Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead

E. Chum salmon

February 2003

Co-manager review draft

This section deals specifically with chum salmon. It is part of a larger report, the remaining sections of which can be accessed from the same website used to access this section (http://www.nwfsc.noaa.gov/). The main body of the report (Background and Introduction) contains background information and a description of the methods used in the risk analyses.

E. CHUM

E.1 BACKGROUND AND HISTORY OF LISTINGS

Chum salmon (*Oncorhynchus keta)* are semelparous, spawn primarily in freshwater, and apparently exhibit obligatory anadromy, as there are no recorded landlocked or naturalized freshwater populations (Randall et al. 1987). The species is known for the enormous canine-like fangs and striking body color (a calico pattern, with the anterior two thirds of the flank marked by a bold, jagged, reddish line and the posterior third by a jagged black line) of spawning males. Females are less flamboyantly colored and lack the extreme dentition of the males.

The species has the widest natural geographic and spawning distribution of any Pacific salmonid, primarily because its range extends further along the shores of the Arctic Ocean than other salmonids. Chum salmon have been documented to spawn from Korea and the Japanese island of Honshu, east, around the rim of the North Pacific Ocean, to Monterey Bay in California. Presently, major spawning populations are found only as far south as Tillamook Bay on the Northern Oregon coast. The species' range in the Arctic Ocean extends from the Laptev Sea in Russia to the Mackenzie River in Canada. Chum salmon may historically have been the most abundant of all salmonids: Neave (1961) estimated that prior to the 1940s, chum salmon contributed almost 50% of the total biomass of all salmonids in the Pacific Ocean. Chum salmon also grow to be among the largest of Pacific salmon, second only to chinook salmon in adult size, with individual chum salmon reported up to 108.9 cm in length and 20.8 kg in weight (Pacific Fisherman 1928). Average size for the species is around 3.6 to 6.8 kg (Salo 1991).

Chum salmon spend more of their life history in marine waters than other Pacific salmonids. Chum salmon, like pink salmon, usually spawn in coastal areas, and juveniles out migrate to seawater almost immediately after emerging from the gravel that covers their redds (Salo 1991). This ocean-type migratory behavior contrasts with the stream-type behavior of some other species in the genus *Oncorhynchus* (e.g., coastal cutthroat trout, steelhead, coho salmon, and most types of chinook and sockeye salmon), which usually migrate to sea at a larger size, after months or years of freshwater rearing. This means survival and growth in juvenile chum salmon depends less on freshwater conditions than on favorable estuarine conditions. Another behavioral difference between chum salmon and species that rear extensively in freshwater is that chum salmon form schools, presumably to reduce predation (Pitcher 1986), especially if their movements are synchronized to swamp predators (Miller and Brannon 1982).

In December 1997 the first ESA status review of west coast chum salmon (Johnson et al. 1997) was published which identified four ESU: 1) Puget Sound/Strait of Georgia ESU, which includes all chum salmon populations from Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca up to and including the Elwha River, with the exception of summer-run chum salmon from Hood Canal; 2) Hood Canal Summer Run ESU, which includes summer-run populations from Hood Canal and Discovery and Sequim Bays on the Strait of Juan de Fuca; 3) Pacific coast ESU, which includes all natural populations from the Pacific coasts of California, Oregon, and Washington, west of the Elwha River on the Strait of Juan de Fuca; and 4) Columbia River ESU.

In March 1998, NMFS published a federal register notice describing the four ESUs and proposed a rule to list two--Hood Canal summer-run and Columbia River ESUs--as threatened under the ESA (NMFS 1998). In March 1999, the two ESUs were listed as proposed, with the exception that the Hood Canal Summer Run ESU was extended westward to include summer-run fish recently documented in the Dungeness River (NMFS 1999).

The NMFS convened a BRT to update the status of listed chum salmon ESUs coastwide. The chum salmon BRT[1] met in January 2003 in Seattle, Washington to review updated information on each of the ESUs under consideration.

[1] The Biological Review Team (BRT) for the updated chum salmon status review included, from the NMFS Northwest Fisheries Science Center: Tom Cooney, Dr. Robert Iwamoto, Dr. Robert Kope, Gene Matthews, Dr. Paul McElhany, Dr. James Myers, Dr. Mary Ruckelshaus, Dr. Thomas Wainwright, Dr. Robin Waples, and Dr. John Williams; from the NMFS Southwest Fisheries Science Center: Dr. Peter Adams, Dr. Eric Bjorkstedt, and Dr. Steve Lindley; from the NMFS Alaska Fisheries Science Center (Auke Bay Laboratory): Alex Wertheimer; and from the USGS Biological Resource Division: Dr. Reginald Reisenbichler.

E.2.1 HOOD CANAL SUMMER CHUM

E.2.1.1 Previous BRT Conclusions

Status and trends

In 1994, petitioners identified 12 streams in Hood Canal as recently supporting spawning populations of summer chum salmon. At the time of the petition, summer chum salmon runs in five of these streams may already have been extinct, and those in six of the remaining seven showed strong downward trends. Similarly, summer chum salmon in Discovery and Sequim Bays were also at low levels of abundance. Spawner surveys in 1995 and 1996 revealed substantial increases in the number of summer chum salmon returning to some streams in Hood Canal and the Strait of Juan de Fuca. However, serious concerns remained (Johnson et al. 1997). First, the population increases in 1995 and 1996 were limited to streams on the western side of Hood Canal, especially the Quilcene River system, while streams on the southern and eastern sides continued to have few or no returning spawners. Second, a hatchery program initiated in 1992 was at least partially responsible for adult returns to the Quilcene River system. Third, the strong returns to the west-side streams were the result of a single, strong year class, while declines in most of these streams have been severe and have spanned two decades. Last, greatly reduced incidental harvest rates in recent years probably contributed to the increased abundance of summer chum salmon. Spawning escapement to the ESU in 1997 was estimated to be 10,013 fish and estimated in 1998 to be 5,290 fish. Of these totals, 8,734 spawners in 1997, and 3,959 spawners in 1998 returned to streams with supplementation programs.

Threats

A variety of threats to the continued existence of the summer chum populations in Hood Canal were identified, including degradation of spawning habitat, low river flows, possible competition among hatchery fall chum salmon juveniles and naturally produced summer chum salmon juveniles in Hood Canal, and high levels of incidental harvest in salmon fisheries in Hood Canal and the Strait of Juan de Fuca.

Previous BRT conclusions

The BRT last reviewed the Hood Canal summer chum ESU status in November 1998. Their conclusion was that the ESU was likely to become endangered in the foreseeable future. The primary concerns of the BRT relating to ESU status were low current abundance relative to historical, extirpation of historical populations on the eastern part of Hood Canal, declining trends, and low productivity. Other concerns included the increasing urbanization of the Kitsap Peninsula, recent increases in pinniped populations in Hood Canal, and the fact that recent increases in spawning escapement have been associated primarily with hatchery supplementation programs. Concerns were mitigated to some extent by recent reforms in hatchery practices for fall chum salmon and measures taken by the state and tribes to reduce harvest impacts on summer chum salmon.

Listing status—Threatened

Table E.2.1.1. Historical populations of summer chum salmon in the Hood Canal ESU. (WDFW and PNPTT 2001).

Stock	Status
Union River	Extant
Lilliwaup Creek	Extant
Hamma Hamma River	Extant
Duckabush River	Extant
Dosewallips River	Extant
Big/Little Quilcene River	Extant
Snow/Salmon Creeks	Extant
Jimmycomelately Creek	Extant
Dungeness River	Extant
Big Beef Creek	Extinct
Anderson Creek	Extinct
Dewatto Creek	Extinct
Tahuya River	Extinct
Skokomish River	Extinct
Finch Creek	Extinct
Chimacum Creek	Extinct

E.2.1.2 New Data

ESU status at a glance

Historical peak abundance	NA
Historical populations	16
Extant populations	9
5-year geometric mean escapement per population	1 – 4,500
overall λ per population	0.73-1.1
recent λ per population	0.70-1.7

ESU structure

The Hood Canal summer chum ESU is comprised of 16 historically quasi-independent populations, nine of which are presumed to be extant currently (Table E.2.1.1). Most of the extirpated populations occur on the eastern side of Hood Canal, and some of the seven putatively extinct stocks are the focus of extensive supplementation programs underway in the ESU (WDFW and PNPTT 2000 and 2001).

Table E.2.1.2. Abundance and estimated fraction of hatchery fish in natural escapements of Hood Canal summer chum spawning populations. Data years for all populations span 1974-2000. Critical escapement thresholds and management units are defined by the co-managers (Data are from WDFW and PNPTT 2000 and 2001; Puget Sound TRT, unpublished data).

Management Unit	Population	Critical escapement threshold	Most recent 5-year geomean escapement	% hatchery in natural escapement
Sequim Bay	Jimmycomelately[4]	200	17	NA
Discovery Bay	Salmon[1]/Snow	850	478	72.9-100
Quilcene/Dabob B	Combined Quilcene[1]	1,110	4,485	60.8
Mainstem Hood C	Lilliwaup[1]		5.1	NA
	Hamma Hamma[3]		201	NA
	Duckabush		414	NA
	Dosewallips		546	NA
SE Hood Canal	Union[5]	300	345	NA
undefined	Tahuya		1.6	NA
	Anderson		1	NA
	Big Beef[2]		2.4	NA
	Dewatto		4.2	NA

[1]supplementation program began in 1992
[2]reintroduction program began in 1996
[3]supplementation program began in 1997
[4]supplementation program began in 1999
[5]supplementation program began in 2000

E.2.1.3 New Updated Analyses

The Hood Canal summer chum salmon are part of an extensive rebuilding program developed and implemented since 1992 by the state and tribal co-managers (WDFW and PNPTT 2000 and 2001). The Summer Chum Salmon Conservation Initiative involves six supplementation and two reintroduction projects. The primary supplementation program occurs at the Big Quilcene River fish hatchery, and beginning with the 1997 brood year, all fry from the Quilcene facility have been adipose-fin-clipped. Other supplementation programs in Hood Canal have recently begun thermal mass-marking of otoliths to distinguish hatchery-origin from natural-origin spawners. Reintroduction programs have been started in Big Beef and Chimacum creeks. Small numbers of marked fish collected in streams ($\leq$ 3 per stream) over the 1999-2000 season indicate that straying of summer chum from the Big Quilcene River supplementation program is occurring into other Hood Canal streams (WDFW and PNPTT 2001).

Abundance of natural spawners

Recent geometric mean abundance of summer chum in Hood Canal streams ranges from one to almost 4,500 spawners (median = 109, mean = 542) (Table E.2.1.2; Fig. E.2.1.1). Estimates for the fraction of hatchery fish in the combined Quilcene and Salmon/Snow populations are greater than 60%, indicating that the reintroduction program through hatchery supplementation is resulting in spawners in streams.

