ESA-listed Hood Canal Summer Chum Salmon: A brief update on supplementation programs, natural-origin vs. supplementation-origin returns, and recovery

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Abstract

Hood Canal summer chum (including the eastern Strait of Juan de Fuca) were listed as threatened under the Endangered Species Act in 1999. Recovery planning and implementation were underway prior to the listing, with harvest reductions and supplementation programs enacted in the early 1990's. The Washington Department of Fish and Wildlife and Point No Point Treaty Tribes distributed the Summer Chum Salmon Conservation Initiative (SCSCI) in April 2000. The initiative described a comprehensive plan for the implementation of summer chum salmon recovery in Hood Canal and eastern Strait of Juan de Fuca. The Summer Chum Recovery Plan, prepared by the Hood Canal Coordinating Council, incorporated the harvest and artificial production management provisions of the SCSCI and also addressed habitat protection and restoration. The Recovery Plan was formally adopted by National Marine Fisheries Service (NMFS) under rule 4(f) of the Endangered Species Act in March 2007.

Run sizes of summer chum have been on the rise since the mid-1990's, with some of the highest returns on record occurring in recent years. Supplementation programs have succeeded in reducing the extinction risk of several stocks that were at critically low levels prior to supplementation and these stocks have demonstrated strong returns of both supplementation-origin and natural-origin fish in recent years. Reintroduction programs also appear to be succeeding, with natural-origin spawners returning to three streams where summer chum had been extinct for more than 10 years.

Interim recovery goals for summer chum have been developed by the Washington Department of Fish and Wildlife and the Point No Point Treaty Tribes – the fish resource co-managers in the summer chum region - based on historic population sizes, and include abundance, escapement, productivity, and diversity targets. Summer chum populations are not yet meeting the Co-managers' abundance-based recovery goals, due in part to the requirement that all stocks must meet recovery abundance thresholds over a period of 12 years. The outlook for summer chum, however, is much brighter than it was just 10 years ago, based on recent increased abundances and other indicators.
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Introduction and Background

Summer chum in Hood Canal and the Strait of Juan de Fuca experienced a severe decline in abundance in the 1980's, extending into the early 1990s. Abundances reached record lows in 1989 and 1990, with less than 1,000 spawners escaping to the region each year. By 1991, seven of the sixteen recognized summer chum stocks were considered extinct, eight stocks were at high risk of extinction, and one stock was at moderate risk of extinction. In 1992, the state and tribal Co-managers implemented harvest reductions aimed at protecting summer chum, and together with the U.S. Fish and Wildlife Service and local citizen groups, initiated three hatchery supplementation programs utilizing native brood stocks. In 1999, the Hood Canal summer chum Evolutionarily Significant Unit (ESU) (including the Strait of Juan de Fuca), was listed as threatened under the Endangered Species Act. The Washington Department of Fish and Wildlife and Point No Point Treaty Tribes distributed the Summer Chum Salmon Conservation Initiative (SCSCI) in April 2000 (WDFW and PNPTT 2000). The initiative described a comprehensive plan for the implementation of summer chum salmon recovery in Hood Canal and eastern Strait of Juan de Fuca. The harvest and artificial production components of the SCSCI were subsequently approved by the National Marine Fisheries Service (NMFS) under Limits 6 and 5, respectively, of the Endangered Species Act 4(d) rule (NMFS 2001, 2002). Since then, the SCSCI hatchery (supplementation) programs have been reviewed favorably by the Hatchery Scientific Review Group (HSRG 2002, 2004) and by the Recovery Science Review Panel (RSRP 2004). The SCSCI's harvest and artificial production management provisions were also incorporated into the Summer Chum Recovery Plan prepared by the Hood Canal Coordinating Council (HCCC 2005). A key premise of the SCSCI is that "commensurate, timely improvements in the condition of habitat critical for summer chum salmon survival are necessary to recover the listed populations to healthy levels". The HCCC Recovery Plan, which also addressed habitat protection and restoration, was formally adopted by NMFS as an acceptable plan to recover the listed summer chum ESU under section 4(f) of the Endangered Species Act in March, 2007 (NMFS 2007a, 2007b).

