Chapter 2. Nearshore Assessment: Fish use of the Elwha estuary

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Abstract

We assessed fish use of three main areas (east, west, and impounded west sections) of the Elwha River estuary using standard beach seining techniques from March-September 2007. Species diversity, richness, and evenness were all highest in the connected section of the west estuary, which constitutes only 20% of the total Elwha estuary. Further, over 60% of total fish, 90% of salmonids, and 94% of juvenile Chinook salmon were collected from the connected west estuary. Species diversity and richness of the Elwha east estuary and impounded west estuary were very similar for months both were sampled. Juvenile salmon were the same size in the east and west connected estuary. We theorize that sediment processes closed off fish access to the majority of the east estuary. We hypothesize that migrating juvenile salmon responded to this closure by using the small proportion of west estuary left to them. These results indicate that: 1. Fish use of the Elwha estuary is complex and even fragments of connected estuary are critically important for migrating salmon; 2. Sediment processes in the Elwha estuary are dynamic, and; 3.Juvenile salmon appear to be able to respond to dynamic sediment environment. Projecting these

conclusions to the upcoming dam removal project lead us to recommend that increasing habitat options available for juvenile salmon in the Elwha estuary is a top priority for nearshore restoration This includes, at a minimum, modification of the west levee currently impounding portions of the west estuary to provide, at a minimum, fish passage, and optimally to provide at least partial ecosystem recovery. More detailed monitoring of fish migration in the Elwha estuary, including radio tracking of fish to better define fish use of this complex and dynamic estuarine habitat, is warranted and strongly recommended.

Introduction

The Elwha estuary, which connects the Elwha watershed with the Strait of Juan de Fuca, is critical habitat to a number of federally listed species and a complex, though not well understood, ecosystem. It includes approximately 88 acres of estuarine habitat that may be split into three sections: 1. The east estuary, located east of the river mouth and which includes approximately 63 acres (71 % of the total estuary) that are bordered to the east and south by rock dikes; 2. The west estuary, located on the west side of the river mouth, which in total is approximately 22 acres (29% of the total Elwha estuary) and includes approximately 18 acres of habitat that is bordered to the west by a earthen levee and connected directly to the west river mouth (19% of the total estuary), and; 3. The impounded west estuary which includes 9 acres (10% of total estuary) of impounded estuary, that is immediately west of, and separated from the rest of the west estuary by an earthen and rock dike along the west river channel. This west levee creates a total fish barrier between the river and the 9 acres of impounded estuary (Figure 1).

The Elwha estuary is limited by approximately 100 years of sediment starvation due to two dams installed in the watershed. The sediment starvation has resulted in loss of estuarine side channel habitat (Pess et al 2008). Dikes along the east and west estuary have also resulted in truncated and disconnected estuary.

The Elwha watershed will undergo a large scale restoration event with the removal of two large hydroelectric dams. Dam removal is slated to begin in 2012. Dam removal will result in the transport of approximately 10 million cubic yards of material from the upper river to be to the nearshore, including the Elwha estuary, within five years of dam removal (Randal et al 2004). Given the critical importance of estuarine systems for juvenile fish survival (Beamer et al 2003, 2005, Fresh et al 2006), understanding how the Elwha estuary functions is central to defining additional restoration necessary to achieve full ecosystem recovery (Shaffer et al 2008). The WDFW and LEKT, with numerous partners, have been monitoring the Elwha estuary for habitat function. This report summarizes findings of a one year study defining fish use of the Elwha estuary. Based on these observations we provide restoration and monitoring recommendations necessary to achieve the goal of understanding and promoting ecosystem function within the Elwha estuary.

Methods and Materials

The east, west, and impounded areas of the Elwha etuary, as well as the eastern shoreline of Freshwater Bay, were sampled using beach seines during the salmon outmigration period (March-September) 2007. The shoreline of Freshwater Bay was seined as well. Results of the Freshwater Bay sampling are provided in the companion shoreline report.

Large and small Puget Sound Protocol nets were used in the west estuary. Large PSP seine net was used in the east estuary. A total of 4-6 seines were conducted across three stations of the east estuary every other week. A total of 1-2 seines were conducted along the west estuary weekly. Two seines were conducted in the impounded estuary weekly. Large accumulations of green sea weed in the impounded estuary made the area unworkable. The impounded portion of the west estuary was therefore sampled only March-June.

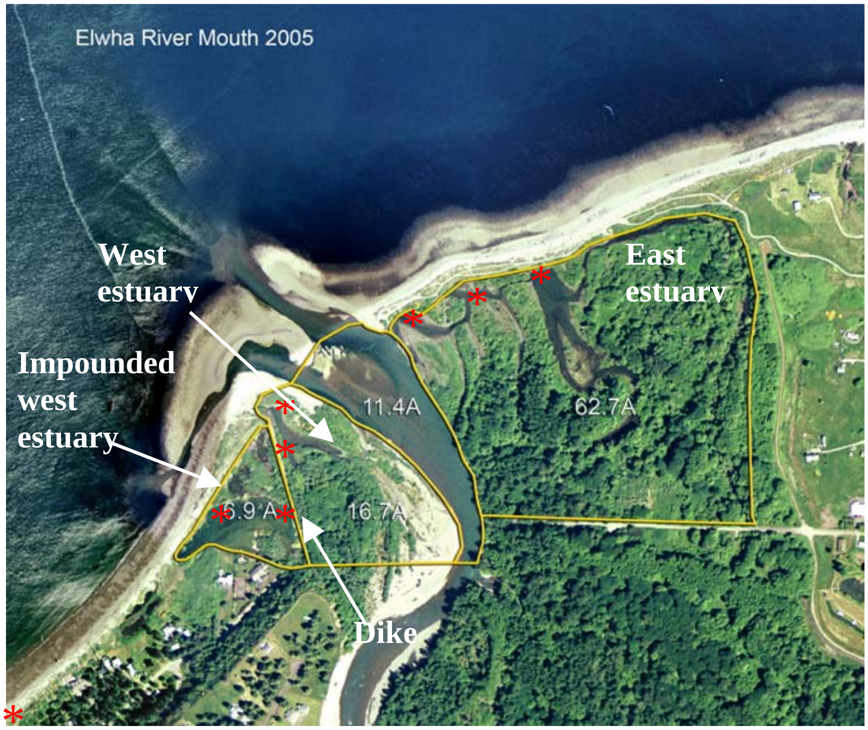


Figure 1. Sample locations east and west Elwha estuary with acreages. Asterisk indicates sample site.