Trends in natural spawners

Long-term trends in abundance and median population growth rates for naturally spawning populations of summer chum in Hood Canal both indicate that only two populations (combined Quilcene and Union River) are increasing in abundance over the length of available time series (Table E.2.1.3). Long-term population growth rates (λ) were calculated under two assumptions about the reproductive success of naturally-spawning hatchery fish: the reproductive success was 0 (i.e., HO), or the reproductive success was equivalent to that of wild fish (i.e., H1). Calculations of long-term λ for Hood Canal summer chum populations were not affected by the assumptions about the reproductive success of hatchery fish because of the dearth of information on the fraction of hatchery fish in time series (Table E.2.1.3). The median over all populations of long-term population growth rates is λ = 0.88 (regardless of assumptions about hatchery fish reproduction), indicating that most populations are declining at an average rate of 12% per year. Similarly, the probability that the long-term trend (median across populations = 1.0, mean = 0.85) or long-term λ (median across populations = 0.91-0.83, mean = 0.72-0.80) is less than one indicates that on average, populations have declining trends and growth rates (Table E.2.1.4). The most extreme long-term declines in natural spawning abundance have occurred in the Big Beef Creek, Dewatto, Tahuya, and Lilliwaup populations. Those populations with the greatest long-term population growth rates are the Union and Quilcene. The Quilcene population positive growth rate is almost surely due to the supplementation program on that stream.

The number of populations with declining abundance over the short term is fewer than those with declining long-term trends—three of 12 (short-term trend) and four of 12 (short-term λ) populations in the ESU are declining. The median short-term λ over all populations is more positive than the long-term estimates of λ, likely a reflection of the supplementation program and possibly recent improvements in ocean conditions (median short-term λ-H0 = 1.05; median short-term λ–H1 = 1.07). The probability that the short-term trend (median across populations = 0.24, mean = 0.42) or short-term λ (median across populations = 0.38, mean = 0.44) is less than one indicates that on average, populations have stable to increasing trends and growth rates (Table E.2.1.4). The most extreme short-term declines in natural spawner abundance have occurred in the Jimmycomelately Creek and Lilliwaup populations. The populations with the most positive short-term trends and population growth rates are the Quilcene, Big Beef Creek, and Dosewallips populations.

Table E.2.1.3. Estimates of long- and short-term trend, median population growth rate (λ), and their 95% confidence intervals for spawners in Hood Canal summer chum populations (data are from the Puget Sound TRT, unpublished data). "H0" and "H1" indicate whether λ is calculated assuming the reproductive success of naturally spawning hatchery fish is 0 or 1 (equivalent to that of natural-origin spawners).

A.1. Population	**LT Trend (CI)**	**LT λ-H0 (CI)**	**LT λ-H1 (CI)**	**ST Trend (CI)**	**ST λ-H0 (CI)**	**ST λ-H1 (CI)**
Anderson	0.904 (0.854-0.956)	0.814 (0.604-1.098)	0.814 (0.633-1.152)	1 (1-1)	1 (0.741-1.349)	1 (0.742-1.349)
Big Beef	0.807 (0.742-0.877)	0.816 (0.605-1.1)	0.816 (0.675-1.228)	1.151 (1.011-1.309)	1.307 (0.969-1.762)	1.037 (0.969-1.762)
Combined Quilcene	1.02 (0.915-1.137)	1.032 (0.765-1.391)	1.031 (0.854-1.553)	1.815 (1.373-2.401)	1.656 (1.228-2.233)	1.654 (1.226-2.231)
Dewatto	0.82 (0.776-0.867)	0.838 (0.621-1.13)	0.838 (0.645-1.173)	1.067 (0.855-1.333)	0.982 (0.728-1.325)	0.982 (0.728-1.325)
Dosewallips	0.941 (0.857-1.034)	0.924 (0.685-1.246)	0.924 (0.714-1.298)	1.266 (0.864-1.854)	1.101 (0.816-1.485)	1.101 (0.816-1.485)
Duckabush	0.919 (0.854-0.989)	0.899 (0.667-1.213)	0.899 (0.692-1.223)	1.134 (0.88-1.46)	1.055 (0.782-1.422)	1.055 (0.782-1.422)
Hamma Hamma	0.874 (0.818-0.932)	0.86 (0.638-1.16)	0.86 (0.973-1.184)	1.085 (0.913-1.289)	1.08 (0.801-1.456)	1.08 (0.801-1.456)
Jimmycomelately	0.88 (0.831-0.931)	0.908 (0.673-1.225)	0.908 (0.651-1.037)	0.749 (0.562-0.997)	0.786 (0.583-1.06)	0.786 (0.583-1.06)
Lilliwaup	0.832 (0.786-0.88)	0.79 (0.586-1.066)	0.79 (0.57-1.336)	0.802 (0.583-1.103)	0.701 (0.52-0.946)	0.701 (0.52-0.946)
Salmon/Snow	0.938 (0.901-0.977)	0.967 (0.717-1.304)	0.966 (0.735-1.03)	1.037 (0.88-1.223)	1.083 (0.803-1.46)	1.078 (0.799-1.454)
Tahuya	0.755 (0.723-0.789)	0.734 (0.723-0.789)	0.734 (0.566-1.443)	0.934 (0.838-1.041)	0.872 (0.647-1.177)	0.872 (0.647-1.177)
Union	1.078 (1.038-1.121)	1.068 (0.792-1.44)	1.068 (0.793-1.443)	1.051 (0.919-1.201)	1.078 (0.799-1.453)	1.078 (0.799-1.453)

Table E.2.1.4. Estimates of the probability that short- and long-term trends and λ are less than one for populations of summer chum in the Hood Canal summer chum ESU. "H0" and "H1" indicate whether λ is calculated assuming the reproductive success of naturally spawning hatchery fish is 0 or 1 (equivalent to that of natural-origin spawners).

Population	**P (LT Trend > 1)**	**P (LT λ-H0 <1)**	**P (LT λ-H1 <1)**	**P (ST Trend < 1)**	**P (ST λ-H0 <1)**	**P (ST λ-H1 <1)**
Anderson	0.999	0.984	0.954	0.992	--	--
Big Beef	1.000	0.929	0.754	0.018	0.098	0.098
Combined Quilcene	0.354	0.402	0.133	0.000	0.043	0.043
Dewatto	1.000	0.909	0.855	0.261	0.518	0.518
Dosewallips	0.902	0.757	0.633	0.098	0.383	0.383
Duckabush	0.987	0.899	0.799	0.145	0.404	0.404
Hamma Hamma	1.000	0.948	0.858	0.158	0.339	0.339
Jimmycomelately	1.000	0.912	0.964	0.976	0.909	0.909
Lilliwaup	1.000	0.990	0.995	0.924	0.900	0.900
Salmon/Snow	0.998	0.681	0.551	0.314	0.213	0.231
Tahuya	1.000	1.000	0.989	0.906	0.772	0.772
Union	0.000	0.189	0.182	0.212	0.254	0.254

Updated threats information

The Puget Sound TRT (unpublished data) has estimated adult equivalent fishing rates for each population of chinook in the ESU (Table E.2.1.5). Fishing rates are estimated as the proportion of the available population caught in the ocean (often in mixed fisheries) or in terminal fisheries at each age. These estimates include sport and commercial fishing, and should include incidental mortalities. Fishing rates are a function of catch-and-escapement estimates, and usually are based on CWT recoveries, and estimates of incidental mortalities and natural mortality constants provided by the CTC. Catch estimates for Hood Canal summer chum are derived by proportioning terminal and ocean catch to individual stocks based on relative abundance.

Harvest rates on Hood Canal summer chum populations averaged 9.6% (median = 9.6%; range 7.2%-11.8%) in the earliest 5 years of data availability and have dropped to an average of 5% (median = 3.5; range 0.2%-14.4%) in the most recent 5-year period (Table E.2.1.6). The most intensive harvest occurred on Hood Canal summer chum during the period 1976-1991, when the total exploitation rate on the aggregate of Hood Canal summer run stocks reached up to 86% in 1989 (WDFW and PNPTT 2000). During the high harvest years, exploitation rates on individual summer chum populations averaged 20% (median = 21%; range 3%–29%).

Table E.2.1.5. Ratings of region-wide factors for decline of summer chum salmon in Hood Canal and Strait of Juan de Fuca streams. Impact ratings: +++ Major, ++Moderate, +Low or not likely, and **?** Undetermined (ratings from WDFW and PNPTT 2000).

Factor		**Hood Canal**	**Strait of Juan de Fuca**
Climate	Ocean conditions	**?**	**?**
	Estuarine conditions	**?**	**?**
	Freshwater conditions	++	+++
Ecological Interactions	Wild fall chum	+	+
	Hatchery fall chum	+**?**	+
	Other salmonids (including hatchery)	++	+
	Marine fish	+	+
	Birds	+	+
	Marine mammals	+	+
Habitat	Cumulative impacts	+++	+++
Harvest	Canadian pre-terminal catch	+	++
	U.S. pre-terminal catch	+	+
	Terminal catch	+++	+

Table E.2.1.6. Estimated harvest rates on populations of Hood Canal summer chum salmon from 1972 – 2000. Harvest rates are estimated as "adult equivalent" exploitation rates, and are derived from a cohort run reconstruction based on the total fishing rates in mixed and mature fisheries (WDFW and PNPTT 2000 & 2001; Puget Sound TRT, unpublished data).

Population	1972-1976 mean exploitation rate (%)	1976-1991 mean exploitation rate (%)	Most recent 5-year mean exploitation rate (%)
Anderson	8.3	3	0.2
Big Beef	9.6	9	0.6
Combined Quilcene	11.8	26	2.1
Dewatto	9.0	17	2.7
Dosewallips	9.0	29	12.2
Duckabush	9.7	23	14.4
Hamma Hamma	10.2	26	3.5
Jimmycomelately	7.2	24	4.6
Lilliwaup	9.2	22	3.5
Salmon	10	20	3.2
Snow	9.1	20	3.6
Tahuya	10.4	18	12.2
Union	11.5	21	2.5

Very few of the streams in Hood Canal containing summer chum populations have data on returns of hatchery adults to the stream (Table E.2.1.7). The marking of hatchery-origin fish has begun recently (fin clips began in Quilcene in 1997, otolith marks: 1992 in Salmon Creek, 1997 in Lilliwaup, Hamma Hamma; 1998 in Big Beef Creek; 1999 in Chimacum and Jimmycomelately creeks; 2000 in Union River). Therefore, distinguishing hatchery-produced from naturally born summer chum will not be possible in most Hood Canal streams until 2001 at the earliest. The SSHAG group identified all hatchery stocks of Hood Canal summer chum as category "1" (Table E.2.1.8).

Table E.2.1.7. Total estimated annual average returns of hatchery-born summer chum salmon to streams containing independent populations of summer chum in Hood Canal from 1997 to the present (WDFW and PNPTT 2000 & 2001; Puget Sound TRT, unpublished data).

Population	Average annual hatchery return to stream (min, max)	Data years
Anderson	NA	
Big Beef	NA	
Combined Quilcene	55 (0 – 952)	1974(?) - 2000
Dewatto	NA	
Dosewallips	NA	
Duckabush	NA	
Hamma Hamma	NA	
Jimmycomelately	NA	
Lilliwaup	NA	
Salmon	31 (0 – 521)	1974(?) - 2000
Snow	NA	
Tahuya	NA	
Union	NA	

Table E.2.1.8. Hood Canal summer-run chum hatchery stocks and their corresponding SSHAG category scores (SSHAG 2003).

