Review of the draft Biological Assessment and Essential Fish Habitat Assessment for Proposed Oregon LNG Terminal Project

Juvenile salmonid sampling - Lower Columbia River Partnership photo

Report to:

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Introduction and Background

This review focuses on impacts of the proposed Oregon LNG (Liquiefied Natural Gas) project on Endangered Species Act (ESA) listed salmonids below the high-water mark at the proposed Oregon LNG (OLNG) terminal site.

The report specifically addresses the likely impacts of construction and operation of the proposed OLNG Terminal and associated facilities on ESA-listed salmonids in the project area, especially in relation to Youngs Bay, an important salmonid producing and rearing site. Potential impacts are described in two sets of documents:

1. Applicant-Prepared Draft Biological Assessment and Essential Fish Habitat Assessment for the Oregon LNG Terminal and Oregon Pipeline Project, prepared by CH2MHill (December 2013);
2. Supplement to Applicant-Prepared Draft Biological Assessment and Essential Fish Habitat Assessment for the Oregon LNG Terminal and Pipeline Project, prepared by CH2MHill (April 2014); and
3. Supplement to the Joint Permit Application for the Oregon LNG Bidirectional Project, prepared for the U.S. Army Corps of Engineers by CH2MHill (October 2014).

The report has three sections and conclusions that discuss:

1. ESA-listed salmonid presence and use of the section of Youngs Bay where OLNG proposes dredging and building an industrial dock.
2. The impact of dredging and building an industrial dock on ESA-listed species.
3. The potential impacts of LNG vessel traffic on ESA-listed salmonids.

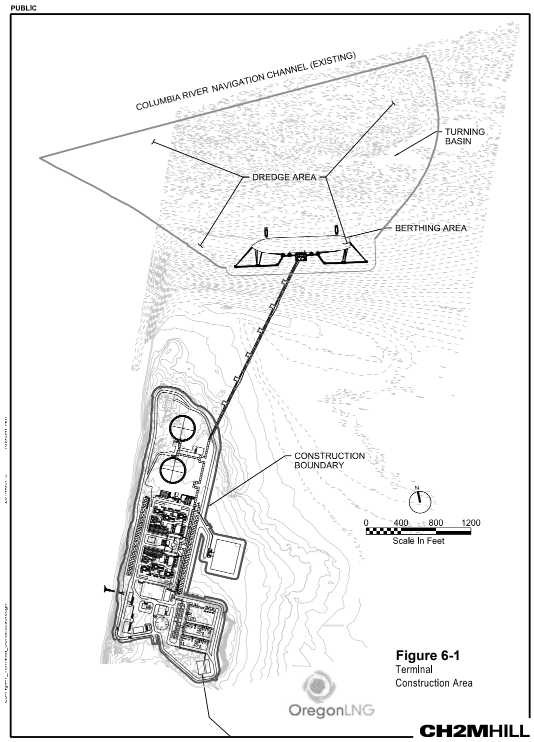
The report also discusses the overall role that the Lower Columbia River and estuary (LCRE) play in the life history of Columbia River salmonids, particularly for ESA-listed salmonids. It summarizes recent research and knowledge about adult and juvenile abundance and distribution in the LCRE and in the vicinity of the OLNG project. It also discusses how the BA does not adequately report on recent relevant research studies and or adequately consider their implications with respect to the project's likely impacts to these resources.

The Oregon LNG Project

Oregon LNG proposes to construct and operate a bidirectional onshore LNG Terminal and facilities on the northern portion of the east side of the Skipanon Peninsula near the confluence of the Skipanon and Columbia rivers in Clatsop County, Oregon (Figure 1). The Terminal would be located at RM 11.5 on the Columbia River and would include a turning basin and berth for loading and unloading LNG carriers and onshore facilities to process natural gas for shipment to foreign markets or transport into the U.S. natural gas transmission grid.

The proposed Terminal site would comprise 81 land acres above the mean high water line, while the marine facilities associated with the Terminal would be located in an adjacent aquatic area of approximately 150 acres. The aquatic facilities would require dredging of 17 acres in the berthing area and 135 acres in the Turning Basin adjacent to the federal navigation channel, where LNG carrier ships could be maneuvered (with the assistance of tugs) from the river's navigation channel to the berthing dock for LNG transfer.

Figure 1. Proposed Oregon LNG Terminal including land-based receiving and processing facilities, LNG storage tanks, pier and ship berth, and dredged turning basin (Figure from USACE NWP 2005-748).



The Role of the Estuary in Salmonid Life History and Productivity

The Lower Columbia River estuary is one of three major habitats that all Columbia River salmonids transit in their life history pathway moving between freshwater and marine environments. All salmonids migrating out of and back into the Columbia River Basin pass through the estuary twice. A growing body of evidence, much of it quite recent (Bottom et al. 2005; Roegner et al. 2012; Weitkamp et al. 2012), provides increasing insight into the important role that shallow water estuarine habitats in the LCRE play in stabilizing production for Columbia River salmon and steelhead, particularly upriver ESA-listed populations.

A properly functioning estuary, with its diversity of habitats, functions as a vital link in the overall productivity of Columbia River salmon and steelhead stocks, especially for ESA-listed stocks and wild fish recovery goals. Estuarine habitats provide diverse rearing habitat and high growth opportunities for outmigrating juvenile salmonids and also provide protection from predators (NMFS 2011; Roegner et al. 2012). The estuary is also an important staging area where juvenile and adult salmon, steelhead, and trout undergo significant physiological changes that allow transition to and from saltwater.

The Lower Columbia River Estuary

Regional fisheries planners broadly define the Columbia River estuary as the portion of the Columbia River from Bonneville Dam (River Mile [RM] 146) to the mouth of the Columbia River, including the Columbia River plume. This area includes the entire continuum where tidal forces and river flows interact, regardless of the extent of saltwater intrusion (Northwest Power and Conservation Council 2004; Fresh et al. 2005; NMFS 2011). To further aid management and planning for this 150+ mile river reach, planners organize the estuary between the mouth and Bonneville Dam into eight lettered reaches (Lower Columbia River Estuary Partnership 2005). The current total surface area of the Columbia River estuary is approximately 159 square miles, reduced about 15% from historical estimates (circa 1880) of 186 square miles (Simenstad et al. 1984 as cited in Northwest Power and Conservation Council 2004).

The Oregon LNG Project Site and adjacent Habitats

The proposed Oregon LNG Project site (land-based facilities, 5000 foot pier, loading berth, and the dredged turning bay) lies along the Oregon (southern) shore in the middle of Reach A. the lowest of the eight designated LCRE management reaches (Figure 2). Conservation and recovery planning efforts in the Oregon portion of Reach A are directed by the Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead, which serves as both a federal recovery plan for Oregon fish populations listed under the ESA and a State of Oregon conservation plan under Oregon's Native Fish Conservation Policy (ODFW 2010).

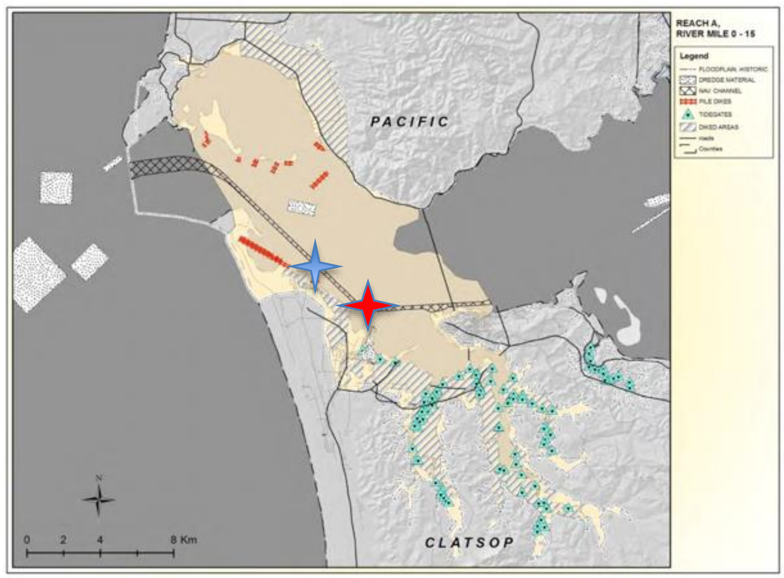


Figure 2. Site of Proposed Oregon LNG Terminal (red star in figure) within the Lower Columbia River Estuary Reach A management zone. The blue star denotes Point Adams Beach, a sampling site near the OLNG project site for several juvenile salmon research studies. (Figure from NMFS 2011).

This area (Reach A) includes the estuary entrance (Clatsop Spit and Trestle Bay), Bakers Bay, and Youngs Bay. The entrance is dominated by subtidal habitat and has the highest salinity in the estuary. Historically, the estuary entrance was a high-energy area of natural fluvial landforms with a complex of channels, shallow water, and sand bars (NMFS 2011). Coastal range tributary rivers in the LCRE include the Elochoman and Grays rivers in Washington and the Lewis and Clark, Youngs, and Clatskanie rivers in Oregon.

Youngs Bay, the major Oregon tributary in Reach A, is characterized by a broad floodplain and historically was abundant in tidal marsh and swamp habitat. Diking and flood control structures have been used to convert floodplain habitat in the area to pasture. Reconnecting wetlands that were disconnected by dikes is a priority recommendation in the Youngs Bay Watershed Assessment (E&S Environmental Chemistry, Inc. and Youngs Bay Watershed Council 2000) and the Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (ODFW 2010). Similarly, the 2008 BiOp for upriver salmon stocks (coho, Chinook, sockeye, steelhead above Bonneville) also sets a high priority on restoring shallow water habitats throughout the estuary, including Reach A, including some of the restoration projects in Youngs Bay and the Skipanon River, which were specifically designed to improve survival of upriver stocks (NMFS 2008).

ESA-Listed Salmonid use of the Lower Columbia River Estuary.

Many Columbia River runs of salmon, steelhead and trout are presently listed under the ESA and pass through waters that would be affected by the OLNG project during their life cycle. Several of these ESA-listed runs also spawn or rear in adjacent areas and would be affected by various aspects of the project. The project would have numerous negative effects on habitats for a sizable number of these populations of salmon, steelhead, and trout, as listed in Table 1. The ONLG Biological Assessment's determinations of the project's effects on these salmonid populations are summarized in Table 1.

The OLNG BA's determinations are likely to underestimate the negative effects on these populations, as the BA does not fully consider the extent, intensity, and duration of the proposed project's likely negative cumulative effects on these populations and their habitats into the future, as explained in greater detail in these comments.

While many ESA-listed salmonids (Table 1) occur near or in proximity to the proposed OLNG project site, shallow estuarine habitats near the site are not used equally by all salmonids. The following section of the report provides an overview of species presence and habitat quality in the area Oregon LNG proposes dredging and building a dock. It describes an evolving view of how salmonids use the LCRE area and summarizes recent research in and around Youngs Bay, the nearest salmon production zone to the project site. Finally, it describes likely impacts of the proposed Oregon LNG project on ESA-listed salmonids in the project area.

Salmon Recovery and the Lower Columbia River Estuary

Salmon recovery efforts started in earnest in the 1980s with the passage of the Northwest Power and Conservation Act, which formed the Northwest Power and Conservation Council and led to development of its Columbia River Fish and Wildlife Program (McConnaha et al. 2006; Williams 2006). The Council's Fish and Wildlife Programs attempt to mitigate for development of the federal Columbia River hydroelectric system's impacts on fish and wildlife. The program initially focused primarily on hatchery development and fish passage issues, but after the suite of ESA listing of Columbia River salmon and steelhead populations in the early 1990s (Table 1), the program became more ecosystem oriented including directing attention and mitigation funding toward fisheries projects in the Columbia River estuary (ISG 1999; Northwest Power and Conservation Council 1994; 2000; Bottom 2006;).

In the early stages of salmon recovery planning, the Lower Columbia River and estuary were thought of primarily as a corridor of poor habitat, through which outmigrating juvenile salmonids and returning adults passed in their journeys between the important upriver freshwater spawning areas and the nutrient-rich marine environments where salmon and steelhead obtained the majority of their growth. The fisheries community's understanding of the role and importance of LCRE habitats for salmon survival and production has changed considerably since the ESA listings, especially over the last decade, due to research conducted in the LCRE by fisheries scientists in the Pacific Northwest.

A key series of research articles produced by Dan Bottom and colleagues at NOAA and ODFW have elucidated the important role that estuarine habitats play in reducing juvenile mortality and stabilizing salmon production (Bottom 2005a, 2006, 2008). Recent comprehensive sampling of juvenile salmonid distributions in the LCRE (Roegner et al. 2012; Weitkamp et al. 2012), and of adult salmonids in Youngs Bay (ODFW; Josie Thompson, lead researcher) are demonstrating the greater use and greater importance of these habitats for downstream migrating salmonids than previously recognized. For example, a recent summary of habitat monitoring (2005 – 2010) in the LCRE by the Lower Columbia River Estuary Partnership showed that juvenile Chinook abundance was positively related to species richness of all vegetation species (Sagar et al. 2013). <u>The proposed Oregon LNG project site lies in the midst of all the areas sampled in these studies, so their results have direct bearing on how the project is likely to impact salmonids in Reach A of the LCRE</u>.