Since recovery efforts for Hood Canal summer chum were initiated, six conservation-directed supplementation and three reintroduction programs have been undertaken. Harvest rates on summer chum have been severely curtailed, and are currently managed under the risk averse harvest management plan described by the SCSCI. Harvest rates were decreased from an average of ~49% prior to implementation of protective harvest measures (1974-1991) to an average of <5% after the measures were applied (1992-2006). A variety of habitat restoration and protection projects have also been implemented by local, state and federal governmental entities and non-governmental cooperative groups on summer chum streams and in critical estuarine areas. Reports covering stock assessment, management, and supplementation activities from 2000-2006 have been completed (WDFW and PNPTT 2001, 2003; WDFW and PNPTC 2004, 2005, 2006, 2007a, 2007b), and the Co-managers have identified interim recovery goals for summer chum (PNPTT and WDFW 2003).

This paper gives general updates on population trends, supplementation programs, and achievement of SCSCI performance standards meant to measure progress toward recovery of the Hood Canal summer chum ESU. For more detailed information, consult the five-year report on progress of the SCSCI (WDFW and PNPTT 2007b) available on the Washington Department of Fish and Wildlife (WDFW) website (http://wdfw.wa.gov/fish/chum/chum.htm).

Abundance Trends and Extinction Risk

Abundances of summer chum in Hood Canal declined from the late 1970's through the early 1990's (Figure 1). All stocks of summer chum in Hood Canal except the Union River suffered declines in abundance during this period. In the Strait of Juan de Fuca, the decline started approximately 10 years later, with a noticeable and lasting drop in abundance in 1989. Populations rebounded to higher levels quickly in the mid-1990's, after the initiation of harvest reductions and several supplementation programs. Larger escapements were seen from 1995-1997 for the major streams entering the west side of Hood Canal. Abundances were down again in 1998 and 1999 (although still five times higher than abundances just prior to recovery efforts), but began to increase in 2000. The 2003 and 2004 escapements were the largest on record, with a total of over 79,000 fish escaping to the region in 2004. However, 2004 is the peak return year in a strong 4-year production cycle and, as expected, production declined in 2005 as the run cycled down from the high year. Overall, the average total annual escapement has increased from 2,367 fish in 1988-1991 to 38,353 fish in 2004-2007.

