Evaluate juvenile salmonid use of restored floodplain wetlands in the Lower Columbia River Estuary
31014

Response to ISRP

Introduction

The Lower Columbia River estuary is the cornerstone of Ducks Unlimited's Pacific Northwest wetland conservation initiative. Wetland restoration strategies in this ecoregion are driven by the degree to which the tidal pulse dominates the hydrologic regime. In the lower estuary, tidal pulse is the single driving factor influencing wetland habitat, while in the upper estuary river flow levels dictate degree and duration of inundation. Key areas in the lower estuary have been diked, eliminating the tidal pulse and thus converting wetlands. These areas can be easily restored by removing all, or portions of the dikes. However, in the upper estuary, where fluctuating river levels affect inundation of floodplain wetlands, restoration is not as simple. Add to the equation juvenile salmonids and rearing habitat questions, and lack of knowledge severely limits our ability to direct restoration with certain salmon recovery benefits. This proposal intends to evaluate juvenile salmonid use in the upper and lower Columbia River Estuary, and specifically target restoration sites to evaluate use of different wetland ecosystems. We selected sites representative of the upper and lower estuary, and excluded the section of river from St. Helens, Oregon to Cathlamet, Washington. This reach was excluded because of the degree of channelization, extensive diking network, and the general lack of "fish friendly" restoration opportunities. This is not to say that this reach is not important, but rather we felt investigating the upper and lower estuary would yield more useful data.

Restoration sites in the lower estuary are typically subject to "passive restoration" techniques, such as removing dikes and tide-gates, and filling ditches. This is possible because the tide drives the hydrology, and typically what is needed is to provide connectivity of the site with the estuary. In the upper estuary, river channelization, floodplain development, and dams have altered the hydrology. Because the of the disruption of the natural hydrology in the upper estuary an "active restoration" approach is required which mimics the historic hydrology in terms of duration, timing, predictability and recession of the spring flood during draw-down, but cannot mimic the magnitude or frequency of flooding. An example of an active restoration strategy would be the use of a "fish friendly" water control structure to plug a ditch, retain water in the wetland, and hydraulically connect the river with the wetland via the structure.

There is little known about juvenile salmon ecology in the lower Columbia River with regard to off-channel habitat use, especially during winter before the spring smolting migration. Preliminary data, taken near the confluence of the Willamette and Columbia

Rivers, suggests a movement of juvenile (0+ and 1+ age classes) salmon into floodplain wetland habitat upon the first fall freshet. No documentation has been found, however, that suggests a juvenile life-history strategy in which chinook and/or coho salmon move downstream into more productive habitat to overwinter, in which they find a suitable location and rear, or if they are generally migrating downstream, stopping along the way as they head for the estuary. It is also unknown if any life history strategy exists where juvenile salmonids respond to available floodplain habitat in the upper estuary rather than seeking the lower estuary. These basic unknowns demonstrate the need for better information regarding rearing patterns of juvenile salmonids in order to predict the relative contribution of a given habitat restoration project. Without this information, limited funds for salmon habitat restoration will continue to be spent in an opportunistic manner and likely not achieve the goal of salmon recovery.

We have selected five sites representative of restoration opportunities in the lower estuary, and five sites representative of restoration opportunities in the upper estuary. In the lower estuary, we included one site that was restored in 2001, two sites that will be restored in 2003, and two sites that are functioning naturally. We intend to compare fish utilization patterns between the five sites and look for any trend changes as newly restored habitats progress along the successional continuum. In the upper estuary, our objective is to compare juvenile salmon timing of use by age class with the lower estuary, measure trends in seasonal use within the upper estuary and between the upper and lower estuary, and establish residence time and individual growth rates of salmon in the wetland floodplains.

In the upper estuary, where active restoration strategies are implemented, we will evaluate timing of use, residence times, growth rates, but will also address ingress/egress through "fish friendly" structures. This is the fundamental difference between lower and upper estuary projects: the methods of restoration in the upper estuary involve a physical structure that must pass fish. The use of structures has long been a popular wildlife and habitat management tool, but their use in benefiting fishes is relatively new. Uncertainty, revolving around these new applications for water control structures has resulted in a regulatory quagmire that effectively retards habitat restoration projects at a cost that our fish and wildlife resources ultimately bare. An additional benefit from this evaluation will be detailed information on fish passage through several commonly used structures, and ecological information that will assist biologists, planners and managers.

