Focal Species and Representative Habitats

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Wenatchee Subbasin

Priority Stocks and Geographic Use

Overview of limiting factors

Within the Wenatchee River Basin, human alterations to the environment are thought to be exacerbating naturally limiting conditions. These alterations have primarily occurred in the lower gradient, lower reaches of watersheds in the lower subbasin. Road building and placement, loss of riparian habitat, water diversion, reduced large woody debris (LWD) recruitment, and flood control efforts that include LWD removal, berm construction, and stream channelization (Andonaegui 2001).

Andonaegui (2001) had five recommendations for increasing salmonid production in the Wenatchee River Basin: 1) maintain highly functional habitat in Wenatchee subbasin watersheds**;** 2) maintain and restore habitat on the mainstem Wenatchee River; 3) restore ecosystem functions and connectivity within the Wenatchee subbasin; 4) evaluate the relationship between stream flows and water use in the subbasin; and 5) increase instream low-flows negatively impacted by human impacts.

Habitat use

Mullan et al. (1992) looked extensively at habitat use and conditions within the Wenatchee River Basin. They used the Habitat Quality Index (HQI; Binns 1982) which rates late summer flow, annual flow variation, water temperature, food, cover, water velocity, nitrate nitrogen and stream width; with an index of non-salmonids substituted for bank erosion. They did not use the bank erosion factor since it is directed towards livestock destabilization, and not natural processes.

They compared the HQI to densities of fish found in various sampling sections within the Wenatchee River and its tributaries. They found that chinook salmon and age-0 steelhead were significantly related to HQI scores, but not steelhead parr. Cover and species interactions explained most of the variability in densities of chinook and age-0 steelhead, although it was still a weak correlation.

They postulated that the index was weak because it was designed for larger trout, and not “ephemeral” populations of salmon or steelhead. However, they still did not find a strong relationship between the HQI and trout in the headwaters, where they anticipated it would have been more applicable.

Temperature, nitrogen, velocity, and cover influenced cutthroat trout biomass. Stream temperatures explained less than 20% of the biomass and densities of rainbow trout.

None of the HQI variables explained any of the variation for bull trout, while the total salmonid density and biomass varied significantly with food only, accounting for about 10% of the variation.

Given the weak correlations observed by Mullan et al. (1992), they reevaluated all of the variables used in the HQI and concluded,

". . . no methodology is likely to be successful on a broad scale in precisely defining the actual factors controlling abundance and in understanding their subtle interaction. . . Limitations aside, characterization of habitat in a theoretically sound and consistent manner to a known though low degree of accuracy (+/- 50%) has merit. . . It allows correct rather than precise judgments. For example, total possible HQI score is 335. Average score for the 186 stations in the Wenatchee, Entiat, and Methow drainages was 47 (range 11-113) indicating low overall salmonid potential."

Their conclusion is further evidenced by the lowest growth rates for fish in the literature (see appendix _). We also understand that it is incumbent on subbasin planners to make wise choices on the projects that get carried forward, and thus, we need the best information to guide our efforts where it will have the most impact on the target species.

Spring chinook

Life history
Spring chinook generally spawn in the higher order streams within a subbasin. Juveniles spend one year after emergence in freshwater prior to migrating to sea. A proportion of juveniles spend their entire freshwater life in the stream of which they were born, while others migrate downstream to larger streams to complete this phase. Upon their return, most adults have spent two years in the ocean, although in a given year, a significant number of 3-ocean fish may make up the population. Precocious males (jacks that have spent one year at sea or individuals that have not migrated to sea) may make up a significant proportion of the spawning population in some demes.

The Wenatchee basin spring chinook migrate past Rock Island Dam and enter the Subbasin in May and June, peaking after mid-May. Spawning occurs late July through mid-September.

Distribution
Spring chinook are found throughout the Wenatchee River Basin. Most fish spawn in the secondary tributaries, primarily upstream of Tumwater Canyon, although some spawning occurs in the mainstem Wenatchee River in the section immediately downstream of the lake to approximately the mouth of the Chiwawa River. The primary spawning and rearing areas for spring chinook in the Wenatchee River Basin, in order of importance, are: Chiwawa River, Nason Creek, Little Wenatchee, and White River (Icicle Creek is not included because it is believed that most of the spawning population from this stream consist of adult returns to the Leavenworth NFH; Peven 1994). Icicle Creek may have

been an important stream for spring chinook historically, but it depends if the primary habitat was available or not, which is unclear. Spawning has also been observed within Peshastin and Chiwaukum creeks (Mosey 2002).

Historically, spring chinook used the same streams as they do today, although the order of importance was probably different (Fulton 1968; Mullan 1987). More fish likely used the mainstem Wenatchee River and Peshastin Creek. Nason Creek was believed to be the most heavily used stream for anadromous fish (Craig and Suomela 1941).

Use

Spawning areas described above are also used for juvenile rearing. In addition, a portion of each year's standing crop (parr) migrate from the natal areas downstream in the fall, presumably for thermal refuge, as the upper tributaries become colder. Hillman and Chapman (1989) showed that Tumwater Canyon is where most fish rear over the winter before their smolt migration begins in the spring the following year. During the daytime, juvenile chinook used instream and overhead cover extensively, although as they got larger (and stream flows reduced), they sought areas that were deeper and higher velocity (Hillman et al. 1989 CPa). Substrate preference also changed as the juvenile chinook got larger and hydraulic conditions changed from predominantly sand, large boulder, and bedrock to sand, sand-gravel, and cobble. As temperatures dropped below 10 °C, salmon were observed primarily near boulder rip-rap, or concealed themselves in the substrate.

During nighttime hours during the warmer months, chinook moved inshore and rested all night in shallow, quiet water (Hillman et al. 1989 CPb). In the colder months, chinook sought deeper water with larger substrate.

The natal tributaries and mainstem Wenatchee River are used for a migration corridor for both juveniles and adults. Adults, on their return use the large pools of the main river as resting and staging areas prior to spawning. They enter the Wenatchee from May through August. Adults migrate towards spawning areas throughout June and July, and begin spawning in early August through September.

Within the known areas of distribution, historic habitat in Nason Creek is most likely the highest area of perturbation. However, restoration of natural channel migration and other geo-fluvial processes to a large extent is not likely within the lower drainage because of a railroad and highway on either side of the river.

Currently, the center of abundance, the Chiwawa River, is in very good shape, although there are some minor disturbances associated with residential development in the lower river. Other areas, such as the White and Little Wenatchee River have been disturbed, but distribution has most likely always been limited in these drainages because of barrier natural falls. However, both are in need of conservation to retain the existing quality habitat, and potentially restoration, where appropriate.

Providing access to upper Icicle Creek is currently underway. However, if spring chinook are not able to negotiate a potential naturally barrier about rivermile 5, large increases in productivity should not be expected, since most of the habitat that would be conducive to spring chinook lies upstream of this point.

Peshastin Creek drainage was most likely historic habitat, but also not likely to have produced large quantities of spring chinook because of the gradient of the basin. However, restoration of natural geo-fluvial processes would most likely restore additional habitat. Potential barriers exist from water withdrawal too.

In summary, many areas of high quality habitat still exist in the Wenatchee River Basin for spring chinook. The main river in Tumwater Canyon and upstream to the lake, has the best remaining habitat for rearing and spawning, respectively. There are areas within tributaries that would benefit from increases in natural habitat restoration or conservation, but some areas would not yield large effects from such efforts. However, these areas of lesser potential still may function in providing ecologic diversity of the independent population of Wenatchee River spring chinook.

Summer/fall chinook

Life history

Summer/fall chinook spawn in the mainstem areas of tributaries and the Columbia River, where suitable habitat prevails. Juveniles begin migrating to the ocean shortly after emergence. Apparently, some juveniles use the mainstem Columbia River to overwinter before entering the ocean in their second year of life. Adults have usually spent two years in the ocean upon return, but significant proportions of 1-ocean fish make up the run in some years, along with 3-ocean fish too.

Earlier returning adults (“summer-run”) and later returning adults (“fall-run”) show similar life histories and cannot be distinguished on the spawning grounds (see Appendix __ for further discussion).

Wenatchee River summer/fall chinook pass Rock Island Dam after mid- to late June. Adults enter the Wenatchee in July through September and stage in the larger pools within the river until spawning begins in mid October through November.

Distribution

Summer/fall chinook salmon typically spawn in the Wenatchee River between RM 1.0 and Lake Wenatchee (RM 54). Within that area the distribution of redds of summer/fall chinook has changed. Peven (1992 CPa) notes that, since the early 1960s, numbers of redds have decreased downstream from Dryden Dam (RM 17.5), while they have increased upstream from Tumwater Dam (RM 32.7). On a smaller scale, Peven (1992) reports that, since at least 1975, densities of redds (i.e., redds/mile) were highest near Leavenworth (RM 23.9-26.4) and in Tumwater Canyon (RM 26.4-35.6).

Historically, there is no reason to believe that the distribution of spawning is different than what it is today in the Wenatchee Basin.

Use

Hillman and Chapman (1989) noted that the density of age-0 chinook decreased in the lower Wenatchee River reaches by 85% as the summer progressed. This timing coincided with emergence of summer/fall chinook. This suggests that within the first few weeks after emergence, most, if not all of the summer/fall juveniles have emigrated from the Wenatchee River. It appeared that most of the age-0 fish emigrated from survey reaches within 48 hours after being marked (Hillman and Chapman 1989). The primary reason Hillman and Chapman attribute to the rapid exodus of fish from the lower Wenatchee River was lack of flow refugia, although other factors, such as hatchery "thinning" releases and species interaction with sculpin and redside shiners may have also played a role. Potential increases in off-channel habitat (for flow refugia) may increase the length of residence of age-0 chinook in the lower Wenatchee River, however this strategy needs to be balanced with natural processes and known life history characteristics of ocean-type chinook before assigning an importance of this (or other) strategy in increasing summer/fall chinook production increases.

Because most spawning occurs within the mainstem Wenatchee River, and the river is constrained by roads, railroads, urban development and other land use activities, it may be difficult to increase production of summer chinook. However, a channel migration study has identified areas within the lower Wenatchee River that may be used as off channel habitat after modifications are made (Jones and Stokes 2003). However, it must be noted that Wenatchee River summer/fall chinook have not shown any signs of being depressed, and in fact have been increasing in abundance since the 1960s (Appendix).

In summary, summer chinook in the Wenatchee River may benefit from off-channel habitat. However, because of their life history, the benefits for this species may be limited. Wenatchee River summer/fall chinook have been increasing in abundance since the 1960s.

Sockeye salmon

Life history

Sockeye salmon primarily spawn in river systems that contain at least one lake, which is used for juvenile rearing. After emergence, fish generally migrate quickly (either upstream or down) to the lake, where they reside usually one, but sometimes two or three years before migrating to the ocean. Fish predominantly spend two years in the ocean prior to return, although in some systems, a significant proportion may return after one or three years.

Wenatchee River sockeye pass Rock Island Dam primarily in July and enter the Wenatchee River. Adult sockeye enter Lake Wenatchee in July and August, and hold until spawning in September.

Distribution

Sockeye from the Wenatchee River Basin spawn primarily in the White River, followed by the Little Wenatchee. Small numbers are frequently seen in Icicle Creek and occasionally in Nason Creek. Fish spawn primarily in the lower five miles of the White River, and lower four miles of the Little Wenatchee. The Napequa River, a major tributary of the White River, has some spawning also. Lake Wenatchee is used for juvenile rearing.

Use

Chapman et al. (1995) suggested that Tumwater Canyon may cause adult migration delays because of high stream flows in the Wenatchee River. Temperature and oxygen levels do not appear to be limiting in Lake Wenatchee.

Most fry emerge from the gravel from mid-March through May in the Wenatchee Basin (in Chapman et al. 1995). Fry may concentrate along near-shore areas for a few weeks before heading for deeper water. This may be because the timing of entry into the lake may not coincide with times of zooplankton production, and foraging may be more profitable in the littoral zones. Juvenile sockeye usually exhibit a diel vertical migration to balance trophic opportunities with safety from predators.

Lake Wenatchee is highly oligotrophic, and this may be limiting production of sockeye salmon within the Wenatchee Basin. Most opportunities for maintaining or increasing production may lie in preserving spawning habitat in the Little Wenatchee and White River basins.

In summary, Wenatchee sockeye may be limited mostly by juvenile rearing within Lake Wenatchee. Spawning habitat is mostly in good shape; however, conservation of existing habitat may be needed. Adding nutrients to Lake Wenatchee may increase sockeye production, but is unlikely because of water quality and other issues.

Steelhead

Life history

Steelhead generally spawn throughout a basin, wherever appropriate habitat exists. Juveniles may spend up to seven years in freshwater prior to migrating to the ocean, but average 2-3 years. Adults may spend from 1-3 years in the ocean before migrating back to natal areas. True assessment of the spawning population is difficult because non-anadromous fish may contribute to the anadromous population (and vice versa). Environmental factors (primarily temperature) appear to dictate whether an individual fish migrates to the sea or not.

