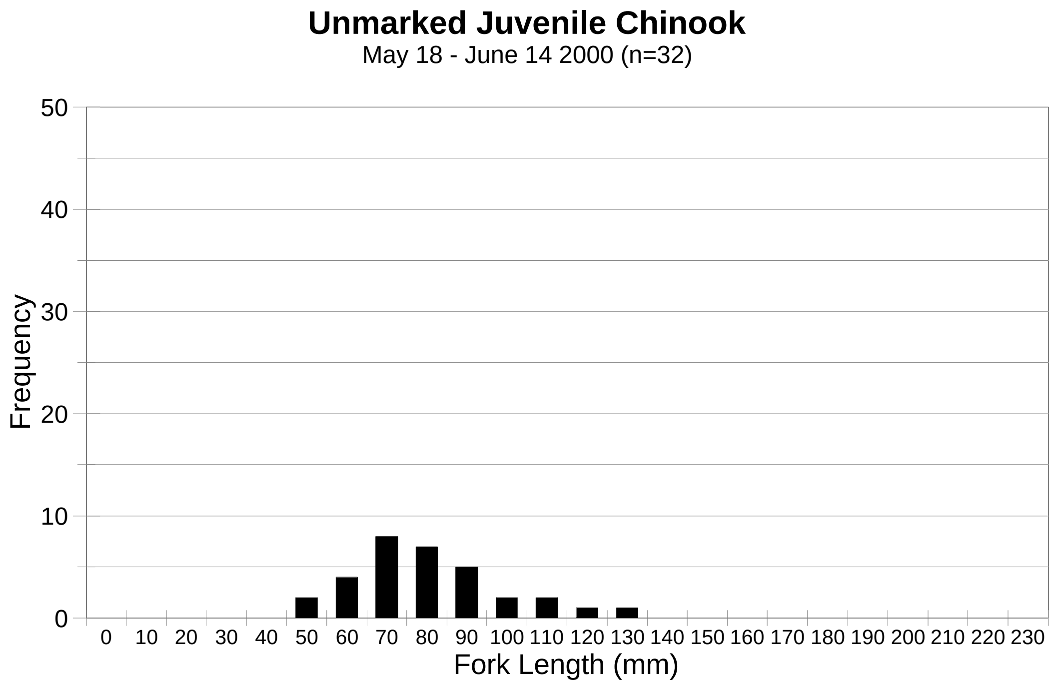

Figure 8. Length frequency distribution of unmarked juvenile chinook captured between May 18 and June 14, 2000. Fish in the 30-50 mm range are under-represented due to dipnet mesh size and evasion into interstitial spaces in rip-rap.

4.4 Volunteer Hook-and-line Event

Three piscivorous fish species (northern pikeminnow, black crappie, largemouth bass) were collected by hook-and-line on May 7, 2000. The digestive tracts of these fishes contained mayflies (*Baetis* sp.), amphipods, *(Corophium* sp.), scuds (*Gammarus* sp.), crawfish, or were empty. Results from this digestive tract sampling were added to the feeding results discussed later.

Several bass anglers also noted that they had fished around the floating structure several times since its construction, but had not found it to be a good fishing area.

4.5 Mark-Recapture Experiment

Forty-six adult piscivorous fish were marked with streamer-type Floy tags during the 2000 sampling season. Tagged fishes included smallmouth bass (n=44), largemouth bass (n=1), and black crappie (n=1). No tagged fish were recaptured by FES or reported by anglers. No PIT tags were detected in scanned juvenile chinook in 2000 (fish were not scanned in 1999).

4.6 Video Observations (R.O.V.)
No fish were observed with the R.O.V. underneath or near the floating structure when the equipment was used on June 15, 1999. Several fishes were observed in areas away from the floating structure: three smallmouth bass, a common carp, and an unidentified salmonid juvenile were observed in shallow water (approximately 5 to12 feet deep) near shoreline site S2; one white sturgeon was encountered in deep water near the Burnside Bridge.