The success of a wetland restoration project is not dependent upon its use by salmonids. Both passive and active approaches have been demonstrated to be successful for waterfowl use but other animals such as amphibians and fishes are likely to benefit as well. We suspect that since salmonids evolved in a Columbia River ecosystem with historically large expanses of floodplain wetland habitat and a very dynamic annual hydrograph, that they took advantage of the access to very productive areas and fed on the abundant invertebrates prior to ocean entry which may have given them a survival advantage. Given the diversity of adult salmon life histories in the Columbia Basin, it is reasonable to expect that similar diversity would be evident in juvenile life histories. Such diversity likely capitalized on rearing habitats being available throughout the lower

Columbia estuary, and seeding different habitats at different times reduced competition and predation.

We expect this information to test the assumptions that water control structures allow passage of salmon as designed and that salmon use floodplain wetlands in the upper estuary as well as the lower estuary throughout the winter and spring. This information will contribute to a more directed restoration effort with known benefits to salmonids.

Study Sites

Lower Estuary
Two natural tidal marshes and three recently restored tidal marshes will be sampled for juvenile salmonid use in Grays River from November to June 2003 through 2005. The two natural sites are at the mouth of Secret River and Seal Slough (fig. 1), which are spruce bog wetlands. Of the restored sites (fig. 1), one had been restored in 2001 and the other two will have dikes removed and some re-contouring of the area around the dike during the summer of 2003. They will be in an early successional phase that will eventually reach the condition of the natural sites.

Some preliminary sampling has been done in Seal Slough late May of 2001 in which juvenile coho from 40 to 60mm were caught from samples taken within several tidal channels.

Upper Estuary
Five sites near the confluence of the Willamette and Columbia Rivers that are under active management have three different types of water-control structures and will be sampled for fish use from November to June 2003 through 2005 (fig. 2).

The furthermost upstream site is a large seasonal wetland that was impounded to create Smith and Bybee Lakes in the Portland area (fig. 2). During the summer of 2002, the existing dam will be removed and replaced with three box culverts and a fish ladder. This will permit fish use of the wetland from the North Columbia Slough and management capabilities of the water level to better mimic historic conditions and allow tidal influence into the wetlands.

Preliminary sampling in the North Columbia Slough (that drains the lakes) during November 2001, February and March 2002 has demonstrated juvenile coho and chinook salmon in the 1+ and 0+ age classes. Juvenile salmonids have been known to enter Smith and Bybee Lakes during high-water events that topped the existing structure (Fishman 1986) however, the existing structure does not allow for their egress.

Two sites to the west of the Multnomah Channel have a full-round riser and reverse tide-gate (Multnomah North) and a sloping-weir-fishway (Multnomah South) (fig 2). The sloping-weir-fishway at Multnomah South is an experimental structure similar to a baffled culvert but has water management capabilities. Multnomah North has been sampled during the winter and spring of 2000/01 and 2001/02. The water-control

structure was built during the summer of 2001 but the riser boards have not been put in and water is allowed to flow through freely, so that there will be two years of "pre-treatment" data. Riser boards will be used beginning in November of 2002 so that the structure functions as designed.

Two sites on the north end of Sauvie Island, Ruby and Wigeon Lakes have full-round riser water control structures with reverse tide-gates (fig 2). The structure at Ruby Lake has been functioning since the monitoring effort began in the winter of 2000/01. The structure at Wigeon Lake, which is identical to Ruby Lake and Multnomah North, was built but did not have the riser boards installed so water flows freely providing two seasons of "pre-treatment" data. The boards will be installed in November of 2002 so that the structure functions as designed.

Methods

Lower Estuary
Fish use - Tidal channels in the Grays River area will be sampled with seines. Channels will be block netted off at high tide and seined at low tide to capture fish. This will be done in a standard manner using the same method of Dr. Bottom so that catch data can be compared not only between our sites, but between studies. Each of the five sites will be sampled monthly between November and June. Species, fork length, and weight will be recorded.