Table 1. Summary of salmonids[1] (salmon or trout populations) that might be affected by the Oregon LNG project, including the ESA Listing status of each population, times that adults or juveniles might be in the project area[2], and the and effect determination[3] for each of these populations and their critical habitat in the Biological Assessment.

DPS or ESU populations of salmon or trout potentially affected	ESA Status	Salmonid Use in Project Area			BA Effect Determination	
		Adult Migration	Juvenile Migration	Juvenile Rearing	ESU / DPS	Designated Critical Habitat
Lower Columbia River Chinook	T	Mar – Apr	Feb – Sept (May –Jul peak)	Year round	LAA	LAA
Upper Columbia River Spring-run Chinook	E	Mar – May	Apr - July	Apr – Aug	LAA	LAA
Upper Willamette River Chinook	T	Feb - July	*Two periods:* Feb – June Aug - Dec	Year round	LAA	LAA
Snake River Spring/Summer-run Chinook	T	Feb - Aug	Apr – June	Apr - Oct	LAA	LAA
Snake River Fall-run Chinook	T	Jul – Sept	Feb – Nov	Feb - Nov	LAA	LAA
Columbia River chum	T	Oct - Nov	Feb - May	Feb - June	LAA	LAA
Lower Columbia River coho	T	Aug - Feb	Apr - June	Apr - June	LAA	LAA
Snake River sockeye salmon	E	May - Aug	Apr - June	Apr - July	LAA	LAA
Lower Columbia River steelhead	T	Dec – Sept *Two Peaks:* June – Aug Jan - March	Mar - July	Mar - Aug	LAA	LAA
Middle Columbia River steelhead	T	Apr - Jan	Mar - June	Mar - June	LAA	LAA
Upper Columbia River steelhead	T	June - Oct	Apr - June	Apr - July	LAA	LAA
Upper Willamette River steelhead	T	Nov - Apr	Mar - July	Mar - July	LAA	LAA
Snake River Basin steelhead	T	June - Oct	May - July	May - July	LAA	LAA

[1] Salmonids are listed in terms of a Distinct Population Segment (DPS) or Evolutionary Significant Unit (ESU) by the agencies responsible for the ESA-listed populations.

[2] Dates are derived from tables 3.9.3 – 3.9.5 and others in Section 3 in the OLNG BA.

[3] The agencies responsible for ESA-listed populations of salmonids use a process for estimating the effects of activities on these listed populations in terms of three categories of effect determinations: “May Affect, Likely to Adversely Affect” (LAA), “May affect, not likely to adversely affect” (NLAA), and “No Effect” (NE). See Tables 3.8-1 and 6-1 in OLNG BA.

Thirteen ESA-listed salmonids (salmon or trout populations) pass through the Lower Columbia River and estuary habitat near or in proximity to the proposed Oregon LNG site (Table 1). Likely impacts of the OLNG's proposed project, affected resources, and duration of the impact are listed in Table 2.

Table 2. Summary of the proposed project's likely impacts, affected resources, and duration of the impact[4].

Element / Process affected	***Impact***	***Negatively affected resource***	***Activity contributing to effect***	***Duration***
Shallow mainstem salmonid habitat	Destruction and elimination	Salmonid populations	Dredging	Construction Period; intermittent thereafter
Turbidity and suspended sediment	Degraded	Salmonid populations and water quality	Dredging, terminal construction and operation	Construction Period; intermittent thereafter
Sedimentation	Degraded	Salmonid populations	Terminal construction and operation	Long-term
Water temperature	Degraded	Salmonid populations	Terminal construction and operation	Long-term
Wetland hydrology	Degraded	Salmonid populations, water quality, and water quantity	Terminal construction and operation	Long-term
Water quantity (peakflow and low flows)	Degraded	Salmonid populations	Terminal construction and operation	Long-term
Watershed disturbance levels	Degraded	Salmonid populations, watershed processes	Terminal construction and operation	Long-term

[4] See OLNG BA Tables 3.4-17 and 3.4-18.

Salmon Life History Patterns

A brief discussion of salmonid life histories sets the stage for a review of recent research on juvenile and adult salmonid use of the LCRE and Youngs Bay area. In general, anadromous salmonids employ one of two strategies for juvenile growth and outmigration. Salmonids with "Stream-type" life histories typically reside in freshwater streams for extended periods (1-2 years) before migrating to the ocean as yearlings. They also generally have extensive offshore migrations during their ocean residency. In contrast, salmonids with an "Ocean-type" life history typically migrate to the ocean during their first three months as subyearlings, but move more slowly downstream from their natal tributaries and the Columbia River and may spend up to a year in freshwater before their outmigration to the marine environment. Ocean-type fish generally use estuary and coastal habitats much more extensively than other Pacific salmon.

Chinook salmon exhibit both stream- and ocean-type life histories. Yearling Chinook, coho, sockeye, and steelhead generally display a stream-type life history and are thought to pass quickly thorough the estuary in the broad deep channels that bisect the predominantly flat estuary. In contrast, subyearling Chinook (mostly fall run) and chum salmon transit the estuary much more slowly and may spend extended rearing and growth periods in shallow waters close to shore before outmigration (Bottom et al. 2005a; 2005b).

ESA-listed salmonid use of the LCRE near the OLNG project site

Past and Present Research Studies on Salmonids in the LCRE

a) Studies by Dan Bottom and colleagues.

Dan Bottom, a researcher for NMFS (previously with ODFW), has a four-decade history of research in the Lower Columbia River and estuary (Bottom et al. 2005a; 2006, 2008, 2011).

Studies by Bottom and colleagues over the last several decades have redefined how fisheries scientists and managers think about estuaries and near shore plumes and the important role they play in juvenile salmon survival, and therefore system-level salmon production. Before this work, estuaries were thought of primarily as corridors of poor habitat, through which outmigrating juveniles salmonids and returning adults passed in their journeys between upriver freshwater spawning areas and the nutrient-rich marine environment.

Study of Salmon River (OR) estuary. Bottom et al's work in Oregon's Salmon River estuary (2005b) was pivotal in developing a new understanding of the role estuaries play in stabilizing salmon production. Implications from that work profoundly influenced subsequent research and work by the Action Agencies[5] in the Lower Columbia River estuary.

Work by Bottom and colleagues in Oregon's Salmon River estuary (2005b) examined

[5] The Actions Agencies are three federal agencies charged with operating the Columbia River system and its suite of hydroelectric projects to provide protection to fish. The Action Agencies are the U.S. Army Corps of Engineers, (Corps), Bureau of Reclamation (Reclamation), and Bonneville Power Administration (BPA).

variations in juvenile life history of fall-spawning Chinook salmon for evidence of change in estuarine residency and migration patterns following the removal of dikes from 145 ha of former salt-marsh habitat in the Salmon River estuary. The research identified three distinct juvenile life history patterns that included extensive use of restored marsh habitats by fry and fingerings. In an earlier study before the restoration of the diked wetland marshes (1975-1977), fry were absent from the estuary during the spring and early summer.

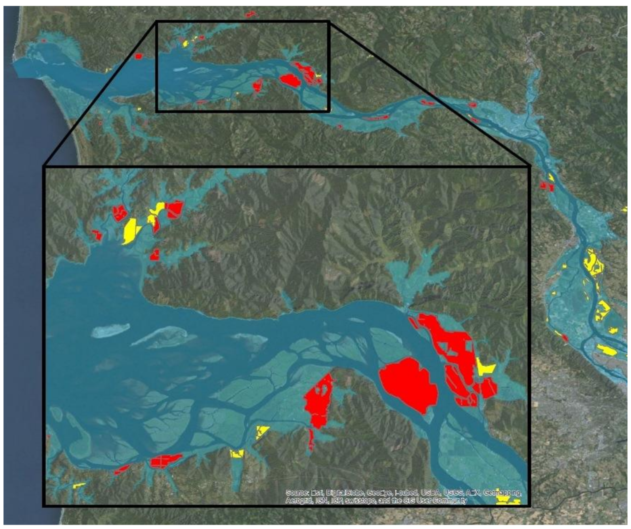
Summary of Salmon River Study. Many fry and fingerlings from mid- and upper-basin spawning areas in Oregon's Salmon River distributed throughout a greater portion of the estuary during the spring and summer and migrated to the ocean over a broader range of sizes and time periods than thirty years ago. The results suggest that wetland recovery expanded life history variation in the Salmon River population by allowing greater expression of estuarine-resident behaviors. Further research has refined the benefits of estuary habitat for fish and identified a linkage to overall salmon production. For example, Magnusson and Hilborn (2003) found that hatchery Chinook salmon passing through estuaries with larger proportions of intact habitat survived to adulthood at higher rates than those that transit degraded estuaries with less pristine habitat.

Columbia River Estuary studies and reports. Bottom and various colleagues had also been working for years in the Columbia River estuary (Bottom and Jones 1990) and combined this work with results from the Salmon River study above in a seminal report, *Salmon at River's End: The Role of the Estuary in Decline and Recovery of Columbia River Salmon* (Bottom et al. 2005a). In that report, Bottom et al. describe the state of knowledge about the estuary, its role in historic Columbia River salmon production, as well as the status of juvenile salmonids and estuarine habitats. The report made many recommendations for increasing estuarine shallow water habitats and their diversity as well as for additional research into seasonal and distributional use patterns by juvenile salmonids in the estuary. Much of current research in the estuary (e.g., Roegner et al. 2012; Weitkamp et al. 2012), as well as many of the subsequent planning documents for salmon recovery and habitat management in the LCRE can be traced back to *Salmon at River's End* and its influence.

Bottom and colleagues' work also led to a significant restoration effort in the LCRE (Figures 3 and 4) to increase overall habitat diversity and specifically to restore degraded wetland habitats and reconnect diked wetland and marsh habitats to the larger estuary (Bischoff et al. 2000; Lev et al. 2006; USACE and BPA 2013). These projects, specifically those in Youngs Bay and the Skipanon River were designed to improve ESA-listed juvenile salmonid survival, and are driven by the court-mandated Federal Columbia River Power System Biological Opinion (NMFS 2008, 2010). The implicit assumption is that no degradation is allowed to occur under the BiOp and this guides the selection and review of projects, including the construction and operation of the proposed Oregon LNG project.

Summary of work by Bottom and colleagues. The work of Bottom and colleagues over the last 3-4 decades also highlighted the extent to which estuaries are presently degraded, what role they played historically in the maintenance of salmon life history diversity and in overall system-level salmon production, and what benefits might be accrued by long-term restoration of estuary habitats. Bottom and colleagues' work (including that of Roegner and Weitkamp discussed below) also identify the critical role that estuary shallow water habitat restoration will play in the recovery of ESA-listed salmonids.

In summarizing their work, Bottom et al. (2008; 2011) noted that Chinook salmon throughout the Columbia River Basin rear in the estuary portion of the Columbia River. With the likely exception of spring-run fish from interior basin ESUs, which may rarely occupy shallow estuarine habitats, Chinook salmon from all Columbia River ESUs with subyearling life histories reside in the estuary for extended periods, utilize a diversity of alternative habitat pathways, and interact with wetland food webs for periods of weeks to months. Extensive use of estuarine habitats by Chinook salmon suggests that actions above Bonneville Dam alone cannot satisfy salmon recovery goals and that populations throughout the basin would benefit from estuarine habitat restoration.



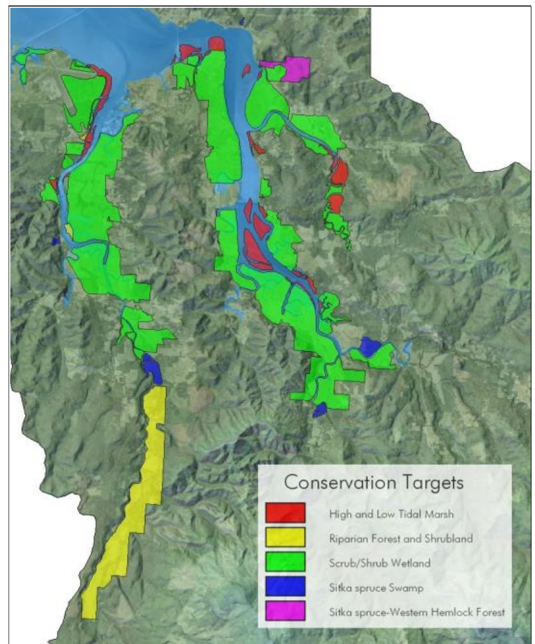


Illustration 3: Conservation Targets

Figure 3a. *Figure 3b.*

Figure 3. Figure 3a shows habitat restoration projects recently completed (2012) by the Action Agencies (red) and others (yellow) in the LCRE with several in close proximity to the proposed Oregon LNG project site (USACE and BPA 2013). Figure 3b shows conservation targets identified

in the Youngs Bay Conservation and Restoration Plan that are immediately upstream of the proposed Oregon LNG project site (Lev et al. 2006).