4.7 Digestive Tract Contents
Digestive tract samples from 91 piscivores were dominated by invertebrate prey (Figure 9). Mayflies (mostly *Baetis* sp.) were found in 33%, and crayfish parts were found in 29.7% of sampled digestive tracts. No salmonids were identified in sampled piscivore digestive tracts. Unidentifiable fish parts were found in 9.9% of examined fishes. Twenty-three percent of sampled digestive tracts were empty.

Digestive tract contents varied seasonally and were often similar among piscivore species. For example, on June 17, 1999, hundreds of mayfly larvae were found in smallmouth bass, largemouth bass, and prickly sculpin digestive tracts. For two days in 1999 (April 27 and May 14), mysid shrimp were seen reacting to the electrofisher current and were found in large quantities in largemouth and smallmouth bass digestive tracts.

In 1999, the occurrence of empty piscivore digestive tracts appeared to have a negative correlation with water temperature and a positive correlation with total juvenile salmonid CPUE (FES 1999). These relationships were less clear in the 2000 data (Figure 10).

4.8 Other Trends and Observations
Several large adult salmonids were observed evading the electrofishing boat near the shoreline upstream of the Hawthorne Bridge on May 28 (2 fish) and June 17 (1 fish) 1999. On July 9, 1999, three adult male hatchery-clipped steelhead were captured in shallow water between the walkway and the shoreline.

5 DISCUSSION

The goal of this study was to develop information about the possible attraction of piscivorous fish to a large floating structure, and document the relative level of predation associated with the structure compared to areas without such a structure. A variety of factors influence the abundance and distribution of piscivorous fishes and their dietary habits, and it is difficult for a study of this type to eliminate or explain the effects of these variables. Nevertheless, there are some major findings from this study that answer the posed questions.

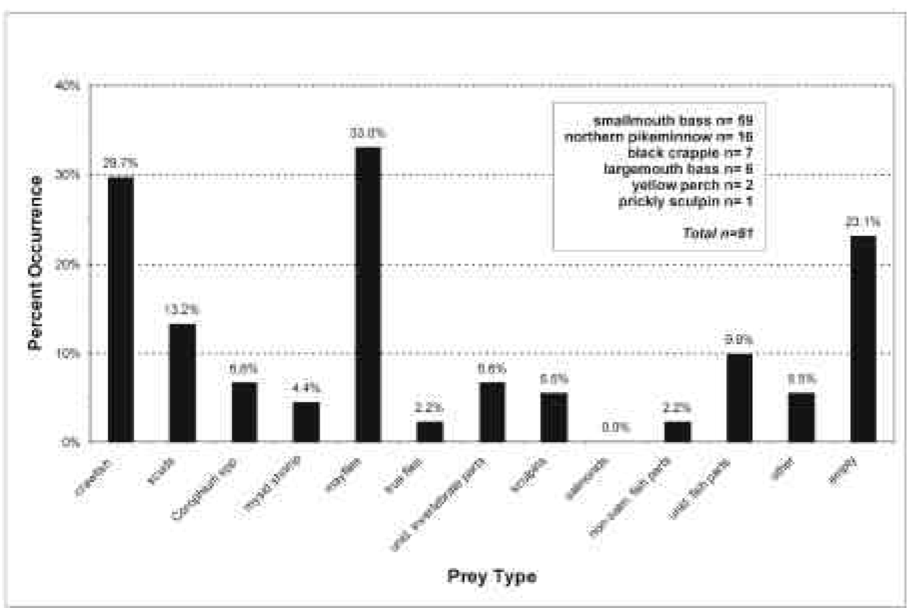

Figure 9. Percentage of various prey types found in digestive tracts of potentially piscivorous fishes larger than 100 mm (all gears, sampling sites, and years combined).