Upper Estuary
Fish use - Sampling within wetlands will be done seasonally using trap nets (Oneida, fyke and box traps) in a standard fashion. The standard seasonal wetland sampling (SSWS) has three objectives; first to capture salmonids in the wetlands prior to encountering the structures in order to tag the fish so that they may be captured later below the structure to show passage, duration of stay and perhaps growth; second, so that catch of the assemblage of fishes in the wetlands, which may not include the more mobile fishes caught at the traps below the water control structures, can be documented on a seasonal basis and a comparison made with catch at the control structures, which will be monitored more continuously than the SSWS; and third, because the sampling is done similarly at all sites, a comparison of relative abundance (catch per unit effort) and species composition can be made between sites. Sampling may be stratified, depending on the site, and locations within strata will be randomized. Trap, location, set, species, fork length (±1mm) and wet weight (± 0.1g) (salmonids only) will be recorded for fish caught during the SSWS. Salmonids will be scanned for previous PIT (passive integrative transponder) tags and PIT tagged (if > 70mm) if no previous tag has been inserted.

Fish sampling in wetlands has not been done extensively by fisheries biologists and poses some significant challenges. Water levels and shorelines make it difficult to compare from time to time. In a typical pond or lake sampling situation, there is a distinct shoreline that fluctuates somewhat but not to the degree of a seasonal wetland. The surface area of the seasonal wetland can expand or contract by an order of magnitude

depending on the discharge of the river thereby causing capture efficiency of any gear to change drastically. Since the shoreline is a moving target and the set nets are anchored from shore so, randomization of net sets becomes very difficult to plan before going out to the site. We have tested different gear to determine what is practical to use in seasonal wetlands, what yields the greatest capture efficiency, and if a mark and recapture population estimate is possible. We are working with the monitoring and evaluation group of NMFS (Dr. Steven Katz) to develop standard methods that can be used regionally so that cross-study comparisons can be made.

Trapping below the water control structures with two-way vertical slot traps will allow us to ascertain what fish, tagged or not, salmonids or other species, are entering and leaving the wetlands and will begin as soon as the water begins to flow through the wetlands. Traps will be checked on a regular basis (daily or every other day). Salmonids will be scanned for previous tags and tagged if no previous tag exists. Salmonids caught within a wetland will be PIT tagged so that they may be detected lower in the river at a juvenile fish bypass PIT tag interrogator or by the PIT tag trawl in the Lower Columbia River. Fish caught in traps will be identified to species and fork length (± 1mm), wet weight (± 0.1g) (salmonids only), trap type (*i.e.* fyke, 2-way), and direction (*i.e.* in, out for 2-way traps) will be recorded.

Twenty 1+ salmonids at Multnomah north and south units will be surgically implanted with radio transmitters (Lotek model NTC-3-1 – 0.85g air weight, up to 23d battery life) to track movements through wetlands and over water control structures. Fish will be caught entering the wetlands in fyke nets or two-way traps, anesthetizes with MS-222, and surgically implanted with the radio tag as described by Summerfelt and Smith (1990). After implantation, fish will be kept in a net pen in the wetland for up to 24 hours and released. The transmitters have an expected life of 23 days. Each transmitter has a unique code on a frequency (up to 212 codes per frequency), making each tagged fish individually recognizable. Fish will be tracked with mobile antennae and receiver on a daily basis and fixed station antennae will be installed at the trap sites or locations where the fish would leave the wetland to re-enter riverine habitat. There may be opportunities to track the radio-tagged fish down the Columbia further if we can get on an Oregon State Patrol (OSP) flight. OSP has a fixed-wing aircraft that is equipped with an antennae with a pilot experienced in tracking fish who helps ODFW with waterfowl counts on a bi-weekly basis. Also, Oregon State University Department of Fish and Wildlife has been studying juvenile salmon movement in the Lower Columbia River and may be continuing their work during the same time period in which they will have fixed station antennae and will be able to record fish tagged by DU. We are coordinating with them this year to record our radio tagged fish as they pass by their fixed-station antennae in the lower Columbia River.