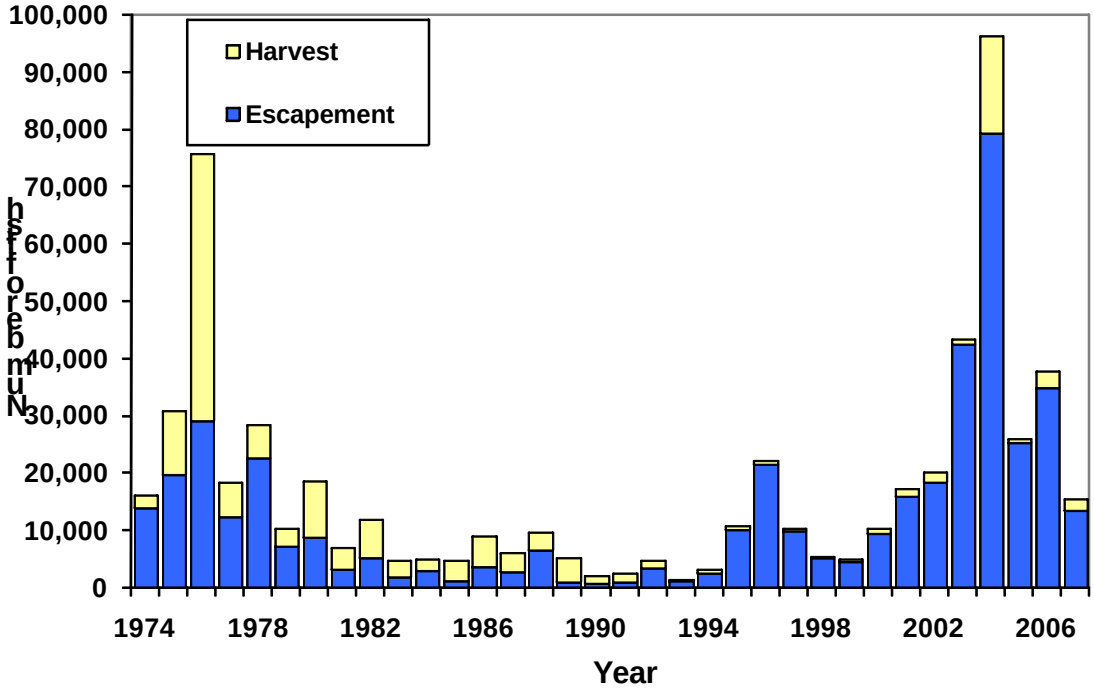

Figure 1. Total escapement and harvest of summer chum salmon returning to Hood Canal and Strait of Juan de Fuca, 1974-2007.

Extinction risks for all stocks have decreased since the onset of recovery activities, with increases in population sizes, and effective population sizes per generation greater than 500 for all but two stocks (Adicks et al. 2005, WDFW and PNPTT 2007b). In addition, three stocks have been reintroduced into watersheds where the indigenous stock was extinct, further reducing the extinction risk for the donor stocks and reinitiating natural summer chum production in these streams.

Supplementation Programs

Artificial production was identified as an important tool for use in recovery of summer chum salmon, and supplementation programs were initiated early in the recovery process. Supplementation as a salmon recovery tool has been the subject of much debate, in part due to differing application of the term supplementation itself. Supplementation, as defined by the SCSCI, is "The use of artificial propagation to maintain or increase natural production while maintaining the long-term fitness of the target population, and keeping the ecological and genetic impacts to non-target populations within specified biological limits." Implicit in this definition is the intent to halt supplementation when the wild population has recovered.

The controversy surrounding the use of artificial production techniques to supplement depressed wild salmon populations is based on the uncertainty of whether this type of intervention would lead to irreversible losses of fitness and genetic diversity, and a concern that the hatchery programs would continue indefinitely to enhance fishing opportunities. Because of past chum salmon supplementation successes (Ames and Adicks 2003), the Co-managers were confident that well-founded hatchery programs would result in rapid increases in the numbers of returning fish and a corresponding reduction in extinction risk. The primary challenge facing the Co-managers was to develop a set of protocols that would minimize the risk of deleterious hatchery-related effects on supplemented stocks.

The definition of supplementation used in the SCSCI is central to the strict criteria and standards used for selecting and conducting supplementation programs for Hood Canal summer chum. Supplementation is to be used only when a summer chum stock is at risk of extinction, or to develop a broodstock in support of a program to reintroduce summer chum to previously occupied habitats. Tynan et al. (2003) summarized the strict standards guiding supplementation programs set forth by the SCSCI. These standards included strategies for minimizing potential deleterious effects of supplementation, and requirements for monitoring and evaluation of supplementation programs. Schroder and Ames (2004) further detail specific protocols to be followed during artificial production to insure the SCSCI standards are met. Early results of monitoring and evaluation of supplementation programs are presented in WDFW and PNPTT (2001, 2003, 2007b) and Johnson and Weller (2003).

Table 1 lists the supplementation (and reintroduction) programs undertaken to date for Hood Canal summer chum and Figure 2 shows the distribution of the programs in the

Table 1. Listing of summer chum supplementation and reintroduction programs, including brood years when programs began and brood years when mass marking (otolith marking or adipose clipping) was initiated. Also shown are the first year of marked adult returns and, where applicable, the last brood year before program termination.

Supplementation/ reintroduction program	Brood year program initiated	Brood year mass marking initiated	First year marked adults to return[1]	Brood year program terminated
Salmon Creek	1992	1993	1996	2003
Big Quilcene River[2]	1992	1997	2000	2003
Lilliwaup Creek[3]	1998	1997	2000	
Chimacum Creek (reintro.)	1996	1999	2002	2003
Big Beef Creek (reintro.)	1996	1998	2001	2004
Hamma Hamma River	1997	1997	2000	
Jimmycomelately Creek	1999	1999	2002	
Union River	2000	2000	2003	2003
Tahuya River (reintro.)	2003	2003	2006	

[1] First year of returning age 3 fish is shown. Most adults return at ages 3 and 4, with perhaps a few at ages 2 and 5.