Steelhead destined for the Wenatchee River enter the Columbia River between May and September and pass Rock Island Dam from July through the following May. All steelhead spawn in the spring, and those that pass Rock Island Dam in the spring have over-wintered in the mainstem of the Columbia River. Fish may also use appropriate areas within the Wenatchee River to over-winter (French and Wahle 1959; English et al. 2001).

Distribution

Beginning in 2001, WDFW has been conducting spawning ground surveys for steelhead in the Wenatchee and Methow rivers (Murdoch et al. 2001; Jateff and Snow 2002). These efforts are in conjunction with hatchery evaluations that are currently taking place within the Upper Columbia Basin for Chelan and Douglas County Public Utility Districts (PUD) funded mitigation efforts. Current spawning distribution in the Wenatchee Basin, in order of importance appears to be: the Wenatchee River between the Chiwawa River and Lake Wenatchee, Nason, Chiwawa, and Icicle creeks. Other tributaries were not surveyed, such as the Little Wenatchee and White rivers, or Chiwaukum, Peshastin, or Mission creeks, but are most likely used by steelhead for possible spawning and rearing.

Steelhead historically used all major (and some minor) tributaries within the Upper Columbia Basin for spawning and rearing (Chapman et al. 1994). Fulton (1970) described steelhead using the Wenatchee River and eight of its tributaries: lower Mission, Peshastin, Icicle, Chiwaukum, Nason creeks, and the Chiwawa, Little Wenatchee, and White rivers. These areas are still believed to be used. The current spawning surveys are going to be expanded within the Wenatchee River (Chris Jordan, personal communication).

Use

For those fish that enter and over-winter in the Wenatchee River, large pools with proximity to cover is most likely used prior to spawning. They are also found in the deeper runs near larger pools.

Steelhead use a wide range of habitats and habitat types throughout their freshwater life history. Since they spend more time in freshwater than other anadromes, they are more prone to habitat perturbations and may ultimately benefit from freshwater habitat restoration and conservations measures to a greater degree than other anadromes.

In the Wenatchee River, Hillman and Chapman (1989) found most juvenile steelhead rearing in Tumwater Canyon. During daylight, age-0 steelhead used slower, shallower water than chinook, stationed individually over small boulder and cobble substrate (Hillman et al. 1989 CPa). As they grew, they picked deeper and faster habitat over cobble and boulders. As with chinook juveniles, in winter, they concealed themselves in interstitial spaces among boulders near the stream bank, but did not cluster together. No interaction was observed between chinook and steelhead at anytime (Hillman et al. CPa, CPb).

During nighttime hours, steelhead moved downstream and closer to shore. At dawn, steelhead moved upstream. Most steelhead chose sand and boulder substrates, and during winter, chose deeper, larger substrate (Hillman et al. 1989 CPb).

Most of the discussion above on spring chinook concerning habitat conditions would apply equally to steelhead. However, since they are prone to use smaller tributaries and have an extended freshwater life history, the likelihood of increases in productivity from habitat improvements may be greater for steelhead than spring chinook.

In summary, steelhead appear to use most available habitat types within the Wenatchee River Basin. Conservation and restoration of known limiting factors will potentially aid steelhead to a great degree than other focal species.

Bull trout

Life history

Bull trout generally exhibit three main life history forms; fluvial, which migrate between smaller spawning streams and larger streams to grow; adfluvial, which migrate between spawning streams and a lake, where growth occurs; and non-migratory, which generally spend their entire lives in the stream they were born. A fourth ecotype, anadromous, does not occur in the Wenatchee River basin. Assessments of bull trout populations are difficult because non-migratory forms may give rise to migratory forms (and vice versa).

Historically, there were most likely three life histories (or ecotypes) of bull trout within the Wenatchee Basin (adfluvial, fluvial and non-migratory), with distribution and population levels dictated by temperature and gradient (Mullan et al. 1992). All three ecotypes of bull trout still currently exist in the Wenatchee River Core Area (WDFW 1998).

Distribution

The six "migratory" bull trout local (sub) populations in the Wenatchee River are found in the Chiwawa River (including Chikamin, Phelps, Rock, Alpine, Buck and James creeks), White River (including Canyon and Panther creeks), Little Wenatchee River (below the falls), Nason Creek (including Mill Creek), Chiwaukum Creek, and Peshastin Creek (including Ingalls Creek). There also appears to be non-migratory subpopulations within some of these streams, as well as in Icicle Creek.

In the Wenatchee subbasin, the adfluvial form matures primarily in Lake Wenatchee and ascends the White and Little Wenatchee rivers, and the Chiwawa River (Kelly-Ringold and DeLavergne 2003), where the young reside for one to three years. Fluvial bull trout populations spawn in the other streams identified above.

While historic distribution is difficult to determine (Rieman et al. 1997), bull trout are believed to have been historically present in the Wenatchee Basin (Brown 1992; Mongillo 1993). Because current connectivity appears nearly equal to historic (exceptions noted below), it is reasonable to assume that historic distribution was most likely no different than what is observed today.

Use

Current information suggests that bull trout are generally not limited in their movements in the Wenatchee Basin, with the potential exception of the Chiwawa River spring chinook hatchery weir (Kelly-Ringold, personal communication) and Icicle Creek. Culverts in some of the lower areas may also be problematic to migration. Bull trout appear to move between Lake Wenatchee and other tributaries for feeding, thermal refuge and spawning. Large pools on the main Wenatchee River appear to hold larger adult bull trout that are probably seeking thermal refuge and feeding opportunities. The mainstem Columbia River is also used by Wenatchee River Basin bull trout (Kelly-Ringold and DeLarvergne 2003) for the reasons listed above.

The higher order streams (Chiwawa, White, etc.) are used for spawning and rearing. Lake Wenatchee is also used for rearing, where adfluvial bull trout sometimes attain large growth (over 15 pounds). Bull trout are known to be more sensitive to habitat perturbations, especially increases in temperature, and therefore would benefit greatly from habitat restoration activities that increased riparian habitat, where appropriate. Most of the existing areas where bull trout are known to spawn are already in areas that have been conserved, in the upper reaches of the watersheds. However, for those areas that are still potentially vulnerable, it is important to further conserve or protect them.

Flow conditions in some streams (e.g., Peshastin, Icicle) may also affect bull trout movements. Channel stability in areas of Peshastin, the lower Wenatchee, and Nason Creek are most likely areas that could increase production if natural process were restored. However, because of roads and railroads, and other land use activity, it is not likely that much can be done, except for specific smaller reaches of these streams.

Obstructions in Peshastin, Icicle, Nason, and potentially the lower mainstem Wenatchee and Chiwawa River may also be limiting bull trout movements. Sediment loads, temperature, and riparian conditions may also be limiting production in some steams or reaches.

Introgression and competition with introduced brook trout has also been widely identified as a threat to the health of bull trout populations. Areas within the mainstem Wenatchee River, Icicle and Nason creeks, the Little Wenatchee and Chiwawa Rivers have brook trout populations.

In summary, much of bull trout spawning habitat is in tact. However, some areas may be vulnerable to perturbation if not protected. Other rearing areas may need restoration, including evaluation of potential migratory problems. However, it is likely that total distribution in the Wenatchee River is similar to historic.

Westslope cutthroat trout (WSCT)

Life history

Westslope cutthroat trout generally exhibit three main life history forms; fluvial, which migrate between smaller spawning streams and larger streams to grow; adfluvial, which migrate between spawning streams and a lake, where growth occurs; and non-migratory, which generally spend their entire lives in the stream they were born.

Much of the life history of WSCT in the Wenatchee River is unknown at this time.

Distribution

Through stocking programs that began with Washington state's first trout hatchery in the Stehekin River valley in 1903 (that targeted WSCT), WSCT have been transplanted in almost all available stream and lake habitat, including the Wenatchee River Basin (Williams 1998).

Currently WSCT are found throughout the Wenatchee Basin (Williams 1998). WSCT are found within streams and lakes throughout the basins, but spawning (for stream populations) usually occurs in the upper portions of each basin.

The primary historic distribution of westslope cutthroat trout (WSCT) occurred in the upper Columbia and Missouri River basins (USFWS 1999). WSCT were originally believed to occur in three river basins within Washington State; Methow, Chelan, and Pend Oreille, although only abundant in the Lake Chelan Basin (Williams 1998). However, recent information, based on further genetic analyses (Trotter et al. 2001; Behnke 2002; Howell et al. 2003), indicates that the historic range of WSCT in Washington State is now believed to be broader. Historic distribution now includes the headwaters of the Wenatchee, Entiat, and Yakima River basins (Behnke 2002).

Use

WSCT use many of the smaller streams within the Wenatchee Basin and occasionally the mainstem Wenatchee too. Most reside in the upper reaches of higher order streams within the basin, and some of the Alpine lakes.

Limiting factors for WSCT in the Wenatchee River may be channel stability, habitat diversity, obstructions, temperatures and riparian conditions in streams such as the mid-mainstem Wenatchee River, Peshastin and Nason Creeks, and potentially the lower Chiwawa River. These factors need to be considered in relation to life history of WSCT (e.g., temperatures probably always limited WSCT distribution within Wenatchee River streams). However, conservation of known areas of abundance would increase the likelihood that they could persist in high quality habitats.

In summary, little is known of the life history and habitat needs of WSCT in the Wenatchee River Basin. However, it is reasonable to assume that some known limiting factors, such as channel stability, habitat diversity, obstruction, land use that affects temperatures may be limiting production of WSCT in the Wenatchee River, and that they would benefit from improvements to those factors.

References

Entiat Subbasin

Priority Stocks and Geographic Use

Overview of limiting factors

A lack of overwintering juvenile rearing habitat is thought to be the most limiting factor in the Entiat watershed to fully sustain salmon populations (Andonaegui 1999). This is a function of the alteration of the natural hydrologic and geomorphic processes in the watershed chiefly resulting from losses in floodplain connectivity and riparian zone conditions (Andonaegui 1999). Protection, rehabilitation and restoration of these habitats will presumably provide for other life cycle needs of the focal species within the Entiat Basin.

Habitat use

Mullan et al. (1992) looked extensively at habitat use and conditions within the Entiat River Basin. They used the Habitat Quality Index (HQI; Binns 1982) which rates late summer flow, annual flow variation, water temperature, food, cover, water velocity, nitrate nitrogen and stream width; with an index of non-salmonids substituted for bank erosion. They did not use the bank erosion factor since it is directed towards livestock destabilization, and not natural processes.

They compared the HQI to densities of fish found in various sampling sections within the Entiat River and its main tributary, the Mad River. They found that chinook salmon and age-0 steelhead were significantly related to HQI scores, but not steelhead parr. Cover and species interactions explained most of the variability in densities of chinook and age-0 steelhead, although it was still a weak correlation.

They postulated that the index was weak because it was designed for larger trout, and not "ephemeral" populations of salmon or steelhead. However, they still did not find a strong relationship between the HQI and trout in the headwaters, where they anticipated it would have been more applicable.

Temperature, nitrogen, velocity, and cover influenced cutthroat trout biomass. Stream temperatures explained less than 20% of the biomass and densities of rainbow trout. None of the HQI variables explained any of the variation for bull trout, while the total salmonid density and biomass varied significantly with food only, accounting for about 10% of the variation.

Given the weak correlations observed by Mullan et al. (1992), they reevaluated all of the variables used in the HQI and concluded,

". . . no methodology is likely to be successful on a broad scale in precisely defining the actual factors controlling abundance and in understanding their subtle interaction. . . Limitations aside, characterization of habitat in a theoretically sound and consistent manner to a known though low degree of accuracy (+/- 50%) has merit. . . It allows correct rather than precise judgments. For example, total possible HQI score is 335.

Average score for the 186 stations in the Wenatchee, Entiat, and Methow drainages was 47 (range 11-113) indicating low overall salmonid potential."

Their conclusion is further evidenced by the lowest growth rates for fish in the literature (see appendix _). We also understand that it is incumbent on subbasin planners to make wise choices on the projects that get carried forward, and thus, we need the best information to guide our efforts where it will have the most impact on the target species.

Spring chinook
Life history
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The Entiat basin spring chinook migrate past Rocky Reach Dam and enter the Subbasin in May and June, peaking after mid-May. Spawning occurs late July through mid-September. Adults may also use the mainstem Columbia as a staging area prior to spawning.

Distribution
Spring chinook are currently found in the mainstem Entiat and Mad Rivers. Hamstreet and Carie (2003) describe the current spawning distribution for spring chinook as between river miles 16 and 28 in the Entiat River and 1.5 to 5 in the Mad River, its major tributary.

Historically, Fulton (1968) included most of the mainstem Entiat as habitat for spring and summer chinook, noting that steep gradients of tributaries prevent salmon use (probably not intending to exclude the Mad River).

Use
Spawning areas described above are also used for juvenile rearing. In addition, a portion of each year's standing crop (parr) most likely migrate from the natal areas downstream in the fall, presumably for thermal refuge, as these areas become colder. In the Wenatchee River, during the daytime, juvenile chinook used instream and overhead cover extensively, although as they got larger (and stream flows reduced), they sought areas that were deeper and higher velocity (Hillman et al. 1989 CPa). Substrate preference also changed as the juvenile chinook got larger and hydraulic conditions changed from predominantly sand, large boulder, and bedrock to sand, sand-gravel, and cobble. As temperatures dropped below 10 C, salmon were observed primarily near boulder rip-rap, or concealed themselves in the substrate. During nighttime hours during

the warmer months, chinook moved inshore and rested all night in shallow, quiet water (Hillman et al. 1989 CPb). In the colder months, chinook sought deeper water with larger substrate. Chinook in the Entiat River Basin most likely use the same habitat preferences as in the Wenatchee Basin that Hillman observed.