Stock	Run	Basin	SSHAG Category
Big Quilcene	summer	Quilcene	1
Lilliwaup Creek	summer	S. Hood Canal	1
Hamma Hamma	summer	S. Hood Canal	1
Big Beef Creek	summer	N. Hood Canal	1
Salmon Creek	summer	Dungeness	1
Chimacum Creek	summer	Dungeness	1
Union River	summer	Union	1
Jimmycomelately	summer	Dungeness	1

Additional potential threats to Hood Canal summer chum salmon include negative interactions with hatchery fish (fall chinook, coho, pink, and fall chum salmon) through predation, competition and behavior modification, or disease transfer. The Hood Canal summer Chum Conservation Initiative reports annually on the predicted risks associated with each of the hatchery species on summer chum (WDFW and PNPTT 2000 and 2001). Specific mitigation measures have been identified for those hatchery programs deemed to pose a risk to summer chum, and most of the mitigation measures had been implemented by 2000. In addition, some programs have been discontinued.

Predation on summer chum by marine mammals in Hood Canal has been monitored by WDFW since 1998. The most recent results from these studies estimate that a few harbor seals are killing hundreds of summer chum each year (WDFW and PNPTT 2001). Estimates of seal predation ranged from 2% to 29% of the summer chum returning to each river annually.

New activities related to mitigating and improving degraded habitat quality in Hood Canal are reported in the Supplemental Report No. 3 under the co-managers' Summer Chum Conservation Initiative (WDFW and PNPTT 2001). Such activities include new shoreline management rules issued by Washington Department of Ecology (but no resulting change in shoreline master programs yet), Jefferson County improved some development codes under the Growth Management Act, Clallam County provided limited improvements in upgrading its Critical Areas Ordinance in 1999, and several habitat improvement projects have been funded by the Washington State SRFB.

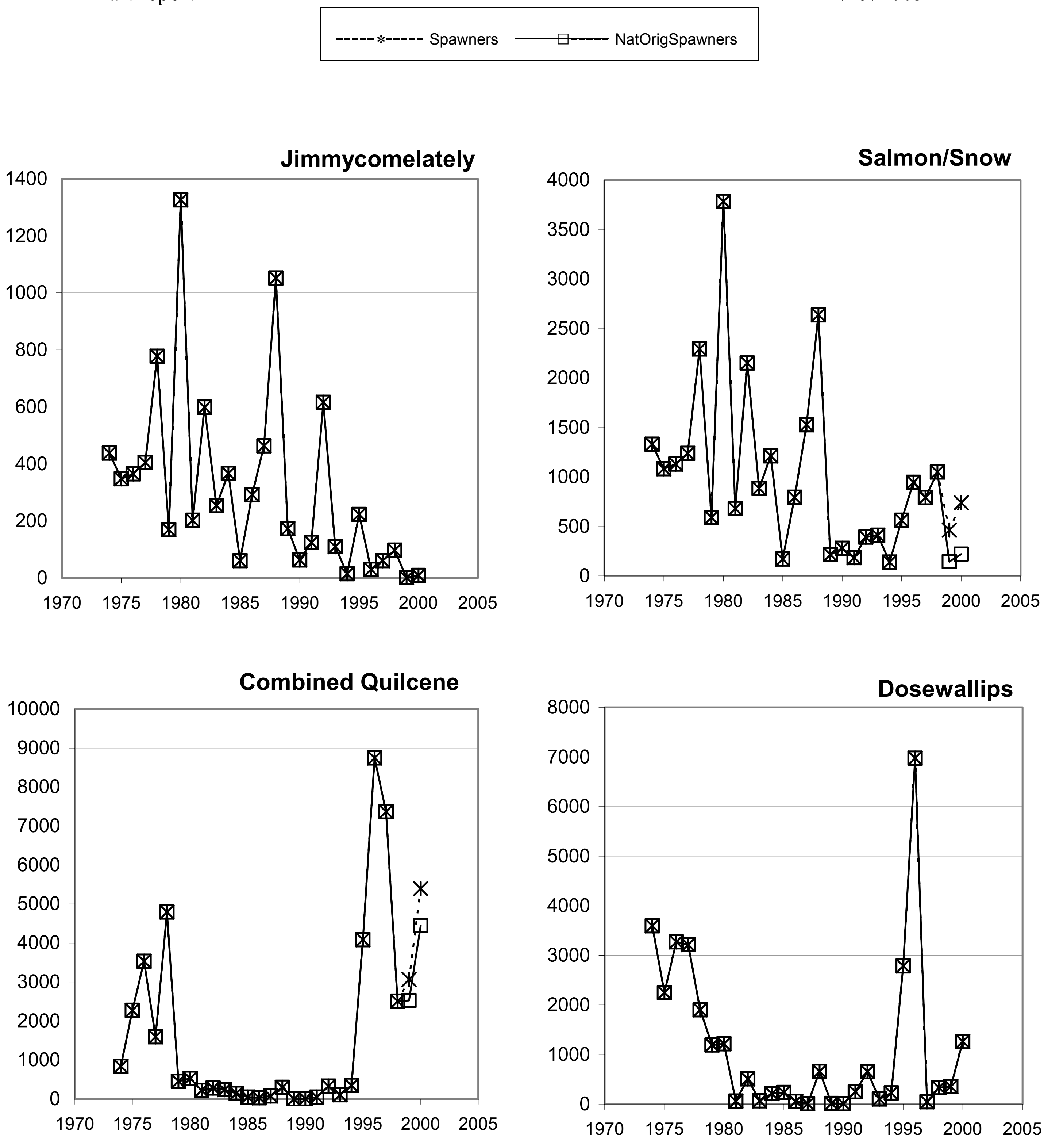
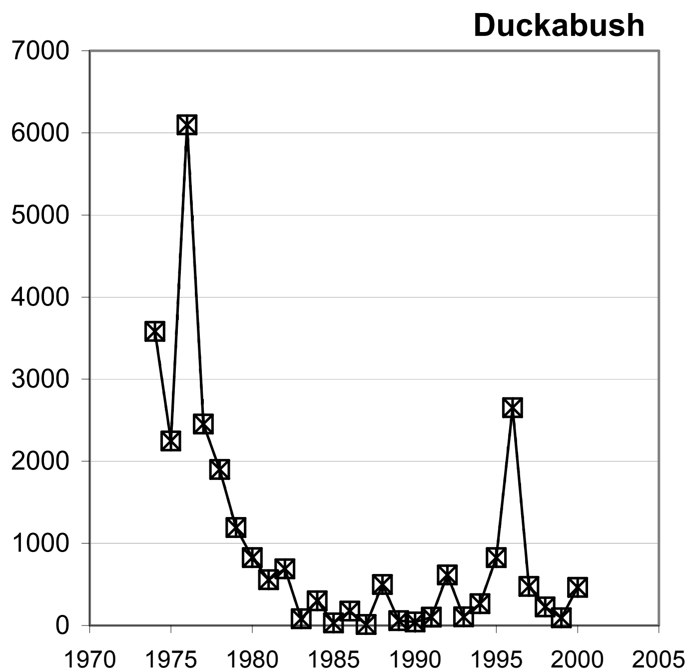
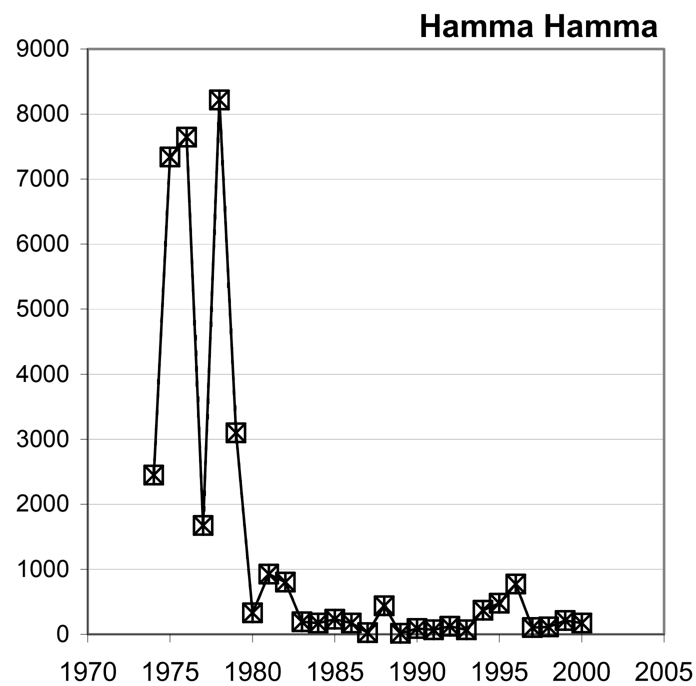
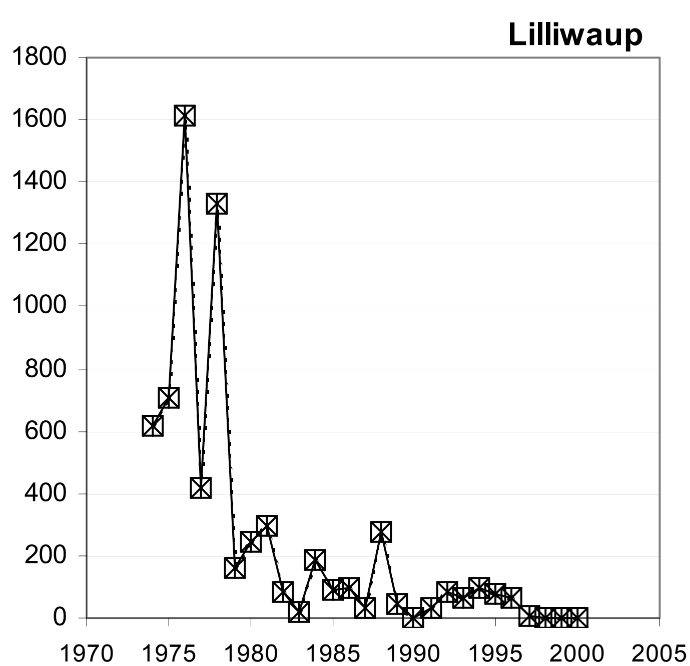
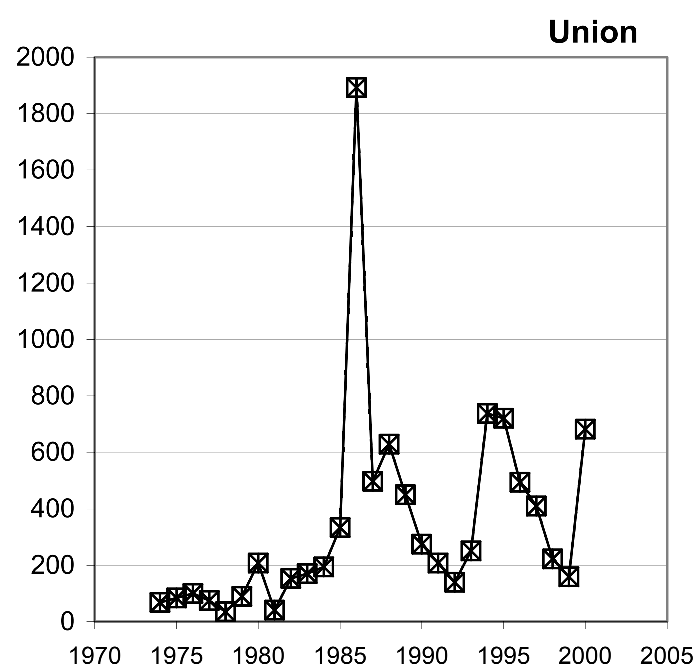