[2] Adipose clip.

[3] Attempts to initiate supplementation efforts at Lilliwaup began in 1992, but broodstock collection efforts were largely unsuccessful until the 1998 brood, when a functional trap was first installed on the creek.

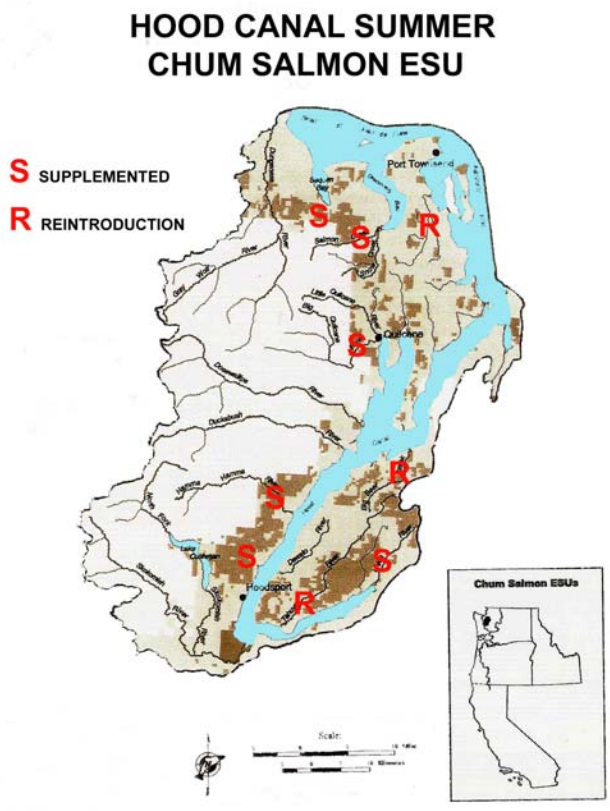

Figure 2. Map of Hood Canal summer chum Evolutionarily Significant Unit (ESU). Locations of supplementation programs indicated by "S", and locations of reintroduction programs by "R".

ESU. Four of the programs have been terminated after either reaching the three chum generation (12-year) maximum program duration limit specified by the SCSCI (Quilcene and Salmon), or because adult return targets were being met before the three generation limit was reached (Chimacum and Union).

Natural-origin vs. supplementation-origin returns: Since 1997, all supplementation program-origin fish have been mass marked with adipose clips (Quilcene) or with program-unique otolith marks (all other programs). This means that beginning with the 2001 return, the vast majority of supplementation origin recruits were identifiable as supplementation fish, and also to their program of origin. Reintroduction fish were not necessarily marked for the first few years of the program, since the streams selected for reintroduction did not have extant summer chum populations, and all returns were assumed to be of supplementation origin.

Summer chum adults returning to Hood Canal streams are sampled for marks as a part of broodstock collection, and on the spawning grounds. This allows determination of natural-origin and supplementation-origin returns, and evaluation of return rates and straying of supplementation-origin fish. Scales are also sampled, allowing analysis, by brood year, of age structure and productivity for natural-origin fish and of contributions of supplementation-origin fish. For the years 1999 to 2006, summer chum from most of the spawning aggregations within each population were sampled for age, mark, and genetic composition. Sample sizes meet or exceed goal collection levels each year, with generally well over 100 fish sampled per stream, and from 300-1000 fish for the Strait of Juan de Fuca population and 300-3000 for the Hood Canal population (WDFW and PNPTT 2000, 2001, 2003; WDFW and PNPTC 2004, 2005, 2006).

In the Strait of Juan de Fuca region, total supplementation-origin recruits accounted for 19% to 74% of annual summer chum returns from 1999 to 2006 (Table 2). In the Discovery Bay and Chimacum management units, supplementation programs were discontinued after brood year 2003 and the proportion of supplementation-origin fish declined as summer chum populations returned to primarily natural production. For example, mark data indicates that 4,909 (89%) and 1,480 (73%) of the fish returning in 2006 to Discovery Bay and Chimacum, respectively, were of natural origin, indicating that success of the programs in increasing spawner abundances has not been limited to supplementation-origin fish.