The mainstem Entiat River is used as a migration corridor for both juveniles and adults. Adults, on their return use the large pools of the main river as resting and staging areas prior to spawning.

Within the known areas of distribution, historic habitat in the lower reaches of both the Entiat and Mad rivers are most likely the highest area of perturbation. However, restoration of natural channel migration and other geo-fluvial processes to a large extent will be difficult to implement because of existing land uses and roads.

In summary, many areas of high quality habitat still exist in the Entiat River Basin for spring chinook. It appears that overwinter habitat may be limiting to spring chinook production. Various cooperative land use modifications may increase the overwinter habitat needed to increase production.

Summer/fall chinook

Life history

Summer/fall chinook spawn in the mainstem areas of tributaries and the Columbia River, where suitable habitat prevails. Juveniles begin migrating to the ocean shortly after emergence. Apparently, some juveniles use the mainstem Columbia River to overwinter before entering the ocean in their second year of life. Adults have usually spent two years in the ocean upon return, but significant proportions of 1-ocean fish make up the run in some years, along with 3-ocean fish too.

Earlier returning adults ("summer-run") and later returning adults ("fall-run") show similar life histories and cannot be distinguished on the spawning grounds (see Appendix __ for further discussion).

Entiat River summer/fall chinook pass Rocky Reach Dam after mid-June and begin entering the Entiat River July through October.

Distribution

Currently, summer/fall chinook are observed spawning from river mile 0.3 to 28.1 (Hamstreet and Carrie 2003). Spawning of summer/fall chinook salmon in the Entiat River is at least partially a result of the Entiat National Fish Hatchery, which released late-run chinook into the river between 1941 and 1976 (Mullan 1987). Hatchery fish still may make up a significant proportion of the spawners within the Basin, even though no targeted releases are made there (Hamstreet and Carrie 2003). While late-run chinook may never have spawned naturally in the Entiat River (Craig and Suomela 1941; Mullan 1987), there does appear to be a self-sustaining population present. This population is small in relation to the Wenatchee or Similkameen River basins.

Use

Hillman and Chapman (1989) noted that the density of age-0 chinook decreased in the lower Wenatchee River reaches by 85% as the summer progressed. This timing coincided with emergence of summer/fall chinook. This suggests that within the first few weeks after emergence, most, if not all of the summer/fall juveniles have emigrated from the Wenatchee River. It appeared that most of the age-0 fish emigrated from survey reaches within 48 hours after being marked (Hillman and Chapman 1989). The primary reason Hillman and Chapman attribute to the rapid exodus of fish from the lower Wenatchee River was lack of flow refugia, although other factors, such as hatchery "thinning" releases and species interaction with sculpin and red sided shiners may have also played a role. Potential increases in off-channel habitat (for flow refugia) may increase the length of residence of age-0 chinook in the lower Wenatchee River, however this strategy needs to be balanced with natural processes and known life history characteristics of ocean-type chinook before assigning an importance of this (or other) strategy in increasing summer/fall chinook production increases.

It is reasonable to assume that fish emerging in the Entiat River behave similarly to fish in the Wenatchee River. Therefore, improvement to off-channel habitat may have little or no benefit for summer/fall chinook in the Entiat River. However, restoration of other geo-fluvial processes that may increase adult holding and spawning areas may be beneficial.

In summary, it is probable that summer/fall chinook did not use the Entiat River historically. However, after hatchery releases, a small population has been established. It is unclear if off-channel habitat improvement would be beneficial for juvenile fish, but increased spawning and adult holding habitat most likely would be.

Steelhead

Life history

Steelhead generally spawn throughout a basin, wherever appropriate habitat exists. Juveniles may spend up to seven years in freshwater prior to migrating to the ocean, but average 2-3 years. Adults may spend from 1-3 years in the ocean before migrating back to natal areas. True assessment of the spawning population is difficult because non-anadromous fish may contribute to the anadromous population (and vice versa). Environmental factors (primarily temperature) appear to dictate whether an individual fish migrates to the sea or not.

Steelhead destined for the Entiat River enter the Columbia River between May and September and pass Rocky Reach Dam from July through the following May. All steelhead spawn in the spring, and those that pass Rocky Reach Dam in the spring have over-wintered in the mainstem of the Columbia River. Others may also over-winter in appropriate areas within the Entiat River (English et al. 2001).

Distribution

Beginning in 1997, the USFS has been conducting limited spawning ground surveys for *O. mykiss* in the Mad River (Archibald 2003). The area covered has increased from the first 3 miles of the Mad River to up to 10 miles (currently the first 7 miles) of the Mad River. Roaring Creek has been surveyed too, but apparently not the mainstem Entiat River.

Steelhead historically used all major (and some minor) tributaries within the Upper Columbia Basin for spawning and rearing (Chapman et al. 1994). Fulton (1970) described steelhead historically using the Entiat and Mad Rivers.

Use

For those fish that enter and over-winter in the Entiat River, large pools with proximity to cover is most likely used prior to spawning. They are also found in the deeper runs near larger pools.

Steelhead use a wide range of habitats and habitat types throughout their freshwater life history. Since they spend more time in freshwater than other anadromes, they are more prone to habitat perturbations and may ultimately benefit from freshwater habitat restoration and conservations measures to a greater degree than other anadromes.

In the Wenatchee River, Hillman and Chapman (1989) found most juvenile steelhead rearing in Tumwater Canyon. During daylight, age-0 steelhead used slower, shallower water than chinook, stationed individually over small boulder and cobble substrate (Hillman et al. 1989 CPa). As they grew, they picked deeper and faster habitat over cobble and boulders. As with chinook juveniles, in winter, they concealed themselves in interstitial spaces among boulders near the stream bank, but did not cluster together. No interaction was observed between chinook and steelhead at anytime (Hillman et al. CPa, CPb). During nighttime hours, steelhead moved downstream and closer to shore. At dawn, steelhead moved upstream. Most steelhead chose sand and boulder substrates, and during winter, chose deeper, larger substrate (Hillman et al. 1989 CPb). Steelhead most likely use similar habitat types in the Entiat as they do in the Wenatchee Basin as described above.

In summary, most of the discussion above on spring chinook concerning habitat conditions would apply equally to steelhead. However, since they are prone to use smaller tributaries and have an extended freshwater life history, the likelihood of increases in productivity from habitat improvements may be greater for steelhead than spring chinook.

Bull trout

Life history

Bull trout generally exhibit three main life history forms; fluvial, which migrate between smaller spawning streams and larger streams to grow; adfluvial, which migrate between spawning streams and a lake, where growth occurs; and non-migratory, which generally spend their entire lives in the stream they were born. A fourth ecotype, anadromous, does not occur in the CCP. Assessments of bull trout populations are difficult because non-migratory forms may give rise to migratory forms (and vice versa).

Historically, there were most likely two life histories (or ecotypes) of bull trout within the Entiat Basin (fluvial and non-migratory), with distribution and population levels dictated by temperature and gradient (Mullan et al. 1992). Both ecotypes of bull trout still exist in the Entiat River Core Area (WDFW 1998).

Distribution

In the Entiat Basin, two spawning populations of migratory bull trout are known. One each in the mainstem Entiat and Mad Rivers. Non-migratory forms may occur in other areas too.

While historic distribution is difficult to determine (Rieman et al. 1997), bull trout are believed to have been historically present in the Entiat Basin (Brown 1992; Mongillo 1993).

Use

Current information suggests that bull trout are generally not limited in their movements in the Entiat Basin, with the exceptions of the falls on the mainstem Entiat at rivermile 34. The mainstem Columbia River is also used by Entiat River Basin bull trout (BioAnaylsts 2002, 2003; Kelly-Ringold and DeLarvergne 2003) for refuge, migration, and trophic opportunities. Kelly-Ringold and DeLavergne (personal communication) also noted movements of bull trout between the Entiat and Wenatchee rivers.

Bull trout are known to be more sensitive to habitat perturbations, especially increases in temperature, and therefore would benefit greatly from habitat conservation or restoration activities that increased riparian habitat and natural fluvial geomorphological processes, where appropriate.

Flow conditions may also affect bull trout movements. Channel stability in the lower Entiat is most likely an area that could increase production if natural process were restored. However, because of roads and other land uses, it is not likely that much can be done, except for specific smaller reaches of these streams. Areas of known spawning may also need to be preserved to a greater degree and/or restoration activities may be needed.

Introgression and competition with introduced brook trout has also been widely identified as a threat to the health of bull trout populations. Areas within the mainstem Entiat River have brook trout populations.

In summary, Entiat River bull trout distribution has not changed from historic areas. However, known spawning and rearing areas would benefit from habitat preservation and/or restoration activities.

Westslope cutthroat trout (WSCT)

Life history

Westslope cutthroat trout generally exhibit three main life history forms; fluvial, which migrate between smaller spawning streams and larger streams to grow; adfluvial, which migrate between spawning streams and a lake, where growth occurs; and non-migratory, which generally spend their entire lives in the stream they were born.

Little is known of the life history of Entiat River WSCT.

Distribution

Through stocking programs that began with Washington state's first trout hatchery in the Stehekin River valley in 1903 (that targeted WSCT), WSCT have been transplanted in almost all available stream and lake habitat, including the Entiat River Basin (Williams 1998).

Currently WSCT are found throughout the Entiat Basin (Williams 1998). WSCT are found within streams and lakes throughout the basins, but spawning (for stream populations) usually occurs in the upper portions of each basin.

The primary historic distribution of westslope cutthroat trout (WSCT) occurred in the upper Columbia and Missouri River basins (USFWS 1999). WSCT were originally believed to occur in three river basins within Washington State; Methow, Chelan, and Pend Oreille, although only abundant in the Lake Chelan Basin (Williams 1998). However, recent information, based on further genetic analyses (Trotter et al. 2001; Behnke 2002; Howell et al. 2003), indicates that the historic range of WSCT in Washington State is now believed to be broader. Historic distribution now includes the headwaters of the Wenatchee, Entiat, and Yakima River basins (Behnke 2002).

Use

WSCT use many of the smaller streams within the Entiat Basin and occasionally the mainstem Entiat too. Most reside in the upper reaches of higher order streams within the basin, and some of the Alpine lakes.

Limiting factors for WSCT in the Entiat River may be channel stability, habitat diversity, obstructions, temperatures and riparian conditions in streams such as the lower mainstem Entiat River. These factors need to be considered in relation to life history of WSCT (e.g., temperatures probably always limited WSCT distribution within Entiat River streams). However, conservation of known areas of abundance would increase the likelihood that they could persist in high quality habitats.

In summary, little is known of the life history and habitat needs of WSCT in the Entiat River Basin. However, it is reasonable to assume that some known limiting factors, such as channel stability, habitat diversity, obstruction, land use that affects temperatures may be limiting production of WSCT in the Entiat River, and that they would benefit from improvements to those factors.

References

Lake Chelan

Priority Stocks and Geographic Use

Overview of limiting factors

Kaputa et al.(2002) suggested that there were four main factors limiting production of trout[1]; 1) natural production of trout in the tributaries to Lake Chelan is limited primarily by the scarcity of spawning habitat; 2) competition between native fish species and introduced game fish has reduced and possibly eliminated certain native fish populations; 3) the importance of the recreational fishery, which is based largely on introduced species, could limit the ability to reintroduce bull trout; and 4) Lake Chelan Hydroelectric Project operations have created barriers to tributaries for spawning adfluvial trout by limiting access to these tributaries at critical times.

Brown (1984) suggested that a combination of several factors contributed to the decline of the cutthroat trout fishery: 1) from about 1890 to 1920, the Washington Department of Game (WDG, now the Washington Department of Fish and Wildlife [WDFW]) trapped adult cutthroat trout in tributaries to use as broodstock for a statewide hatchery program (the fish that were planted back in Lake Chelan did not survive well); 2) in 1917, WDG introduced non-native rainbow trout and kokanee salmon into the lake, resulting in some hybridization of adfluvial rainbow and cutthroat trout and decreased productivity from competition between the species; and 3) high harvest rates of cutthroat trout, a species typically vulnerable to high fishery exploitation, rapidly reduced their abundance and productivity.

Habitat use

The predominant salmonid species native to the Lake Chelan Basin are westslope cutthroat trout and bull trout; however, bull trout are presumed to be extirpated from the basin (Brown 1984). The other native top-level predator in the lake is burbot (freshwater ling cod). Anadromous fish are not known to have ever inhabited the Basin upstream of the lower river gorge (below the lake; R. Behnke, personal communication; Hillman and Giorgi 2000).

Lake Chelan supports an important sport fishery consisting of kokanee, landlocked chinook salmon, rainbow trout, cutthroat trout, lake trout and burbot. Other game fish found in Lake Chelan include smallmouth bass, pygmy and mountain whitefish, and a variety of spiny rays. Kokanee, rainbow trout, Lake trout, and smallmouth bass are all introduced species (introduced brook trout are established in the 25-Mile and Stehekin drainages too).