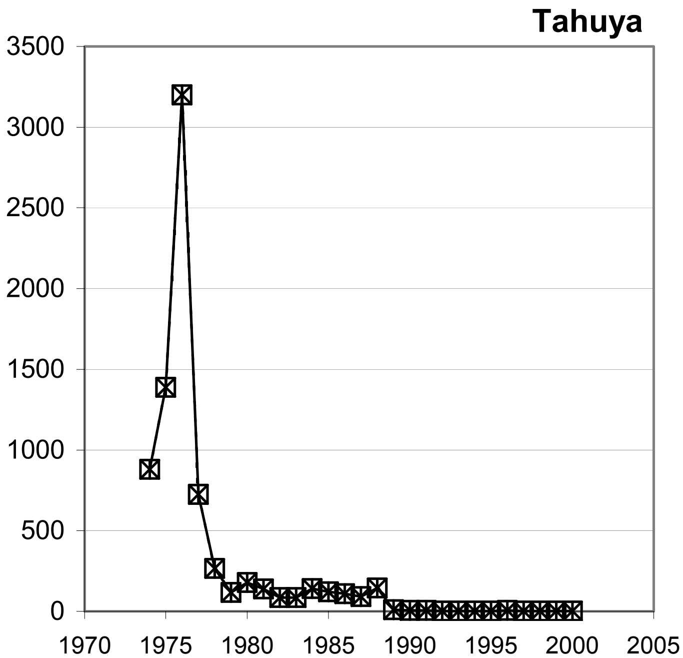
Figure E.2.1.1. Annual numbers of summer chum salmon escaping to spawn in streams in the Hood Canal and Strait of Juan de Fuca. The number of naturally spawning hatchery fish in each population is reported where available (source: WDFW and PNPTT 2000, 2001).

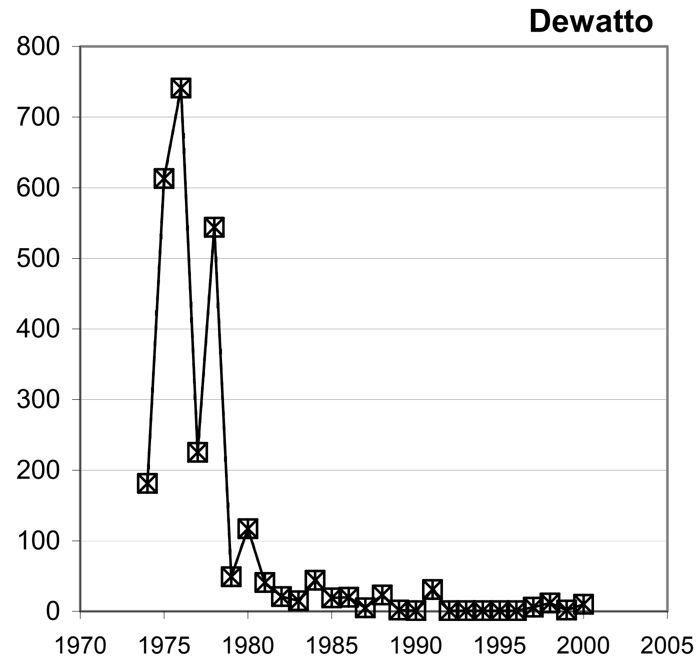

Duckabush
7000
6000
5000
4000
3000
2000
1000
0
1970
1975
1980
1985
1990
1995
2000
2005

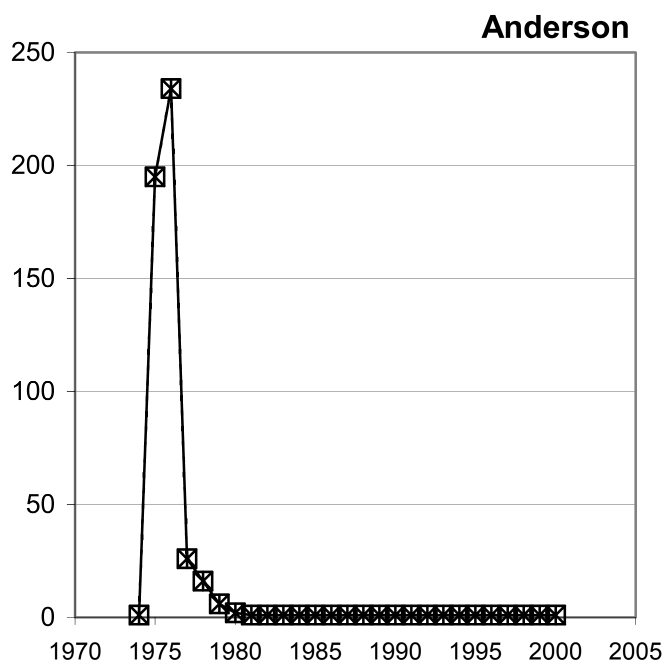

Hamma Hamma
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1970
1975
1980
1985
1990
1995
2000
2005

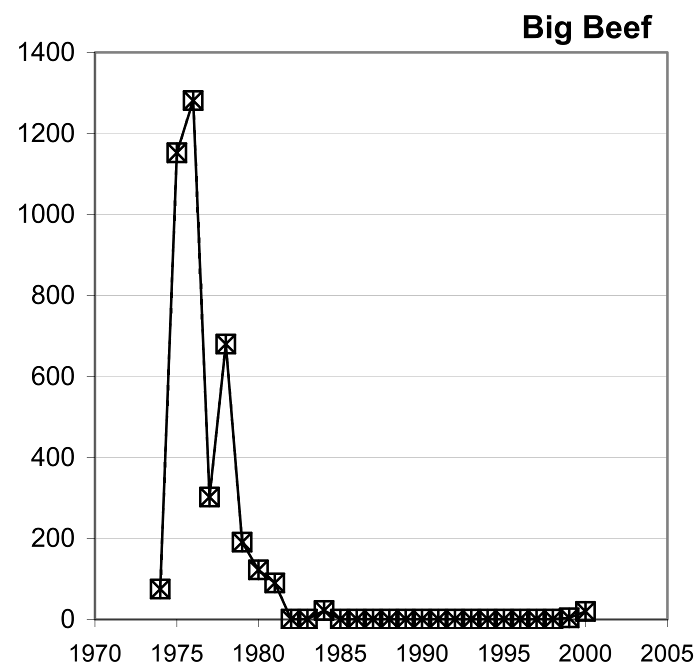

Lilliwaup
1800
1600
1400
1200
1000
800
600
400
200
0
1970
1975
1980
1985
1990
1995
2000
2005


Union
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1970
1975
1980
1985
1990
1995
2000
2005


Tahuya
3500
3000
2500
2000
1500
1000
500
0
1970
1975
1980
1985
1990
1995
2000
2005


Dewatto
800
700
600
500
400
300
200
100
0
1970
1975
1980
1985
1990
1995
2000
2005


Anderson
250
200
150
100
50
0
1970
1975
1980
1985
1990
1995
2000
2005


Big Beef
1400
1200
1000
800
600
400
200
0
1970
1975
1980
1985
1990
1995
2000
2005

E.2.2 LOWER COLUMBIA RIVER CHUM

E.2.2.1 Previous BRT Conclusions

- The previous BRT was concerned about the dramatic declines in abundance and contraction in distribution from historical levels.
- The previous BRT was also concerned about the low productivity of the extant populations, as evidenced by flat trend lines in the face of low population sizes.
- A majority of the previous BRT concluded that the Columbia River chum ESU is likely to become endangered in the foreseeable future and a minority concluded that the ESU is currently in danger of extinction.

Current Listing Status—Threatened

E.2.2.2 New Data and Analyses

New Data include:

- Spawner abundance through 2001
- New information on hatchery program

New analyses include

- Designation of relatively demographically independent populations
- Recalculation of previous BRT metrics with additional years data
- Estimates of median annual growth rate (λ)
- Estimates of current and historically available kilometers of stream

Results of new analyses

Historical population structure—As part of its effort to develop viability criteria for CR chum, the Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) has identified historically demographically independent populations (Myers et al. 2002). Population boundaries are based on an application of Viable Salmonid Populations definition (McElhany et al. 2000). Myers et al. (2002) hypothesized that the ESU historically consisted of 16 populations (Figure E.2.2.1). The populations identified in Myers et al. (2002) are used as the units for the new analyses in this report.

The WLC-TRT partitioned CR chum populations into a number of “strata” based on ecological zones (McElhany et al. 2002). The WLC-TRT analysis suggests that a viable ESU would need a number of viable populations in each of these strata. The strata and associated populations for coho are identified in Table E.2.2.1.

Abundance, distribution and trends

Chum in the Columbia River once numbered in the hundreds of thousands of adults and, at times, approach a million (Figure E.2.2.2). The total number of chum salmon returning to the

Table E.2.2.1. The ecological zones are based on ecological community and hydro dynamic patterns. The recent abundance is the geometric mean of natural origin spawners of the last 5 years of available data and the min-max are the lowest and highest 5-year geometric means in the time series. The data years are the data years used for the abundance min-max estimates, the extinction risk estimate and the trends (Table E.2.2.3). Two different data sets were analyzed for the Grays River. The Lower Gorge time series analyzed is a sub set of the total population that includes Hamilton and Hardy Creeks. The fraction hatchery is the average percent of spawners of hatchery origin over the last 4 years. The harvest rate is the percent of adults harvested averaged over the last 4 years. The EDT estimate of historical abundance is based on analysis by WDFW of equilibrium abundance under historical habitat conditions.

Ecological Zone	**Population**		**Recent Abundance**	**Data Years**	**Hatchery Fraction (%)**	**Harvest Rate (%)**	**EDT Estimate of Historical Abundance**
Coastal	Youngs Bay						
	Grays River	(Hymer)	330 (75-1196)	1945-2000	0	5	7,511
		(Rawding)	705 (113-906)	1967-1998			
	Big Creek						
	Elochoman River						
	Clatskanie River						
	Mill, Abernathy, Germany						
	Scappoose Creek						
Cascade	Cowlitz River						141,582
	Kalama River						9,953
	Lewis River						89,671
	Salmon Creek						
	Clackamas River						
	Sandy River						
	Washougal river						15,140
Gorge	Lower Gorge Tributaries		>425 (78-959)	1944-2000	0	5	>3,141
	Upper Gorge Tributaries						>8,912
	Total		**755**				**>283,421**
	Average				**0**	**5**	

Columbia in the last 50 years has averaged perhaps a few thousand, returning to a very restricted subset of the historical range (Table E.2.2.1 and Figures E.2.2.2 – E.2.2.3). The status of individual populations is discussed below. References for abundance time series and related data are in Appendix E.5.2. Significant spawning occurs in only two of the 16 historical populations, meaning that 88% of the historical populations are extirpated, or nearly so. The two extant populations are at Grays River and the Lower Gorge (Figure E.2.2.2). The status of individual populations and groups of populations are discussed below.