Table 2. Estimates of natural-origin and supplementation-origin runsize for Strait of Juan de Fuca summer chum management units from 1999 through 2007.

Management Unit (MU)	Origin		Return year							
			1999	2000	2001	2002	2003	2004	2005	2006
Sequim Bay	Nat. origin	No.	7	55	253	2	69	614	496	346
		%	100%	100%	97%	5%	15%	37%	38%	48%
	Supp. origin	No.	0	0	9	40	381	1,051	821	382
		%	0%	0%	3%	95%	85%	63%	62%	52%
Discovery Bay	Nat. origin	No.	141	460	1,230	4,100	4,021	4,402	4,656	4,909
		%	27%	52%	44%	68%	67%	68%	66%	89%
	Supp. origin	No.	391	419	1,581	1,972	1,983	2,028	2,356	605
		%	73%	48%	56%	32%	33%	32%	34%	11%
Chimacum	Nat. origin	No.	0	0	0	129	229	593	894	1480
		%	0%	0%	0%	15%	41%	52%	64%	73%
	Supp. origin	No.	38	52	909	738	334	548	510	554
		%	100%	100%	100%	85%	59%	48%	36%	27%
SJFuca total	Nat. origin	No.	148	515	1,483	4,231	4,319	5,609	6,046	6,735
		%	26%	52%	37%	61%	62%	60%	62%	81%
	Supp. Origin	No.	429	471	2,499	2,750	2,698	3,627	3,687	1,541
		%	74%	48%	63%	39%	38%	39%	38%	19%
	Total		577	986	3,982	6,981	7,017	9,359	9,735	8,279

In the Hood Canal region, total supplementation-origin recruits accounted for 12% to 41% of annual summer chum returns from 2001 to 2006 (Table 3). Supplementation programs were discontinued after brood year 2003 in the Big Quilcene River (Quilcene/Dabob Bays management unit) and the Union River (Southeast Hood Canal management unit), but the reintroduction program in the Tahuya River (also in the Southeast Hood Canal management unit) is ongoing. Again, the proportion of supplementation-origin fish declined as summer chum populations returned to primarily natural production. For example, mark data indicates that 13,093 (92%) and 1,747 (48%) of the fish returning in 2006 to Quilcene and Southeast Hood Canal, respectively, were of natural origin.

Table 3. Estimates of natural-origin and supplementation-origin runsize for Hood Canal summer chum management units from 2000 through 2006.

Management Unit (MU)	Origin		Return year						
			2000	2001	2002	2003	2004	2005	2006
Quilcene/Dabob Bays	Nat. origin	No.	- -	3,632	4,330	10,850	59,333	6,231	13,093
		%	- -	48%	72%	84%	94%	89%	92%
	Supp. origin	No.	6,704	3,964	1,720	2,013	3,833	792	1,198
		%	- -	52%	28%	16%	6%	11%	8%
Mainstem Hood Canal	Nat. origin	No.	2,035	2,696	2,832	8,748	20,905	4,767	8,928
		%	- -	63%	46%	79%	81%	67%	78%
	Supp. origin	No.	- -	1,552	3,388	2,394	4,984	2,360	2,497
		%	- -	37%	54%	21%	19%	33%	22%
SE Hood Canal	Nat. origin	No.	757	1,517	890	7,974	3,611	709	1,747
		%	100%	100%	100%	66%	60%	35%	48%
	Supp. origin	No.	0	0	0	4,045	2,386	1,293	1,883
		%	0%	0%	0%	34%	40%	65%	52%
Hood Canal total	Nat. origin	No.	- -	7,845	8,052	27,572	83,849	11,707	23,768
		%	- -	59%	61%	77%	88%	72%	81%
	Supp. origin	No.	- -	5,516	5,108	8,452	11,203	4,445	5,578
		%	- -	41%	39%	23%	12%	28%	19%
	Total		9,542	13,361	13,160	36,024	95,062	16,152	29,346

Reintroduction programs also appear to be succeeding. Hatchery-origin summer chum adults originating from stock reintroduction programs on Chimacum Creek, Big Beef Creek, and the Tahuya River returned in high numbers to the watersheds to spawn naturally. As a result, natural-origin spawners are now returning again to Chimacum and Big Beef Creeks, streams where summer chum had been extinct for more than 10 years (WDFW and PNPTC 2004, 2005, 2006, 2007a); the first natural-origin recruits in the Tahuya River are expected in 2009.