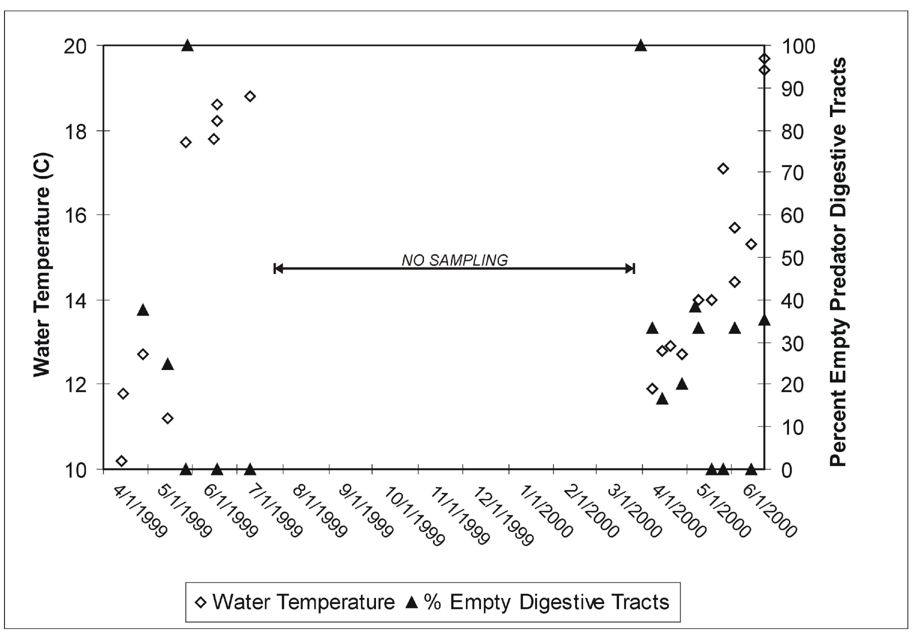

Figure 10. Water temperature and percentage of examined piscivore digestive tracts that were empty by sampling date (1999 and 2000 sampling seasons). See Figure 5 for salmonid abundance.

5.1 Smallmouth Bass Biology/Ecology

The smallmouth bass was the most abundant piscivore in our samples over the two year study; we therefore conducted a literature review of smallmouth bass biology and ecology to inform this discussion. This information is summarized below.

Adult smallmouth bass feed on fish and crayfish in rivers and lakes, and the diet is influenced by prey abundance and availability (Edwards *et al*. 1983[3], Keating 1970). The stomachs of 72 adult smallmouth bass larger than 100 mm length sampled in the Snake River, ID contained 86% crayfish and 11% fish, by weight; 45 bass stomachs sampled from the Clearwater River, ID contained 84% fish and 2% crayfish, by weight (Keating 1970). No salmonids were identified in bass stomach samples; dace, shiners and small suckers were dominant fish remains (Keating 1970).

Scientific literature for the lower, unimpounded Columbia and Willamette Rivers supports the conclusion that juvenile salmonids are typically not a major part of adult smallmouth bass diets in these reaches (Ellis 1999, Zimmerman 1999, Summers and Daily 2001). A study of bass diets in the Willamette River between river miles 36 and 152 (upstream of Willamette Falls) was conducted by Oregon Department of Fish and Wildlife (Summers and Daily 2001) specifically to assess the impacts of bass (large- and smallmouth) predation on ESA-listed salmonids. The major food items in bass stomachs were "other fish", crayfish, sculpins and insects. Zimmerman (1999) found that smallmouth bass and northern pikeminnow in the un-impounded lower Columbia River fed more in the summer (July - September) than in spring (April - June).

Smallmouth bass spawn from mid-April to July, depending on geographic location and water temperature. Bass build spawning nests in shallow water (Scott and Crossman 1973). Nest building and spawning occur at water temperatures of 12.8° to 21.0° C; most spawning occurs at temperatures of 15° C or warmer (Edwards *et al.* 1983). Bass growth starts when water temperatures reach 10-14° C, and adults prefer summer water temperatures of 21-27° C.

Optimum habitat for smallmouth bass consists of cool, clean, mid-order streams wider than 10.5 meters, with abundant shade and cover, deep pools, moderate current, and gravel or rubble substrate. Bass exhibit strong cover-seeking behavior (Wydoski and Whitney 1979) and prefer protection from light (Edwards et al. 1983). Adult smallmouth bass in streams occupy pools or deep areas behind rocks where there is little current (Edwards et al. 1983).