Results

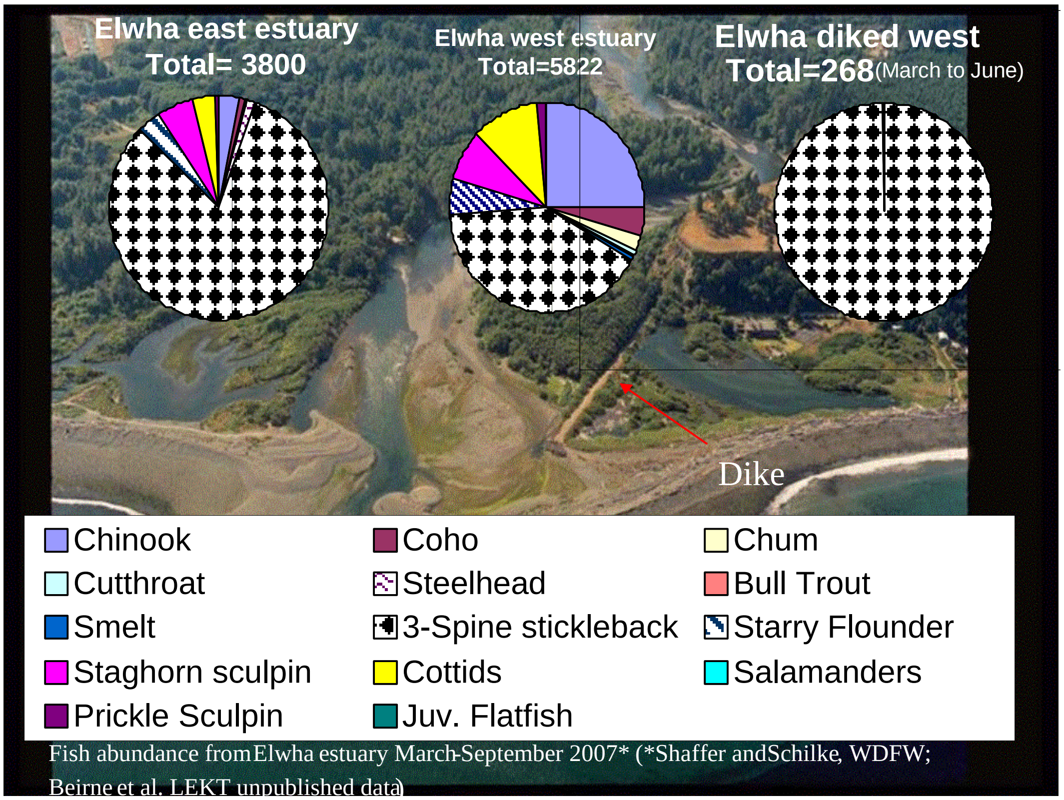
A total of 118 seines were conducted from March-September 2007 (Table1). Combining seining results from summer 2007 revealed a number of differences in fish use within the Elwha estuary. Species composition, diversity, and richness varied by each area (Figure 2-5).

Table 1. Seining summary Elwha estuary 2007. *=seining study lead by LEKT.

Date		Number of Seines by Site		
	East*	West	Impounded estuary	Total
March	10	2	2	14
April	12	6	6	24

May	15	6	10	31
June	8	6	na	14
July	10	8	na	18
August	4	5	na	9
Sept	4	4	na	8

Figure 2. Percent composition, by species, in each of the three sections of the Elwha estuary.



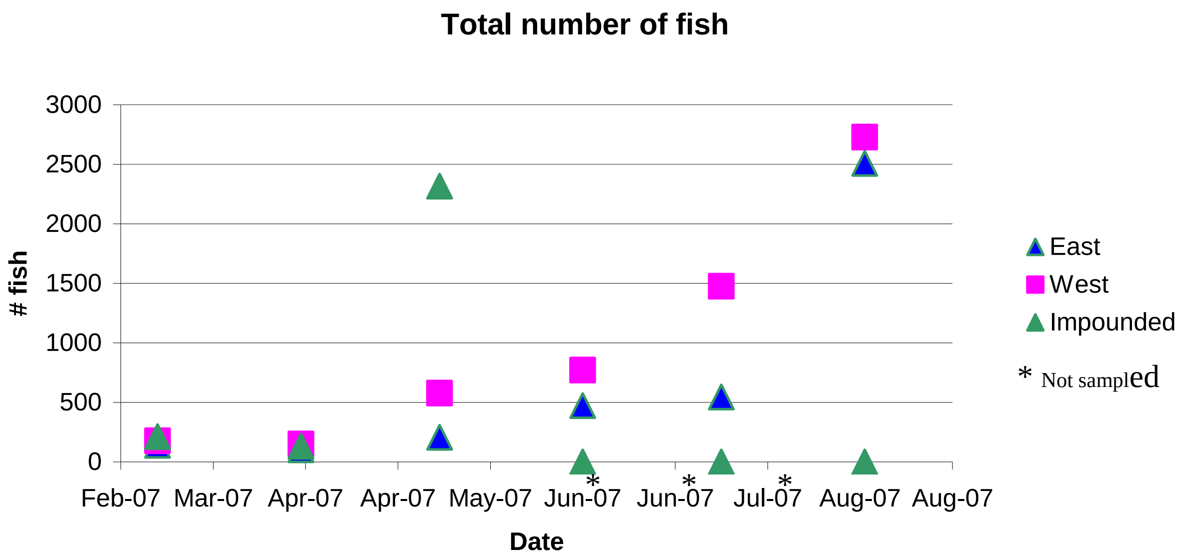


Figure 3. Total number of fish collected at each of the three sections of Elwha estuary March-September 2007, by month (Impounded area sampled March-June).