Grays River—The majority of chum spawning in the Grays River currently occurs in less than 1 mile of the river. Prior to its destruction in a 1998 flood, an artifical spawning channel created by WDFW in 1986, was the location of approximately 50% of the spawning in the Grays River population. Two time series of abundance were available for the Grays River chum population (Table E.2.2.1 and Figures E.2.2.4 -E.2.2.5). One data set by Hymer and others was available on Stream net and covered the years 1944-2000. The other data set covers the years 1967-1998 and was provided by Dan Rawding of WDFW to correct some perceived errors in the expansions used in the Hymer et al.. dataset. The Rawding estimates are believed to be more accurate, but both datasets are included in this report because the Hymer et al. series includes estimates both earlier and more recent than the Rawding data set. The Rawding data set shows a small upward trend and λ from 1967-1998 (Table E.2.2.2) and a low probability that the population is declining (Table E.2.2.3). However, the longer Hymer et al. data set indicates both long- and short-term negative trends are negative over the period 1950-2000, with a high probability that the trend and λ values are less than one. There was insufficient data to estimate the short-term trend (i.e. since 1990) using the Rawding data.

Table E.2.2.2. Trend and growth rate for subset of CR chum populations. Ninety-five percent confidence intervals are in parentheses. The long-term analysis used the entire data set (see Table E.2.2.2 for years), except the period 1950-2000 was used for the Grays River Hymer et al. data set because of missing values in the 1945-1949 period. The criteria for the short-term data set are defined in the methods section. There was insufficient data for a short-term statistics on the Grays River (Rawding) data set (see Appendix E.5.2 for data sources references).

Population	Long-Term		Short-Term	
	Trend	□	Trend	□
Grays River (Rawding)	1.058 (1.021-1.096)	1.043 (0.957-1.137)		
Grays River (Hymer)	0.990 (0.965-1.016)	0.954 (0.855-1.064)	0.904 (0.661-1.235)	0.807 (0.723-0.9)
Lower Gorge Tributaries	0.979 (0.961-0.997)	0.984 (0.883-1.096)	1.003 (0.882-1.141)	1.001 (0.899-1.116)

Table E.2.2.3. Probability the trend or growth rate is less than one.

Population	Long-term		Short-term	
	Trend	λ	Trend	λ
Grays River (Rawding)	0.001	0.197		
Grays River (Hymer)	0.776	0.774	0.759	0.934
Lower Gorge Tributaries	0.987	0.657	0.478	0.494

Final abundance estimates for 2002 are not available, but preliminary estimates have been received (Rawding, pers. commun.). The preliminary estimates suggest a substantial increase in abundance in 2002 over what has been observed over the last 50 years. Survey crews have handled over 7,000 chum carcasses in the Grays River in 2002, but the total population size is in the neighborhood of 10,000 adults (Figure E.2.2.4). However, a new chum hatchery program in the Grays River started in 1999 confounds the abundance estimates. In 1999, 120,000 hatchery chum were released into the Grays River and 60,000 hatchery chum were released into the

Chinook River. These fish returned as 3 year olds in 2002 and are included in the 10,000 adult estimate. The hatchery fish were otolith marked, so it will be possible to determine the fraction of hatchery origin spawners once the otoliths are read, but that information is not available at this time. The Chinook River is a sub-population of the Grays River population that had essentially no chum in recent years, prior to 2002 return of hatchery fish. In 2002, a preliminary estimate of 600 chum returned to the Chinook River, suggesting a 1% return of 3 year olds from the hatchery fish. Extrapolating this return rate to the Grays River, 1,200 of the estimated 10,000 returns would be of hatchery origin, suggesting that the large increase in the Grays River is not simply the result of the hatchery program. Potential causes of this increase in 2002 are discussed below.

Lower Gorge Population—The Lower Gorge population consists of a number of subpopulations immediately below Bonneville dam. The subpopulations include Hardy Creek, Hamilton Creek, Ives Island, and the Mutnomah area. Both the Ives Island and Mutnomah area sub-populations spawn in the Columbia mainstem. The time series used for analysis of the Lower Gorge population is based on summing the abundance in the Hardy Creek, Hamilton Creek, and the artificial spawning channel in Hamilton Creek (Tables E.2.2.1- E.2.2.3, Figures E.2.2.6- E.2.2.7). There is some question about whether or not these data provided a representative index of the population, as it does not include the mainstem spawning areas. Chum may alternate between the tributaries and the mainstem, depending on flow conditions, causing counts in only a subset of the population to be poor indicators of the total population abundance in any given year. Base on these data, the population has shown a downward trend since the 1950s and has been at relatively low abundance up to 2000. However, preliminary data indicate that the 2002 abundance has shown a substantial increase estimated at greater than 2,000 chum in the Hamilton and Hardy creeks, plus another 8,000 or more in the mainstem. There have been no hatchery releases in the lower gorge population, so hatcheries are not responsible for this increase in 2002. Potential causes of the 2002 increase are discussed below.

Washougal Population—A group of chum were recently observed (within the last 3-4 years) to be spawning in the mainstem Columbia on the Washington side, just upstream of the I-205 bridge (the "I-205 population"). These spawners would be considered part of the WLC-TRT's Washougal population, as that is the nearest tributary mouth. It is not clear if this is a recently established population or only recently discovered by WDFW. In 2000, WDFW estimated 354 spawners at this location (Figure E.2.2.8). As with the two other Columbia chum spawning populations, preliminary data indicate a dramatic increase in 2002. Preliminary estimates put the abundance of this population in the range of several thousand spawners.

Upper Gorge Population—A large portion of the Upper Gorge population chum habitat is believed to have been inundated by Bonneville Dam. However, small numbers of chum still pass Bonneville Dam (Figure E.2.2.9). The number of fish passing Bonneville showed some increase in 2002, but not the dramatic increases estimated in the other three populations.

Other Washington populations

In 2000, WDFW conducted a study to determine the distribution and abundance of chum in on the Washington side of the Columbia River. The results of that survey are shown in Figure E.2.2.8. Very small numbers of chum were observed in several locations, but with the possible exception of the I-205 population (discussed above), none of the populations would be considered close to self-sustaining abundances.

Oregon populations

Chum spawn on the Oregon side of the lower gorge population (Multnomah area), but appear to be essentially absent from other populations in the Oregon portion of this ESU. In 2000, ODFW conducted surveys with a similar purpose to the WDFW 2000 surveys (i.e. to determine the abundance and distribution of chum in the Columbia). Out of 30 sites surveyed, only one chum was observed. With the exception of the Lower Gorge population, Columbia chum are considered extirpated, or nearly so, in Oregon.

Reason for 2002 increase in abundance

It is unknown why the Columbia chum dramatically increased in abundance in 2002. As of the writing of this draft, the run has just ended and firm abundance estimates are not even available yet. However, several hypotheses have already been floated regarding this increase. These include:

- Improved ocean conditions
- Grays and Chinook river hatchery program
- Mainstem flow agreements (the lower gorge population is in the tailrace of Bonneville Dam and subject to hydrosystem induced flow fluctuations)
- Favorable freshwater conditions
- Increased sampling effort (Since the 2000 survey, effort seems to have increased, though this alone certainly does not explain the apparent increase).

These are all possible contributors to the increase, but the reason for the increase is unknown, just as it is unknown exactly why chum were restricted to low abundance and limited distribution for the last 50 year. It does not appear that chum have expanded their range in 2002 beyond the Grays River, Lower Gorge, and I-205 areas, though not all the data on the 2002 survey has been reported. Since the cause of the 2002 increase is unknown, it is impossible to know if it will continue.

EDT-based estimates of historical abundance

The Washington Department of Fish and Wildlife (WDFW) has conducted analyses of Columbia River chum populations using the Ecosystem Diagnosis and Treatment (EDT) model, which attempts to predict fish population performance based on input information about reach-specific habitat attributes (http://www.olympus.net/community/dungenesswc/EDT-primer.pdf). WDFW populated this model with estimates of historical habitat condition, which produced the estimates of average historical abundance shown in Table E.2.2.1. There is a great deal of unquantified uncertainty in the EDT historical abundance estimates, which should be taken into consideration when interpreting these data. In addition, the habitat scenarios evaluated as "historical" may not reflect historical distributions, since some areas that were historically accessible but currently blocked by large dams are omitted from the analyses and some areas that were historically inaccessible but recently passable because of human intervention are included.

The EDT outputs are provided here to give a sense of the historical abundance of populations relative to each other and an estimate of the historical abundance relative to the current abundance.

Loss of habitat from barriers

An analysis was conducted by Steel and Sheer (2002) to assess the number of stream km historically and currently available to salmon populations in the Lower Columbia River (Table E.2.2.4). Stream km usable by salmon are determined based on simple gradient cut offs and on the presence of impassable barriers. This approach will over estimate the number of usable stream km, as it does not take into consideration habitat quality (other than gradient).

Table E.2.2.4. Loss of habitat from barriers. The potential current habitat is the kilometers of stream below all currently impassible barriers between a gradient of 0% and 3.5%. The potential historical habitat is the kilometers of stream below historically impassible barriers between a gradient of 0% and 3.5%. The current to historical habitat ratio is the percent of the historical habitat that is currently available. This table does not consider habitat quality.

Population	**Potential Current Habitat(%)**	**Potential Historical Habitat (km)**	**Current to Historical Habitat Ratio**
Youngs Bay	269	287	94
Grays River (Hymer)	229	230	100
Grays River (Rawding)	229	230	100
Big Creek	369	407	91
Elochoman River	242	242	100
Clatskanie River	160	165	97
Mill, Abernathy, Germany	266	306	87
Scappoose Creek	888	1,048	85
Cowlitz River	114	120	95
Kalama River	382	579	66
Lewis River	319	362	88
Salmon Creek	416	471	88
Clackamas River	148	194	76
Sandy River	125	240	52
Washougal river	81	82	99
Lower Gorge Tributaries	55	77	71
Upper Gorge Tributaries			
Total	4,292	5,041	85

E.2.2.3 New ESU Information

Based on the updated information provided in this report, the information contained in previous LCR status reviews, and preliminary analyses by the WLC-TRT, we have tentatively identified the number of historical and currently viable populations (Table E.2.2.5). This table indicates that at least 88% of the historical populations are extirpated, or nearly so. The extant populations have been at low abundance for the last 50 years in the range where stochastic processes could lead to extinction. Encouragingly, there has been a substantial increase in the abundance of these two populations and the new (or newly discovered) I-205 population. However, it is not known if this increase will continue and the abundance is still substantially below the historical levels.

Table E.2.2.5. Number of populations in the ESU. Populations with "some current natural production" have some natural origin recruits present but are not necessarily considered self-sustaining ("viable").