SCSCI Performance Standards

The SCSCI describes performance standards "meant to provide immediate criteria upon which to measure progress toward recovery of summer chum populations". The standards, described for abundance, escapement, productivity and management actions, are evaluated in the five year review of the SCSCI (WDFW and PNPTC 2007). Following is a brief overview of how well some of the standards have been met.

One standard is that annual abundance should be stable or increasing and the five year mean abundance must be higher than the critical abundance threshold. Post season abundance estimates for the five years, 2000 through 2004, are provided in Table 4 for

the ESU, each population (region), and each management unit. The ESU and the Hood Canal population exceeded the abundance critical thresholds each year and exceeded the recovery threshold several times; the Strait of Juan de Fuca population exceeded the recovery threshold in 4 of 5 years, but was lower than the critical threshold in 2000. Similarly, each management unit has generally exceeded the critical thresholds, the exceptions being Sequim Bay in 2000 and 2002 and Mainstem Hood Canal in 2000.

Table 4. Abundance thresholds and post-season runsize estimates for Hood Canal and Strait of Juan de Fuca summer chum, 2000-2004.

	Abundance Thresholds		Post Season Estimates				
Unit	Critical	Recovery	2000	2001	2002	2003	2004
H. Canal - SJFuca ESU	5,590	22,760	10,483	17,342	20,141	**43,040**	**104,289**
Strait of Juan de Fuca	1,010	2,080	987	**3,982**	**6,981**	**7,016**	**9,236**
Sequim	220	520	55	262	42	450	**1,665**
Discovery	790	1,560	879	**2,811**	**6,072**	**6,004**	**6,430**
Chimacum	na	na	52	909	867	563	1,141
Hood Canal	4,580	20,680	9,496	13,360	13,160	**36,024**	**95,053**
Quilcene	1,260	4,570	6,704	**7,595**	**6,050**	**12,863**	**63,167**
Mainstem Hood Canal	2,980	15,560	2,035	4,248	6,220	11,142	**25,889**
SE Hood Canal	340	550	757	**1,516**	**890**	**12,019**	**5,997**

Note: Boxed entries indicate abundance below critical threshold. Bolded entries indicate abundance above recovery threshold.

Another standard is that natural-origin escapement should be stable or increasing and the five year mean escapements must be higher than the critical abundance thresholds. The natural-origin escapements have been estimated for management units and stocks beginning with 2001, the first year when the vast majority of returning supplementation fish were marked and the ongoing sampling of spawners would accommodate separating natural-origin from hatchery-origin for all stocks. Table 5 shows that the four year mean natural-origin recruit (NOR) escapement exceeded the critical threshold for all management units, that annual escapements generally exceeded the critical thresholds, and that, excepting Lilliwaup, the management units and stocks show increasing trends over the four years.

A third standard is that the five-year mean productivity should be greater than 1.2 natural-origin recruits per spawner. As shown in Table 6, mean productivity for the five brood years, 1996 through 2000 (or for available years as indicated), has ranged from 3.22 to 6.89 natural-origin recruits per spawner for the stocks or management units. The table results are based on analysis of collected mark and age data for adult return years 1999 through 2004.

Table 5. Thresholds, actual annual, and mean NOR escapement estimates for Hood Canal summer chum, 2001-2004.