Native bull trout are thought to be extirpated in Lake Chelan. None have been observed in Lake Chelan, its tributaries or in sport catch counts since the late 1950s (Brown 1984). The historical population probably exhibited both adfluvial (lake-resident) and stream-

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[1] We note that there are summer/fall chinook and steelhead that use the area near the confluence of the Columbia and Chelan River, but these will be considered in the Upper Middle Mainstem Columbia Subbasin Plan.

resident life history patterns. Some remnant populations may still reside in several tributaries of Lake Chelan, but verified captures of bull trout have not occurred from the lake in five decades (Brown 1984).

Introduced Mysis shrimp have limited production of kokanee salmon, and potentially other species too (Brown 1984).

Westslope Cutthroat trout

Life history

Westslope cutthroat trout generally exhibit three main life history forms; fluvial, which migrate between smaller spawning streams and larger streams to grow; adfluvial, which migrate between spawning streams and a lake, where growth occurs; and non-migratory, which generally spend their entire lives in the stream they were born.

Fluvial and adfluvial ecotypes of WSCT are present within the basin. Spawning is limited both because of habitat scarcity, and also access to tributaries and occurs in the spring.

Distribution

WSCT are still present in the Chelan Basin, but apparently at much reduced numbers than historic (Brown 1984). Spawning and rearing occurs in most suitable tributaries, including 25-Mile, Safety Harbor, Railroad, Prince, Fish, Fourmile creeks, and the Stehekin River drainage.

The primary historic distribution of westslope cutthroat trout (WSCT) occurred in the upper Columbia and Missouri River basins (USFWS 1999). WSCT were originally believed to occur in three river basins within Washington State; Methow, Chelan, and Pend Oreille, *although only abundant in the Lake Chelan Basin* (Williams 1998). However, recent information, based on further genetic analyses (Trotter et al. 2001; Behnke 2002; Howell et al. 2003), indicates that the historic range of WSCT in Washington State is now believed to be broader. Historic distribution now includes the headwaters of the Wenatchee, Entiat, and Yakima River basins (Behnke 2002).

Use

Historically, tributary inflows to Lake Chelan most likely served as important spawning and rearing areas for WSCT. Barriers to upstream spawning migration, in the form of depth, gradient, and/or velocity, were identified in most tributary mouths investigated during studies conducted for Chelan PUD’s relicensing effort. The Natural Sciences Working Group[2] concluded that these barriers were created as a result of hydro project operations since 1981, the term of the second license, and are, most likely, contributing to the decline of trout populations in Lake Chelan tributaries (Chelan PUD 2001). Chelan

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[2] A group of mostly fish and wildlife biologists representing all stakeholder agencies and a number of non-governmental organizations, which is participating in the relicensing process for the Lake Chelan Hydroelectric Project.

PUD has agreed to modify operations to address tributary access under the terms of the new license (Chelan PUD 2001).

The effects are limited to adfluvial cutthroat. Cutthroat refugia upstream from the glacial trough-wall zone (nearly vertical walls created by the glacier) are naturally isolated and not affected by lake level fluctuation (in Kaputa et al. 2002).

The spawning timing of both adfluvial and resident trout appears to also coincide with sucker spawning, and competition for the limited spawning habitat may occur. Since spawning substrate is limited in the stream channels, the bridgelip sucker, which is a larger and more numerous fish, may push the trout further upstream or into less favorable spawning habitat. In addition, the emergent sucker fry may compete with the emergent trout fry for food. The increased competition for spawning and rearing habitat may diminish natural production of trout.

The biology of WSCT in the lake is not clearly understood. Brown (1984) found that for adult WSCT, terrestrial insects made up the bulk of the stomach contents that could be identified. Mysis made up a large proportion in one year too. However, there have been no studies conducted to date to determine the life history of juvenile adfluvial WSCT that might enter the lake at smaller sizes. It is likely that given the limited rearing potential of the smaller streams that are adjacent to the lake that WSCT fry may immigrate to the lake. The effects of mysis and other exotic species may reduce survival at this life stage through competition for the limited food sources within the lake.

In summary, bull trout may be extirpated within the Lake Chelan Basin. However, additional research is needed to clearly understand whether there are still fluvial populations in upper tributaries. WSCT have been impacted from various activities including introduction of exogenous species and hydroproject operations. Reducing the influence of exotic species and modification to hydro operations will most likely increase production of WSCT within the Lake Chelan Basin.

References

Methow Subbasin

Priority Stocks and Geographic Use

Overview of limiting factors

Natural environmental conditions can limit natural production of salmonids in the Methow watershed (Andonaegui 2000). Extreme winter conditions contribute to reduced fish growth and activity (Mullan et al. 1992). In years when moisture availability is limited by climatic conditions, instream flows become severely reduced, resulting in dewatered reaches, winter icing, and higher summertime water temperatures. These conditions restrict salmonid access to habitat, dewater redds, and strand juveniles, resulting in direct mortality to salmonids.

In some portions of the watershed, human alterations to the environment are exacerbating naturally limiting conditions by reducing habitat quality and quantity thereby limiting production of focal species (Andonaegui 2000). These alterations have primarily occurred in the lower gradient, lower reaches of subwatersheds and include road building and placement, land use and development, water diversions, and diking. However, in some drainages, impacts also extend into the upper reaches of the drainages. These impacts are mostly the result of past timber harvest operations, road building and placement, and grazing (Andonaegui 2000).

The limiting factors analysis for the Methow Basin (Andonaegui 2000) lists the following recommendations to increase production of focal species within the Methow Basin: 1) protection of properly functioning habitat; 2) restoration of fish passage and screening of water diversions; 3) restoration of stream functions in the lower 15 miles of the Twisp River; 4) research, analyze and assess the relationship between stream flows and water use in the watershed; and 5) development and implementation of water conservation practices. Williams (2000 in Foster et al. 2002) concluded that three habitat factors limited salmon, steelhead, and bull trout production in the Methow Basin and require additional research. Those factors are 1) the extent to which irrigation diversion affects natural runoff patterns, water temperature, chemical enrichment, and fish production; 2) the role that large woody debris played historically within the Methow in producing fish; and 3) the affect of man’s placement of 35 miles of riprap on fish production.

Habitat use

Mullan et al. (1992) looked extensively at habitat use and conditions within the Methow River Basin. They used the Habitat Quality Index (HQI; Binns 1982) which rates late summer flow, annual flow variation, water temperature, food, cover, water velocity, nitrate nitrogen and stream width; with an index of non-salmonids substituted for bank erosion. They did not use the bank erosion factor since it is directed towards livestock destabilization, and not natural processes.

They compared the HQI to densities of fish found in various sampling sections within the Methow River and its tributaries. They found that chinook salmon and age-0 steelhead were significantly related to HQI scores, but not steelhead parr. Cover and species interactions explained most of the variability in densities of chinook and age-0 steelhead, although it was still a weak correlation.

They postulated that the index was weak because it was designed for larger trout, and not "ephemeral" populations of salmon or steelhead. However, they still did not find a strong relationship between the HQI and trout in the headwaters, where they anticipated it would have been more applicable.

Temperature, nitrogen, velocity, and cover influenced cutthroat trout biomass. Stream temperatures explained less than 20% of the biomass and densities of rainbow trout. None of the HQI variables explained any of the variation for bull trout, while the total salmonid density and biomass varied significantly with food only, accounting for about 10% of the variation.

Given the weak correlations observed by Mullan et al. (1992), they reevaluated all of the variables used in the HQI and concluded,

". . . no methodology is likely to be successful on a broad scale in precisely defining the actual factors controlling abundance and in understanding their subtle interaction. . . Limitations aside, characterization of habitat in a theoretically sound and consistent manner to a known though low degree of accuracy (+/- 50%) has merit. . . It allows correct rather than precise judgments. For example, total possible HQI score is 335. Average score for the 186 stations in the Wenatchee, Entiat, and Methow drainages was 47 (range 11-113) indicating low overall salmonid potential."

Their conclusion is further evidenced by the lowest growth rates for fish in the literature (see appendix _). We also understand that it is incumbent on subbasin planners to make wise choices on the projects that get carried forward, and thus, we need the best information to guide our efforts where it will have the most impact on the target species.

Spring chinook

Life history
Spring chinook generally spawn in the higher order streams within a subbasin. Juveniles spend one year after emergence in freshwater prior to migrating to sea. A proportion of juveniles spend their entire freshwater life in the stream of which they were born, while others migrate downstream to larger streams to complete this phase. Upon their return, most adults have spent two years in the ocean, although in a given year, a significant number of 3-ocean fish may make up the population. Precocious males (jacks that have spent one year at sea or individuals that have not migrated to sea) may make up a significant proportion of the spawning population in some demes.

The Methow basin spring chinook migrate past Wells Dam and enter the Subbasin in May and June, peaking after mid-May. Spawning occurs late July through mid-September. Fry emerge the following spring and are assumed to smolt as yearlings, although fall parr migrations from upper reaches have been observed (Hubble 1993; Hubble and Harper 1995). Juvenile chinook have been found rearing in most of the spawning areas, mainstem margins and side channels associated with the rivers, as well as some of the mouths of smaller tributaries (Mullan et al. 1992; Hubble and Sexauer 1994; Hubble and Harper 1995).

Distribution

Methow Basin spring chinook spawn primarily in the upper reaches of the Chewuch, Twisp and Methow rivers, including the Lost River, Early Winters and Wolf Creek tributaries; in order of importance: the mainstem Methow, Twisp, Chewuch, Lost rivers, and Early Winters Creek (Scribner et al. 1993).

Historically, Fulton (1968) suggested that the Chewuch was the largest producer of spring chinook in the Methow River Basin.

Use

Spawning areas described above are also used for juvenile rearing. In addition, a portion of each year's standing crop (parr) migrate from the upper reaches of tributaries downstream in the fall, presumably for thermal refuge, as the upper reaches become colder. Hillman and Chapman (1989) showed that Tumwater Canyon in the Wenatchee River is where most fish rear over the winter before their smolt migration begins in the spring the following year. During the daytime, juvenile chinook used instream and overhead cover extensively, although as they got larger (and stream flows reduced), they sought areas that were deeper and higher velocity (Hillman et al. 1989 CPa). Griffith and Hillman (1986) observed that juvenile chinook in the Methow also used deep pools and selected stations close to woody debris and boulder rip-rap. However, Giffith and Hillman note that chinook appeared to be more dispersed in the Methow than in the Wenatchee. Substrate preference also changed as the juvenile chinook got larger and hydraulic conditions changed from predominantly sand, large boulder, and bedrock to sand, sand-gravel, and cobble. As temperatures dropped below 10 C, salmon were observed primarily near boulder rip-rap, or concealed themselves in the substrate.

During nighttime hours during the warmer months, chinook moved inshore and rested all night in shallow, quiet water (Hillman et al. 1989 CPb). In the colder months, chinook sought deeper water with larger substrate.

The natal tributaries and mainstem Methow River are used for a migration corridor for both juveniles and adults. Adults, on their return use the large pools of the main river as resting and staging areas prior to spawning.

Within the known areas of distribution, historic habitat in the lower 50% of the Chewuch River and lower 15 miles of the Twisp River are most likely the highest area of perturbation (Andonaegui 2000). Restoration of natural channel migration (removal, or set back of dikes) and restoration of other geo-fluvial processes may be difficult to remedy because of current land use. Water conservation may improve some of the habitat limiting factors however.

In the mainstem Methow River, loss of potential riparian zones from land use practices and diking appear to be the largest impacts to primarily juvenile rearing (Andonaegui 2000). Lack of side-channel habitat, low LWD recruitment, and impacts from roads all may be limiting production of focal species. However, spawning habitat does not seem limiting. Connectivity may be hampered both from naturally occurring events (see above) and because of water and land use activities.

In summary, many areas of high quality habitat still exist in the Methow River Basin for spring chinook. The main river and some of the larger tributaries, have the best remaining habitat for rearing and spawning. There are areas that would benefit from increases in natural habitat restoration or conservation, but some areas would not yield large effects from such efforts. However, these areas of lesser potential still may function in providing ecologic diversity of the independent population of Methow River spring chinook.

Summer/fall chinook

Life history

Summer/fall chinook spawn in the mainstem areas of tributaries and the Columbia River, where suitable habitat prevails. Juveniles begin migrating to the ocean shortly after emergence. Apparently, some juveniles use the mainstem Columbia River to overwinter before entering the ocean in their second year of life. Adults have usually spent two years in the ocean upon return, but significant proportions of 1-ocean fish make up the run in some years, along with 3-ocean fish too.

Earlier returning adults (“summer-run”) and later returning adults (“fall-run”) show similar life histories and cannot be distinguished on the spawning grounds (see Appendix __ for further discussion).

Summer/fall chinook destined for the Methow River pass Wells Dam after mid- to late June. They enter the river beginning in July, and spawn during late September through November.