Other standard procedures that will be implemented at all structure locations, include recording the stage of the water from the staff gage at the structures on a regular basis and deploying temperature probes, such as Onset Corp. Hobo® temperature probes, that will be set to record temperatures on an hourly basis. Water level and temperature are

likely important variables that may help explain why fish are moving into and perhaps staying in the off-channel habitat as well as why they may be leaving this habitat.

Study Being Developed

An important component of our overall objective is to compare juvenile salmonid diet with food availability among and between sites in the lower and upper estuary. We believe that the reason that juvenile salmonids are seeking out and using these tidal marsh and floodplain wetland habitats is for the abundant food present which presumably translates into increased biomass and survival at the individual and population levels. This in combination with fish use and instantaneous growth rates (see below) will further our understanding of how salmonids are benefiting from this habitat.

We will be seeking other funding for a study that quantifies invertebrate availability and juvenile salmonid diet in the lower and upper Columbia River estuary sites so that direct comparisons can be made. We have approached the Stream Ecology Lab at Oregon State University Fish and Wildlife Department for partnering opportunities. To determine invertebrate availability we will stratify each site by channel and tidal marsh/floodplain wetland habitats. We will compare the two natural sites and two recently restored sites in the lower estuary and two active restoration sites in the upper estuary. In this study, lower and upper estuary data can be directly compared. Standard sampling methods of the channel involve the use of drift nets and a Surber sampler and for the tidal marsh/floodplain wetland sampling we will use a Hess sampler, in which the vegetation is agitated so that invertebrates on the surface are collected into the sock and sod is extracted with a trowel and processed by breaking it up over a series of screens and running water (previously strained) over it to remove invertebrates. Plankton-tow nets will also be used in each strata. The drift net and plankton tows yield a density of invertebrates per volume of water filtered and the Surber and Hess samplers yield a density of invertebrates per area metric. From this data we can compare density and diversity of invertebrates at each site. To determine juvenile salmonid diet, a minimum of 10 1+ coho salmon will be sampled by gastric evacuation during regular monthy sampling. Sampling will occur in January, March and May from 2003 to 2005.

Related Studies

Dr. Dan Bottom at the Fish Ecology Division of the National Marine Fisheries Service is studying juvenile salmon used of tidal marshes nearby in channels on Karlson and Russian Islands, which are part of the Lewis and Clark National Wildlife Refuge. We are sampling in the same manner as Dr. Bottoms so that our data may be compared.

Dave Ward at Oregon Department of Fish and Wildlife has been studying seasonal use of tributaries and the mainstem of the lower Willamette by juvenile salmon. His fisheries technicians have been sampling smaller tributaries with backpack electrofishing and some seining in the mainstem from sandy beaches. A preliminary data collection effort by Ducks Unlimited and the City of Portland in the North Columbia Slough and Columbia Slough near Smith and Bybee Lakes (fig. 2) using Oneida Lake Traps has yielded several 1+ chinook and coho salmon as well as fry. Though the sampling methods used by ODFW are not practical for this habitat type, presence by species and

age class by season can be compared and the information adds to the general knowledge of salmonids entering off-channel habitats during the winter and spring.

Ducks Unlimited, in partnership with others such as Willapa Bay National Wildlife Refuge, Washington Department of Fish and Wildlife, Tualatin National Wildlife Refuge, and the Yakama Nation, are monitoring fish use of wetland habitats and passage through many types of water-control structures currently in use. We are working to gain understanding of fish use of freshwater wetlands in Willapa Bay, near the mouth of the Chehalis River, wetlands in a meander of the Yakama River at Satus Wildlife Area, and in the lower Tualatin River.