- Implications for OLNG Project.

The body of research conducted by Bottom and colleagues, and the research, conservation, and recovery planning efforts it has spawned demonstrate how incompatible the impacts from construction, operation, and long-term maintenance of the proposed Oregon LNG project will be for the recovery of ESA-listed salmonids and other aquatic species that rely on estuarine shallow water habitats. Impacts to nearshore habitats from turbidity and sedimentation associated with project construction, dredging, and operation of the OLNG Terminal and loading berth will have long-term negative effects on these species and their recovery. Similarly, siting and construction of the OLNG Terminal and facilities immediately adjacent and downstream of significant restoration efforts in Youngs Bay involving a suite of stakeholders (and large investments) that include federal, state, tribal and local constituents does not seem wise.

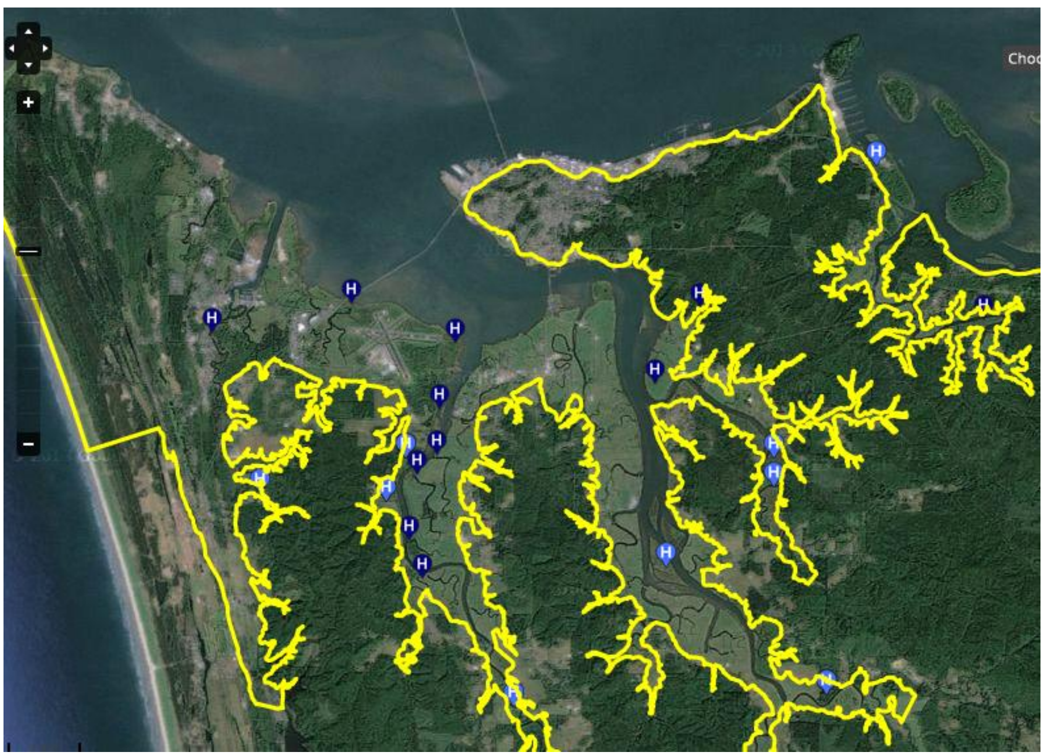


Figure 4. Map of all habitat restoration projects within the Lower Columbia River Estuary Partnership study area for which the Partnership has compiled information. Habitat projects are marked with a blue circle enclosing a capital H. Note several projects at the mouth of the Skipanon River and throughout Youngs Bay, sites that are within or adjacent to the proposed OLNG project site. Map from the Lower Columbia River Estuary Partnership website (http://www.estuarypartnership.org/our-work/habitat-restoration/map).

b) Study by Roegner et al. (2012).

Title: Distribution, size, and origin of juvenile Chinook salmon in shallow-water habitats of the Lower Columbia River and estuary, 2002 – 2007.

Research Study Background. Curtis Roegner and colleagues at NMFS studied juvenile salmon distribution in shallow water habitats in the lower Columbia River estuary over a 6-year period from 2002 – 2007. Their study objective was to determine the distribution patterns of Chinook salmon in shallow, tidal fresh and brackish water habitats of the lower Columbia River and estuary and to resolve broad patterns of salmon abundance and size at the landscape and seasonal scales. A specific study objective was to identify stock-specific patterns of shallow-water habitat use and migration. The study occurred in shallow estuary habitats near the proposed Oregon LNG Project site, so the results have direct implications for potential impacts to ESA-listed salmonids.

Sampling Effort. Fish communities were sampled by beach seine at six primary sites (three in Washington and three in Oregon), ranging from tidal freshwater to marine-dominated estuarine habitats. The middle estuary sampling zone included two sites located near the seasonally fluctuating boundary of the salt–freshwater interface: Point Ellice (rkm 22.0) and Point Adams Beach (rkm 19.8). Point Adams Beach is in the downstream proximity of the proposed Oregon LNG Project site. All sampling sites were sandy beaches subjected to tidal fluctuations. Sites were sampled monthly from January 2002 through September 2007, although adverse weather prevented sampling on 25 of 460 (5.4%) sample dates, usually in November through February. Sampling resulted in capture of more than 15,000 juvenile salmon.

Study Results. Catches included:

11,988	Chinook salmon	2	sockeye salmon
2,970	chum salmon	23	steelhead trout
202	coho salmon	23	cutthroat trout

Temporal patterns of habitat use. Chinook salmon were found in every monthly sample, although at low abundance during October–January. Shallow-water habitat use varied by life history type among Chinook salmon with about 97% subyearlings and only 3% yearlings. Abundance of yearling juvenile Chinook was concentrated in March and early April in the tidal freshwater zone. In the middle estuary, yearling abundance (2.5% of the salmonid population) was concentrated in late March to early May. The fewest number and smallest proportion of yearlings were found in the lower estuary zone. Thus, while yearling juvenile Chinook appear to be a small component within overall Chinook juvenile population, they are concentrated in the middle estuary mixing zone near the proposed OLNG project in late March to early May.

Spatial patterns of habitat use. Chinook fry (≤60 mm length) were found at all sites, but primarily in the middle (27.5%) and upper estuary zones (64.3%) suggesting these sites may function as rearing zones for small salmonids. Based on size at capture and adipose fin clips, 30% of the Chinook salmon were fry and likely of natural origin, while the remaining 70% were fingerlings and yearlings and probably predominantly of hatchery origin.

Roegner et al. (2012) noted the presence of fry in the 30–40-mm range synchronously across all sample sites in January–March indicating a rapid dispersion of newly emerged fish from their natal streams. Fry comprised a high percentage of the catch at most sites from January through April with the proportion of fry diminished at lower and middle estuary sites after April, while remaining relatively high in the upper estuary tidal freshwater zone until August.

In sampling at the Point Adams Beach site (downstream of the proposed Oregon LNG site) from 2002 – 2007, Roegner et al. (2012) captured 1,827 subyearling Chinook, but only 31 yearling Chinook (Table 2 in Roegner et al. (2012)). <u>These data clearly show the use of shallow water habitats by the smaller subyearling Chinook, who rely on these habitats along with chum salmon as important rearing areas.</u>

<u>Implications for ESA-listed wild fish</u>. Roegner et al. note that their abundance, size, and stock data support the premise that many small juvenile Chinook salmon reside and accumulate in shallow, tidal freshwater sites, with larger fish moving down into the estuary. Chinook salmon are known to migrate as fry from the Salmon (Bottom et al. 2005a), Sixes (Reimers 1973), and Rogue Rivers (Schluchter and Lichatowich 1977). For comparison, chum salmon are predominantly fry migrants and historically comprised a large biomass of adults returning to the lower Columbia River basin (Johnson et al. 1997). Based on these examples, one might expect that a fry migrant life history type continues to contribute to Chinook salmon spawner success in the Columbia River Basin, especially to the lower-river populations.

<u>Study Summary</u>. Subyearling Chinook and chum salmon were the predominant species and life history types utilizing the monitored sites. The chum population was composed almost entirely of fry-sized animals and was most prevalent in estuarine sites over a contracted migration period during March–May (Roegner et al. 2008). Few yearling Chinook or other salmon species were present.

In contrast to Weitkamp et al.'s (2012) study of deep, mid-channel habitats in the Columbia River estuary where they found high proportions of yearling Chinook salmon, Roegner et al. found that yearlings comprised only 2.5% of their shallow-water population.

- Implications for OLNG Project.

Roegner et al.'s (2012) study examined seasonal juvenile salmonid abundance at several shallow water sites in the lower Columbia River estuary from 2002 - 2007, including sampling at Point Adams Beach, a site on the Oregon shore downstream of the proposed OLNG project site. Subyearling Chinook and chum salmon were the predominant species and life history types utilizing the study sites. Sampling sites were sandy beaches subjected to tidal fluctuations, typical of the shallow water habitats near the proposed Oregon LNG project site and adjacent Youngs Bay. The land-based facilities of the OLNG site and the proximal portion of the pier occur in these habitats.

Consequently, it is clear that construction and operation of the proposed Oregon LNG project would negatively impact ESA-listed juvenile subyearling Chinook and chum salmon, which use the shallow water habitats of the Lower Columbia River estuary extensively for rearing and growth prior to outmigration.

Based on the work of Roegner et (2012) and others (Bottom 2005a; 2005b), one might expect that a fry migrant life history type (i.e., subyearling) continues to contribute to Chinook salmon spawner success in the Columbia River basin, especially to the lower-river populations. Similarly, chum salmon are predominantly fry migrants and historically comprised a large biomass of adults returning to the lower Columbia River basin (Johnson et al. 1997). Both of these ESA-listed species are dependent upon utilizing shallow water habitats for extended periods that conflict with the construction and operation of the proposed Oregon LNG project.

c) Study by Weitkamp et al. (2012).

Title: Seasonal and interannual variation in juvenile salmonids and associated fish assemblage in open waters of the lower Columbia River estuary.

Research Study Background. Laurie Weitkamp and colleagues at NMFS studied juvenile salmonid use of open waters in the lower Columbia Estuary from 2007 – 2010 (Weitkamp et al. 2012). Their sampling focused on deeper water (25 – 33 foot depth) habitats adjacent to two deep channels that bisect the north and south portions of the estuary, respectively, in the "estuarine mixing" region. The sampling locations also have historical significance as they have been used as study sites since the late 1960s. The south migration channel lies immediately north (~500 yards) of the proposed OLNG loading berth and turning bay. The study occurred in estuary habitats near the proposed loading berth and turning bay of the Oregon LNG Project site, so the results have direct implications for potential impacts to ESA-listed salmonids.

Sampling Effort. Sampling occurred for four spring seasons where researchers conducted 291 purse seines, collecting more than 300,000 fish from 27 species, including all Pacific salmon species present in the Columbia River: Chinook, coho, chum and sockeye salmon, steelhead and sea-run coastal cutthroat trout. Juvenile Chinook, coho and steelhead were caught in roughly half (34–65%) of all sets, whereas both chum and sockeye salmon were encountered less frequently (<24%).

Abundance and timing of juvenile salmon in the estuary. The abundance and timing of juvenile salmon in the estuary was consistent among years. When sampling began in mid-April, catches of all juvenile salmon were extremely low, but increased as the spring progressed. Maximum abundances occurred in mid-May for yearling Chinook and coho salmon and steelhead. An earlier abundance peak occurred for chum salmon in early May, while sockeye salmon abundance peaked later in early June, and for subyearling Chinook salmon in late June or early July. When sampling stopped in late June or early July, only subyearling Chinook salmon were still being caught.

Seasonal abundance patterns. The seasonal pattern of juvenile salmon abundance was consistent between years of the study, consistent with studies of juvenile salmonids from other Pacific Northwest river estuaries, and consistent with historical patterns in the Columbia River including Willis Rich's early work (1914 – 1916; cited and reviewed in Bottom et al. 2008), as well as from the 1960-70s, prior to the advent of large-scale hatchery production.

Time in residence in the LCRE. Residence time in the estuary also differed among the various salmonid species. Both chum and sockeye salmon were typically caught only during a 2–4 week period, yearling Chinook and coho salmon and steelhead were caught readily in the estuary for 6–8 weeks each year, and subyearling Chinook salmon were present for at least 2 months (and presumably longer but sampling was terminated by early July).

Geographic origins of juvenile salmonids. Weitkamp et al. (2012) also determined the geographic origins of juvenile salmon captured in their study. Most fish were of hatchery origin and came from locations throughout the Columbia River basin – lower, mid-, and upper Columbia River and the Snake and Willamette rivers.

Wild and hatchery fish. Weitkamp et al. (2012) noted that their study was conducted in deeper waters of the estuary, specifically targeting juvenile salmonids in the main deeper migration corridor. The percentages of clipped subyearling (76.0%; Table 4) and yearling (86.9%) Chinook salmon Weitkamp observed were higher than the percentages reported for juvenile subyearling and yearling Chinook salmon collected in nearby shallow water with a beach seine in 2007–08 (53.2% and 73.7%, respectively; Roegner et al., in press). This finding suggests that relatively more unclipped (presumably wild) Chinook salmon were closer to shore.