Distribution

Summer/fall chinook salmon typically spawn in the Methow River between RM 2.0 and Winthrop Hatchery diversion (RM 51.6). Redds are scattered throughout the whole area, with the highest concentration between Carlton and Twisp (RM 27.2-39.6), and least abundant near the upper limit of spawning.

Historically, Craig and Suomela (1941) believed no summer/fall chinook spawned in the Methow River. Meekin (1967) agreed with Craig and Suomela, however added that a few might have spawned in the lower river. Regardless, summer/fall chinook currently use the mainstem Methow River for spawning, the result of various hatchery programs since the 1940s (Appendix ___).

Use

Hillman and Chapman (1989) noted that the density of age-0 chinook decreased in the lower Wenatchee River reaches by 85% as the summer progressed. This timing coincided with emergence of summer/fall chinook. This suggests that within the first few weeks after emergence, most, if not all of the summer/fall juveniles have emigrated from the Wenatchee River. It appeared that most of the age-0 fish emigrated from survey reaches within 48 hours after being marked (Hillman and Chapman 1989). The primary reason Hillman and Chapman attribute to the rapid exodus of fish from the lower Wenatchee River was lack of flow refugia, although other factors, such as hatchery "thinning" releases and species interaction with sculpin and red sided shiners may have also played a role. Potential increases in off-channel habitat (for flow refugia) may increase the length of residence of age-0 chinook in the lower Wenatchee River, however this strategy needs to be balanced with natural processes and known life history characteristics of ocean-type chinook before assigning an importance of this (or other) strategy in increasing summer/fall chinook production increases. Chapman et al. (1994) believed that summer/fall chinook behaved similarly in the Methow as they do in the Wenatchee.

In summary, summer/fall chinook in the Methow River may benefit from off-channel habitat. However, because of their life history, the benefits for this species may be limited.

Steelhead

Life history

Steelhead generally spawn throughout a basin, wherever appropriate habitat exists. Juveniles may spend up to seven years in freshwater prior to migrating to the ocean, but average 2-3 years. Adults may spend from 1-3 years in the ocean before migrating back to natal areas. True assessment of the spawning population is difficult because non-anadromous fish may contribute to the anadromous population (and vice versa). Environmental factors (primarily temperature) appear to dictate whether an individual fish migrates to the sea or not.

Steelhead destined for the Methow River enter the Columbia River between May and September and pass Wells Dam from July through the following May. All steelhead spawn in the spring, and those that pass Wells Dam in the spring have over-wintered in the mainstem of the Columbia River. Fish may also use appropriate areas within the Methow River to over-winter (French and Wahle 1959; English et al. 2001).

Distribution

Beginning in 2001, WDFW has been conducting spawning ground surveys for steelhead in the Wenatchee and Methow rivers (Murdoch et al. 2001; Jateff and Snow 2002). These efforts are in conjunction with hatchery evaluations that are currently taking place within the Upper Columbia Basin for Chelan and Douglas Counties Public Utility District

(PUD) funded mitigation efforts. Current spawning distribution in the Methow Basin, in order of importance from Jateff and Snow (2002) appears to be: the Twisp River, Winthrop National Fish Hatchery Creek, mainstem Methow River, Chewuch River, and Beaver Creek. Other areas surveyed that had steelhead spawning in less abundance were: Methow Hatchery Creek, Lost River, Buttermilk, Boulder, Eight-mile, and Lake creeks. War and Wolf creeks were surveyed but no redds were found.

Steelhead historically used all major (and some minor) tributaries within the Upper Columbia Basin for spawning and rearing (Chapman et al. 1994). Fulton (1970) described steelhead using the same areas that they use currently.

Use

For those adult fish that enter and over-winter in the Methow River, large pools with proximity to cover is most likely used prior to spawning. They are also found in the deeper runs near larger pools.

Steelhead use a wide range of habitats and habitat types throughout their freshwater life history. Since they spend more time in freshwater than other anadromes, they are more prone to habitat perturbations and may ultimately benefit from freshwater habitat restoration and conservations measures to a greater degree than other anadromes.

In the Wenatchee River, Hillman and Chapman (1989) found most juvenile steelhead rearing in Tumwater Canyon. During daylight, age-0 steelhead used slower, shallower water than chinook, stationed individually over small boulder and cobble substrate (Hillman et al. 1989 CPa). As they grew, they picked deeper and faster habitat over cobble and boulders. As with chinook juveniles, in winter, they concealed themselves in interstitial spaces among boulders near the stream bank, but did not cluster together. No interaction was observed between chinook and steelhead at anytime (Hillman et al. CPa, CPb). Methow River steelhead use similar habitat as described in the Wenatchee above.

During nighttime hours, steelhead moved downstream and closer to shore. At dawn, steelhead moved upstream. Most steelhead chose sand and boulder substrates, and during winter, chose deeper, larger substrate (Hillman et al. 1989 CPb).

Most of the discussion above on spring chinook concerning habitat conditions would apply equally to steelhead. However, since they are prone to use smaller tributaries and have an extended freshwater life history, the likelihood of increases in productivity from habitat improvements may be greater for steelhead than spring chinook.

In summary, steelhead appear to use most available habitat types within the Methow River Basin. Conservation and restoration of known limiting factors will potentially aid steelhead to a great degree than other focal species.

Bull trout

Life history

Bull trout generally exhibit three main life history forms; fluvial, which migrate between smaller spawning streams and larger streams to grow; adfluvial, which migrate between spawning streams and a lake, where growth occurs; and non-migratory, which generally spend their entire lives in the stream they were born. A fourth ecotype, anadromous, does not occur in the CCP. Assessment of bull trout populations are difficult because non-migratory forms may give rise to migratory forms (and vice versa).

Methow Subbasin juvenile bull trout rear in the coldest headwater locations until they reach a size that allows them to compete with other fish (75-100mm) (Mullan et al. 1992). Resident forms above barrier falls probably experience a limited amount of recruitment downstream, nevertheless, this recruitment contributes to fluvial and adfluvial productivity.

Distribution

Historically, there were most likely three life histories (or ecotypes) of bull trout within the Methow Basin (adfluvial, fluvial and non-migratory), with distribution and population levels dictated by temperature and gradient (Mullan et al. 1992). In the Methow River system, the USFWS (2002) has identified bull trout spawning populations in Gold Creek, Twisp River, Chewuch River, Wolf Creek, Early Winters Creek, the Upper Methow River, Lost River, and Goat Creek. In the Upper Methow River, sub populations have been identified in the West Fork and Trout Creek (USFWS 2002).

The fluvial forms migrate to the warmer mainstem Methow and Columbia rivers (e.g. Twisp River, Wolf Creek), while the adfluvial populations (e.g. Lake Creek, Cougar Lake) migrate to nearby lakes

While historic distribution is difficult to determine (Rieman et al. 1997), bull trout are believed to have been historically present in the Methow Basin (Brown 1992; Mongillo 1993).

Use

Bull trout distributions in the Methow watershed parallel the habitat conditions; the more pristine the habitat, the more robust the bull trout populations (Andonaegui 2000). Proebstel et al. (1998) reported that in general, bull trout were found to be persisting in small headwater populations. The Lost River and Robinson Creek Watershed Analysis (in Andonaegui 2000) states, “Roads, access and resultant overfishing in most waters are probably the most limiting production factors to bull trout resulting from man’s influence”. To minimize further declines of stocks of this species, it will be important to maintain functioning habitat in its current healthy condition, reduce fishing pressure, minimize the access and colonization of brook trout into bull trout waters, and restore degraded habitat conditions that contribute to increased sediment recruitment, increased instream temperatures and low flows (in Andonaegui 2000).

Current information suggests that bull trout are generally not limited in their movements in the Methow Basin (BioAnalysts 2002, 2003), although extensive tracking of bull trout has not occurred yet in the Basin. Culverts in some of the lower areas may be problematic to migration. Bull trout appear to move between smaller tributaries and the mainstem Methow for thermal refuge, food availablility and spawning. The mainstem Columbia River is also used by Methow River Basin bull trout (BioAnalysts 2002, 2003) most likely for the reasons listed above.

Bull trout are known to be more sensitive to habitat perturbations, especially increases in temperature, and therefore would benefit greatly from habitat restoration activities that increased riparian habitat, where appropriate. Most of the existing areas where bull trout are known to spawn are already in areas that have been conserved, in the upper reaches of the watersheds. However, for those areas that are still potentially vulnerable, it is important to further conserve or protect.

Flow conditions in some streams may also affect bull trout movements. Channel stability projects could increase production if natural process were restored. However, because of roads and other land uses, it is not likely that much can be done, except for specific smaller reaches of these streams.

Introgression and competition with introduced brook trout has also been widely identified as a threat to the health of bull trout populations. Areas within the Methow Basin are known to have established brook trout populations (Foster et al. 2002).

In summary, much of bull trout spawning habitat is in tact. However, some areas may be vulnerable to perturbation if not protected. Other rearing areas may need restoration, including evaluation of potential migratory problems. However, it is likely that total distribution in the Methow River is similar to historic, except in a few of the smaller streams.

Westslope cutthroat trout (WSCT)

Life history

Westslope cutthroat trout generally exhibit three main life history forms; fluvial, which migrate between smaller spawning streams and larger streams to grow; adfluvial, which migrate between spawning streams and a lake, where growth occurs; and non-migratory, which generally spend their entire lives in the stream they were born.

Much of the life history of WSCT in the Methow River is unknown at this time.

Distribution

Through stocking programs that began with Washington state’s first trout hatchery in the Stehekin River valley in 1903 (that targeted WSCT), WSCT have been transplanted in almost all available stream and lake habitat, including the Methow River Basin (Williams 1998).

Currently WSCT are found throughout the Methow Basin (Williams 1998). WSCT are found within streams and lakes throughout the basins, but spawning (for stream populations) usually occurs in the upper portions of each basin.

The primary historic distribution of westslope cutthroat trout (WSCT) occurred in the upper Columbia and Missouri River basins (USFWS 1999). WSCT were originally believed to occur in three river basins within Washington State; Methow, Chelan, and Pend Oreille, although only abundant in the Lake Chelan Basin (Williams 1998). However, recent information, based on further genetic analyses (Trotter et al. 2001; Behnke 2002; Howell et al. 2003), indicates that the historic range of WSCT in Washington State is now believed to be broader. Historic distribution now includes the headwaters of the Wenatchee, Entiat, and Yakima River basins (Behnke 2002).

Use

WSCT use many of the smaller streams within the Methow Basin and the mainstem Methow too. Most reside in the upper reaches of higher order streams within the basin, and some of the Alpine lakes.

Limiting factors for WSCT in the Methow River may be channel stability, habitat diversity, obstructions, temperatures and riparian. These factors need to be considered in relation to life history of WSCT (e.g., temperatures probably always limited WSCT distribution within Methow River streams). However, conservation of known areas of abundance would increase the likelihood that they could persist in high quality habitats.

In summary, little is known of the life history and habitat needs of WSCT in the Methow River Basin. However, it is reasonable to assume that some known limiting factors, such as channel stability, habitat diversity, obstruction, land use that affects temperatures may be limiting production of WSCT in the Methow River, and that they would benefit from improvements to those factors.

References

Okanogan Subbasin

Priority Stocks and Geographic Use

Overview of limiting factors

WDFW (1989), notes that thermal pollution has resulted from tributary irrigation return flows, over-appropriated flows, and physical characteristics of the Okanogan River channel. A thermal barrier to migrating adult salmon exists in the late summer and early fall. High summer and fall water temperatures throughout the basin also severely limit rearing habitat for juvenile salmonids.

> WDW et al. (1989) state:
>
> *Riparian areas in the Okanogan Basin are quite narrow as the result of extensive agricultural development throughout the system. Reclamation of wetlands, vegetation removal for additional crop production and weed control, and poor grazing practices in this semi-arid area, has virtually eliminated bank vegetation in some areas and has modified the plant community to such a degree only undesirable annual species are present. The result has been accelerated erosion, with most river reaches typically possessing vertical cut banks. Additionally, the reduction in bank vegetation has increased the vulnerability of the stream to thermal pollution, resulting from reduced shading.*

WDW et al. (1989) state that spawning gravel quantity and quality in the Okanogan and Similkameen basins have been compromised to a large extent by sand and sediments originating in the upper Similkameen, where extensive mining activity still occurs, and from both systemwide range practices and agricultural sources. The substrate of the Ellisford to Riverside reach is all sand and silt. Substrates in the lower reaches of the Okanogan are said to be essentially unusable. Mainstem conditions improve somewhat above the Omak-Okanogan area. Substrate between the head of Lake Osoyoos to Oliver, B.C. are said to be fair to poor as a result of flood control measures such as dredging and channelization (WDW et al. 1989). The substrate quality of the lowest 8.8 miles of the Similkameen River downstream from Enloe Dam is limited by sand and silt from the upper Similkameen River.

The Okanogan River system differs from the Wenatchee and Methow rivers by containing four main-stem lakes. These are Osoyoos, Vaseaux, and Skaha lakes, and the much larger Okanogan lake. The lowest 82 miles of the basin have a low-gradient channel, with a fall of only 165 feet (0.38% gradient). The sinuous Okanogan River cannot purge itself of fine sediments.