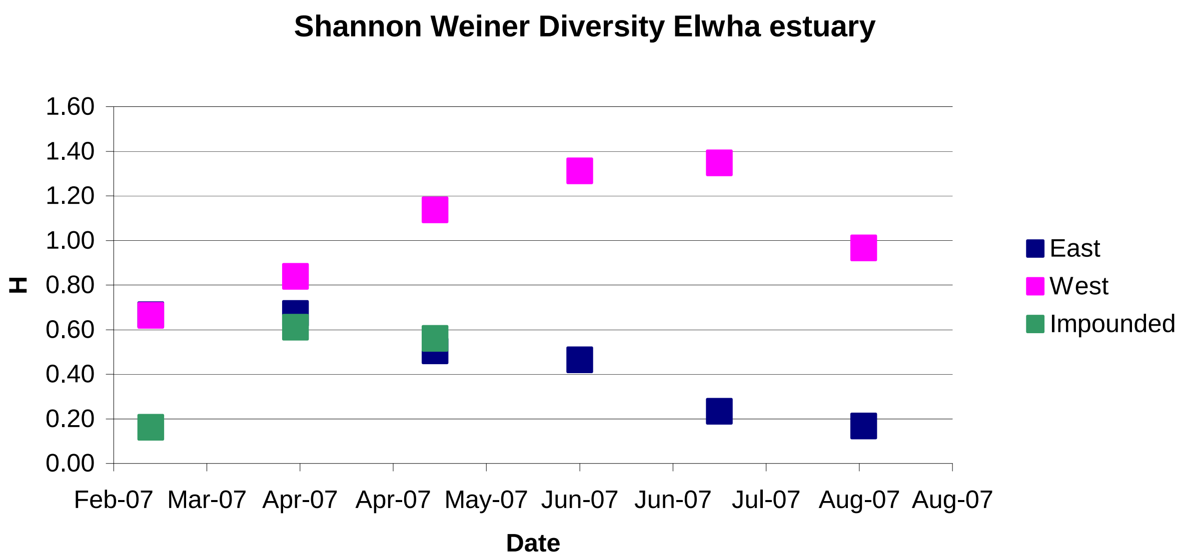


Figure 4. Shannon Weiner Diversity, Elwha estuary

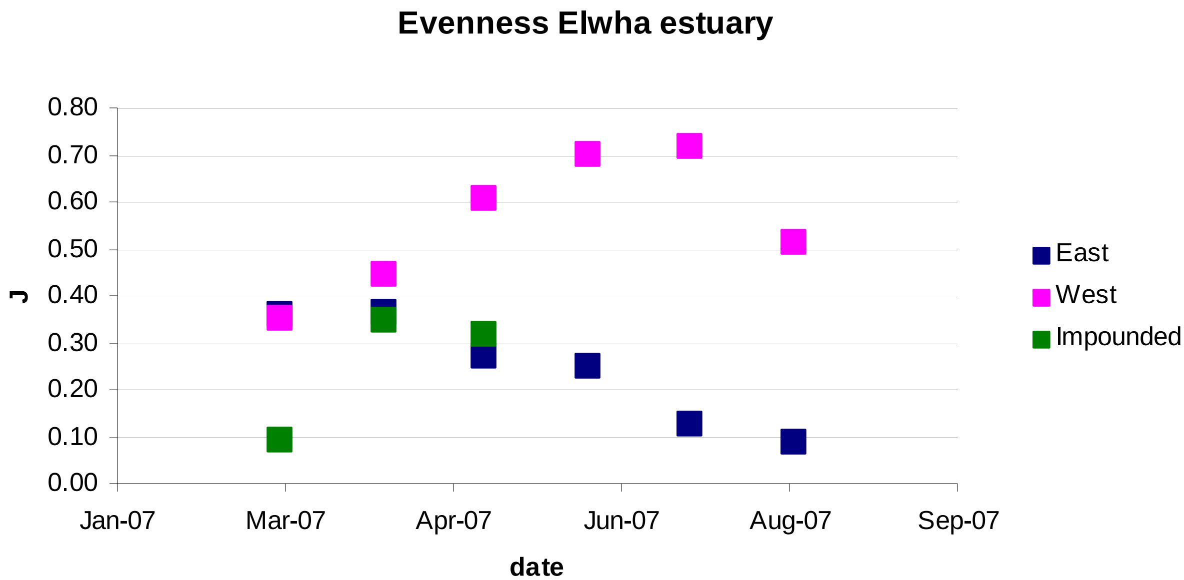


Figure 5. Evenness, Elwha estuary.

In total 47% of the fish were collected in 20% of the Elwha estuary (the west estuary). In addition, over 90 percent of combined juvenile salmonids and 94% of juvenile Chinook salmon were collected in the west estuary (Table 2). Densities of Chinook, coho, and chum salmon densities were all much higher in the west estuary than other areas of the Elwha estuary Figure 6-8). Fish size was similar across the estuary (Figure 9-13). Average juvenile Chinook size increased with time (Figure 14). Average coho size, on the other hand, initially increased and then decreased across the sampling season.

Table 2. Salmonid abundance summary Elwha estuary

		East estuary	Connected west estuary	Impounded west estuary	Combined estuary
Total salmon	Number	250	2527	3	2780
	Percent	9	91	0	100
Chinook	Number	130	1942	1	2073
	Percent	6	94	0	75
Coho	Number	37	335	0	372
	Percent	10	90	0	14
Chum					
	Number	37	180	0	217

	Percent	17	83	0	10
Cutthroat	Number	2	65	0	67
	Percent	3	97	0	2
Steelhead	Number	44	5	1	50
	Percent	88	10	2	2