Weitkamp et al. (2012) goes on to note that the overwhelming percentage of hatchery origin juvenile salmonids in their study is consistent with the low variation they observed in the timing of juvenile salmon presence and abundance in the estuary and fish size, because most hatchery fish are released at a target size and date, with little variation from year to year. Accordingly, one would expect to see greater variation in both timing and size of salmon, if more fish were of wild origin, because of the greater fine-scale life history diversity observed in other wild-dominated systems and historically within the Columbia River (Rich, 1920; Bottom et al., 2005; Roegner 2012).

- Implications for OLNG Project.

Weitkamp et al.'s (2012) study examined seasonal juvenile salmonid abundance at several sites in Reach A of the LCRE, including a site on the Oregon shore downstream of the proposed OLNG project site. The study looked only at juvenile salmon abundance in deeper water along the migration corridor during the spring migration season (April through late June to early July) for four years (2007-10). Juvenile outmigration was concentrated in May and early June and consisted primarily of yearling Chinook and coho salmon and steelhead. An early abundance peak occurred for chum salmon (early May), while sockeye abundance peaked in early June, and subyearling Chinook salmon in late June or early July.

Sampling occurred in water depths of approximately 25 – 33 feet, a depth similar to the tidal areas surrounding the OLNG loading berth and turning bay (which itself would be dredged to approximately 50 feet depth). Therefore, the results of Weitkamp's study are primarily applicable to the loading berth and turning bay portion of the OLNG project site, as these are in deeper water and are in proximity to the main river salmon migration and commercial shipping navigation channel.

Consequently, it is clear that construction and operation of the proposed Oregon LNG project would negatively impact outmigrating ESA-listed juvenile salmonids from throughout the Columbia River Basin, at least during the spring outmigration season sampled for this study.

d) Study by ODFW, Jodie Thompson, Lead Researcher (2014).

Title: 2013-14 Youngs Bay Test Fishing: Purpose, sampling method, and results

The ODFW test fishing project in Youngs Bay during 2013-14 is part of the Lower Columbia River Fisheries Management Reform process (Figure 5). The purpose of the sampling was to evaluate the viability of expanding current Select Area sites to allow for more fishing opportunity and enhanced harvest. Test fishing was initiated in 2013 and is planned to continue through 2015. ODFW gathered data from four sampling areas, two within the current Youngs Bay Select Area fishing site (Inner Youngs Bay) and two outside the current fishery area (Outer Youngs Bay), which encompasses the area being considered for fishery expansion.

Sampling occurred in a spring/summer season (March – July 31) and fall season August – mid-October) in 2013 and 2014, with an average of two sampling trips per week. During late spring and summer, test fishing was restricted to Outer Youngs Bay to reduce conflict with the ongoing commercial fishery in Inner Youngs Bay.

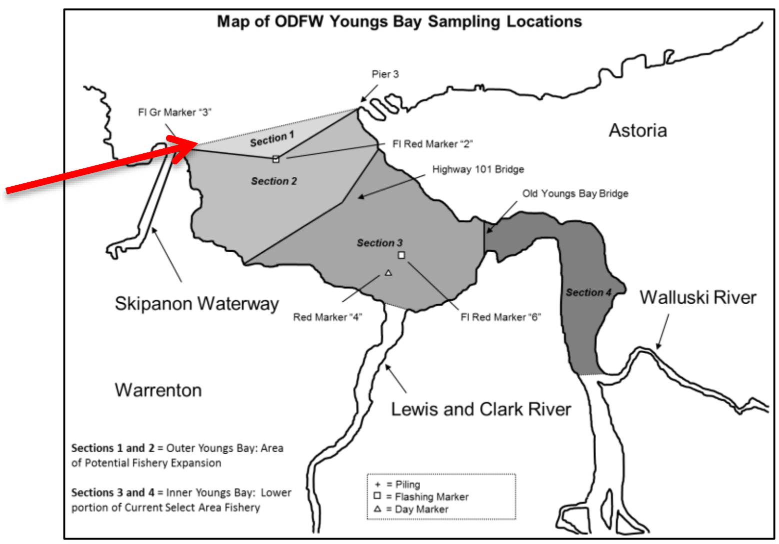


Figure 5. Map of ODFW's Youngs Bay Fishery Test Sampling area (2013-2015). Sections 1 and 2 (see red arrow) abut the proposed Oregon LNG project site. (Figure from ODFW work report, 2014).

Results of Youngs Bay Test Fishery. Spring Chinook adult salmon were captured in both 2013 and 2014 in the Outer Youngs Bay Sections 1 and 2 of the test fishery, 18 and 25, respectively in both years. Most adult salmon (65%) were captured in Section 2. Fall Chinook (n=148) were captured only in the summer and fall sampling period, and coho salmon (n=363) only in the fall sampling period. Fall Chinook and coho were caught in both Sections 1 and 2 in approximately equal proportions. Adult steelhead were caught in very low numbers (n=11), but interestingly in all sampling periods and both test sections.

- Implications for OLNG Project.

Results from the first two years of a 3-year planned test fishery for adult salmon and steelhead in Youngs Bay showed the area is transited by adult Chinook (both spring and fall runs), coho, and to a limited degree by steelhead. Even one sockeye salmon was caught in the summer of 2013. Consequently, it is likely that construction and operation of the proposed OLNG project would negatively impact in-river migrating adult ESA-listed salmonids that transit the Oregon shoreline migration route that includes the project site and the outer portions of Youngs Bay.

Summary of Recent Research and Impacts of Oregon LNG to ESA-listed salmonids

Research efforts in the Lower Columbia River and estuary over the last several decades have led to an evolving and increasingly nuanced understanding of the important role the estuary and its diverse shallow water habitats play with respect to juvenile salmonid survival and overall production in the Columbia River system. Studies discussed above (Bottom, Roegner, Weitkamp, and colleagues, ODFW sampling of Youngs Bay) all show that salmon of all species and life stages, including all ESA-listed salmonids, use the variety of deeper water, shallow water, and near shore habitats along the Oregon shore of the Columbia River in and around the proposed OLNG project site. Salmon of various species and life stages are in the nearshore habitats surrounding the OLNG site during all months of the year.

Roegner et al.'s (2012) study sampled continuously over a six-year period (2002-07) and showed subyearling Chinook and chum salmon as the predominant species and life history types utilizing shallow water habitats at Point Adams Beach, a site on the Oregon shore downstream of the proposed OLNG project site. Chinook were found in the samples during every month over the 6-year period. Sampling sites were sandy beaches subjected to tidal fluctuations, typical of the shallow water habitats near the proposed Oregon LNG project site and adjacent Youngs Bay. The land-based facilities of the OLNG site and the proximal portion of the pier occur in these habitats.

Weitkamp et al.'s (2012) study examined juvenile salmonid abundance at deeper water (25-33 feet) along the lower estuary migration corridor during the spring migration season (April through late June to early July) for four years (2007-10). The study included several sites in Reach A of the LCRE, including a site on the Oregon shore downstream of the proposed OLNG project site. The juvenile salmon outmigration was concentrated in May and early June and consisted primarily of yearling Chinook, coho salmon, and steelhead. Chum salmon exhibited an early May abundance peak while sockeye abundance peaked in early June, and subyearling Chinook salmon abundance peaked in late June or early July.

Sampling in Weitkamp's study occurred in water depths of approximately 25-33 feet, a depth similar to the tidal areas surrounding the OLNG pier, loading berth, and turning bay (which itself would be dredged to approximately 50 feet depth). Thus, the results of Weitkamp's study are applicable to the outer pier, loading berth, and turning bay portion of the OLNG project site, as these are in deeper water and are in proximity to the main Columbia River salmon migration and commercial shipping navigation channel.

Finally, recent sampling by ODFW in 2013-14 in the Youngs Bay Test Fishery showed the area is transited by adult Chinook salmon (both spring and fall runs), coho salmon, and to a limited degree by sockeye salmon and steelhead trout. The Youngs Bay fishery is part of the Youngs Bay Select Area Fisheries Enhancement project and an RPA in the FCRPS Biological

Opinion. Adult salmon were captured in the two outer test zones, both of which abut the proposed Oregon LNG site at their northwest edges. Consequently, it is likely that construction and operation of the proposed Oregon LNG project would negatively impact in-river migrating adult ESA-listed salmonids that transit the Oregon shoreline migration route that includes the project site and the outer portions of Youngs Bay.

Based on results of the studies described above, it is clear that construction and operation of the proposed OLNG project would negatively impact ESA-listed salmonids of a variety of species and life stages throughout the entire year. The habitats surrounding the proposed Oregon LNG site, both shallow water and deeper water, are used extensively by salmonids fry for rearing, by juvenile salmonids for rearing and outmigration, and by returning adult salmon. Impacts would likely be greatest for fry-stage juvenile subyearling Chinook and chum salmon, which use the shallow water habitats of the Lower Columbia River estuary extensively for rearing and growth prior to outmigration.

The work of Roegner et al. (2012) and others (Bottom 2005a; 2005b), suggests that the fry migrant life history type (i.e., subyearling) contributes to Chinook salmon spawner success in the Columbia River basin, especially to the lower-river populations. For example, chum salmon are predominantly fry migrants and historically comprised a large biomass of adults returning to the lower Columbia River basin (Johnson et al. 1997). Both of these ESA-listed species (chum and fall Chinook) are dependent upon utilizing shallow water habitats for extended periods that conflict with the construction and operation of the proposed Oregon LNG project.

Impacts to nearshore habitats from turbidity and sedimentation associated with project construction and dredging will have long-term negative effects on these species and their recovery. Similarly, construction of the OLNG project site immediately adjacent and downstream of significant restoration efforts involving a suite of stakeholders (and large investments) that include federal, state, tribal and local constituents does not seem wise.

Impact of dredging and building the Oregon LNG on ESA-listed species

This section of the report discusses impacts to ESA-listed species from dredging and building an industrial dock, loading berth, and its associated turning bay in the vicinity of Youngs Bay, the site of a major RPA in the FCRPS Biological Opinion: the Youngs Bay Select Area Fisheries Enhancement project.

At the proposed project site of OLNG, the primary estuarine-marine impact would be construction and operation of a pier with a single berth for LNG carrier ships to moor and load and unload LNG, and the dredging and maintenance of a 135-acre turning basin (Figure 1). The berth would consist of a loading/unloading platform, breasting and mooring structures, interconnecting walkways, and an access trestle (pier) to shore. The berth would be accompanied by a 135-acre turning basin that would lie immediately adjacent to the federal navigation channel (i.e., the southern estuary channel) that is also the major migration route for juvenile salmon. The turning basin would be designed with adequate depth for LNG ships to safely navigate to the berth, perform docking and undocking maneuvers, and 180-degree turns.

The berth would be located where the natural water depth is currently about 20 to 30 feet deep. To create the berthing area and turning basin, Oregon LNG would dredge to a depth of -48 and -43 feet, respectively, with two additional feet allowed for overdredging in both cases (i.e., -50 and -45 feet, respectively). The footprint of the turning basin would be about 135 acres and would require dredging of about 109 acres and removal of about 1.2 million cubic yards of dredged material.

Dredging activities are expected to occur 24 hours per day during the seasonal dredging period (three months in the winter each construction year). Maintenance dredging of the berth and turning basin is expected to occur every three years, putting the first maintenance dredging in June 2019 with an estimated volume of 300,000 cubic yards of material to be disposed.

Concerns and Implications for OLNG Project

Dredging of the proposed Oregon LNG loading berth and turning basin will have multiple negative impacts on salmonids, their habitats, and water quality. The dredging, together with terminal construction, would destroy and/or alter important shallow-water habitat for salmonids. This is significant because research and assessments (described above and below) have repeatedly concluded that such habitats are vital to salmonid restoration and protection. While there is limited direct habitat alteration by construction and operation of the OLNG project, some nearshore, wetland, and channel side habitats will be affected and reduce feeding opportunities for fish and birds.

a) Potential disruption of juvenile salmonid migratory pathways

Dredging and placement (location) of the turning basin have the potential to significantly negatively impact survival of downstream migrating ESA-listed juvenile salmon and steelhead. Dredging the turning basin will essentially double the width and cross-section of the channel at a key location in the Lower Columbia River estuary where the navigation channel changes from a west-southwest direction to northwest. Under historic conditions both the north and south channels split the flow; however, now the south channel directs the bulk of the flow. The OLNG project is in a location where strong tidal and river currents are mixing throughout the year. Dredging and placement of the turning basin in this location may exacerbate sedimentation or erosion in this critical area if a large-scale eddy were formed in this mixing zone during incoming or outgoing tides. Assessing this potential would likely require the assistance of an estuary hydrologist to model the potential changes to reduce uncertainty.