Habitat use

Mullan et al. (1992) looked extensively at habitat use and conditions within the Wenatchee, Entiat, and Methow River basins. They used the Habitat Quality Index (HQI; Binns 1982) which rates late summer flow, annual flow variation, water temperature, food, cover, water velocity, nitrate nitrogen and stream width; with an index of non-salmonids substituted for bank erosion. They did not use the bank erosion factor since it is directed towards livestock destabilization, and not natural processes.

They compared the HQI to densities of fish found in various sampling sections within the these rivers and its tributaries. They found that chinook salmon and age-0 steelhead were significantly related to HQI scores, but not steelhead parr. Cover and species interactions explained most of the variability in densities of chinook and age-0 steelhead, although it was still a weak correlation.

They postulated that the index was weak because it was designed for larger trout, and not "ephemeral" populations of salmon or steelhead. However, they still did not find a strong relationship between the HQI and trout in the headwaters, where they anticipated it would have been more applicable.

Temperature, nitrogen, velocity, and cover influenced cutthroat trout biomass. Stream temperatures explained less than 20% of the biomass and densities of rainbow trout. None of the HQI variables explained any of the variation for bull trout, while the total salmonid density and biomass varied significantly with food only, accounting for about 10% of the variation.

Given the weak correlations observed by Mullan et al. (1992), they reevaluated all of the variables used in the HQI and concluded,

". . . no methodology is likely to be successful on a broad scale in precisely defining the actual factors controlling abundance and in understanding their subtle interaction. . . Limitations aside, characterization of habitat in a theoretically sound and consistent manner to a known though low degree of accuracy (+/- 50%) has merit. . . It allows correct rather than precise judgments. For example, total possible HQI score is 335. Average score for the 186 stations in the Wenatchee, Entiat, and Methow drainages was 47 (range 11-113) indicating low overall salmonid potential."

Their conclusion is further evidenced by the lowest growth rates for fish in the literature (see appendix _). We also understand that it is incumbent on subbasin planners to make wise choices on the projects that get carried forward, and thus, we need the best information to guide our efforts where it will have the most impact on the target species.

Spring chinook

Life history
Spring chinook generally spawn in the higher order streams within a subbasin. Juveniles spend one year after emergence in freshwater prior to migrating to sea. A proportion of juveniles spend their entire freshwater life in the stream of which they were born, while others migrate downstream to larger streams to complete this phase. Upon their return, most adults have spent two years in the ocean, although in a given year, a significant

number of 3-ocean fish may make up the population. Precocious males (jacks that have spent one year at sea or individuals that have not migrated to sea) may make up a significant proportion of the spawning population in some demes.

There are no naturally spawning populations of spring chinook in the Okanogan Basin at this time. However, there are cooperative efforts underway to reintroduce them.

Distribution

Historically, Omak and Salmon creeks were used by spring chinook (Bryant and Parkhurst 1950; Fulton 1968). These runs were extirpated by the late 19th – early 20th centuries from land use practices and commercial fishing. Spring chinook are not believed to have spawned in Canada (Fulton 1968; Chapman et al. 1995).

It has been suggested that spring and summer chinook (and steelhead) formerly used the Similkameen River upstream from falls that lay at the present site of Enloe Dam. Chapman et al. (1995 CPa) found no evidence that such use occurred. The underlying source for Fulton's (1968) inclusion of the Similkameen River upstream from the site of Enloe Dam as anadromous salmon habitat was WDF (1938). Perusal of that source does not support the Fulton observation. WDF (1938) describes existence of potential spawning habitat in the area upstream from Enloe Dam, but provides no documentation of historical use of the area by salmon or steelhead. Cox and Russell (1942) state:

> *From testimony of a Mr. McGrath at Nighthawk, who had been in that country over 40 years, we learned that before any power dam was built* (Enloe Dam)*, the 15' to 20' natural falls already mentioned prevented salmon ascending any farther. He had often fished the river at Nighthawk but had never heard of a salmon being seen or caught above the natural falls. He stated that the Indians came in to fish at these falls each summer.....Therefore, we conclude that this power dam did not interfere with any salmon runs....*

Accounts of the traditional story of coyote suggest that salmon never passed upstream of the falls, and the Native people of the Similkameen valley never sought to have fish passage there, further confirming that anadromous fish never passed the falls (Vedan 2002).

In summary, spring chinook are being reintroduced into Omak Creek, and the potential remains if land use practices are modified to reintroduce spring chinook back into Salmon Creek within the Okanogan Basin.

Summer/fall chinook

Life history

Summer/fall chinook spawn in the mainstem areas of tributaries and the Columbia River, where suitable habitat prevails. Juveniles begin migrating to the ocean shortly after emergence. Apparently, some juveniles use the mainstem Columbia River to overwinter before entering the ocean in their second year of life. Adults have usually spent two years in the ocean upon return, but significant proportions of 1-ocean fish make up the run in some years, along with 3-ocean fish too.

Earlier returning adults ("summer-run") and later returning adults ("fall-run") show similar life histories and cannot be distinguished on the spawning grounds (see Appendix __ for further discussion).

The fish that hatch in the Similkameen River most likely emigrate shortly after emergence to the Okanogan, a warm, relatively fertile river. These fish encounter growing conditions that are more favorable than those found by fish that originate from the Methow and Wenatchee drainages (or even the mainstem Columbia River). Consequently, fish from the Similkameen River may achieve the physiological size of smoltification sooner than their conspecifics in the other drainages and thus may emigrate at a faster rate to the ocean (Chapman et al. 1994).

Summer/fall chinook destined for the Okanogan River Basin pass Wells Dam after mid- to late June. They enter the river beginning in July, and spawn during late September through November.

Distribution

In the Okanogan Basin, summer/fall chinook salmon spawn in both the Okanogan and Similkameen rivers. In the Okanogan River, chinook usually spawn between RM 14.5 (just downstream of Malott) and Zosel Dam (RM 77.4). In the Similkameen River, chinook spawn between its mouth and Enloe Dam (RM 8.9). In both rivers, redds are highly clumped, and those distributions have not changed since 1987 when ground surveys were first conducted (Hillman and Miller 1993; Miller 2003). During that period, densities of redds in the Okanogan River were highest between Okanogan and Omak (RM 26.1-30.8), McLoughlin Falls and Tonasket (RM 48.9-56.8), and the Similkameen River confluence and Zosel Dam (RM 74.1-77.4); they were lowest between Tonasket and the Similkameen River confluence (RM 56.8-74.1) (Hillman and Miller 1993). In the Similkameen River during the same period, densities of redds were highest between the mouth and the county road bridge (RM 0-5).

Hillman and Miller (1993) found that summer/fall chinook in the Okanogan Basin constructed most of their redds near islands, i.e., in braided segments. This may be a function of the reduced opportunity for spawning in other areas because of sediment deposition (see above), and the geofluvial processes near islands may decrease sediment deposition.

The main river and Similkameen River were historically used by summer/fall chinook. Fulton (1968) indicates that chinook of the spring- and summer-run races used the Similkameen River before Enloe Dam was constructed just upstream from what he called *passable falls*. The underlying source is WDF (1938). As noted above, that source does not document use of the river upstream from Enloe Dam.

Use

Hillman and Chapman (1989) noted that the density of age-0 chinook decreased in the lower Wenatchee River reaches by 85% as the summer progressed. This timing coincided with emergence of summer/fall chinook. This suggests that within the first few weeks after emergence, most, if not all of the summer/fall juveniles have emigrated from the Wenatchee River. It appeared that most of the age-0 fish emigrated from survey reaches within 48 hours after being marked (Hillman and Chapman 1989). The primary reason Hillman and Chapman attribute to the rapid exodus of fish from the lower Wenatchee River was lack of flow refugia, although other factors, such as hatchery “thinning” releases and species interaction with sculpin and red sided shiners may have also played a role. Potential increases in off-channel habitat (for flow refugia) may increase the length of residence of age-0 chinook in the lower Wenatchee River, however this strategy needs to be balanced with natural processes and known life history characteristics of ocean-type chinook before assigning an importance of this (or other) strategy in increasing summer/fall chinook production increases. As stated above, fish that hatch in the Similkameen River may rear in Okanogan and attain larger size prior to seaward emigration. There may be more flow refugia in the Okanogan Basin than other basins, however, as the summer progresses, rearing temperatures become limiting.

In summary, summer chinook in the Okanogan River Basin may benefit from projects that enhance reduced sediment deposition and temperatures. Some of the temperature problems are naturally occurring because of the lake systems upstream of the main river in the United States.

Sockeye salmon

Life history

Sockeye salmon primarily spawn in river systems that contain at least one lake, which is used for juvenile rearing. After emergence, fish generally migrate quickly (either upstream or down) to the lake, where they reside usually one, but sometimes two or three years before migrating to the ocean. Fish predominantly spend two years in the ocean prior to return, although in some systems, a significant proportion may return after one or three years.

Okanogan River sockeye pass Wells Dam primarily in July and enter the Okanogan River sometime after. Adult sockeye enter Lake Okanogan after July, and hold until spawning in October.

Distribution

Sockeye from the Okanogan River Basin spawn in the main Okanogan River from Lake Osoyoos to primarily McIntyre Dam. In some years, sockeye have been observed spawning upstream of McIntyre Dam (Fisher et al. 2002). Small numbers are frequently seen in Similkameen River. Lake Osoyoos is used for juvenile rearing.

Historically, sockeye spawned throughout the upper basin into Canada, including Lake Okanogan.

Use

Sockeye are delayed in entering the Okanogan River because of high water temperatures (Chapman et al. 1995 CPb). A temperature of higher than 21° C appears to be the temperature threshold for delaying migration. Spawning habitat has been limited by channelization and damming of the river upstream of Lake Osoyoos.

Most fry emerge from the gravel from late March through early April in the Okanogan Basin (in Chapman et al. 1995 CPb). Fry may concentrate along near-shore areas for a few weeks before heading for deeper water. This may be because the timing of entry into the lake may not coincide with times of zooplankton production, and foraging may be more profitable in the littoral zones. Juvenile sockeye usually exhibit a diel vertical migration to balance trophic opportunities with safety from predators.

Lake Okanogan is highly eutrophic, and certain abiotic factors (temperature, oxygen, etc.) may limit production in the lake. Most opportunities for maintaining or increasing production may lie in increasing and restoring spawning habitat and reducing temperatures in the mainstem Okanogan River.

In summary, Okanogan sockeye may be limited mostly by temperature regimes within the lower river and spawning and rearing areas in the upper basin. Some of these factors are naturally occurring (e.g., temperature to some degree), but others (e.g., increase in spawning area) may benefit from restoration activities.

Steelhead

Life history

Steelhead generally spawn throughout a basin, wherever appropriate habitat exists. Juveniles may spend up to seven years in freshwater prior to migrating to the ocean, but average 2-3 years. Adults may spend from 1-3 years in the ocean before migrating back to natal areas. True assessment of the spawning population is difficult because non-anadromous fish may contribute to the anadromous population (and vice versa). Environmental factors (primarily temperature) appear to dictate whether an individual fish migrates to the sea or not.

Steelhead destined for the Okanogan River enter the Columbia River between May and September and pass Wells Dam from July through the following May. All steelhead spawn in the spring, and those that pass Wells Dam in the spring have over-wintered in the mainstem of the Columbia River. Fish may also use appropriate areas within the Okanogan and Similkameen Rivers to over-winter (French and Wahle 1959; English et al. 2001).

Distribution

Steelhead are currently known to spawn naturally in Omak Creek and the Similkameen River. In 2001, redds were also observed in Bonaparte Creek and Tonasket Creek, although the success of spawning in these areas remains unknown (Fisher et al. 2002).

Although the historical record for steelhead in the Okanogan Watershed is not complete, Mullan et al. (1992) asserts that few steelhead historically used the Okanogan River. Salmon and Omak creeks had historically runs, but lack of flow currently restricts access in most years in Salmon Creek. Some evidence suggests that steelhead may also have historically used other tributaries in the Okanogan Basin (Chapman et al. 1994CPb). Current habitat conditions in the Okanogan basin are generally poor to support most life history requirements of steelhead.

Although steelhead were probably never abundant in the Okanogan River due to natural habitat limitations, an estimated half of the steelhead production may have been lost as a result of fish access restrictions to Salmon Creek by irrigation water withdrawals (Fisher et al. 2002).

Use

For those adult fish that enter and over-winter in the Okanogan River, large pools with proximity to cover is most likely used prior to spawning. They are also found in the deeper runs near larger pools.

Steelhead use a wide range of habitats and habitat types throughout their freshwater life history. Since they spend more time in freshwater than other anadromes, they are more prone to habitat perturbations and may ultimately benefit from freshwater habitat restoration and conservations measures to a greater degree than other anadromes.

In the Wenatchee River, Hillman and Chapman (1989) found most juvenile steelhead rearing in Tumwater Canyon. During daylight, age-0 steelhead used slower, shallower water than chinook, stationed individually over small boulder and cobble substrate (Hillman et al. 1989 CPa). As they grew, they picked deeper and faster habitat over cobble and boulders. As with chinook juveniles, in winter, they concealed themselves in interstitial spaces among boulders near the stream bank, but did not cluster together. No interaction was observed between chinook and steelhead at anytime (Hillman et al. CPa, CPb). Habitat similar to that found in the Wenatchee River is limited in the Okanogan River, although restoration projects may enhance those habitat types both in the mainstem and suitable tributaries.