Ducks Unlimited, in collaboration with Dr. Barbara Shields at Oregon State University, is researching the use of RNA:DNA ratios to determine instantaneous growth rates of salmonids in habitat where it is difficult to recapture uniquely marked individuals across time to assess growth that has occurred between sampling periods. Development of a repeatable, accurate methodology for quantifying the ratio of RNA:DNA in fishes will facilitate rapid and reliable assessment of relative growth of any of several species of animal that utilize wetlands with which Ducks Unlimited is involved. Such assessments can be used to monitor the relative success of various habitat-restoration and management plans for production of various target fish and wildlife species. The procedure involves taking a tissue sample about the size of half-grain of rice, and flash freezing the sample. This has been successfully done in coho salmon as small as 60mm without mortality (Baker and Strobel 2000). In the lab, RNA and DNA fractions are extracted and quantified. The RNA:DNA ratio reflect increased quantities of RNA per cell in the fish's tissue at the time the tissue sample was taken (Bulow 1987). This ratio has been shown to be well-correlated with growth rate and condition of fish (Varnavskiy et al. 1992, Azuma et al. 1998, Steinhard and Eckmann 1992,). This has been shown to be a sensitive method of assessing long-term (Haines 1973) as well as instantaneous growth for numerous freshwater and marine species (Clemmesen and Doan 1996, Buckley et al. 1999), including salmonids (Varnavskiy et al. 1992). Using newly-developed, fluorometic dye-binding assays for quantitative assessment, responses indicating the resumption of growth in starved fish can be detected within literally hours of resumed feeding of starved fish (Bulow 1987). Dr. Shields will be validating that the extraction method accurately measures RNA and DNA concentrations and estimating extraction efficiencies for further method development in April of 2002. We will be submitting a grant for further validation correlating growth over time in an experimental aquaria study then field-testing the method after the initial validation in April. Field testing will compare juvenile salmonids in the lower and upper estuary sites described in this proposal and with juvenile salmonids in the mainstem. This method will be standardized across the region for cross-study comparisons and will provide a useful tool for evaluating performance of juvenile salmon in different habitats without having to recapture individuals across time.

Ducks Unlimited is undertaking a hydrologic modeling exercise in which historic gage data (daily average water surface elevations [WSE] of the Columbia River at The Dalles), from 1898 to present, is related to a gage on the lower Columbia River (Columbia River

at Vancouver). We will overlay pre- and post-Columbia River dam WSE adjusted for the lower Columbia River over a digital elevation model (10m pixel) in the Sauvie Island area to compare historic and current extent of inundation (spatially and temporally), and patters of rise and fall of water in wetlands so that we can compare historic patterns with our water management plans. We will validate our model with historic photos of known date to test accuracy of our model. If this endeavor is successful, we will consider expanding this effort to other locations that we are working to compare the historic hydrologic patterns with what we are trying to mimic.

Comments

Our overall vision for monitoring in the lower and upper Columbia River estuary is to compare fish use of these habitats seasonally, diet of juvenile salmonids using the tidal marsh and floodplain wetland habitat compared with food availability in these habitats, and compare instantaneous growth rates using RNA:DNA ratios of juvenile salmonids in the lower and upper estuarine habitats with those in riverine habitats. All this is in context of the hydrology, in which fish use and off-channel productivity revolves around.