Studies by Carl Schreck and colleagues (Fisheries Unit Leader, Oregon Cooperative Fish and Wildlife Research Unit, Oregon Sate University) have shown the southern estuary channel to be the primary migration corridor for downstream migrating juvenile salmon including ESA-listed species (Schreck et al. 2006). Consequently, anything that slows or disorients juvenile salmonids or moves them from their normal outmigration path could affect juvenile survival through the estuary and therefore, be an issue for concern. The proposed OLNG turning basin has the potential to disrupt or alter outmigration patterns for juvenile salmonids, as it will double the width and cross-section of the channel at a key location in the Lower Columbia River estuary where the navigation channel changes from a west-southwest direction to northwest. Weitkamp et al. (2012) showed extensive use of the southern estuary channel by outmigrating yearling Chinook, sockeye, and steelhead.

Many of the outmigrating juvenile ocean-type (subyearling) salmonids move along the southern shore (Roegner et al. 2012) in the shallow nearshore habitats. Because there is no alternative migration pathway for them, they are forced into deeper water if the area is dredged and pilings and overhead structures are built. This will likely result in more predation on this specific suite of juveniles by fish and birds. Construction and placement of a 'stringer' of piling to support the pier from the terminal to the loading berth also has the possibility to alter flow patterns and sediment transport in the vicinity of the OLNG project. This can potentially affect nearshore habitats and rearing and outmigration movements by subyearling (ocean-type) salmon (subyearling Chinook and chum).

b) ESA-listed salmonids, Oregon LNG, and the LCRE

The Lower Columbia River estuary is identified in NMFS's Biological Opinions 2008, 2010, 2014) as a large survival bottleneck for upriver stocks of salmon, and is also key rearing and migration habitat for lower river stocks (below Bonneville) (NMFS 2011). The 2008 BiOp and the 2010 BiOp Supplement both drive the Action Agencies (US Army Corps of Engineers, NOAA, and the Bonneville Power Administration (BPA)) to improve survival of juveniles from upriver stocks (overall by 20%) with very specific survival targets to reach for each ESA listed population. Anything that slows the progress of the Action Agencies toward recovery goals is a major issue. For example, the 2008 BiOp for upriver salmon stocks (coho, chinook, sockeye, steelhead above Bonneville) also sets a high priority on restoring shallow water habitats throughout the estuary, including Reach A, including some of the restoration projects in Youngs Bay and the Skipanon River, which were specifically designed to improve survival of upriver stocks.

Any change in currents, habitat, or food resources could adversely affect survival during passage as the fish transition from brackish to marine waters. For example, should residence time of fish increase in the OLNG Project area (likely if currents change), the juveniles will become more vulnerable to avian predation. Avian predation already accounts for a large proportion of the mortality of juvenile salmon, particularly in the lower estuary.

c) Impacts of avian predation on migrating juvenile salmonids

Impacts of dredging, dredge material deposition, and maintenance of the commercial navigation channel in the LCRE, created or enlarged sandy island habitat in the LCRE that inadvertently promoted avian predation on outmigrating juvenile salmonids. Avian predation on juvenile salmonids in the LCRE represents a significant mortality source for outmigrating juvenile salmon and steelhead (Lyons et al. 2007; NMFS 2011). Over the last 30 years (1984 to present), Caspian terns, along with double-crested cormorants, ring-billed gulls, glaucous-winged/western gulls, and brown pelicans, have formed large nesting colonies on East Sand Island and Rice Island in the LCRE, allowing birds direct access to outmigrating juvenile salmon and steelhead in the north and south estuary channels, particularly at Rice Island (Anderson et al. 2005; Evans et al. 2012).

Daniel Roby (Wildlife Unit Leader, Oregon Cooperative Fish and Wildlife Research Unit, OSU) and colleagues at Oregon Sate University investigated the impacts of avian predation on juvenile salmonids in the lower Columbia River in a series of studies since 2000 (Roby el al 2005; Lyons et al. 2007; Evans et al. 2012). These studies assess impacts, provide management recommendations, and express concern over linkages between migration delays in the lower river to delayed mortality in migrating juvenile salmonids.

A recent study by Goode et al. (2007) illustrates the magnitude of the predation impacts of Caspian terns on outmigrating steelhead trout juveniles. Predation rates were assessed using data from PIT (passive induced transponder) tags collected at East Sand and Rice islands. From 2001 to 2003, terns in the LCRE captured up to the following percentage of steelhead smolts based their origin: 10.70% of Snake River steelhead smolts, 25.86% of Upper Columbia River steelhead smolts, 10.10% of Mid-Columbia River steelhead smolts, and 9.31% of Lower Columbia River origin steelhead smolts (Goode et al. 2007).

These impacts on juvenile salmon survival are significant and are addressed in numerous planning documents including the NMFS's 2008 Biological Opinion and its 2010 and 2014 Supplements (NMFS 2008, 2010, 2014) as well as the 2011 Columbia River Estuary ESA recovery plan module for salmon and steelhead (NMFS 2011). In 2008, the U.S. Army Corps of Engineers began implementing a management plan that seeks to redistribute at least half of the East Sand Island Caspian tern colony to alternative colony sites in Oregon and California by 2015 (USFWS 2005).

d) Impacts of dredging on turbidity and sedimentation

Dredging will also increase turbidity and suspended sediment for at least as long as dredging occurs – the OLNG project construction phase and subsequent periodic maintenance dredging of turning basin. These impacts degrade water quality and have negative effects on salmonids. Elevated turbidity can violate water quality standards and increase treatment costs for downstream water uses. Elevated turbidity and suspended sediment levels can also impair the ability of salmonids to feed and cause gill damage (Rhodes et al., 1994; Rosetta 2005; Rhodes 2007). Elevated turbidity and sediment delivery can also adversely affect benthic macroinvertebrates that are an essential part of aquatic foodweb for salmonids and other aquatic fauna.

Dredging will increase the turbidity of the river and lead to higher water temperatures. Without justification or citation to sources, Oregon LNG's application concludes that dredging 1.2 million cubic yards will not exacerbate temperature conditions in the Columbia River estuary or contribute to elevated turbidity. The best available science demonstrates that Oregon LNG's dredging will contribute to elevated temperature and turbidity, which harms water quality. Turbidity has a number of adverse effects on water quality, including reducing light for photosynthesis by algae and plants, increasing temperature, and decreasing dissolved oxygen levels. Direct and indirect impacts of excessive turbidity to endangered salmonids, other migratory species, and other fish species are well documented in the literature and may reach lethality at time or cause behavioral impact (Rosetta, 2005).

The Columbia River is classified as water quality limited under the Clean Water Act, Section 303(d) for temperature; however, EPA has not on yet completed a TMDL for temperature. Elevated temperature has a number of well-documented, negative impacts on species including ESA-listed salmonids. Increases in temperature, as a result of increased turbidity, are caused by the suspended particles absorbing more heat from sunlight and, therefore, increasing the temperature of the water around the particles. Also, as a result of turbidity and increased water temperatures, dissolved oxygen levels and light will decrease, harming aquatic biota including federally protected fish species.

Oregon LNG fails to analyze how dredging will alter water temperature due to increases in turbidity, and how any changes in water temperature resulting from increased turbidity due to dredging activities will exacerbate the DEQ 303(d) water quality-limited status of these waters.

All of the physical and chemical changes discussed above are exacerbated by the large-scale channel deepening in the lower Columbia River. The channel deepening alone has detrimental impacts on the physical and chemical characteristics of the lower Columbia River. The Corps must analyze the cumulative effects of the Oregon LNG's proposed dredging, taking into account the channel deepening, increased ship traffic from both the channel deepening and LNG tankers, the increase erosion from both projects, increased wave action, and geomorphic and hydraulic changes.

A final issue pertaining to dredging and the construction of piers, docks and berths in the near-shore environment is the potential release of hydrocarbon-contaminated sediments that may be disturbed during new construction.

Potential impacts of LNG vessel traffic on ESA-listed salmonids.

This section of the report discusses the impacts of LNG vessel traffic on ESA-listed salmonids including issues such as juvenile salmonid wake-stranding and ballast water entrainment. The proposed OLNG Project would operate as a bidirectional project, capable of importing or exporting LNG, though it is presently envisioned as primarily an export facility.

Concerns and Implications for OLNG Project

The OLNG BA notes that an estimated 127 vessels will arrive at the Terminal annually, with only two of the vessels as import vessels. LNG carrier ships have significant requirements for ballast and cooling water that run into the millions of gallons on a annual basis. Only import vessels will need to take on ballast water, while all vessels will require cooling water. The potential for entrainment is much higher with ballast water withdrawal, because of the larger volumes required, and the resultant higher intake velocities at the sea chests (openings in the hull used for water intake). The cooling water system operates independently of the ballast water system. However, the cooling water system can, and sometimes will, use the same sea chests as the ballast water system.

a) Entrainment of juvenile salmonids due to ballast water

Entrainment occurs when fish are sucked into mechanical equipment, such as dredges, turbines, or an ocean-going ship's ballast or cooling water systems. The OLNG BA notes that ballast water intake velocities at the sea chests exceed the ODFW and NMFS recommended maximum screen intake velocities of 0.4 foot per second (fps) for fry and 0.8 fps for fingerlings during at least part of the offloading period. When both ballast and cooling water are being withdrawn, maximum velocity at the sea chest face would be 2.2 fps, and the area that exceeds 0.4 fps extends out approximately 5 feet from the hull. Because the intake grill openings and the intake velocities exceed ODFW and NMFS screening criteria (NMFS, 2008d *cited in OLNG BA*), salmonid fry and fingerlings potentially could be entrained or impinged on the intake screen or filter if they were close enough to the sea chest intakes during the ballast- water intake period. The Terminal would require a total cooling/ballast water intake of 1,610 million gallons per year, versus 3,538 million gallons per year for the analyzed export-only facility.

Juvenile salmon, adult and juvenile smelt, and juvenile sturgeon are susceptible to entrainment in ballast water and also for entrainment during dredging operations where vacuum suction intakes are used, such as channel deepening or excavation and maintenance of the proposed OLNG turning basin. Some fish species, such as sturgeon, can be attracted to dredging operations because of the stirred up organic matter and benthic invertebrates, which make up their food.

For threatened and endangered fish species, the impact of reducing the populations of juveniles on the remaining populations of fish and other estuarine and riverine populations (e.g., shrimp, razor clams, and Pacific sandlaces, etc.) can negatively affect the estuarine foodweb and have serious repercussions on the survival of both endangered and other area species

b) Entrainment of Eulachon due to ballast water

The greatest potential for entrainment/impingement for eulachon is at the larval stage (OLNG BA, p. 3-73; CH2MHill 2013). Adult eulachon will likely be able to avoid entrainment/impingement because of their swimming ability. Seasonal eulachon larval abundance was obtained from a recent study of planktonic fish larvae in the LCRE (Marko, 2008, *cited in OLNG BA*). Each import vessel requires 12.3 million gallons of cooling water and each export vessels requires 37 million gallons of cooling water. Using these data, the OLNG BA estimates entrainment of 1,225,920 larval eulachon, which equates to removing the reproductive output of 1,837 female eulachon.

In 2007, the National Marine Fisheries Service (NMFS) was petitioned to list the southern eulachon under the Endangered Species Act. The NMFS determined (March 2008) that the petition presented substantial scientific and commercial information indicating the petitioned action may be warranted, and initiated a status review. In turn, this led to a March 2010 listing of the southern eulachon DPS as threatened under the ESA. Critical habitat was designated in October 2011. The southern eulachon “Distinct Population Segment” (DPS) extends the U.S.-Canada border south to include populations in California, Oregon, and Washington, including the Lower Columbia River estuary where the proposed OLNG project site is located.

Consequently, it is clear from the analysis presented in the OLNG BA that the construction and operation of the Oregon LNG Terminal and project would negatively impact eulachon in the Lower Columbia River estuary.

c) Impacts due to juvenile salmonid wake-stranding

Waves from ship wakes frequently travel parallel to the riverbank and estuary shoreline and can erode land from the edges of nearshore habitat. Shoreline erosion from waves can increase sediment and turbidity in nearshore shallow waters utilized by subyearling salmonids and other fishes. Continual shoreline erosion from waves can also continually reset shoreline vegetation and prevent plant growth that could help stabilize shoreline habitat, increase habitat diversity and foodweb productivity – all of which would benefit the rearing, growth, and outmigration of subyearling juvenile salmonids.

Waves from ship wakes can also lift young fish above the water line, stranding them on shoreline banks and causing juvenile mortality.

d) Impacts due to spread of noxious and invasive organisms

The Oregon LNG BA (p. 3-77) notes that ballast water has the potential to harbor non-native, nuisance organisms, which have the potential to cause economic and ecological degradation to affected nearshore areas. These organisms also could arrive on the hulls and exterior equipment (e.g., anchors and anchor chains) of LNGCs. Nevertheless, the OLNG BA fails to reasonably consider the project's cumulative effects on the spread and establishment of noxious weeds and its impacts on aquatic resources. It notes that such impacts are likely, but discounts their impact, noting that most potentially noxious or invasive species will have already been introduced to the system by other ships and shipping activities. While there is clearly some truth to such a perspective, it is not a reasonable viewpoint, and seriously underplays the responsibility of OLNG to have protocols and practices in place that safeguard against unnecessary and unwanted introductions of non-native noxious plants of animals.