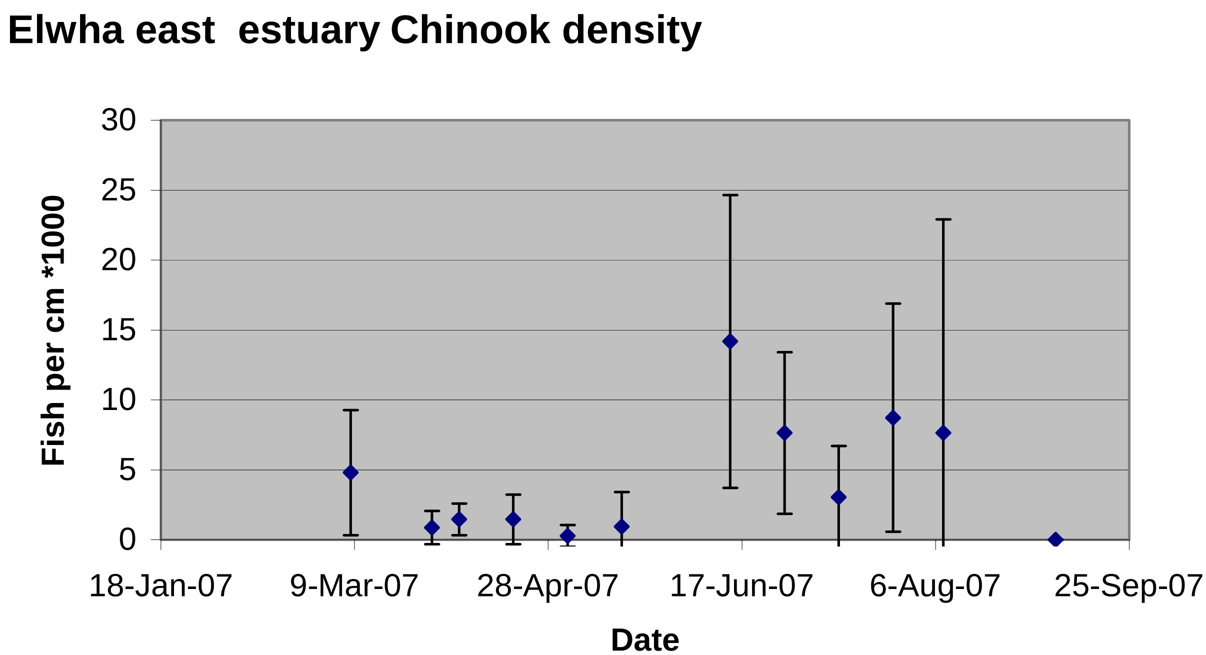


Figure 6. Chinook density, east estuary

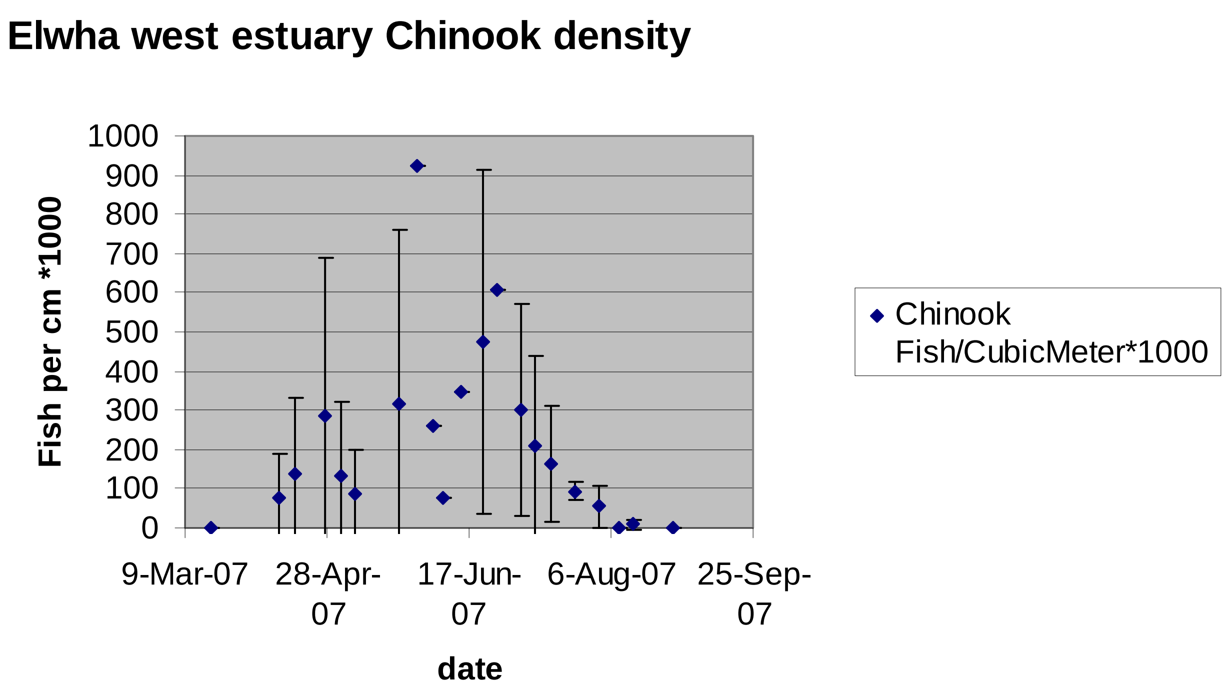


Figure 7. Chinook density, west estuary

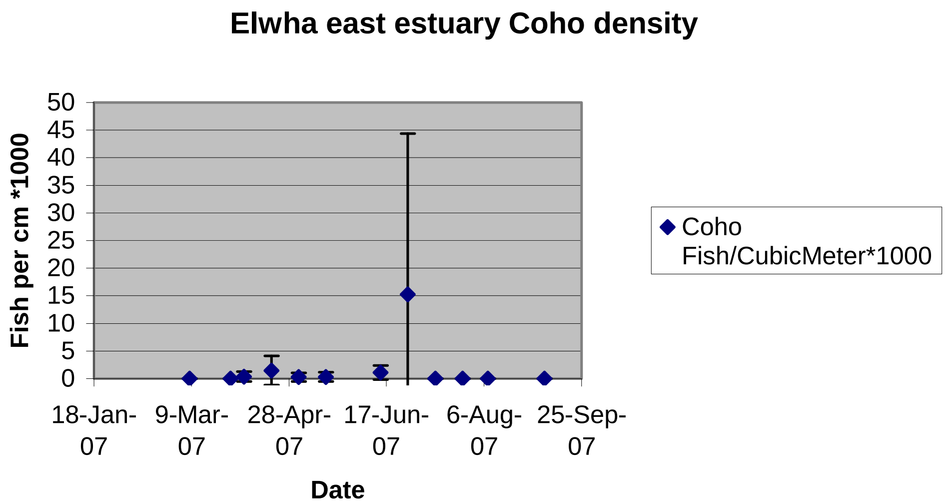


Figure 8. Coho density east estuary.