Habitat suitability information for smallmouth bass in Edwards et al. (1983) uses several parameters for the riverine habitat model, as shown in Table 4. For the Eastbank project study area, some of these habitat parameters are the same across sampling areas (i.e. temperature, turbidity, dissolved oxygen, pH). Substrate type and percent cover, however, are more optimal for smallmouth bass along the shore compared to under or around the floating walkway or away from shore.

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[3] The report by Edwards *et al*. (1983) contains an extensive review of scientific literature on smallmouth bass.

Smallmouth bass habitat use is known to be variable; the species is found in lakes, rivers and streams throughout its range (Wydoski and Whitney 1979, Scott and Crossman 1973). The species has been described as a habitat generalist, occupying a variety of depth, velocity and substrate conditions (Bain and Galbreath 1995).

Bass are inactive at temperatures below about 10° C (Edwards et al. 1983). An examination of water temperature data from the lower Willamette River (Morrison Bridge) for the period 1974 through 1999 shows that river water temperature warmed to 10° C during the period March through May (USGS). For the 25 years of data, the water temperature reached 10° C during April of 17 years (68%), and during March or May during 8 years (32%) each.[4]

Table 4. Smallmouth Bass Habitat Suitability Model Parameters (from Edwards *et al*. 1983)

Smallmouth Bass Life Requisite	Habitat Variables	Comments
Food	Substrate type Percent pools Percent cover	- substrate and cover important for food production; crayfish (a major component of bass diet) live on rocky substrates
Cover	Substrate type Percent pools Depth of pools Percent cover	- smallmouth bass prefer broken rock substrate with crevices - pools are primary habitat - pool depth affects cover quality - cover provided by stumps, trees, boulders, crevices
Water quality	pH Dissolved oxygen Temperature Turbidity Total Dissolved Solids	- affect growth and survival - toxic substances not considered in the model
Reproduction	Temperature Water level fluctuations Substrate type Percent cover Dissolved oxygen Turbidity	- temperature fluctuations can affect spawning - water level fluctuations can affect reproduction success - smallmouth bass spawn only on certain substrate types - smallmouth bass usually nest near cover - DO level critical for embryonic development - high turbidity reduces survivability
Other	Gradient	-smallmouth bass usually occur in mid-order streams of moderate gradient (can occur in all stream sizes) - gradient is a factor in pool/riffle formation

[4] Water quality data were generally collected monthly; however, some years had data gaps of 1-3 months. For some years of record, the data only indicate that the target temperature was reached sometime during a 1- or 2-month period.

River water temperature measured during this study was 10.2° C on April 13, 1999, the first sampling date of that year (the USGS data were 8.18° C on March 30, and 12.33° C on April 19, 1999). In 2000, water temperature was 9.4° C on March 30 and 11.9° C on April 7. These data all indicate that smallmouth bass feeding probably started in early to mid-April during the two sampling years, and that this is probably typical for the lower Willamette River. The relationship of this onset of feeding with juvenile salmonid outmigration timing is not clear. The 1999 sampling data show that the salmonid catch was highest at the beginning of the sampling season (April 13) and decreased steadily from that date. The 2000 sampling data are not as clear; however, salmonid catch generally was higher during April (except for wild sub-yearling chinook salmon) (see Figure 5).

5.2 The Predation Issue

The issue of predation on juvenile salmonids by piscivorous fishes has been a major area of discussion and concern by Oregon Department of Fish and Wildlife and National Marine Fisheries Service permit application reviewers for many years. The concern expressed by these agencies is that human-built over-water structures attract piscivores that "hide" in the shade produced by the structures and consume migrating juvenile salmonids that are passing near or under the structure. Because of this concern, the agencies have tended to either recommend denial of permits to build these structures, or have conditioned the permits to limit the amount of surface area and provide light penetration through the structures (i.e. installed grating). There have also been recommendations by the agencies that barges not be anchored in the Willamette River for projects such as bridge construction, repair and maintenance because of this concern about piscivore attraction and impact. The agencies readily admit that their concern is based mostly on assumptions, and that being conservative is the most prudent approach. This present study was requested by the NMFS in order to gather data about this issue.