During nighttime hours, steelhead moved downstream and closer to shore. At dawn, steelhead moved upstream. Most steelhead chose sand and boulder substrates, and during winter, chose deeper, larger substrate (Hillman et al. 1989 CPb).

Since steelhead are prone to use smaller tributaries and have an extended freshwater life history, the likelihood of increases in productivity from habitat improvements may be greater for steelhead than spring chinook.

In summary, steelhead are most likely using most available habitat in the Okanogan River Basin. Conservation and restoration of known limiting factors will potentially aid steelhead to a great degree than other focal species. Because of land use and naturally occurring factors, habitat restoration projects within the Okanogan Basin may have less impact on steelhead because of their life history needs. Restoration of more normative river flows in Salmon Creek may the largest impact for restoring steelhead in the Okanogan Basin.

Bull trout

Life history

Bull trout generally exhibit three main life history forms; fluvial, which migrate between smaller spawning streams and larger streams to grow; adfluvial, which migrate between spawning streams and a lake, where growth occurs; and non-migratory, which generally spend their entire lives in the stream they were born. A fourth ecotype, anadromous, does not occur in the CCP. Assessment of bull trout populations are difficult because non-migratory forms may give rise to migratory forms (and vice versa).

Distribution

Bull trout are not known to presently exist in the Okanogan Basin, including Canadian waters. Historically, Salmon Creek and Loup Loup Creek were known habitat (Fisher 2002).

Use

One of the factors believed to be responsible for the disappearance of bull trout from Salmon and Loup Loup creeks is the introductions of rainbow and brook trout (Fisher et al. 2002).

In summary, some bull trout spawning habitat may still be in tact in upper Salmon and Loup Loup creeks. However, removal of rainbow and brook trout would be needed, in addition to transplants of artificial production.

Westslope cutthroat trout (WSCT)

Life history

Westslope cutthroat trout generally exhibit three main life history forms; fluvial, which migrate between smaller spawning streams and larger streams to grow; adfluvial, which migrate between spawning streams and a lake, where growth occurs; and non-migratory, which generally spend their entire lives in the stream they were born.

Much of the life history of WSCT in the Okanogan River is unknown at this time.

Distribution

Through stocking programs that began with Washington state’s first trout hatchery in the Stehekin River valley in 1903 (that targeted WSCT), WSCT have been transplanted in almost all available stream and lake habitat, including the Okanogan River Basin (Williams 1998).

Currently WSCT are found in the North Fork Salmon Creek, Sinlahekin headwaters, and in numerous alpine lakes (Williams 1998). They were most likely introduced into these waters (Fisher et al. 2002).

The primary historic distribution of westslope cutthroat trout (WSCT) occurred in the upper Columbia and Missouri River basins (USFWS 1999). WSCT were originally believed to occur in three river basins within Washington State; Methow, Chelan, and Pend Oreille, although only abundant in the Lake Chelan Basin (Williams 1998). However, recent information, based on further genetic analyses (Trotter et al. 2001; Behnke 2002; Howell et al. 2003), indicates that the historic range of WSCT in Washington State is now believed to be broader. Historic distribution now includes the headwaters of the Wenatchee, Entiat, and Yakima River basins (Behnke 2002).

WSCT may never have been in the Okanogan Basin (Fisher et al. 2002), however, this may never be known positively and the potential exists that some of the higher altitude streams may have had some fish present.

Use

Limiting factors for WSCT in the Okanogan River Basin may be channel stability, habitat diversity, obstructions, temperatures and riparian. These factors need to be considered in relation to life history of WSCT (e.g., temperatures probably always limited WSCT distribution within Okanogan River streams, especially the mainstem). However, conservation of known areas of abundance would increase the likelihood that they could persist in high quality habitats. The historic temperature of the mainstem may have always limited connectivity between spawning streams in this basin, assuming that they existed at all.

In summary, little is known of the life history and habitat needs of WSCT in the Okanogan River Basin. However, it is reasonable to assume that some known limiting factors, such as channel stability, habitat diversity, obstruction, land use that affects temperatures may be limiting production of WSCT in the Okanogan River, and that they would benefit from improvements to those factors. However, it is reasonable to assume that they may never have occurred, or at least not in large numbers within this subbasin.

References

Upper middle mainstem Columbia River

Priority Stocks and Geographic Use

Overview of limiting factors

Peven et al. (2002) listed the following potential limiting factors in the upper middle mainstem (UMM) Columbia River as: 1) impacts from hydropower operations and development; 2) land use, such as agricultural practices, urban/suburban development; and 3) predation from native as well as non-native species.

Habitat use

The UMM provides limited spawning and rearing habitat for anadromous salmonids and is used primarily as a migration corridor for adults and juveniles migrating to or from tributary habitats. A wide variety of non-anadromous fish species also use the mainstem river for several life stages such as spawning, rearing, foraging and migrations.

Spawning Habitat (excerpts from Peven et al. 2002)

Although there is little spawning habitat for anadromous salmonids in the mainstem Columbia River, fall chinook redds have been observed where streambed hydraulics and substrate composition allow. At the confluence of the Chelan River with the Columbia River and in the Wells Dam tailrace, salmon redds are observed annually during late fall aerial surveys (Murdoch and Miller 1999).

Spawning habitat types for non-anadromous resident fish that inhabit the mainstem include: rocky rubble; cobble and gravel substrates in swift water (below Wells Dam); rubble and boulder substrate in moderate to calm velocities; sand, silt and imbedded cobble substrates in moderate to calm velocities; and macrophyte beds. White sturgeon spawning occurs in the UMM.

Rearing Habitat (excerpts from Peven et al. 2002)

Besides the steep shorelines and sparse riparian habitat that is common along the Columbia, there are other factors that can potentially affect rearing habitat in the mainstem reservoirs. One factor is the degree of primary and secondary production that occurs in the reservoir system. The invertebrate community in the reservoirs is dominated by lower energy organisms such as chironomidae, oligochaetes and zooplankton (Falter et al. 1991; Rondorf and Gray 1987).

Submergent aquatic plants are increasing in some of the mainstem reservoirs. The benthic community in these submerged macrophyte beds is similarly increasing as riverine macrophytes effectively create substrate by velocity reduction and subsequent particle trapping, encouraging settling of organic-rich soils (Falter et. al 1991). These beds could then eventually increase the production of benthic food organisms as well as providing surface area for algae and invertebrate growth. They may also provide cover for juvenile salmonids as well as other fish species, thereby possibly increasing rearing habitat.

Migratory Habitat (excerpts from Peven et al. 2002)

Hydroelectric project operations, agricultural practices, industrial discharge into the river, and residential developments along the Columbia River can directly influence water quality.

The hydroelectric projects on the mainstem of the Columbia River within the Columbia Upper Middle are run-of-river with reservoirs that have little storage capacity. Water velocities are generally fast enough to prevent the formation of a thermocline and the associated depletion of oxygen in deeper waters. Water quality parameters affected by hydropower production, include total dissolved gas (TDG), water temperature, dissolved oxygen, turbidity, suspended sediments and nutrients.

Spring chinook

Life history

Spring chinook generally spawn in the higher order streams within a subbasin. Juveniles spend one year after emergence in freshwater prior to migrating to sea. A proportion of juveniles spend their entire freshwater life in the stream of which they were born, while others migrate downstream to larger streams to complete this phase. Upon their return, most adults have spent two years in the ocean, although in a given year, a significant number of 3-ocean fish may make up the population. Precocious males (jacks that have spent one year at sea or individuals that have not migrated to sea) may make up a significant proportion of the spawning population in some demes.

Spring chinook adults and juveniles migrate through the UMM from April through mid June.

Distribution

Spring chinook passing through the UMM spawn and rear in the Wenatchee, Entiat, and Methow rivers.

Use

Spring chinook use the UMM as a migration corridor. Some feeding by juveniles may take place as they migrate, but it is probably not extensive.

In summary, the UMM is used as a migration corridor by spring chinook. Reducing the impacts of the hydropower system will most likely make the most difference in recovering spring chinook in the UMM. Current efforts by the hydropower owners are working towards that effect.

Summer/fall chinook

Life history

Summer/fall chinook spawn in the mainstem UMM, where suitable habitat prevails. Juveniles begin migrating to the ocean shortly after emergence. Some juveniles use the mainstem Columbia River to overwinter before entering the ocean in their second year of life. Adults have usually spent two years in the ocean upon return, but significant proportions of 1-ocean fish make up the run in some years, along with 3-ocean fish too.

Earlier returning adults (“summer-run”) and later returning adults (“fall-run”) show similar life histories and cannot be distinguished on the spawning grounds (see Appendix __ for further discussion).

Summer/fall chinook begin entering the UMM in mid- to late June through mid November. Some migrate up tributaries and spawn in late September through November, while others spawn in the mainstem between October and November.

Distribution

Summer/fall chinook salmon currently spawn in the Chelan River and downstream of Wells Dam (Peven 1992). Spawning in the Chelan River is limited to the short segment below the Chelan powerhouse. In 1990 and 1991, Giorgi (1992) found chinook redds in the Chelan River between the boat ramp and about 150 feet downstream from the railroad bridge. There may be other areas, primarily below existing dams (Rocky Reach, Rock Island, Wanapum) where suitable spawning habitat remains, but is difficult to observe because of water depth.

Historically, summer/fall chinook spawned in suitable depths, velocities, and substrates from the current site of Priest Rapids Dam to the uppermost accessible sites in the Columbia River, near Golden, B.C. Chapman (1943) found chinook spawning near Kettle Falls, upstream from Grand Coulee Dam site. Fish and Hanavan (1948) reported chinook redds in the Columbia River upstream from the confluence of the Chelan River to Grand Coulee Dam. Meekin (1967) documented chinook salmon redds in the Columbia River between Brewster and Washburn Island. The suitable sites were not evenly distributed along the river length (Chapman 1943, Edson 1958), just as they are irregularly distributed now in the Hanford Reach (Swan et al. 1988).

Most loss of summer/fall chinook spawning and rearing occurred in the areas upstream from the impassable Grand Coulee Dam. Additional loss occurred when Chief Joseph, Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids dams were emplaced. The degree to which the resulting reservoirs offset loss of productive rearing remains unmeasured.

Use

Summer/fall chinook use the UMM as spawning, rearing, and migration corridor habitat. Spawning areas are mentioned above. Summer/fall chinook salmon exhibit rearing migrations in the mainstem (Lichatowich and Mobrand 1995), outmigrate as sub-yearlings and spend 2-4 years in the ocean before returning as adults (Peven 1992). Fry usually emerge from April through June depending on stream temperatures and spawning and incubation times (Chapman et al. 1994a). Juveniles tend to spend several weeks to months in the reservoirs before migrating to the ocean (Chapman et al. 1994a). Recent information from scale samples indicate that many of these juveniles have been rearing over-winter in the mainstem prior to reaching the ocean (John Sneva, WDFW, personal communication). Juvenile summer and fall chinook salmon generally outmigrate through the UMM between June and August (Peven 1992; Chapman et al. 1994a). The size of juvenile summer and fall chinook during the outmigration generally ranges from 40-165 mm.

Juvenile summer/fall chinook are impacted by passage at dams and changes in river flow that might strand them in the Hanford Reach (downstream of Priest Rapids Dam). However, recent agreements (HCPs, revised Vernita Bar) ensure that actions will be taken to reduce or mitigate any of these potentially harmful effects. Other efforts are underway to reduce the impacts from agriculture and other threats.

In summary, summer/fall chinook in the UMM may benefit from actions to reduce passage mortality at hydroprojects and reduction of fluctuating flows while emerging. Recent agreements are in place to reduce or mitigate these impacts.

Sockeye salmon

Life history

Sockeye salmon primarily spawn in river systems that contain at least one lake, which is used for juveniles rearing. After emergence, fish generally migrate quickly (either upstream or down) to the lake, where they reside usually one, but sometimes two or three years before migrating to the ocean. Fish predominantly spend two years in the ocean prior to return, although in some systems, a significant proportion may return after one or three years.

Sockeye adults pass through the UMM primarily in July and enter the Wenatchee River directly, or the Okanogan River when temperatures are suitable. Juveniles from Lake Wenatchee pass Rock Island Dam primarily in April, while those from Lake Okanogan pass Rock Island primarily in May.

Distribution

Currently, sockeye spawn in the Wenatchee and Okanogan Basins, with minor occurrences in the Entiat and Methow rivers..

Historically, Upper Arrow, Lower Arrow, Whatshan, and Slocan Lakes in the Upper Columbia River drainage in British Columbia were utilized by sockeye salmon as nursery lake habitat (Mullan 1986). In addition, Fulton (1970) stated that sockeye salmon probably ascended to Kinbasket, Windermere, and Columbia Lakes in the Canadian portion of the Columbia River, and Mullan (1986) suggested that the presence of kokanee indicated the past use of these lakes by sockeye salmon too. WDF (1938) and Chapman (1943) reported observations of sockeye salmon at Kettle Falls on the Columbia River and at Upper and Lower Arrow Lakes on the Upper Columbia River in British Columbia prior to Grand Coulee Dam construction.