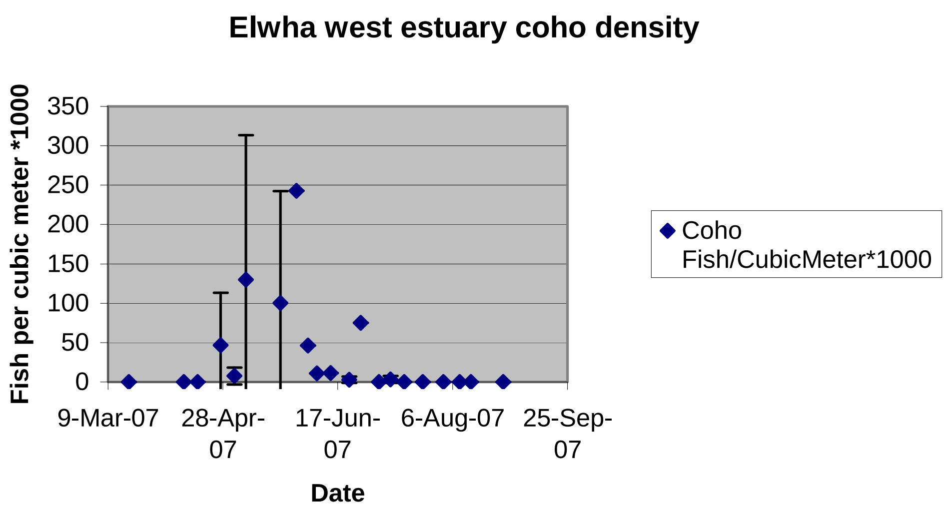


Figure 9. Coho density west estuary

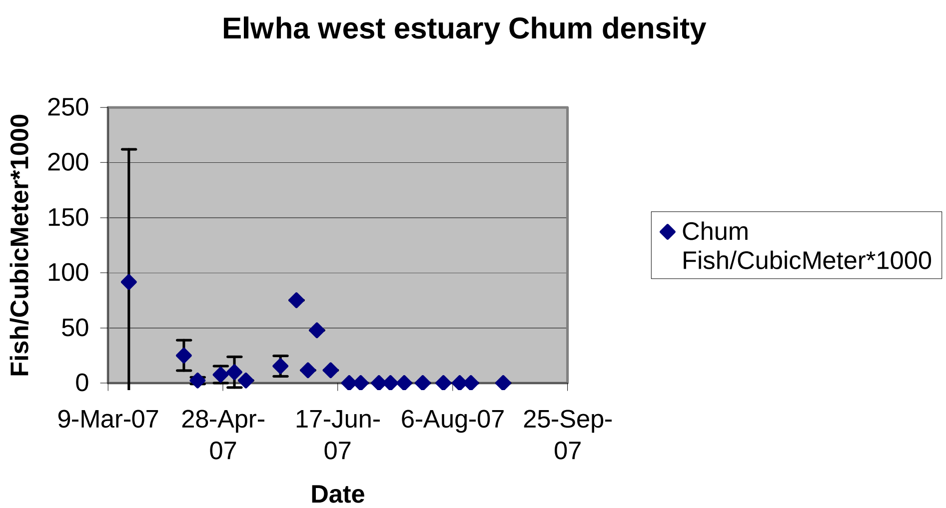


Figure 10. Chum density west estuary

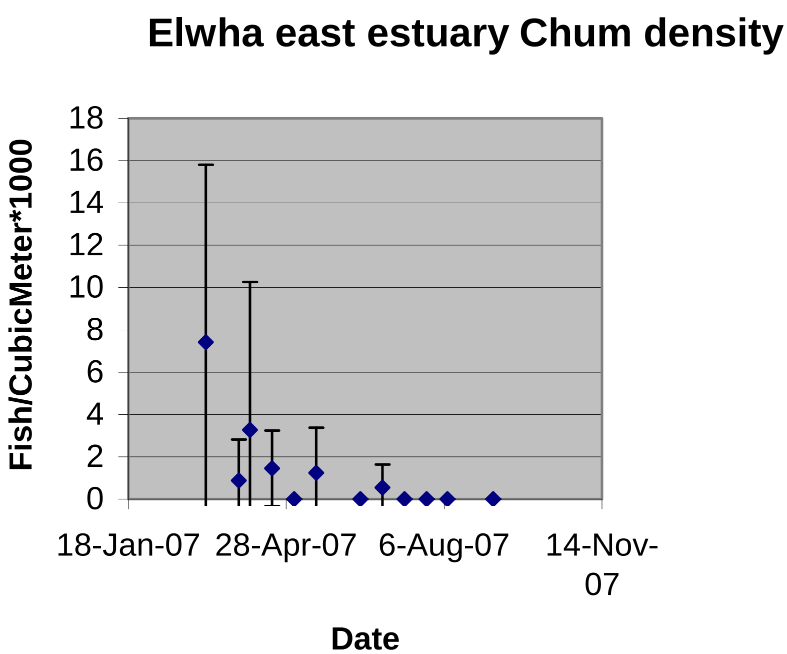
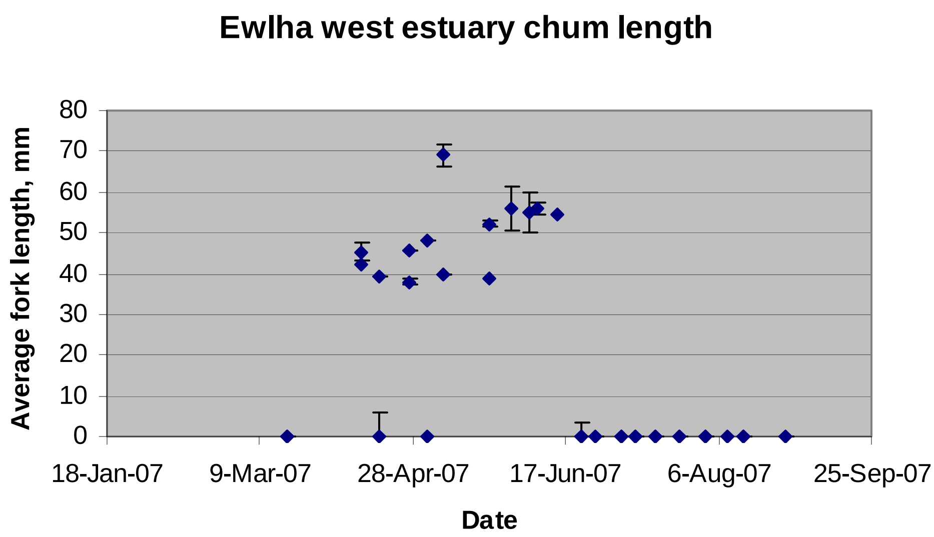
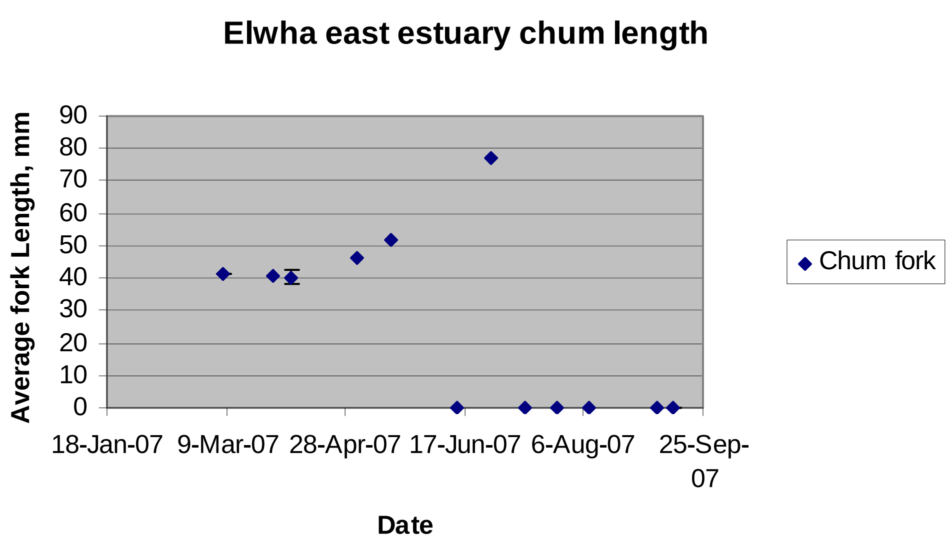