A Programmatic Biological Opinion (PBO) recently prepared by the NMFS for categories of activities authorized by the US Army Corps of Engineers discusses the predation issue (NMFS 2001). The PBO summarizes information from the scientific literature indicating that native northern pikeminnow (*Ptychocheilus oregonensis*), and introduced piscivores such as largemouth bass (*Micropterus salmoide*s), smallmouth bass (*Micropterus dolomieu*), black crappie (*Pomoxis nigromaculatus*) white crappie (*P. annularis*) and, possibly, walleye (*Stizostedion vitreum*) may utilize habitat created by over-water structures such as piers, float houses, floats and docks. The report states that "the extent of increase in predation on salmonids in the lower Columbia River resulting from over-water structures is not well known."

The NMFS PBO also summarizes literature concerning feeding behavior and strategies employed by piscivorous fish (NMFS 2001). The majority of the literature cited by NMFS, however, is for lakes and reservoirs, where conditions such as current velocities are very different from rivers like the Willamette. The NMFS PBO acknowledges that "predatory fish species that may concentrate around these structures are not expected in riverine environments due to the faster currents away from the shoreline that would require higher energy requirements by the predators to remain around the structure" (NMFS 2001).

Zimmerman (1999) provides important information on predation by introduced fish species in the Columbia River system during salmonid outmigration periods (spring and summer). The results of Zimmerman's work indicate that northern pikeminnow predation on salmonid juveniles exceeds predation by smallmouth bass in the lower Columbia Basin. Smallmouth bass consumed smaller salmon juveniles, and therefore probably have a greater impact on sub-yearling wild chinook salmon during summer. Zimmerman references other studies that based high predation rates of small juvenile salmon by smallmouth bass on the habitat overlap between these piscivores and sub-yearling wild chinook in low-velocity nearshore areas of the Columbia River. Zimmerman (1999) also found that smallmouth bass consumed few steelhead, ate smaller chinook salmon during spring than northern pikeminnow did, and ate many more small, sub-yearling chinook during summer than they ate yearling chinook during spring.

There is a body of scientific literature that suggests a relationship between light levels and fish predation; predatory fish waiting in dark areas may have an advantage over prey species in adjacent lighted areas. This hypothesis, however, must be considered in combination with a variety of other factors, such as current velocity, turbidity, cover, depth, substrate, and temperature (Edwards et al 1983).

5.3 Study Findings

The data collected during this two-year study clearly demonstrate that piscivorous fish species did not congregate around the floating structure and associated pilings. These fish were found in significantly greater abundance in near-shore, shallow water without human structures. Smallmouth bass CPUE was higher at shallow shoreline (1-15 ft) sites than at offshore (25-75 ft) and mixed depth (5-75 ft) sites. The difference between smallmouth bass CPUE at sites with and without piles and over-water structure is possibly driven by depth, as such structures tended to be located in deeper water. River substrate might also be a factor, as this species is known in some areas to prefer cover such as rocks and logs. The preference for shallow-water nesting sites might also have influenced the distribution of larger bass found in this study.

The study data also clearly show that piscivorous fish sampled during 1999 and 2000 were not feeding on juvenile salmonids. Invertebrates, mostly crayfish, mayflies and amphipods, were the main food items in sampled piscivorous fish. Almost one fourth (23%) of the piscivores sampled had empty stomachs. No juvenile salmonids were identified in piscivore stomach contents. Other studies on the lower Columbia and Willamette Rivers cited previously agree with this finding.

There is some evidence in our data that salmonid migration timing might be a factor in low predation on these fish. The 1999 data suggested that the salmonid outmigration peak occurs when bass are not actively feeding, as evidenced by a high percentage of empty bass stomachs in late spring. Bass feeding increases as water temperature increases. Although this relationship was not as evident in the 2000 data, it is considered to be a factor since the date of river water temperature reaching the level at which smallmouth bass become active typically is during or following the peak of juvenile salmonid outmigration (see Figure 10).