Management Unit / Stock	Critical Thresh./Flag[1]	2001	2002	2003	2004	Mean
Sequim Bay	200	251	***7***	***68***	613	235
Discovery Bay	720	1,222	4,085	3,986	4,392	3,421
Quilcene	1,110	3,048	3,211	10,740	35,838	13,209
Mainstem H.C.[2]	2,660	***2,616***	2,755	8,672	20,720	8,691
Dosewallips	736	757	1,313	6,510	10,325	4,726
Duckabush	700	***662***	***355***	1,600	7,850	2,617
Hamma	1042	1,155	1,050	***535***	2,409	1,287
Lilliwaup	182	***41***	***36***	***27***	***136***	***60***
S.E. Hood Canal	300	1,491	872	7,923	3,603	3,472

[1] Shown are critical thresholds that apply to management units and minimum escapement flags that apply to stocks within the Mainstem Hood Canal management unit (WDFW and PNPTT 2000). Values that fall below the applicable threshold/flag are shown with bold and italicized font.

Table 6. Mean productivity of management units and stocks, brood years 1996-2000

Management Unit Stock	1996-2000 Mean Productivity (natural-origin recruits/spawner)
Sequim Bay Jimmycomelately	5.83
Discovery Bay Salmon/Snow	4.23
Port Townsend Chimacum	5.52[1]
Quilcene/Dabob Bays Big/Little Quilcene	3.22[2]
Mainstem Hood Canal Dosewallips Duckabush Hamma Hamma Lilliwaup	5.05 6.13 5.68 6.45 6.89[3]
SE Hood Canal Union	5.94

[1] Applies to only two brood years, 1999 and 2000.

[2] Applies to only four brood years, 1997 through 2000.

[3] Applies only to two brood years, 1997 and 1998.

Recovery Goals

In 2003, the co-managers identified interim recovery goals for individual summer chum stocks that addressed annual abundance (run size) and escapement, productivity, and diversity (PNPTT and WDFW 2003). The goals were developed with the information available at that time, with the expectation that the recovery standards will be reviewed and revised as more is learned about the population dynamics of Hood Canal summer chum. The recovery goals were based on historic (pre-decline) population sizes and also specified criteria for meeting the thresholds.

More recently, the Puget Sound Technical Recovery Team (PSTRT 2007) identified two independent summer chum populations (Strait of Juan de Fuca and Hood Canal) within the ESU. The PSTRT also identified viable salmonid population criteria providing for low extinction risk for these two populations. The PSTRT supports managing for recovery at the level of the co-managers' individual stocks (or what may be described as sub-populations of the PSTRT's two independent populations) as compatible with and a reasonable intermediate step toward the PSTRT's long-term population viability criteria.

Despite recent abundant returns of Hood Canal summer chum, it will be some time before stocks can meet recovery thresholds over the period of twelve years required by the recovery goals (WDFW and PNPTC 2007b). These interim goals will be revisited as more is learned about summer chum population dynamics and productivity. One important issue remaining involves how to include reintroduced summer chum populations in recovery goal setting.

Conclusion

The overall goal of the SCSCI is "To protect, restore and enhance the productivity, production, and diversity of Hood Canal summer chum salmon and their ecosystems to provide surplus production sufficient to allow future directed and incidental harvests of summer chum salmon." The SCSCI acknowledged that both short-term and long-term measures would be necessary to meet that goal. Recent returns of summer chum to Hood Canal indicated that the short-term measures have been highly successful. Harvest reductions and supplementation programs, along with favorable freshwater and marine conditions are all believed to have contributed to the recent success in recovering the summer chum populations. The total abundance and escapement of summer chum in 2004 were the largest on record for Hood Canal and returns in 2005 and 2006 have been good. Although summer chum stocks are not yet meeting the Co-managers' recovery targets, recent returns are a positive sign that the goals can be met.

The true measure of success of recovery efforts must be viewed over the longer term, as supplementation programs are discontinued, and as summer chum potentially face less favorable freshwater and marine survival regimes. There is good reason to be optimistic that summer chum can remain at abundances higher than pre-supplementation levels even after supplementation is stopped, as has happened with South Puget Sound summer chum (Ames and Adicks 2003). Continued monitoring of escapement and abundances, careful

management of harvest rates, and commensurate protection and/or restoration of habitat critical to Hood Canal summer chum are all imperative if the goal of the SCSCI is to be met. On-going data collection will contribute to better understanding of the population dynamics of Hood Canal summer chum, and will help to focus long-term management actions to maximize benefits to summer chum.

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