Figure 11. Chum density east estuary


Ewlha west estuary chum length
Average fork length, mm
80
70
60
50
40
30
20
10
0
18-Jan-07
9-Mar-07
28-Apr-07
17-Jun-07
6-Aug-07
25-Sep-07
Date


Elwha east estuary chum length
Average fork Length, mm
90
80
70
60
50
40
30
20
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18-Jan-07
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25-Sep-07
Date
Chum fork

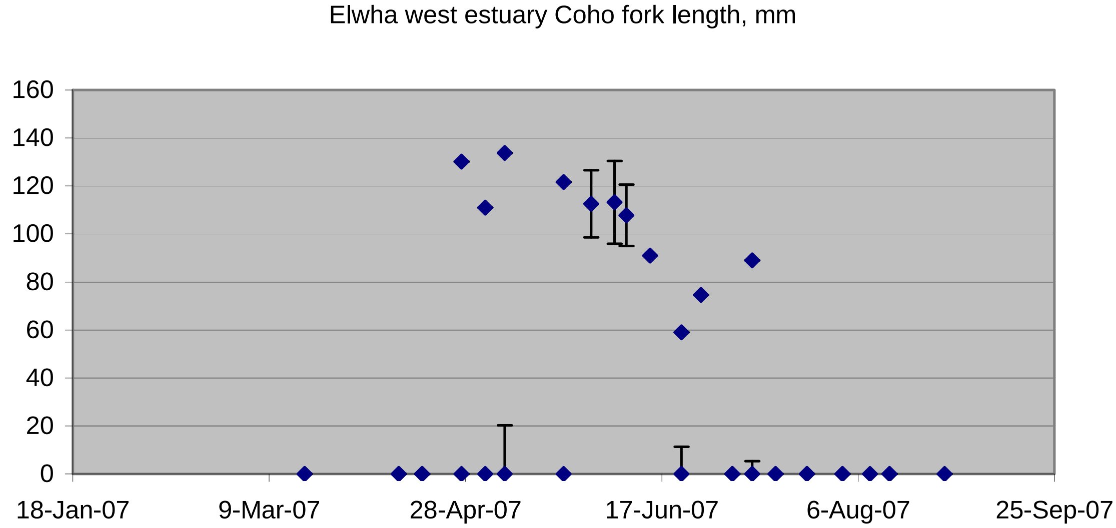

Figure 12. Coho fork length,.west estuary

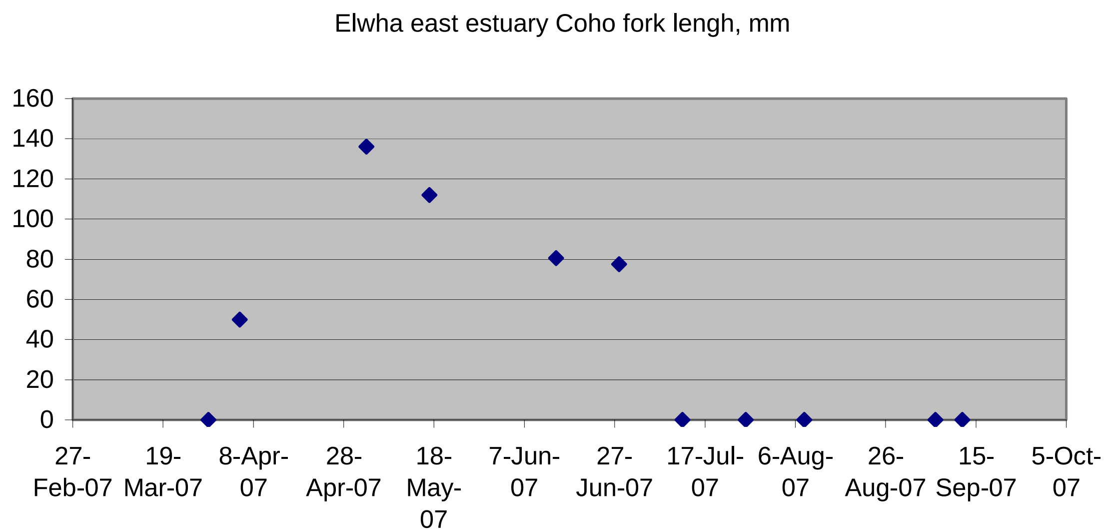

Figure 13. Coho fork length, mm. East estuary

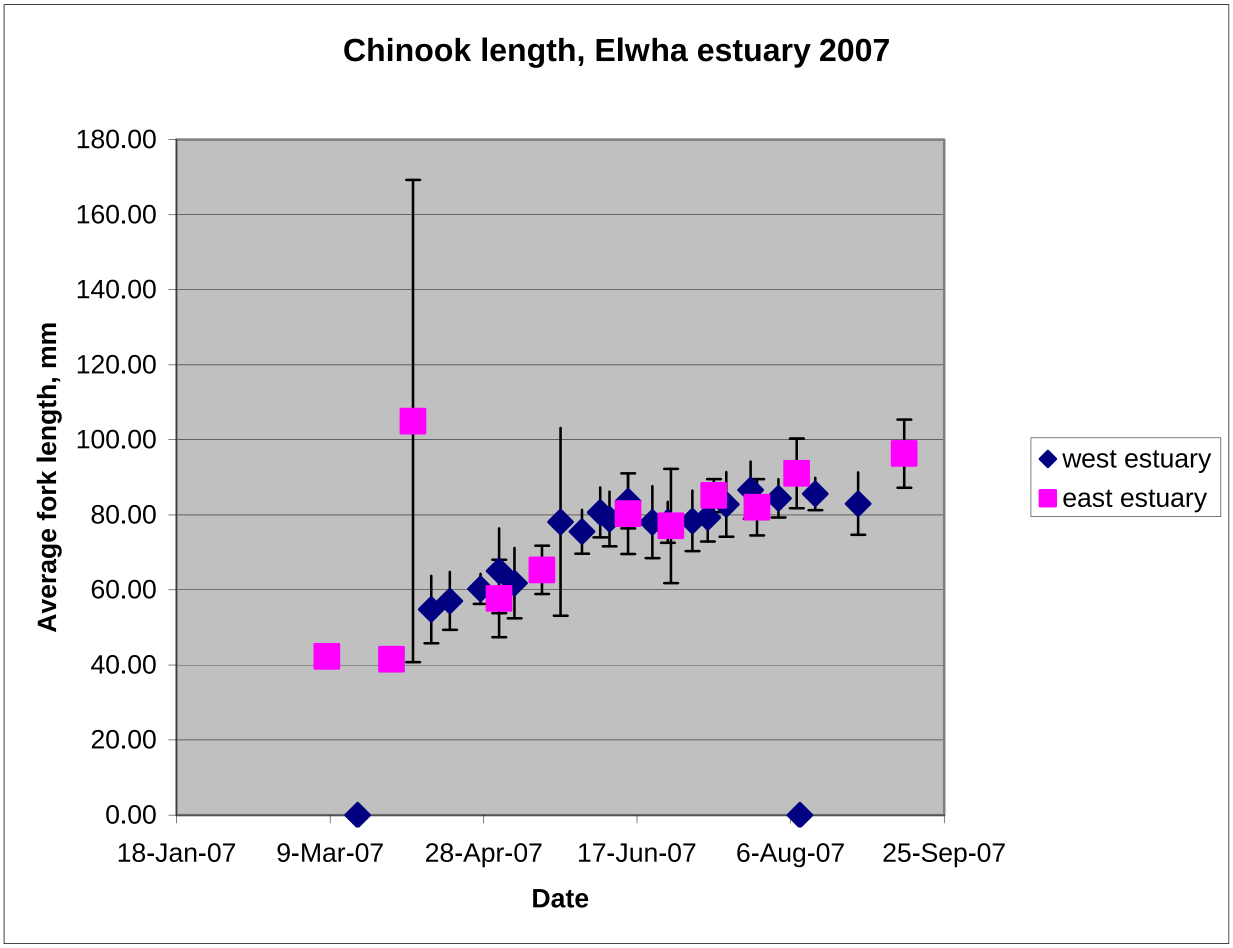

Figure 14. Chinook length Elwha estuary.

Discussion

Based on life history strategies published by Fresh 2006 and others, Chinook use of the Elwha estuary appears to be bimodal with delta fry migrates moving into the Elwha estuary in March and April, and parr migrants appearing in June. (see Beamer et al 2004). Chum use of the Elwha estuary begins in March and abruptly dropped off in June. This use is similar to chum use documented in other Puget Sound systems, where juvenile chum use the nearshore widely during outmigration (Fresh 2006; Brennan et al.2004). The abrupt decrease in chum densities in June is also consistent with life history of chum in other areas of Puget Sound and indicates that these fish are moving off to more neritic environments. (Fresh 2006).

Fish use of the Elwha estuary is complex and appears to be dictated by environmental factors. In this study we observed high fish use in a small area of the estuary that is bordered by a 40 plus year old dike that creates a total barrier to fish passage. The high total fish numbers in the impounded portion of the west estuary indicates that the impounded area is productive fish habitat provided fish can get to it. The low diversity and high evenness of the impounded portion of the west estuary, particularly compared to that of the connected west estuary just feet away, indicate that the structure is a significant limiting factor to the habitat function of the estuary.

The relative observations of the highest abundance of salmon and highest species diversity in the small west estuary are also intriguing. We've attributed the relative low use of the large east estuary to a sediment lens that is said to have formed off the entrance to the east estuary early in 2007 and persisted until late fall 2007/early winter 2008. One assumption is that, with the blockage of the east estuary entrance, the fish switched from the east to the west side of the river and used the only fragment of habitat left to them. This is based on the much lower fish numbers observed in the east estuary in 2007 compared to 2006 (Beirne, LEKT, unpublished data).