Only one member of the targeted piscivorous species (a juvenile northern pikeminnow) was caught near or under the deep water sections of the floating walkway. Of the piscivorous fishes that were caught, most were captured near shore and appeared to have an invertebrate-dominated diet. Piscivore diets were highly variable and appeared to be correlated with changing local abundances of invertebrate species. These data therefore do not yield any evidence that piscivorous fishes use the floating structure as cover from which to prey upon migrating salmonids. The study data indicate that it is unlikely that piscivorous fishes were using the habitat provided by the walkway.

The significantly higher use of shallow-water habitat by piscivorous fishes may indicate that any attraction effect caused by the presence of the floating walkway would be limited to where the structure is near the shoreline. However, no significant difference was seen between shoreline samples with and without the structure.

Water velocity conditions may deter salmonid piscivores from using whatever habitat the floating walkway affords them. Largemouth and smallmouth bass prefer areas with moderate to no current.

A high degree of spatial and temporal variability was seen in samples. Salmonids, carp, northern pikeminnow, and suckers, in particular, appeared in samples irregularly and in large groups. For example, hatchery marked chinook juveniles appeared in large numbers on 13 April 1999, but made up a much smaller percentage of catches in subsequent samples. This is probably attributable to a large upstream hatchery release. Later in the 1999 season, largescale suckers were observed congregating near a combined sewer outfall. Substantial inter-annual variation in wild sub-yearling chinook was also observed.

Small sample sizes and the observed heterogeneity in species abundance complicate data interpretation and indicate that the species in question are somewhat migratory on a daily and seasonal basis. None of the 46 tagged fish were recovered in our samples, and no tags were returned by fishers or other researchers. Local abundance of species appears to depend not only on structural habitat conditions, but on many variables such as food availability, competition, water quality, water velocity, tide, and time of day.

6 CONCLUSIONS

The major conclusions of this study are:

1. Piscivorous fish were not found in greater abundance in association with the floating structure. Only one member of the targeted piscivore species (a juvenile northern pikeminnow) was caught near or under the deep water sections of the floating walkway.

2. Piscivorous fishes were found associated with shallow water and shore, and those sampled possessed highly variable, invertebrate-dominated diets. No juvenile salmonids were identified in piscivore stomachs.

3. Fish samples exhibited a high degree of spatial and temporal variability.

4. Piscivorous fish distribution in the study area appears to be driven more by factors such as depth and flow velocity than by the presence or absence of a human-built floating structure.

5. Water velocity and depth may preclude the use of most of the floating walkway by piscivorous fishes.

The study results indicate that smallmouth bass feeding rates are low during the peak of the spring salmonid outmigration. The study also confirmed conclusions reached by other studies on the lower Columbia River concerning piscivorous fishes and juvenile salmonids. All of these studies provide information that suggests that the relationship between human-built structures and piscivores may not be a major factor limiting populations of outmigrating juvenile salmonids. Any impact to salmonid populations from piscivorous fish in the lower Willamette River is more likely predation on sub-yearling wild chinook salmon in shallow, near-shore habitats during the summer. The abundance and distribution of piscivores and sub-yearling chinook, however, is poorly known because many studies, such as the present one, have focused on the spring outmigration period and daylight hours.

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APPENDIX

Appendix

Sampling gear specifications

Boat electrofisher:
Smith-Root, Inc. Model 5.0 GPP
Settings were adjusted based on conditions (conductivity, temperature) and on observed performance of the unit (strength of observed galvanotaxis and injury/mortality of captured fishes)
In general, electrofisher settings were as follows:

Output pulse mode: DC
Output pulsed frequency: 60-120 Hz
Current output: 2.5 - 4.0 amp
DC output peak voltage: low (50-500 volts)

Gillnets:
Mesh sizes: 3 ½, 3 7/8, 2 7/8 inches

Trot lines:
Hook size: 3/0 Kirbed hooks
Bait: cheese bait, sand shrimp, nightcrawlers
3.5 foot hook interval

Water Quality:
- ICM Aquacheck model 51501 water quality meter (temperature, conductivity, dissolved oxygen, and pH)
- 20 cm secchi disk (water clarity)
- ICM model 11520 turbidimeter (turbidity)