	Total
Historical	16
Some current natural production	3+
Currently "viable"	0-2

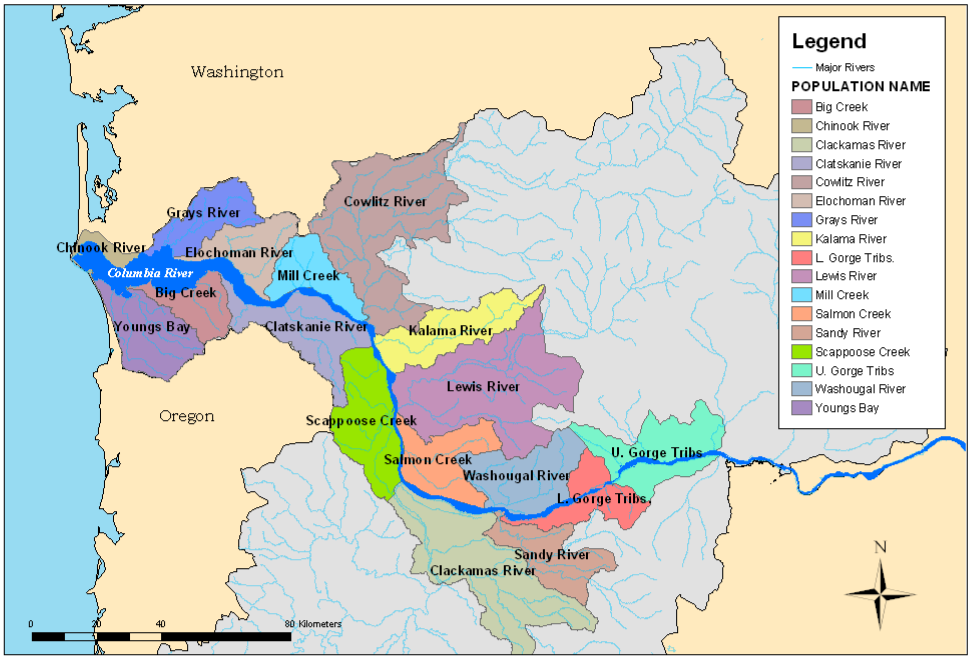


Figure E.2.2.1. Historical chum populations in the Columbia River chum ESU. This map does not reflect the most recent modification of the population designation which merged the Grays River and Chinook River chum into a single population for a total of 16 populations (Myers et al. 2002).

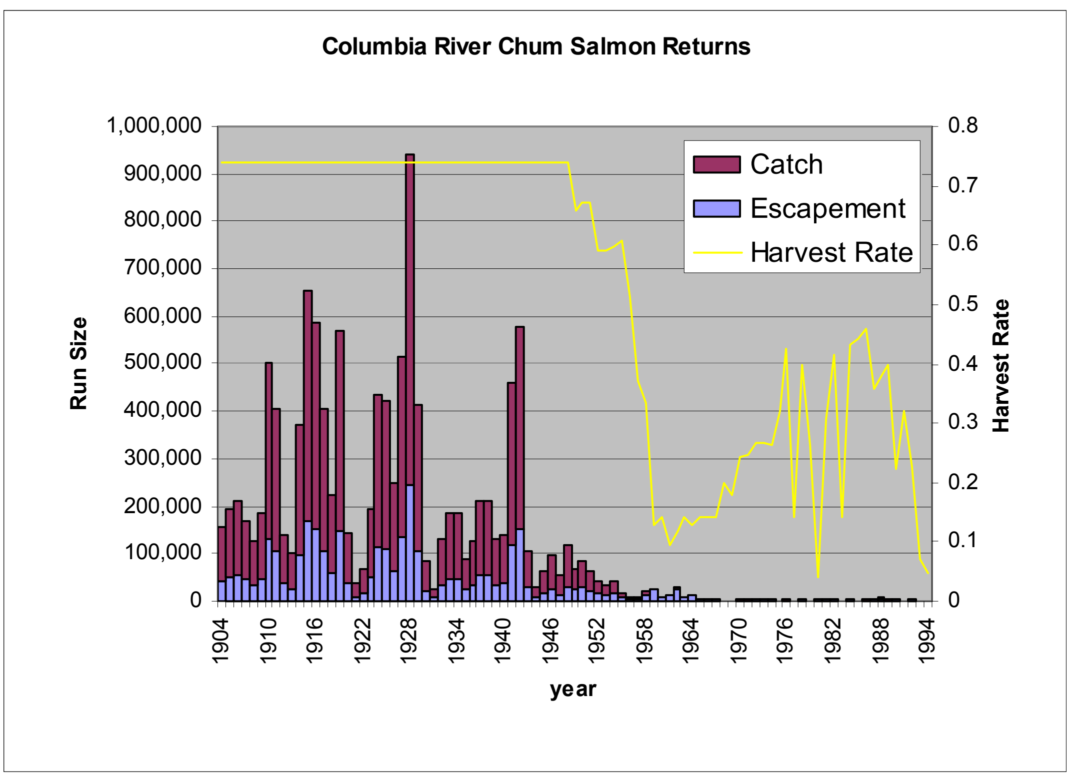


Figure E.2.2.2. Columbia River chum salmon returns.

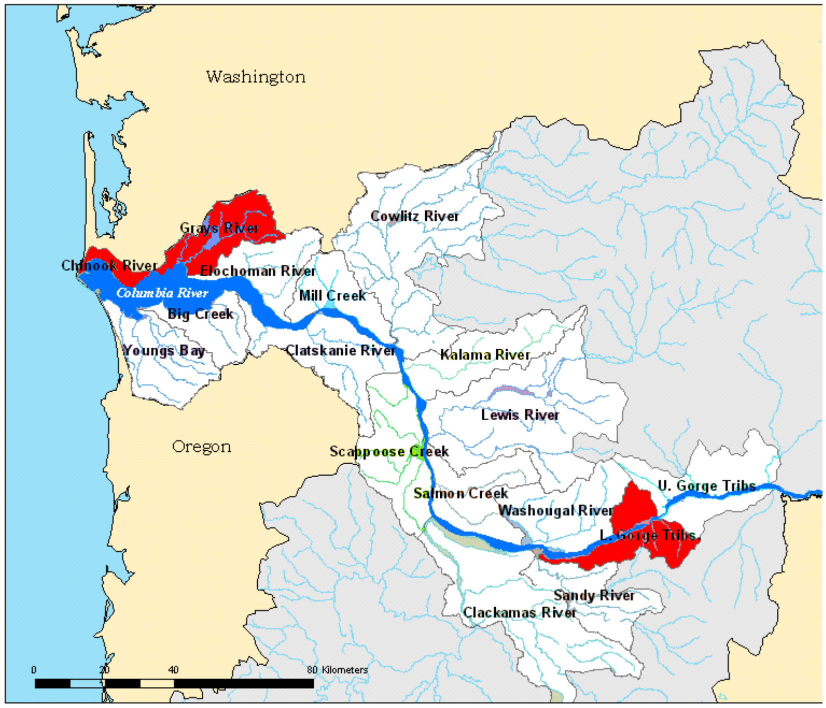


Figure E.2.2.3. Extant Columbia River chum populations.

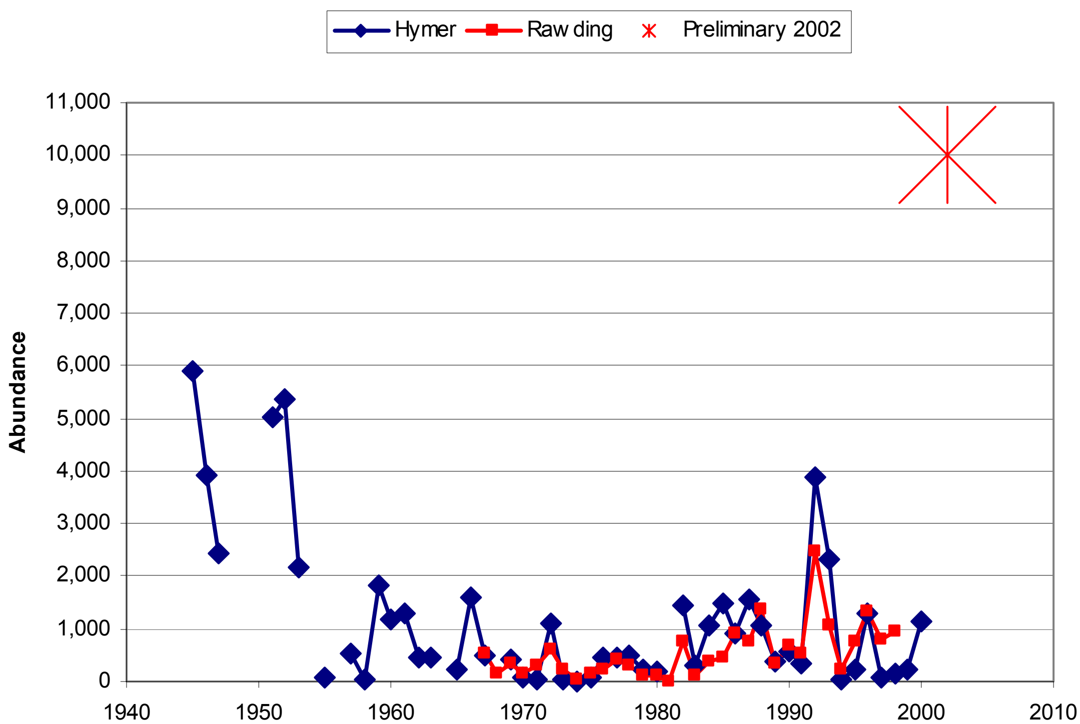
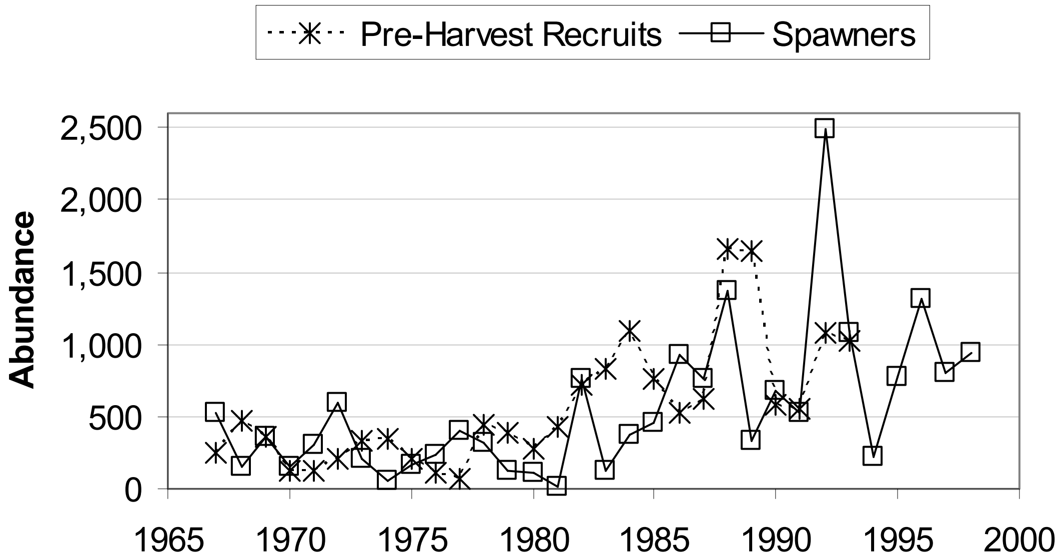


Figure E.2.2.4. Gray's River chum abundance estimate. The two data sets use different information and expansions to estimate the Grays River chum abundance. The 2002 data are preliminary and include an unknown number of hatchery origin spawners.