Use

Sockeye use the UMM as a migration corridor for juveniles and adults. Impacts to sockeye relate primarily to passage mortality at the hydropower projects, and predation by fish and birds.

In summary, UMM sockeye are impacted by hydropower project operations. Recent agreements will help to reduce or mitigate those impacts.

Steelhead

Life history

Steelhead generally spawn throughout a basin, wherever appropriate habitat exists. Juveniles may spend up to seven years in freshwater prior to migrating to the ocean, but average 2-3 years. Adults may spend from 1-3 years in the ocean before migrating back to natal areas. True assessment of the spawning population is difficult because non-anadromous fish may contribute to the anadromous population (and vice versa). Environmental factors (primarily temperature) appear to dictate whether an individual fish migrates to the sea or not.

Steelhead that use the UMM enter the Columbia River between May and September and pass from July through the following May. All steelhead spawn in the spring, and those that pass through the UMM in the spring have over-wintered there (English et al. 2001). Juveiles move through the UMM from April into July.

Distribution

Currently steelhead are not known to spawn in the UMM, and spawn in the tributaries (both major and minor).

Steelhead historically used all major (and some minor) tributaries within the Upper Columbia Basin for spawning and rearing (Chapman et al. 1994 CPa). Howell et al. (1985) also listed minor tributaries of the Columbia River such as Squilchuck, Stemilt, Colockum, Tarpiscan, Brushy, Tekison, and Quilomene creeks as potentially producing steelhead, but never in great numbers. Mullan et al (1992 CPa) noted that the Spokane River, upstream from the current Grand Coulee dam site, was a major producer of steelhead.

Use

Steelhead use of the UMM is for migration corridor for juveniles and adults, staging and resting area for adults, and rearing for juveniles. Some juveniles may not migrate once entering the UMM and rear for an extra year in the reservoirs and migrate downstream the following year or remain as non-anadromous

Some adults remain in the UMM prior to moving upstream to spawn. Exact habitat selection is not known at this time, but does not appear to be limiting at this time. Peven (1992) noted that the occurrence of adults remaining in the mainstem Columbia River has increased in the last 60 years.

Main impacts to steelhead in the UMM are related to hydropower project operations. Recent agreements are designed to reduce or mitigate for these impacts.

In summary, steelhead use the UMM primarily as a migration and resting area. Primary impacts are related to hydropower projects. These impacts are being reduced and/or mitigated.

Coho salmon

Life history

Coho salmon are currently extirpated from the UMM (Fish and Hanavan 1948, Mullan 1984). The extinct populations from the upper Columbia appear to have been the earlier running types (Mullan 1984). Currently, coho from the reintroduction program begin appearing at Rock Island Dam in August and peak in September (Chelan PUD, unpublished data). Spawning begins in October and goes through December (K. Murdoch, personal communication).

Distribution

The current reintroduction program is focusing on bringing coho back to the Wenatchee and Methow rivers, but spawning has also been observed in the Entiat River too (K. Murdoch, personal information).

Mullan (1984) estimated that upstream of the Yakima River, the Methow River and Spokane River historically produced the most coho, with lesser runs into the Wenatchee and Entiat. There are conflicting reports of whether the Okanogan Basin historically produced coho (Craig and Suomela 1941; Vedan 2002).

Use

Coho use the UMM as a migration corridor, and are impacted by hydroproject operations.

In summary, agreements in place will most likely improve coho survival through the UMM, which should aid reintroduction efforts.

Bull trout

Life history

Bull trout generally exhibit three main life history forms; fluvial, which migrate between smaller spawning streams and larger streams to grow; adfluvial, which migrate between spawning streams and a lake, where growth occurs; and non-migratory, which generally spend their entire lives in the stream they were born. A fourth ecotype, anadromous, does not occur in the CCP. Assessments of bull trout populations are difficult because non-migratory forms may give rise to migratory forms (and vice versa).

Historically, there were most likely three life histories (or ecotypes) of bull trout within the UMM (adfluvial, fluvial and non-migratory), with distribution and population levels dictated by temperature and gradient (Mullan et al. 1992). Currently, it is not clearly understood if all three ecotypes of bull trout still currently exist within the UMM.

Distribution

Currently, bull trout are not known to spawn in the UMM. Spawning populations are known in the Wenatchee, Entiat, and Methow basins.

While historic distribution is difficult to determine (Rieman et al. 1997), bull trout are believed to have been historically present in the CCP in the, Methow, Lake Chelan, Entiat, Wenatchee, and possibly Okanogan river basins (Brown 1992; Mongillo 1993). Fish were most likely present within the mainstem Columbia River in this region, including the area upstream of Chief Joseph and Grand Coulee dams. Given the habitat needs of bull trout, it is unlikely they ever spawned within the UMM.

Use

Bull trout are believed to use the UMM as a migration corridor, thermal refugia, and rearing area (Appendix). Recent radio telemetry studies showed that adult bull trout were present in the UMM from about November through primarily July (BioAnalysts 2002, 2003). Juveniles may reside in the reservoirs of the UMM where food is relatively abundant.

Impacts to bull trout in the UMM may be related to hydropower operations, but this remains a critical uncertainty. However, recent agreements (HCPs), while not “targeting” bull trout, will undoubtedly help bull trout too, both in the mainstem Columbia and tributaries.

In summary, bull trout use the UMM as rearing, refuge, and migration. Impacts in the UMM may be related to hydroproject operations, but this remains a critical uncertainty.

Pacific lamprey

Life history

Beamish (1980) suggested lamprey enter fresh water between April and June, and complete migration into streams by September. It is not clear how flow impacts freshwater immigration. Pacific lampreys are considered weak swimmers compared to other fish. Burst swimming speed was calculated to be approximately 2.1 m/sec for lamprey (Bell 1990). On the Fraser River in British Columbia, Pacific lamprey were estimated to migrate 8 km/day (Beamish and Levings 1991). In the Columbia River, the lamprey were estimated to migrate 4.5 km/day (Kan 1975).

Pacific lamprey overwinter in fresh water and spawn the following spring (Beamish 1980). Pacific lamprey do not feed during the spawning migration. The fish utilize carbohydrates, lipids, and proteins for energy (Read 1968). Beamish (1980) observed 20% shrinkage in body size from the time of freshwater entry to spawning. Lamprey over-winter in freshwater and commence spawning the following spring, similar to summer-run steelhead.

Life history of lamprey in the UMM is relatively unknown at this time.

Distribution

The current distribution of Pacific lamprey in the UMM extends to Chief Joseph Dam (Close et al. 1995). This dam lack fishways and limits the distribution of anadromous fish. Within the CCP, the distribution of lamprey is not well known. We know that they still exist in the UMM, Wenatchee, Entiat, and Methow (and possibly Okanogan) systems, but distribution is mostly unknown. See Appendix _ for more discussion on potential distribution within the tributaries of the UMM.

Historical distribution of Pacific lamprey in the Columbia and Snake Rivers was coincident wherever salmon occurred (Simpson and Wallace 1978). It is likely that Pacific lamprey occurred historically throughout the UMM, Wenatchee, Entiat, Methow, and Okanogan basins.

Because Grand Coulee Dam was built without fish passage facilities, the Fish and Wildlife Service developed the Grand Coulee Fish Maintenance Project (GCFMP) (Fish and Hanavan 1948). Fish and Hanavan (1948) do not mention the capture of lamprey. Apparently these fish were allowed to pass Rock Island Dam.

Use

Little is known of lamprey use within the UMM. Juveniles have been found rearing in silted areas within the UMM (Goldar Assoc. 2003), but most likely did not hatch there. After hatching, the larvae drift in the current and settle in slow backwater areas such as pools and eddies. While most of the larvae use their natal streams (Goldar Assoc. 2003), it is reasonable to assume that some may wash down into the mainstem and settle and rear in appropriate areas within the UMM.

Adults are counted yearly as they migrate upstream through fishways at hydroprojects. Spawning is not believed to occur in the UMM, but in the main tributaries (Goldar Assoc. 2003). Adults use deep pool habitat to overwinter. Adults also appear to use the UMM and fishways at hydroprojects to overwinter, and then ascending the tributaries in the spring to spawn.

Currently, information is being gathered by PUDs that own hydroelectric projects within the UMM to understand lamprey behavior and assess potential impacts. If impacts are found, the hydroproject operators will take action to correct or mitigate them.

Other potential impacts could be related to water quality. Little is known about impacts to lamprey from compromised water quality.

In summary, little is known of lamprey use in the UMM. Current information suggests that juveniles rear in the areas below natal streams. Potential impacts from hydroprojects are currently being assessed and will be corrected or mitigated for.

White sturgeon

Life history

Little is known of the life history of white sturgeon within the UMM. However, recent studies have begun to understand the population dynamics and life history of this species. White sturgeon are the largest freshwater species in North American and can attain lengths of greater than 19 feet.

Distribution

Currently, white sturgeon inhabit the UMM. Addition information on distribution is currently being determined by relicensing studies (Appendix _).

Historically, white sturgeon moved throughout the mainstem Columbia River from the estuary to the headwaters, although passage was probably limited at times at large rapids and falls (Brannon and Setter 1992). Beginning in the 1930s, with construction of Rock Island, Grand Coulee, and Bonneville dams, migration was disrupted, because sturgeon generally do not pass upstream through fishways that were built for salmon, although they apparently can pass downstream. Current populations in the Columbia River Basin can be divided into three groups: fish below the lowest dam, with access to the ocean (the lower Columbia River); fish isolated (functionally but not genetically) between dams; and fish in several large tributaries.

Use

White sturgeon spawn in faster moving water at temperatures ranging from 10 to 19 °C. Eggs apparently may drift downstream considerable distances (Parsley et al. 1993). Juvenile fish are found in deep, slow water where they grow rapidly.

Most likely, the largest impact to white sturgeon in the UMM has been disruption of adult migration from construction of hydroprojects. Spawning is known to occur within the UMM, and has not been thoroughly investigated at all probable locations (see Appendix _ for more detail)..

In summary, white sturgeon migration has been the disrupted by hydroproject construction. Additional information is currently being collected, and impacts caused by hydroproject operation will be mitigated by hydroproject owners.

Westslope cutthroat trout (WSCT)

Life history

Westslope cutthroat trout generally exhibit three main life history forms; fluvial, which migrate between smaller spawning streams and larger streams to grow; adfluvial, which migrate between spawning streams and a lake, where growth occurs; and non-migratory, which generally spend their entire lives in the stream they were born.

Much of the life history of WSCT in the UMM is unknown at this time.

Distribution

Through stocking programs that began with Washington state's first trout hatchery in the Stehekin River valley in 1903 (that targeted WSCT), WSCT have been transplanted in almost all available stream and lake habitat (Williams 1998).

Currently WSCT are occasionally caught at juveniles salmonid bypass traps in the UMM and are most likely using the UMM as a migration corridor and for feeding and potentially thermal refuge in the winter.

The primary historic distribution of westslope cutthroat trout (WSCT) occurred in the upper Columbia and Missouri River basins (USFWS 1999). WSCT were originally believed to occur in three river basins within Washington State; Methow, Chelan, and Pend Oreille, although only abundant in the Lake Chelan Basin (Williams 1998). However, recent information, based on further genetic analyses (Trotter et al. 2001; Behnke 2002; Howell et al. 2003), indicates that the historic range of WSCT in Washington State is now believed to be broader. Historic distribution now includes the headwaters of the Wenatchee, Entiat, and Yakima River basins (Behnke 2002).

Use

WSCT use of the UMM is not known at this time.

In summary, little is known of the life history and habitat needs of WSCT in the UMM.

References

Selection of Focal Species (adapted from the Asotin Subbasin Plan)

Seven aquatic species were chosen as focal for Columbia Cascade Province (CCP) Subbasin Planning: steelhead/rainbow trout; spring, and summer/fall chinook; Bull Trout; Pacific lamprey; White sturgeon; and Westslope cutthroat trout. The criteria used to select focal species was the varied aspects of the CCP ecosystems that the life histories represent; the Endangered Species Act (ESA) status; the cultural importance of the species and whether or not there was enough knowledge of the life history of the species to do an effective assessment. These were then presented to the **?**, the citizens advisory group, subbasin planning team and other interested agencies and entities. Consensus was achieved on their selection. CCP summer steelhead, spring, summer/fall chinook, bull trout, Pacific lamprey, white sturgeon, and westslope cutthroat trout life histories intersect a broad range of the CCP aquatic ecosystems. Spatially, the life histories of these seven species cover the entire CCP. These species also occupy all levels of the water column including slack water, swift water and the hyporheic zone. Not only are they present but also the ability of these species to thrive is dependent on being able to successfully occupy these areas. Temporally, these species are present (or were assumed to be present in the past) at one lifestage or another throughout much of the CCP in all seasons. The ability of these species to be present at a particular time in a particular area is also key to the success of these species. Given the wide range of both the spatial and temporal aspects of these life histories it can be assumed that having habitat conditions that are appropriate for these seven species will also produce conditions that allow for the prosperity of other aquatic life in the CCP.