Additionally, it is highly likely that construction activities will increase the noxious weed spread and establishment, because the effects of associated soil disturbance and vehicular activity are highly conducive to weed dispersal and establishment. Many unwanted colonizing species are pre-disposed to quickly take advantage of disturbed habitat such as will occur around the OLNG site due to construction of the Terminal, trestle pier, loading berth, and turning basin.

Conclusions

Completeness of the Oregon LNG Biological Assessment

In spite of presenting a large amount of information on ESA-listed salmon and steelhead populations (Section 3 of the OLNG draft Biological Assessment; CH2MHill 2013), significant recent and highly relevant research on juvenile salmonids in the lower Columbia River estuary (LCRE) and its implications were not included in the OLNG BA. That information is reviewed in this report (pp. 10-18) and includes specific studies on juvenile salmon use of estuarine habitats in the LCRE by researchers from NOAA-NMFS and ODFW (Bottom et al. 2005a, 2005b, 2008, 2011; Roegner et al. 2008, 2012; Weitkamp et al. 2012), and OSU's Oregon Cooperative Fisheries and Wildlife Research Unit (Anderson et al. 2005; Schreck et al. 2005; Roby et al. 2005; Evans et al. 2012).

This body of research is a surprising and significant omission from the OLNG BA as it sheds substantial light on how juvenile salmonids utilize the shallow water habitats and deeper water migratory pathways in the immediate proximity of the Oregon LNG site.

The studies by Bottom, Schreck, Roegner, Weitkamp, and Thompson revealed important habitat associations, juvenile salmonid migratory patterns, and life history diversity patterns that were not previously well understood. Many of them have direct implications on the likely impacts to shallow water habitats and deeper water migratory pathways in the immediate proximity of the OLNG site. The OLNG draft Biological Assessment is deficient in not considering the work these researchers and their studies more thoroughly with respect to the potential impacts of construction and operation of the proposed OLNG project.

Impacts of the proposed Oregon LNG on ESA-listed salmonids

NMFS clearly described the importance of the estuary and its relationship to ESA-listed salmonids in their December 17, 2007 letter denying the application for construction and operation of an LNG project at Bradwood Landing. NMFS noted, "*The survival and recovery of all 13 ESA-listed species of Pacific salmon and steelhead that occur in the Columbia River basin are dependent on the Columbia River estuary. With reference to depleted populations of anadromous salmonids, the Lower Columbia Fish Recovery Board's recovery plan indicates that one of the elements likely to yield the greatest benefit is to "protect and enhance existing juvenile rearing habitat in the lower Columbia River, estuary, and plume.""*

- Research efforts in the Lower Columbia River and estuary over the last several decades have led to an evolving and increasingly nuanced understanding of the important role the estuary and its diverse shallow water habitats play with respect to juvenile salmonid survival and overall production in the Columbia River system. This new understanding is consistent with the language cited from NMFS in the preceding paragraph.

- Studies by Bottom, Schreck, Roegner, Weitkamp, and Thompson document widespread use of nearshore habitats by juvenile salmonids, particularly subyearling Chinook and chum salmon, in Youngs Bay and Point Adams Beach, areas that abut the OLNG site upstream and lie just downstream, respectively. These results highlight the potential impacts that construction and operation of the proposed OLNG Project would have on ESA-listed juvenile salmonids in a manner that the OLNG BA fails to do

- Salmon of all species and life stages, including all ESA-listed salmonids, use the variety of deeper water, shallow water, and nearshore habitats along the Oregon shore of the Columbia River in and around the proposed OLNG project site. Salmon of various species and life stages are in the nearshore habitats surrounding the OLNG site during all months of the year.

- Subyearling Chinook and chum salmon are the predominant species and life history types utilizing shallow water habitats in the LCRE including Point Adams Beach, a site on the Oregon shore downstream of the proposed OLNG project site. Chinook were found in the samples during every month over the six-year period (Roegner et al. 2012). The land-based facilities of the OLNG site and the proximal portion of the pier occur in these habitats.

- Juvenile salmon migrate through the Lower Columbia River estuary primarily from April through early July using deeper water (25-33 feet) along the lower estuary migration corridor. The spring outmigration was concentrated in May and early June and consisted primarily of yearling Chinook, coho salmon, chum salmon, and steelhead, while sockeye salmon abundance peaked in early June, and subyearling Chinook salmon abundance peaked in late June or early July (Weitkamp et al. 2012).

- The southern estuary channel is a primary migration corridor for downstream migrating juvenile salmon including ESA-listed species (Schreck et al. 2006). The proposed OLNG turning basin lies adjacent to the migration channel and has the potential to disrupt or alter outmigration patterns for juvenile salmonids, as it will essentially double the width and cross-section of the channel at a key location in the Lower Columbia River estuary where the navigation channel changes from a west-southwest direction to northwest.

- Many of the outmigrating juvenile ocean-type (subyearling) salmonids move along the southern shore (Roegner et al. 2012). Because there is no alternative migration pathway for them, they are forced into deeper water if the OLNG project area is dredged, pilings are installed, and overhead structures are built. This will likely result in more predation on this specific suite of juveniles by fish and birds.

- Sampling by ODFW in 2013-14 in the Youngs Bay Test Fishery showed the area is used by adult Chinook salmon (both spring and fall runs), coho salmon, sockeye salmon, and steelhead trout. Adult salmon were captured in the two outer test zones, both of which abut the proposed Oregon LNG site at their northwest edges. Consequently, it is likely that construction and operation of the proposed Oregon LNG project would negatively impact in-river migrating adult ESA-listed salmonids that transit the Oregon shoreline migration route that includes the project site and the outer portions of Youngs Bay.

Summary of Impacts of the proposed Oregon LNG on ESA-listed salmonids

Based on these results, it is clear that construction and operation of the proposed Oregon LNG project would negatively impact ESA-listed salmonids of a variety of species and life stages throughout the entire year. The habitats surrounding the proposed Oregon LNG site, both shallow water and deeper water, are used extensively by salmonids including fry for rearing, by juvenile salmonids for rearing and outmigration, and by returning adult salmon. Impacts would likely be greatest for fry-stage juvenile subyearling Chinook and chum salmon, which use the shallow water habitats of the Lower Columbia River estuary extensively for rearing and growth prior to outmigration.

While the importance of LCRE habitats for salmon production in general is increasingly recognized, the LCRE's Reach A may be an especially important nursery, rearing, and transitional stage for aggregated production from the lower Columbia River and its tributaries, particularly for the Youngs Bay watershed and for coho and chum salmon recovery efforts in the lower river. The fry migrant life history type (i.e., subyearling) contributes to Chinook salmon spawner success in the Columbia River basin, especially to the lower-river populations. For example, chum salmon are predominantly fry migrants and historically comprised a large biomass of adults returning to the lower Columbia River basin (Johnson et al. 1997). Both of these ESA-listed species (chum and fall Chinook) are dependent upon utilizing shallow water habitats for extended periods that conflict with the construction and operation of the proposed OLNG project.

Impacts to nearshore habitats from turbidity and sedimentation associated with project construction and dredging will have long-term negative effects on these species and their recovery. Similarly, construction of the OLNG project site immediately adjacent and downstream of significant restoration efforts involving a suite of stakeholders (and large investments) that include federal, state, tribal and local constituents does not seem wise.

Literature Cited

Anderson, S. K., D. D. Roby, D. E. Lyons, and K. Collis. 2005. Factors affecting chick provisioning by Caspian terns nesting in the Columbia River estuary. Waterbirds 28:95-105.

Bischoff, J. M. R. B. Raymond, K. U. Snyder, L. Heigh, and S. K. Binder. 2000. Youngs Bay Watershed Assessment. Report by E&S Environmental Chemistry, Inc. and Youngs Bay Watershed Council. 199 p.

Bottom, D. L., and K. K. Jones. 1990. Species composition, distribution, and invertebrate prey of fish assemblages in the Columbia River estuary. Progressive Oceanography. 25:243–270

Bottom, D. L., and 7 others. 2005a. Salmon at river's end: the role of the estuary in the decline and recovery of Columbia River salmon. United States Department of Commerce, NOAA Technical Memorandum, NMFS-NWFSC-68:246. 279 p.

Bottom, D.L., K.K. Jones, T.J. Cornwell, A. Gray and C.A. Simenstad. 2005b. Patterns of Chinook salmon migration and residency in the Salmon River estuary (Oregon). Estuarine, Coastal and Shelf Science 64: 79-93.
http://andrewsforest.oregonstate.edu/pubs/pdf/pub3989.pdf

Bottom, D. L., B. E. Riddell, and J. A. Lichatowich. 2006. The Estuary, plume, and marine environments. Pages 507 - 570 in R. N. Williams (ed). *Return to the river: restoring salmon to the Columbia River*. Elsevier Academic Press, Amsterdam, The Netherlands.

Bottom, D. L., and 17 others. 2008. Salmon life histories, habitat, and food webs in the Columbia River estuary: an overview of research results, 2002-2006. Report of Research, Fish Ecology and Conservation Biology Divisions, WFSC-NMFS Contract No. W66QKZ 7007 8056. Available online (January 6, 2010). 52 p.
https://pisces.bpa.gov/release/documents/documentviewer.aspx?

Bottom, D. L., et al. 2011. Estuarine Habitat and Juvenile Salmon: Current and Historical Linkages in the Lower Columbia River and Estuary, Final Report 2002-2008, Report of research by Fish Ecology Division, Northwest Fisheries Science Center, U. S. National Marine Fisheries Service.
http://www.nwfsc.noaa.gov/assets/26/8092_04122012_110540_Bottom.et.al.2011-rev.pdf

CH2MHill. 2013. Applicant-prepared Draft Biological Assessment and Essential Fish Habitat Assessment for the Oregon LNG Terminal and Oregon Pipeline Project. Docket Nos. CP09-6-001 and CP09-7-001. 433 p.

CH2MHill. 2014. Supplement to Applicant-Prepared Draft Biological Assessment and Essential Fish Habitat Assessment for the Oregon LNG Terminal and Pipeline Project, prepared by CH2MHill (April 2014).

CH2MHill. 2014. Supplement to the Joint Permit Application for eh Oregon LNG Bidirectional Project, prepared for the U.S. Army Corps of Engineers by CH2MHill (October 2014).

E&S Environmental Chemistry, Inc. and Youngs Bay Watershed Council. 2000. Youngs Bay Watershed Assessment. August 2000. 199 p.

Evans, A.F., N.J. Hostetter, D.D. Roby, K. Collis, D.E. Lyons, B.P. Sandford, and R.D. Ledgerwood. 2012. Systemwide evaluation of avian predation on juvenile salmonids from the Columbia River based on recoveries of Passive Integrated Transponder tags. Transactions of the American Fisheries Society 141:975-989.

Goode, T.P., M.M. McClure, B.P. Sandford, K.A. Barnas, D.M. Marsh, B.A. Ryan and E. Casillas. 2007. Quantifying the effect of Caspian tern predation on threatened and endangered Pacific salmon in the Columbia River estuary. Endangered Species Research 3:11-21.

Independent Scientific Group (ISG) (Richard N Williams and 11 co-authors). 1999. Scientific issues in the restoration of salmonid fishes in the Columbia River. *Fisheries* 24:10-19.

Johnson, O. W., W. S. Grant, R. G. Kope, K. Neely, F. W. Waknitz, and R. S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-32.

Lev, E. D. Vander Schaaf, J. Christy, J. Anderson, P. Adamus, and K. Popper. 2006. Youngs Bay bottomlands conservation and restoration plan. 113 p. http://people.oregonstate.edu/~adamusp/ColumbiaEstuary/Youngs%20Bay%20Conservation%20&%20Restoration%20Plan.pdf

Lyons, D. E., D. D. Roby, and K. Collis. 2007. Foraging patterns of Caspian terns and double-crested cormorants in the Columbia River estuary. Northwest Science 81:91-103.

Magnusson, A., and R. Hilborn. 2003. Estuarine influence on survival rates of Coho (*Oncorhynchus kisutch*) and Chinook salmon (*Oncorhynchus tshawytscha*) released from hatcheries on the U.S. Pacific Coast. Estuaries. 26: 1094-1103. http://link.springer.com/article/10.1007%2FBF02803366#

McConnaha, W. E, R. N. Williams, and J. A. Lichatowich. 2006. Introduction and background of the Columbia River salmon problem. Pages 1-28 in R. N. Williams (ed). *Return to the river: restoring salmon to the Columbia River*. Elsevier Academic Press, Amsterdam, The Netherlands.