Alternatively, fish use of the Elwha west estuary may always be this high-and who knows what happened to the fish that would have used the east estuary in 2007. Another possibility is that there was some blockage at the connection of the west estuary to the main river, and that fish observed in the west estuary were simply resampled through the season, resulting in artificially inflated fish abundance observations for the west estuary. There are several observations to counter this theory. In particular: 1. If the fish numbers observed in the west estuary were a result of resampling we would have expected to see the same trends in total fish numbers on both sides of the estuary (since both were to be closed off). Instead we saw different trends in fish numbers on the east and west estuary. Only the numbers between the impounded west estuary (for the months sampled) and east estuary were similar-in fact almost identical-indicating that the east estuary and west impounded estuary function were driven by similar forces (blocking) and that those forces were different from those operating on the west connected estuary. Also, chum abundances increased steadily in the west estuary (but not the east estuary) indicating that the west estuary had regular fish access while the east estuary did not.

Sediment limitation has played a dominant role in Elwha lower river and nearshore habitat. Unconstrained, low gradient channel reaches in the lower Elwha River historically contained extensive side channels (Pess et al. 2008) and estuarine slack water habitats with suitable substrate for critical fish use including eulachon spawning. Truncation of sediment transport to the lower river, along with channelization, and the systematic removal of large woody debris (LWD), has caused channel incision and an increase in bed substrate size (Pohl 2004). Nearshore effects of this disruption likely include a significant reduction in side channel habitat and a reduction in suitable eulachon spawning habitat (Shaffer et al 2007).

Environmental factors have also been documented to dictate Chinook survival (Greene et al 2005). More specifically, sedimentation has been documented to define fish behavior and abundance in northwest estuaries. Gregory and Levings (1997) found sediment associated turbidity defined predation success by juvenile Chinook in the Fraser river.

Understanding current and future hydrodynamics in the lower Elwha river as well as a detailed understanding of fish movement in the lower river are therefore central to understanding estuarine habitat function during and after dam removal. In general we know that the sediment processes in the lower river are dynamic, and will continue to be so with dam removals (Randal et al 2004). In a longer horizon we need a more detailed model predicting upcoming sediment response in the estuary, as well as a detailed understanding of fish response. Combined, this information will allow us to define how, if at all, we expect to manage for sediment during the restoration process.