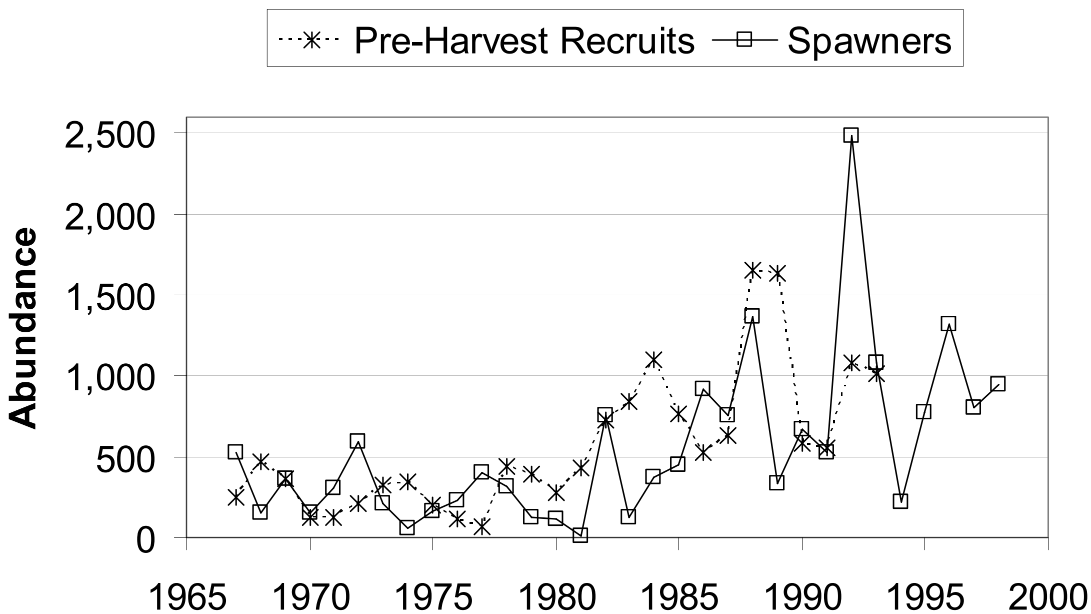


Figure E.2.2.5. Grays River chum recruits and spawners. Based on dataset provided by Rawding (2002; see Appendix E.5.2).

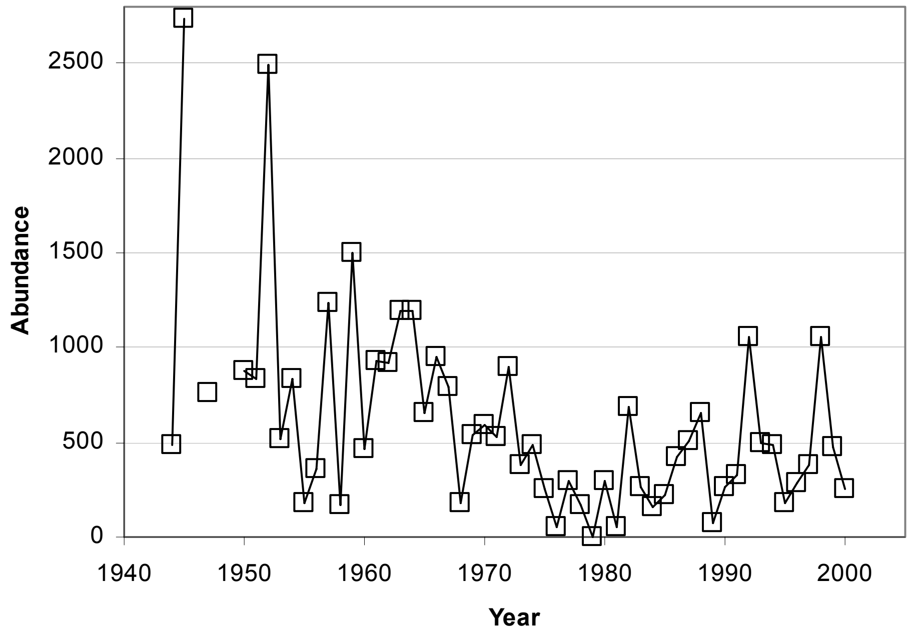


Figure E.2.2.6. Hamilton and Hardy Creek (Lower Gorge population) chum spawner abundance.

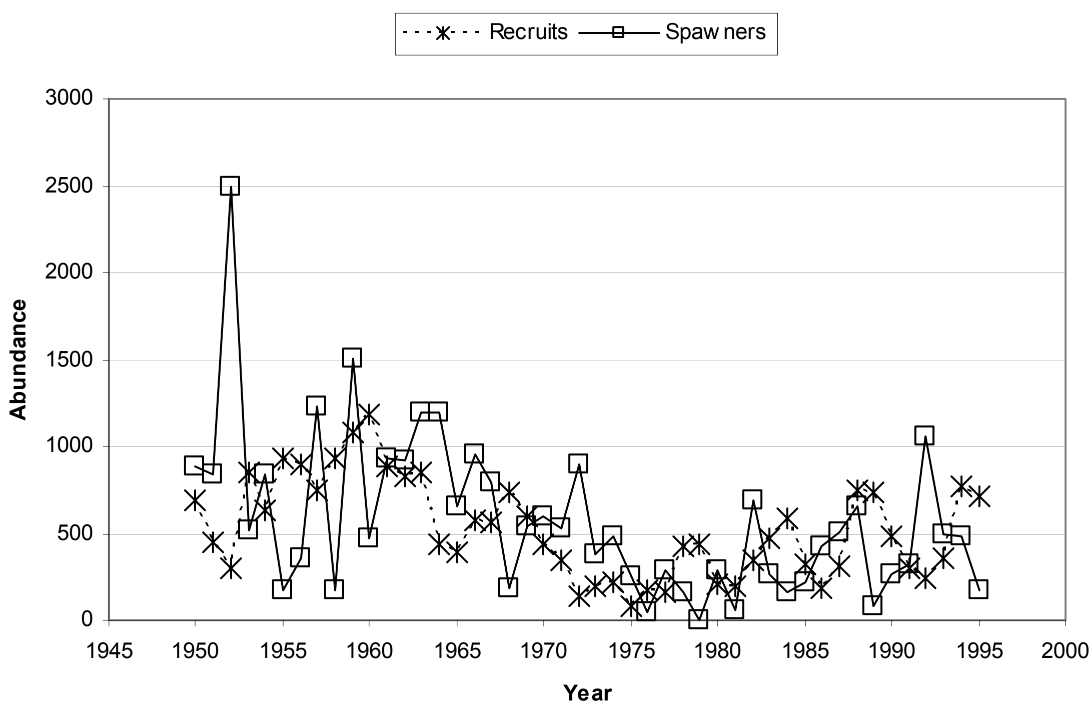


Figure E.2.2.7. Hamilton and Hardy Creek (Lower Gorge population) chum recruits and spawners.

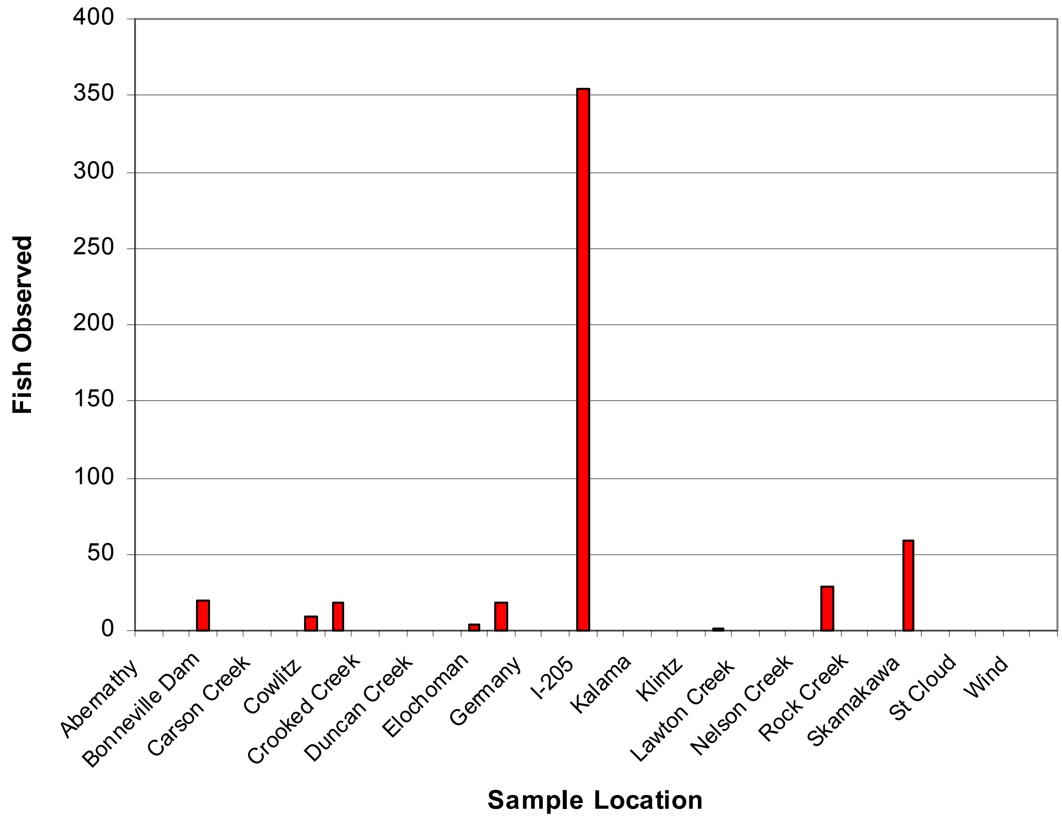


Figure E.2.2.8. Abundance of chum observed in 2000 WDFW surveys.

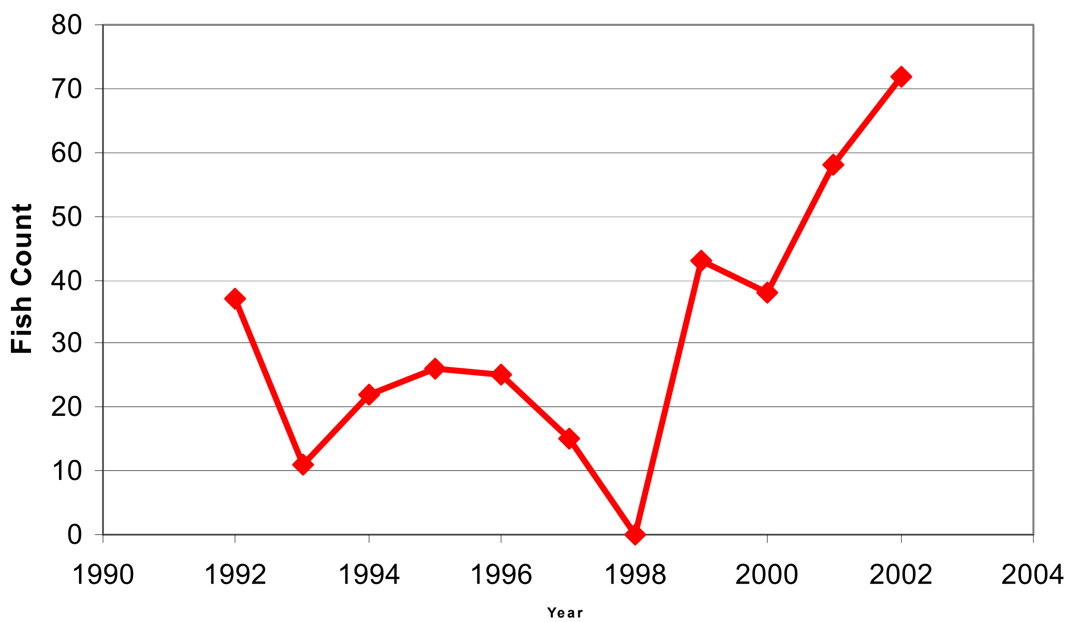


Figure E.2.2.9. Adult chum passing Bonneville Dam.