National Marine Fisheries Service (NMFS). 2008. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion And Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. F/NVVR/2005/05883 https://www.salmonrecovery.gov/Files/BiologicalOpinions/2008/2008%20BiOp.pdf

National Marine Fisheries Service (NMFS). 2010. Endangered Species Act Section 7(a)(2)

Consultation Supplemental Biological Opinion: Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program. F/NWR/2010/02096. https://www.salmonrecovery.gov/Files/BiologicalOpinions/2010/FCRPS_Supplemental_2010_05-20[1].pdf

National Marine Fisheries Service (NMFS). 2011. Columbia River Estuary ESA recovery plan module for salmon and steelhead. Prepared for NMFS by Lower Columbia Estuary Partnership and PC Trask and Associates. 260 p.

National Marine Fisheries Service (NMFS). 2014. Endangered Species Act Section 7(a)(2) Supplemental Biological Opinion: Consultation for remand on operation of the Federal Columbia River Power System. NWR-2013-9562. http://www.westcoast.fisheries.noaa.gov/publications/hydropower/fcrps/2014_supplemental_fcrps_biop_final.pdf

Northwest Power and Conservation Council. 1994. Columbia River Basin Fish and Wildlife Program. Northwest Power Planning Council. Portland, Oregon.

Northwest Power and Conservation Council. 2000. Columbia River Basin Fish and Wildlife Program. Council Document 2000-19, Northwest Power Planning Council, Portland, Oregon

Northwest Power and Conservation Council. 2004. "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan." In *Columbia River Basin Fish and Wildlife Program*. Portland, OR.

Oregon Department of Fish and Wildlife. 2010. Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead. August 6, 2010.

Reimers, P. E. 1973. (*cited in Roegner et al. 2012*). The length of residence of juvenile fall Chinook salmon in Sixes River, Oregon. Oregon Fish Commission, Research report 4(2).

Rhodes, J.J., McCullough, D.A., and Espinosa Jr., F.A., 1994. A Coarse Screening Process for Evaluation of the Effects of Land Management Activities on Salmon Spawning and Rearing Habitat in ESA Consultations. CRITFC Tech. Rept. 94-4, Portland, Oregon.

Rhodes, J.J. 2007. Summary of Review of Federal Energy Regulatory Commission Biological Assessment and Essential Fish Habitat Assessment for Proposed Bradwood LNG Terminal Project. Report to Columbia River Inter-Tribal Fish Commission and Columbia Riverkeeper. July 2007. 15 p.

Rich, W. H. 1920. Early history and seaward migration of Chinook salmon in the Columbia and Sacramento Rivers. *Bulletin of the US Bureau of Fisheries, Washington DC* 37.

Roby, D. D., K. Collis, and D. E. Lyons. 2005. Conservation and management for fish-eating birds and endangered salmon. Pp. 161-165 in C. J. Ralph and T. D. Rich (eds.). Bird conservation implementation and integration in the Americas: Proceedings of the Third

International Partners in Flight Conference. USDA Forest Service Gen. Tech. Rep. PSW-GTR-191.

Roegner, G. C., A. Baptista, D. L. Bottom, J. Burke, L. Campbell, C. Elliot, S. Hinton, D. Jay, M. A. Lott, T. Lundrigan, R. McNatt, P. Moran, C. A. Simenstad, D. Teel, E. Volk, J. Zamon, and E. Casillas. 2008. Estuarine habitat and juvenile salmon: current and historical linkages in the lower Columbia River and estuary, 2002–2004. U.S. National Marine Fisheries Service, Report to the U.S. Army Corps of Engineers, Portland District, Contract W66QKZ20374382, Seattle. 139 p.

Roegner, G.C., R. McNatt, D.J. Teel, and D.L. Bottom. 2012. Distribution, size, and origin of juvenile Chinook salmon in shallow-water habitats of the Lower Columbia River and estuary, 2002 – 2007. Marine and coastal fisheries: Dynamics, Management, and Ecosystem Science, 4(1): 450-472.

Rosetta, T. 2005. Draft – Technical basis for revising Turbidity Criteria. Water Quality Division, Oregon Department of Environmental Quality. October 2005. 129 p.

Sagar, J.P., A. B. Borde, L.L. Johnson, C. A. Corbett, J. L. Morace, K. H. Macneale, W.B. Temple , J. Mason, R.M Kaufmann, V.I. Cullinan, S. A. Zimmerman, R. M. Thom, C.L. Wright, P.M. Chittaro, O. P. Olson, S. Y. Sol, D. J. Teel, G. M. Ylitalo, , N.D. Jahns, 2013. Juvenile Salmon Ecology in Tidal Freshwater Wetlands of the Lower Columbia River and Estuary: Synthesis of the Ecosystem Monitoring Program, 2005–2010. Prepared by the Lower Columbia Estuary Partnership for the Bonneville Power Administration, April 2013. 197 p. http://www.estuarypartnership.org/sites/default/files/resource_files/EMP%20Synthesis%20Final_050913.pdf

Schluchter, M. D., and J. A. Lichatowich. 1977. (*cited in Roegner et al. 2012*) Juvenile life histories of Rogue River spring Chinook salmon, *Oncorhynchus tshawytscha* (Walbaum), as determined by scale analysis. Oregon Department of Fish and Wildlife. Information Reports 77–5, Portland.

Schreck, C. B., T. Stahl, L. Davis, and B. Clemens. 2006. Mortality estimates of juvenile spring/summer Chinook in the lower Columbia River and estuary, 1992-1998: evidence for delayed mortality? Transactions of the American Fisheries Society. 135:457-475.

Simenstad, C. A., D. Jay, C. D. McIntire, W. Nehlsen, C. R. Sherwood, and L. F. Small. 1984. The Dynamics of the Columbia River Estuarine Ecosystem, Vol. I and II. Columbia River Estuary Data Development Program, Astoria, OR.

U.S. Fish and Wildlife Service (USFWS). 2005. Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary, Final Environmental Impact Statement. Portland, Oregon.
http://www.fws.gov/pacific/migratorybirds/pdf/Caspian_Tern_Final_EIS.pdf

U.S. Army Corps of Engineers (USACE) and Bonneville Power Administration (BPA). 2013. Benefits of habitat improvements in the Lower Columbia River and estuary: Results of research, monitoring, and evaluation. https://www.salmonrecovery.gov/Files/Estuary/Final_Estuary_Benefits_9-16-13.pdf

Weitkamp, L. A., P. J. Bentley, and M. N. C. Litz. 2012. Seasonal and interannual variation in juvenile salmonids and associated fish assemblage in open waters of the lower Columbia River estuary. Fisheries Bulletin 110:426-450.

Williams, R. N., editor. 2006. Return to the river: restoring salmon to the Columbia River. Elsevier Academic Press, Amsterdam, The Netherlands. 699 p.

Williams, R. N., and 9 others. 2006. Return to the river: strategies for salmon restoration in the Columbia River Basin. Pages 629-666, in Williams, R. N., editor. Return to the river. Elsevier Academic Press, Amsterdam, The Netherlands.

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Education:

Ph.D., Zoology, April 1986, Brigham Young University, Provo, UT
M. S., Zoology, August 1981, Brigham Young University, Provo, UT
B. S., Zoology and English Literature, 1974, The College of Idaho, Caldwell, ID

Consulting and Research Interests:

- Conservation ecology of native rainbow, redband, steelhead, cutthroat, and bull trout, and Pacific salmon species; stream and habitat restoration; Pacific salmon restoration; genetic structure of salmonid populations; consulting on strategic and prioritization planning.

Positions:

Affiliate Faculty

- Research Associate, Department of Biology, The College of Idaho; 2013 to present.
- Aquaculture Research Institute and the Center for Salmonids and Freshwater Species At Risk, Hagerman Fish Culture Experimental Station, University of Idaho; 2001 to 2011.

Scientific and Technical Consultant

- 2005 - present – Member of the Peer Review Group for the Northwest Planning and Conservation Council, Portland, Oregon.
- 2007 – present – Biological Consultant to JR Simplot Company for stream and fisheries restoration and land management on the Meade Peak Ranch.
- 1996 - 2005 - Member and Chair of the Independent Scientific Review Panel for the Northwest Planning and Conservation Council, Portland, Oregon
- 1989 - 1998 - Member and Chair (1996) of the Independent Scientific Advisory Board for the National Marine Fisheries Service and the Northwest Planning and Conservation Council, Portland, Oregon.
- Fisheries Conservation Foundation – Member of the Board of Directors (2007 to present); focusing on native fish and aquatic community conservation in river and stream systems.
- Federation of Fly Fishers - National Conservation Advisor (2003 to present) and member of the Board of Directors. Focus on native fish and habitat conservation, as well as conservation education.

Columbia River Basin Research and Management Experience:

2005 - present. Member of the Peer Review Group (PRG) for the Northwest Planning and Conservation Council, Portland, Oregon. PRG members assist the Northwest Power Planning Council's Independent Scientific Review Panel with scientific and technical review of projects funded through the Council's Fish and Wildlife Program and the Bonneville Power Administration.

1997 - 2005. Chair of the Independent Scientific Review Panel (ISRP). The ISRP assists the Northwest Power Planning Council, Portland, Oregon with scientific and technical review of projects funded through the Council's Fish and Wildlife Program and the Bonneville Power Administration.

1996 - 1999. Chair of the Independent Scientific Advisory Board (ISAB: formerly the Independent Scientific Group). The ISAB provides technical and scientific review and oversight to the Northwest Power Planning Council, Portland, Oregon and the National Marine Fisheries Service, Seattle Regional Office with respect to recovery efforts for Pacific Salmon. species.

- In September 1996, the ISAB produced a multi-authored and peer-reviewed report called RETURN TO THE RIVER that describes a conceptual framework for salmon restoration in the Columbia River Basin:

1994 - 1996. Chair of the Independent Scientific Group (ISG) (formerly the Scientific Review Group), Northwest Power Planning Council, Portland, Oregon. Overseeing a Review of Science for the Northwest Power Planning Council that examines the scientific assumptions underlying the Columbia Basin Fish and Wildlife Program

1989 - 1994. Member of Scientific Review Group, Columbia Basin Fish and Wildlife Authority. Produced multi-authored technical reviews of program and measures for:

- Critical Uncertainties in the Columbia Basin Fish and Wildlife Program
- Hatchery Effectiveness and Fish Disease
- Supplementation of Wild Salmonids using Hatchery-produced Salmonids
- Mitigation Implementation Plan for Hungry Horse Reservoir

1993 - 1996. Member of Genetics Team for Oregon Trout's Conservation of Genetic Resources Project funded by the Northwest Area Foundation. Goal of project is to develop a peer-reviewed gene conservation program for Pacific Salmon.

1994. Member of Independent Peer Review Team for review of juvenile salmonid transportation. Project goal is to determine the efficacy of transportation (barging) as a means to increase adult salmon returns to natal spawning areas.

Biological Consulting:

2007 – Present. JR Simplot's Meade Peak Ranch in eastern Idaho. Developed and implementing stream and riparian habitat restoration plan on Crow Creek and tributaries. Developed and implementing land and grazing management plan for ranch.

2010 – Present. JR Simplot's Meade Peak Ranch in eastern Idaho. Developed and implementing stream and riparian habitat restoration plan on Crow Creek and tributaries. Developed and implementing land and grazing management plan for ranch.

2006 – 2007. Trout Unlimited. Reviewed potential biological effects of an expansion of the JR Simplot Smoky Canyon Mine into an adjacent roadless area.

2007 – present. Idaho Rivers United. Reviewed effects of Hells Canyon Dam complex on fall Chinook spawning. Evaluated Idaho Power Company's proposed mitigation plan for violation of TMDL (temperature) standards and made recommendations on plan and alternative approaches.

2007 – 2010. South Fork Landing, Garden Valley, Idaho. Consultant in the development of a linked series of streams and ponds in 800 acre development to achieve fishery and wildlife benefits.

Awards and Honors:

2008 - Leopold Conservation Award from the Federation of Fly Fishers for lifetime contribution to native fish conservation.

1997 - Nominated for the Pew Fellows Program in Conservation and the Environment.

1992 - Oregon Trout Award of Scientific Merit for contributions to conservation issues in western trout.

1992 - Election to Full Membership in Sigma Xi, 29 April 1992.

1991 - NATO Advanced Study Institute on Conservation Genetics of Salmonid Fishes, Washington State University and University of Idaho, 24 June - 5 July 1991.

1990 - Molecular Evolution Short Course participant, Woods Hole Marine Biological Laboratory, 19-31 August 1990.

Books:

Williams, Richard N. (Editor). 2006. Return to the River: Restoring salmon to the Columbia River. Elsevier Academic Press, London. 699 p.

Pertinent Refereed Journal Articles:

Williams, J.E., **R.N. Williams**, R.F. Thurow, L. Elwell, D.P. Philipp, F.A. Harris, J.L. Kershner, P.J. Martinez, D. Miller, G.H. Reeves, C.A. Frissell, and J.R. Sedell. 2011. Native Fish Conservation Areas: a vision for large-scale conservation of native fish communities. ***Fisheries*** 36:6, 267-277. .