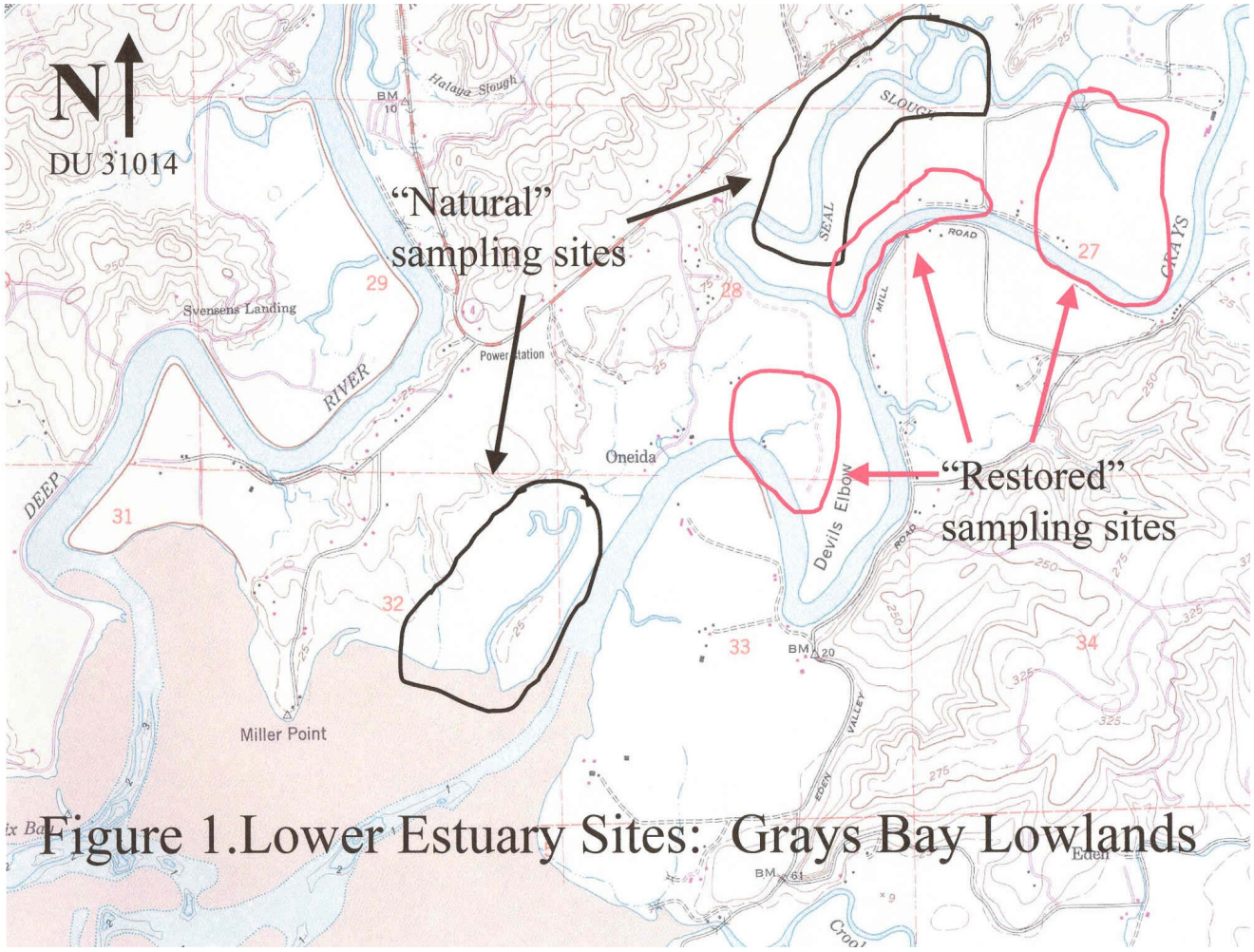

Figure 1.Lower Estuary Sites: Grays Bay Lowlands

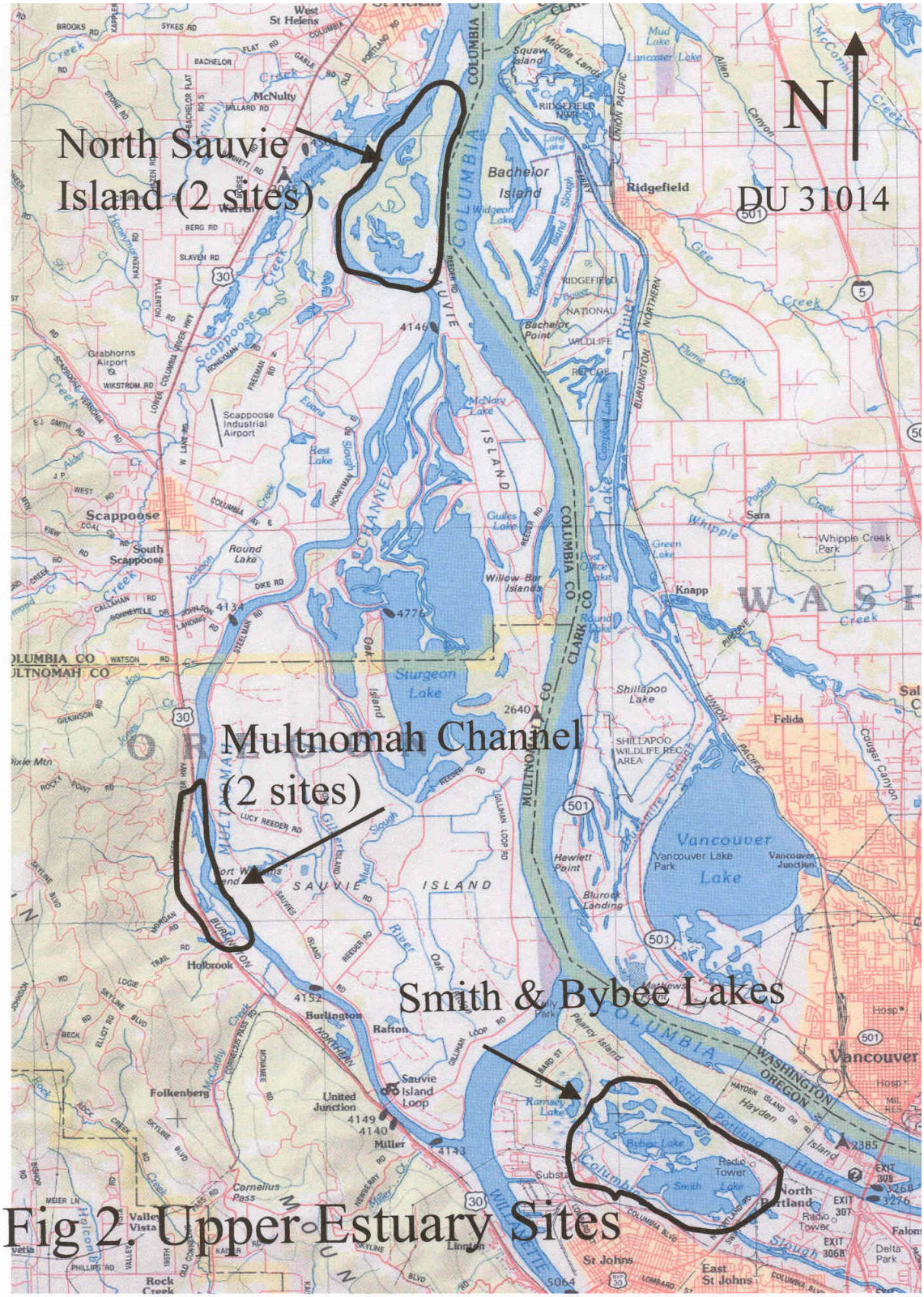

Fig 2. Upper Estuary Sites

Literature Cited

Azuma, T., T. Yada, Y. Ueno, and M. Iwata. 1998. Biochemical approach to assessing growth characteristics in salmonids. N. Pac. Anadr. Fish Comm. Bull. No.1: 103-111.

Baker, C. and B. Strobel. 2000. A comparison of instantaneous growth rates of juvenile coho salmon in North Fork Reservoir, the upper Clackamas River, and off-channel habitat of the Clackamas River, Oregon. *In* 1999 Accomplishments Report for the Clackamas River Fisheries Working Group.

Buckley, L., E. Caldrone and T.-L. Ong. 1999. RNA-DNA ratio and other nucleic acid-based indicators for growth and condition of marine fishes. Hydrobiologia 401: 265-277.

Bulow, F.J. 1987. RNA-DNA ratios as indicators of growth in fish: A review. P. 45-64 *in* Age and Growth of Fish. R.C. Summerfelt and G.E. Hall, eds. The Iowa State University Press, Ames.

Clemmesen, C. and T. Doan. 1996. Does otolith structure reflect the nutritional condition of a fish larva? Comparison of otolith structure and biochemical index (RNA/DNA ratio) determined on cod larvae. Marine Ecology Progress Series 138: 33-39.

Fishman, P. 1986. Smith and Bybee Lakes Environmental Studies: Technical Appendix G- Fish. Fishman Environmental Services, 48pp.

Steinhart, M. and R. Eckmann. 1992. Evaluating the nutritional condition of individual whitefish (Coregonus spp.) larvae by the RNA/DNA ratio. Journal of Fish Biology 40: 791-799.

Varnavskiy, V.S., N.V. Varnavskaya, S.V. Kalinin, and N.M. Kinas. 1992. RNA/DNA index as an indicator of growth rate of coho salmon (*Oncorhynchus kisutch*) during early marine life. J. Ichthyology 32(2): 10-19.