E.3 PRELIMINARY CHUM BRT CONCLUSIONS

Hood Canal summer run chum

Amajority of the BRT votes for this ESU fell in the "likely to become endangered," or "danger of extinction" categories, with a minority falling in the "not likely to become endangered" category. Mean risk matrix scores were high (3.8-4.1) for each VSP element (Table E.3.1), reflecting ongoing BRT concerns for the major risk factors identified in previous assessments. The Puget Sound TRT has estimated that seven of 16 historic populations in this ESU have been extirpated, with most of the population losses occurring on the eastern side of Hood Canal. Widespread loss of estuary and lower floodplain habitat is considered an ongoing risk factor for this ESU. Although many of the remaining populations remain at very depressed levels, adult returns in a number of streams increased somewhat in 2000. Only two populations have a recent abundance above the conservation threshold identified by state and tribal comanagers. With the initiation of a number of new supplementation programs, however, it remains difficult to determine how much of the natural spawning can be attributed to natural production.

Lower Columbia chum

A majority of the BRT votes for this ESU fell in the "likely to become endangered" category, with a minority falling in the "danger of extinction" category. The BRT had substantial concerns about every VSP element, as indicated by mean risk matrix scores that ranged from 3.5 for growth rate/productivity to 4.4 for spatial structure (Table E.3.1). Most or all of the risk factors identified previously by the BRT remain important concerns. The WLC TRT has estimated that close to 90% of the historic populations in the ESU are extinct or nearly so, resulting in loss of much diversity and connectivity between populations. The populations that remain are small, and overall abundance for the ESU is low. This ESU has showed low productivity for many decades, even though the remaining populations are at low abundance and density-dependent compensation might be expected. The BRT was encouraged that unofficial reports for 2002 suggest a large increase in abundance in some (perhaps many) locations. Whether this large increase is due to any recent management actions or simply reflects unusually good conditions in the marine environment is not known at this time, but the result is encouraging, particularly if it were to be sustained for a number of years.

Table E.3.1. Summary of risk scores (1 = low to 5 = high) for four VSP categories (see section "Factors Considered in Status Assessments" for a description of the risk categories) for the two chum ESUs reviewed. Data presented are means (range).

ESU	Abundance	Growth Rate/Productivity	Spatial Structure and Connectivity	Diversity
Hood Canal Summer Run	4.1 (3-5)	3.8 (2-5)	3.9 (3-5)	4.0 (3-5)
Lower Columbia River	3.6 (3-4)	3.5 (2-4)	4.4 (4-5)	3.8 (3-5)

E.4 REFERENCES

Hymer, J. 2000. Gray's River Chum Peak Counts. WDFW. Delivered via e-mail from Chris Jordan on May 26, 2000.

Johnson, O.W., W. S. Grant, R.G. Kope, K. Neely, F.W. Waknitz, and R. S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-32, 280 p.

Keller, K. 2001. 1999 Columbia River Chum Return. Columbia River Progress Report 2000-6. WDFW.

Keller, Ken and Richard Bruce. 2001. 2000 Columbia River Chum Return. Columbia River Progress Report 2001-4. WDFW.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U. S. Dept. Commer. NMFS-NWFSC-42.

McElhany, P., T. Backman, C. Busack, S. Heppell, S. Kolmes, A. Maule, J. Myers, D. Rawding, D. Shively, and C. Steward. 2002. Willamette/Lower Columbia Pacific salmonid viability criteria. Draft report from the Willamette/Lower Columbia Technical Recovery Team. December 2002

Miller, R .J. and E. L. Brannon. 1982. The origin and development of life history patterns in Pacific salmonids. Pp. 296-309 in E.L. Brannon and E.O. Salo, eds. Proceedings of the Salmon and Trout Migratory Behavior Symposium. University of Washington, School of Fisheries, Seattle, WA.

Myers, J. M. , C. Busack, D. Rawding, and A. Marshall. 2002. Identifying historical populations of chinook and chum salmon and steelhead within the lower Columbia River and upper Willamette River evolutionary significant units. Draft report to the co-managers from the Willamette/Lower Columbia River Technical Recovery Team (10 May 2002).

NMFS (National Marine Fisheries Service). 1998. Endangered and threatened species: Proposed threatened status and designated critical habitat for Hood Canal summer-run chum salmon and Columbia River chum salmon. Federal Register [Docket 980219043-8043-01, No. 011498B. 10 March 1998] 63(46):11774-11795.NMFS 1998

NMFS (National Marine Fisheries Service). 1999. Endangered and threatened species: Threatened status for two ESUs of chum salmon in Washington and Oregon. [Docket 980219042-9069-02, No. 011498B. 25 March 1999] 64(57):14508-14517.NMFS 1999

Neave, F. 1961. Pacific salmon: Ocean stocks and fishery developments. Proc. 9th Pac. Sci. Congr. 1957(10):59-62.

Pacific Fisherman. 1928. Record chum caught off Quadra. Pac. Fisherman 1928(Oct.):13.

Pitcher, T. J. 1986. Functions of shoaling in teleosts. *In* T.J. Fisher (ed.). The Behavior of Teleost Fishes. Johns Hopkins University Press, Baltimore, Maryland, pp. 294-337.

Randall, R. G., M. C. Healey, and J. B. Dempson. 1987. Variability in length of freshwater residence of salmon, trout, and char. *In* M.J. Dodswell et al. (editors), Common Strategies of Anadromous and Catadromous Fishes. American Fisheries Society Symposia, Bethesda, MD. 1:27-41.

Rawding, Dan (WDFW). 2001c. Hardy Chum data via e-mail.

Salo, E. O. 1991. Life history of chum salmon, *Oncorhynchus keta*. *In* C. Groot and L. Margolis (editors), Pacific salmon life histories, p. 231-309. Univ. B.C. Press, Vancouver, B.C.

SSHAG (Salmon Steelhead Hatchery Assessment Group). 2003. Hatchery Broodstock Summaries and Assessments for Chum Salmon, Coho Salmon, Chinook Salmon, and Steelhead within Listed and ESUs. Technical review draft. NMFS Northwest and Southwest Fisheries Science Centers.

Steel, E. A. and M. B. Sheer. 2002. Broad-scale habitat analyses to estimate fish densities for viability criteria. Appendix C *in* Willamette/Lower Columbia Pacific salmonid viability criteria. Willamette/Lower Columbia Technical Recovery Team Report. December 2002.

WDFW (Washington Department of Fish and Wildlife) and PNPTT (Point no Point Treaty Tribes). 2000. Summer chum salmon conservation initiative. An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca region . 384 pages plus appendices (available at: www.wa.gov/wdfw).

WDFW (Washington Department of Fish and Wildlife) and PNPTT (Point no Point Treaty Tribes). 2001. Summer chum salmon conservation initiative. An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca region. Supplemental Report No. 3. Annual Report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca region. 123 pp. (available at: www.wa.gov/wdfw).

E.5 APPENDICES

Appendix E.5.1. Preliminary SSHAG (2003) categorizations of hatchery populations of chum salmon of the two ESUs reviewed. See "Artificial Propagation" in General Introduction for explanation of the categories.

ESU	Stock	Run	Basin	SSHAG Category
Hood Canal summer	Big Quilcene	summer	Quilcene	1
	Lilliwaup Creek	summer	S. Hood Canal	1
	Hamma Hamma	summer	S. Hood Canal	1
	Big Beef Creek	summer	N. Hood Canal	1
	Salmon Creek	summer	Dungeness	1
	Chimacum Creek	summer	Dungeness	1
	Union River	summer	Union	1
	Jimmycomelately	summer	Dungeness	1
Lower Columbia River	Sea Resources	fall	Chinook River	3
	Gorley Creek	fall	Grays	1
	Hamilton Creek	fall	Gorge	1

Appendix E.5.2. Columbia River Chum Time Series References

Population	Grays River Chum
Years of Data, Length of Series	1945 - 2000, 34 years
Abundance Type	Live/dead index
Abundance References	Hymer, Joe. 2000; Keller, Ken. 2001; Keller, Ken and Richard Bruce. 2001
Abundance Notes	1999 and 2000 data downloaded from streamnet; references are Keller and Keller and Bruce
Hatchery Reference	Rawding, Dan (WDFW). 2001c.
Hatchery Notes	There has been no significant contribution of hatchery fish to the Grays River chum population
Harvest Reference	Rawding, Dan (WDFW). 2001c.
Harvest Notes	There has been no significant directed harvest on Columbia chum for the duration of the time series. Indirect harvest is believed to be negligible
Age Reference	Salo, E.O.1991.
Age Notes	LCR_Wil Chinook Chum Steelhead from Holmes and McClure

Population	Grays River Chum
Years of Data, Length of Series	1967 - 1998, 34 years
Abundance Type	Live/dead index
Abundance References	Rawding. 2001
Abundance Notes	
Hatchery Reference	Rawding, Dan (WDFW). 2001c.
Hatchery Notes	There has been no significant contribution of hatchery fish to the Grays River chum population
Harvest Reference	Rawding, Dan (WDFW). 2001c.
Harvest Notes	There has been no significant directed harvest on Columbia chum for the duration of the time series. Indirect harvest is believed to be negligible
Age Reference	Salo, E.O.1991.
Age Notes	LCR_Wil Chinook Chum Steelhead from Holmes and McClure

Population	Lower Gorge Tributary Chum (Hamilton Cr, Hamilton Sp. & Hardy Cr Chum)
Years of Data, Length of Series	1944 - 2000, 57 years
Abundance Type	Live/dead index
Abundance References	Rawding, Dan (WDFW). 2001c.

Abundance Notes	Rawding provided separate time series for each subpopulation that were combined for analysis
Hatchery Reference	Rawding, Dan (WDFW). 2001c.
Hatchery Notes	There has been no (or extremely little) hatchery impact on Hardy Creek chum.
Harvest Reference	Rawding, Dan (WDFW). 2001c.
Harvest Notes	There has been no significant directed harvest on Columbia chum for the duration of the time series. Indirect harvest is believed to be negligible
Age Reference	Salo, E.O.1991.
Age Notes	LCR_Wil Chinook Chum Steelhead from Holmes and McClure