Campbell, M.R., C.C. Kozfkay, K.A. Meyer, M.S. Powell, and **R.N. Williams**. 2011. Historical influences of volcanism and glaciation in shaping mitochondrial DNA variation and distribution in Yellowstone cutthroat trout across its native range. ***Transactions of the American Fisheries Society*** 140:91-107.

Williams, Richard N. and James A. Lichatowich. 2009. Science and politics – an uncomfortable alliance: lessons learned from the Fish and Wildlife Program of the Northwest Power and Conservation Council. Pages 1021-1046 *in* C.C. Krueger and C.E. Zimmerman, editors. Pacific salmon: ecology and management of western Alaska's populations. ***American Fisheries Society, Symposium 70***, Bethesda, Maryland.

James A. Lichatowich and Richard N. Williams. 2009. Failures to incorporate science into fishery management and recovery programs: lessons from the Columbia River. Pages 1005-1020 *in* C.C. Krueger and C.E. Zimmerman, editors. Pacific salmon: ecology and management of western Alaska's populations. ***American Fisheries Society, Symposium 70***, Bethesda, Maryland.

Research, Monitoring and Evaluation of Fish and Wildlife Restoration Projects in the Columbia River Basin: Lessons Learned and Suggestions for Large-Scale Monitoring Programs. 2007. Independent Scientific Advisory Board (ISAB) to the Northwest Power and

Conservation Council (Council), Portland, Oregon, NOAA Fisheries, Seattle, Washington, and the Columbia River Basin Indian Tribes and Independent Scientific Review Panel (ISRP) to the Northwest Power and Conservation Council, Portland, Oregon. ***Fisheries*** 32: 582-590.

Williams, Richard N. 2000. Refugia-based conservation strategies: Providing safe havens in managed river systems. Pages 133-138 in Oregon Salmon: Essays on the state of the fish at the turn of the Millennium. Oregon Trout, Portland, Oregon.

Independent Scientific Group (**Richard N. Williams** (Chair), Daniel L. Bottom, Lyle D. Calvin, Charles C. Coutant, Michael W. Erho, Jr., Christopher A. Frissell, James A. Lichatowich, William J. Liss, Willis E. McConnaha, Phillip R. Mundy, Jack A. Stanford, Richard R. Whitney). 1999. Scientific issues in the restoration of salmonid fishes in the Columbia River. Fisheries 24**:** 10-19.

Independent Scientific Group (**Richard N. Williams** (Chair), Daniel L. Bottom, Lyle D. Calvin, Charles C. Coutant, Michael W. Erho, Jr., Christopher A. Frissell, James A. Lichatowich, William J. Liss, Willis E. McConnaha, Phillip R. Mundy, Jack A. Stanford, Richard R. Whitney). 1998. Return to the river: an ecological vision for the recovery of the Columbia River salmon. Environmental Law 28**:** 503-518.

Williams, R. N., R. F. Leary, and K. P. Currens. 1997. Localized genetic effects on resident rainbow trout of a long-term hatchery stocking program in the Metolius River, Oregon. North American Journal of Fisheries Management 17(4):1079-1093.

Williams, R. N., R. P. Evans, and D. K. Shiozawa. 1997. Mitochondrial DNA diversity patterns of bull trout in the Upper Columbia River Basin. Pages 283-297 *in* W. C. Mackay, M. K. Brewin, and M. Monita, editors, Friends of the Bull Trout Conference Proceedings. Calgary, Alberta.

Stanford, J. A., J. V. Ward, W. J. Liss, C. A. Frissell, **R. N. Williams**, J. A. Lichatowich, C. C. Coutant. 1996. A general protocol for restoration of entire river catchments. Regulated Rivers: Research and Management 12:391-413.

Williams, R. N., D. K. Shiozawa, J. E. Carter, and R. F. Leary. 1996. Detection of putative hybridization among native and introduced rainbow trout populations in the upper Snake River. Transactions of the American Fisheries Society 125:387-401.

Williams, R. N., D. K. Shiozawa, R. P. Evans, and E. Bermingham. 1994. Molecular phylogenies of cutthroat trout (Oncorhynchus clarki) based on a hierarchical analysis of mitochondrial DNA polymorphisms. Applications of DNA Technology to the Management of Pacific Salmon, NOAA Technical Memorandum NMFS-NWFSC-17:77-83.

Independent Scientific Group (**Richard N. Williams** (Chair), Daniel L. Bottom, Lyle D. Calvin, Charles C. Coutant, Michael W. Erho, Jr., Christopher A. Frissell, James A. Lichatowich, William J. Liss, Willis E. McConnaha, Phillip R. Mundy, Jack A. Stanford, Richard R. Whitney). 1999. Scientific issues in the restoration of salmonid fishes in the Columbia River. ***Fisheries*** 24**:** 10-19.

Independent Scientific Group (**Richard N. Williams** (Chair), Daniel L. Bottom, Lyle D. Calvin, Charles C. Coutant, Michael W. Erho, Jr., Christopher A. Frissell, James A. Lichatowich, William J. Liss, Willis E. McConnaha, Phillip R. Mundy, Jack A. Stanford, Richard R. Whitney). 1998. Return to the river: an ecological vision for the recovery of the Columbia River salmon. ***Environmental Law*** 28**:** 503-518.

Williams, R. N., R. P. Evans, and D. K. Shiozawa. 1997. Mitochondrial DNA diversity patterns of bull trout in the Upper Columbia River Basin. Pages 283-297 *in* W. C. Mackay, M. K. Brewin, and M. Monita, editors. ***Friends of the Bull Trout Conference Proceedings***. Calgary, Alberta.

Williams, R. N., R. F. Leary, and K. P. Currens. 1997. Localized genetic effects on resident rainbow trout of a long-term hatchery stocking program in the Metolius River, Oregon. ***North American Journal of Fisheries Management*** 17(4):1079-1093.

Williams, R. N., D. K. Shiozawa, J. E. Carter, and R. F. Leary. 1996. Detection of putative hybridization among native and introduced rainbow trout populations in the upper Snake River. ***Transactions of the American Fisheries Society*** 125:387-401.

Stanford, J. A., J. V. Ward, W. J. Liss, C. A. Frissell, **R. N. Williams**, J. A. Lichatowich, C. C. Coutant. 1996. A general protocol for restoration of entire river catchments. ***Regulated Rivers: Research and Management*** 12:391-413.

Williams, R. N., D. K. Shiozawa, R. P. Evans, and E. Bermingham. 1994. Molecular phylogenies of cutthroat trout (*Oncorhynchus clarki*) based on a hierarchical analysis of mitochondrial DNA polymorphisms. Applications of DNA Technology to the Management of Pacific Salmon, NOAA Technical Memorandum NMFS-NWFSC-17:77-83.

Proebstel, D. S., R. P. Evans, D. K. Shiozawa, and **R. N. Williams**. 1993. Preservation of non-frozen issue samples from a salmonine fish *Brachymystax lenok* (Pallas) for DNA analysis. ***Journal of Ichthyology*** 2:9-17.

Shiozawa, D. K., J. Kudo, R. P. Evans, S. R. Woodward, and **R. N. Williams**. 1992. DNA extraction from preserved trout tissues. ***Great Basin Naturalist*** 52(1):29-34.

Book Chapters (Peer Reviewed):

Williams, R. N. (*In press*). The Origin, Decline, and Resurgence of Conservation as a Guiding Principle in the Federation of Fly Fishers. Pages xxx-xxx in *Rivers of Success*. S. Snyder, (editor). Chicago, Chicago Press.

Williams, R. N., J. A. Lichatowich, et al. 2006. The diversity, structure and status of populations. Pages 99-172 in *Return to the river: restoring salmon to the Columbia River*. R. N. Williams (editor). London, Elsevier Academic Press.

Williams, R. N. and nine co-authors. 2006. Conclusions and strategies for salmon restoration in the Columbia River. Pages 629-666 in *Return to the river: restoring salmon to the Columbia River*. R. N. Williams (editor). London, Elsevier Academic Press.

Bisson, P.A., J.A. Lichatowich, W.J.. Liss, D. Goodman, C.C Coutant, L.L. McDonald, D. Lettenmeier, E.J. Loudenslager, and **R.N. Williams**. 2006. The federal approach to salmon recovery at the millennium. Pages 601-628 in *Return to the river: restoring salmon to the Columbia River*. R. N. Williams (editor). London, Elsevier Academic Press**.**

Lichatowich, J.A., W.E. McConnaha, W.J. Liss, J.A. Stanford, and **R.N. Williams**. 2006. The conceptual foundation. Pages 29-50 in *Return to the river: restoring salmon to the Columbia River*. R. N. Williams (editor). London, Elsevier Academic Press**.** 29-50.

Lichatowich, J.A., M.S. Powell, and **R.N. Williams**. 2006. Artificial production and the effects of fish culture on native salmonids. Pages 417-466 in *Return to the river: restoring salmon to the Columbia River*. R. N. Williams (editor). London, Elsevier Academic Press.

Liss, W.J., J.A. Stanford, J.A. Lichatowich, **R.N. Williams**, C.C. Coutant, P.R. Mundy, and R.R. Whitney. 2006. A foundation for restoration. Pages 51-98 in *Return to the river: restoring salmon to the Columbia River*. R. N. Williams (editor). London, Elsevier Academic Press.

McConnaha, W. E., **R. N. Williams**, et al. 2006. The problem of the Columbia River salmon. Pages 1-28 in *Return to the river: restoring salmon to the Columbia River*. R. N. Williams (editor). London, Elsevier Academic Press.

McDonald, L. L., C. C. Coutant, L. D. Calvin and **R. N. Williams**. 2006. Monitoring and evaluation. Pages 571-600 in *Return to the river: restoring salmon to the Columbia River*. R. N. Williams (editor). London, Elsevier Academic Press.

Partial Listing of Recent Reports by the Independent Science Groups

(A complete listing is available at www.nwcouncil.org/library/isrp/Default.htm and at www.nwcouncil.org/fw/isab/Default.htm).

(RNWilliams served as Senior Editor and writer on the majority of the following reports)

Independent Scientific Review Panel. 2004. Scientific Review of Subbasin Plans for the Columbia River Basin Fish and Wildlife Program. ISRP 2004-13. Northwest Planning and Conservation Council, Portland, Oregon.

Independent Scientific Review Panel. 2004. Review of the Action Agencies and NOAA Fisheries Draft RME (Research, Monitoring, and Evaluation) Plan. ISRP 2004-1. Northwest Planning and Conservation Council, Portland, Oregon.

Independent Scientific Review Panel. 2004. Final Review of the US Army Corps of Engineers' Anadromous Fish Evaluation Program for FY2004. ISRP 2004-8. Northwest Planning and Conservation Council, Portland, Oregon.

Independent Scientific Review Panel. 2003. A Review of Protocols for counting salmonids, resident fish, and lamprey in the Pacific Northwest. ISRP 2003-11. Northwest Power Planning Council, Portland, Oregon.

Independent Scientific Review Panel. 2003. Review of Idaho Supplementation Studies. ISRP 2003-8. Northwest Power Planning Council, Portland, Oregon.

Independent Scientific Review Panel. 1999. Review of the Columbia River Basin Fish and Wildlife Program as directed by the 1996 amendment to the Power Act. Northwest Power Planning Council, Portland, Oregon.

Independent Scientific Advisory Board. 2003. A review of salmon and steelhead supplementation. ISAB 2003-3. Northwest Power Planning Council and the National Marine Fisheries Service, Portland, OR.

Independent Scientific Advisory Board. 1999a. Looking for common ground: Comparison of recent reports pertaining to salmon recovery in the Columbia River Basin. Northwest Power Planning Council and the National Marine Fisheries Service, Portland, OR.

Independent Scientific Group. 1997. Review of a Draft Programmatic Environmental Impact Statement: Impacts of Artificial Salmon and Steelhead Production Strategies in the Columbia River Basin. Northwest Power Planning Council and the National Marine Fisheries Service, Portland, Oregon.

Professional Societies:

The American Fisheries Society
Sigma Xi

Invited Papers and Conferences:

"Hatcheries, Salmon and Steelhead: Looking toward Idaho's future". Plenary Talk at Idaho Chapter American Fisheries Society Annual Meeting, Moscow, Idaho, February 13, 2004.

"Development and implementation of Ecosystem-based Management in the Columbia River Basin" A Scientific Perspective". Keynote Speaker, Western Division, American Fisheries Society, Annual Meeting, Spokane, Washington, April 27, 2002.

"Restoration of Columbia River salmon: a case study of proposed actions". Symposium on the Management of Vulnerable Species and Aquatic Systems. 1997 National Meeting of the American Fisheries Society, Monterey, California, 25 August 1997.

"A conceptual foundation for scientific oversight of salmon restoration in the Columbia River Basin". AAAS Program Session Columbia River Basin Salmon Restoration: Can Science help resolve conflicting plan and competing interests? 1997 AAAS National Meeting, Seattle, Washington, 14 February 1997.

"Return to the River: restoration of salmonid fishes in the Columbia River Basin". Who Runs the River Symposium. Northwest Water Law and Policy Project, Northwestern School of Law of Lewis and Clark College. Portland, Oregon, 15 November 1996.