The fish use observed in 2007 may indicate that juvenile salmonids can respond fairly quickly to a dynamic sediment landscape. If this is correct, providing the fish the most options is the best alternative. The most obvious opportunity for providing more habitat is to provide fish access to the impounded west estuary currently blocked by the existing west levee. The dike, which is privately co-owned, is currently scheduled to be modified in place soley to provide current level of flood protection post dam removal-with no provision for fish passage. Clallam County is leading a SRFB funded project to provide fish passage in this structure. Clearly the Elwh nearshore is important habitat for fish, including federally listed salmonids. Detailed longer term monitoring of fish movement in the estuary as well as specific sediment mapping in the nearshore are warranted to define additional actions that might be appropriate for the Elwha nearshore.

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References

Beamer, E., R. Henderson, A. McBride and K.W. Wolf. 2003. The importance of non-natal pocket estuaries in Skagit Bay to wild Chinook salmon: an emerging priority for restoration. Skagit River System Cooperative, Research Department, La Connor. Washington. 10 p.

Beamer, E., A. McBride, C. Greene, R. Henderson, G. Hood, K. Wolf, K. Larsen, C. Rice and K. L. Fresh. 2005. Delta and nearshore restoration for the recovery of wild Skagit River Chinook salmon: linking estuary restoration to wild Chinook salmon populations. Supplement to Skagit Chinook Recovery Plan, Skagit River System Cooperative. La Conner, Washington.

Boehlert, G.W. and Mundy, B.C. (1988) Roles of behavioral and physical factors in larval and juvenile fish recruitment to estuarine nursery areas. American Fisheries Society Symposium 3, 51–67.

Bottom, D.L., Jones, K.K., Cornwell, T.J., Gray, A. and Simenstad, C.A. (2005) Patterns of Chinook salmon migration and residency in the Salmon River estuary (Oregon). Estuarine, Coastal and Shelf Science, 64, 79–93

Breine, J., Maes, J., Quataert, P., Van den Bergh, E., Simoens, I., Van Thuyne, G. and Belpaire, C. (2007) A fish-based assessment tool for the ecological quality of the brackish Schelde estuary in Flanders (Belgium). Hydrobiologia 575, 141–159.

Brennan, J.S., K.F. Higgins, J.R. Cordell and L.A. Stamatiou. 2004. Juvenile salmon composition, timing, distribution, and diet in marine nearshore waters of central Puget Sound in 2001-2002. King County, Department of Natural Resources and Parks, Seattle Washington. 164 p.

Fresh, K.L. 2006. Juvenile Pacific Salmon in Puget Sound. Puget Sound Nearshore Partnership Report No. 2006-06. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Franco, A., Franzoi, P., Malavasi, S., Riccato, F., Torricelli, P. and Mainardi, D. (2006) Use of shallow water habitats by fish assemblages in a Mediterranean coastal lagoon. Estuarine, Coastal and Shelf Science 66, 67–83.

Gray, A., C.A. Simenstad, D.L. Bottom and T.J. Cornwell. 2002. Contrasting functional performance of juvenile salmon habitat in recovering wetlands of the Salmon River Estuary, Oregon, U.S.A. Restoration Ecology 10:514-526.

Greene, C.M. and T.J. Beechie. 2004. Consequences of potential density-dependent mechanisms on recovery of ocean-type Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 61:590- 602.

rGreene, C.M., D. Jensen, G.R. Pess, E.M. Beamer and E.A. Steel. 2005. Effects of environmental conditions during stream, estuary, and ocean residency on Chinook salmon return rates in the Skagit River, Washington. Transactions of the American Fisheries Society 134:1562-1581.

Gregory RS, CD Levings. 1998 Turbidity Reduces Predation on Migrating Juvenile Pacific Salmon. Transactions of the American Fisheries Society: Vol. 127, No. 2 pp. 275–285.

rHarrison, T.D. and Whitfield, A.K. (1995) Fish Community Structure in Three Temporarily Open/Closed Estuaries on the Natal Coast. Ichthyological Bulletin of the J.L.B. Smith Institute of Ichthyology, Grahamstown, SouthAfrica. No. 64, 1–80.

rLevings, C.D., K. Conlin and B. Raymond. 1991. Intertidal habitats used by juvenile Chinook salmon (*Oncorhychus tshawytscha*) rearing in the North Arm of the Fraser River estuary. Marine Pollution Bulletin 22:20-26.

Marshall, S. and Elliott, M. (1998) Environmental influences on the fish assemblage of the Humber estuary, UK. Estuarine, Coastal and Shelf Science, 46, 175–184.

Miller, B.A. and S. Sadro. 2003. Residence time and seasonal movements of juvenile coho salmon in the ecotone and lower estuary of Winchester Creek, South Slough, Oregon. Transactions of the American Fisheries Society. 132:546-559.

Pess, G. R., M. L. McHenry, T. J. Beechie, and J. Davies. 2008. Biological impacts of the Elwha River dams and potential salmonid responses to dam removal. Northwest Science 82 Special Issue.

Pohl, M. 2004. Channel bed mobility downstream from the Elwha dams, Washington. The Professional Geographer 56:422-431.

Randle, T. J., J. Bountry, B. Jackson, and G. Smillie. 2004. Elwha river restoration draft sediment monitoring and management plan, U. S. Department of the Interior, Bureau of Reclamation and National Park Service, Port Angeles.

Pombo, L., Elliott, M. and Rebelo, J.E. (2002) Changes in the fish fauna of the Ria de Aveiro estuarine lagoon (Portugal) during the twentieth century. Journal of Fish Biology 61(Suppl. A), 167–181.

Potter, I.C. and Hyndes, G.A. (1999) Characteristics of the ichthyofaunas of southwestern Australian estuaries, including comparisons with holarctic estuaries and estuaries elsewhere in temperate Australia: a review. Australian Journal of Ecology, 24, 395–421.

Randle, T. J., J. Bountry, B. Jackson, and G. Smillie. 2004. Elwha river restoration draft sediment monitoring and management plan, U. S. Department of the Interior, Bureau of Reclamation and National Park Service, Port Angeles.

Shaffer, J.A. P. Crain, B. Winter, M. McHenry C. Lear and T. Randle 2008. Nearshore Restoration of the Elwha River Through Removal of the Elwha and Glines Canyon Dams: An Overview. Northwest Science 82 Special Issue.

Weinstein, M.P., Weiss, S.L., Hodson, R.G. and Gerry, L.R.(1980) Retention of three taxa of postlarval fishes in an intensively flushed tidal estuary, Cape Fear River, North Carolina. Fishery Bulletin US 78, 419–436.

Whitfield, A.K. and Elliott, M. (2002) Fishes as indicators of environmental and ecological changes within estuaries– a review of progress and some suggestions for the future. Journal of Fish Biology 61(Suppl. A), 229–250.