

THE AGATE PASS SEAPENS COHO PROGRAM: REARING HISTORY, CONTRIBUTION RATES, AND WASHINGTON STATE REVENUES AND BENEFITS

Paul Dorn
Suquamish Tribal Fisheries Department
PO Box 498, Suquamish, WA 98392
(360) 394-5245; fax: (360) 598-4666; Pdorn@silverlink.net

Andy Appleby
Washington Department of Fish & Wildlife
600 Capitol Way N, Olympia, WA 98501-1091
(360) 902-2663; fax: (360) 902-2153

Jay DeLong & Sharon Lutz
Northwest Indian Fisheries Commission
6730 Martin Way E, Olympia, WA 98506
(360) 438-1180; fax: (360) 753-8659; <http://mako.nwifc.wa.gov>

Introduction

Marine net pens have been used since 1972 in Washington State to increase survival rates of coho yearlings, promote residency, and to imprint populations to specific geographic areas (Appleby et al, 1989), (Buckley and Haw, 1978). The Agate Pass Seapens are one of 19 marine net pen facilities producing approximately 4,000,000 coho annually (1995 data). These facilities range in capacity from 50,000 to 2,200,000 salmon and are operated either by Washington Department of Fish and Wildlife (WDFW), a Tribe, or jointly as a WDFW cooperative with a Tribe or regional group.

The Suquamish Indian Tribe (SIT) has operated the Agate Pass Seapens continuously since 1981. This program has been made possible by a cooperative agreement with WDFW. WDFW provides the smolts and fish food and the SIT provides the facility and staffing. The Agate Pass Seapens are located directly west of Seattle in Puget Sound adjacent to the Kitsap Peninsula. These waters comprise an important usual and accustomed fishing area for the Suquamish people and for local sport fishers.

This report presents an overview of the Agate Pass Seapens rearing program, fish health and marine mortality, and multiple interpretations of coded-wire tag data. Contribution rates to all fisheries are presented using recovery data of Agate Pass Seapens coded-wire tag (CWT) groups for 11 of the 14 brood years between 1979 and 1992. Total catches of Agate Pass Seapens coho by gear and areas are detailed, with economic values calculated for Washington fisheries. Recoveries of Agate Pass Seapens coho strays are reported. Estimated survival and fishery contribution rates are compared to similar facilities and parent hatchery broodstock. Finally, a planned facility design change to a spar buoy system is discussed.

Program Overview

Two Puget Sound coho stocks (Wallace River and/or Minter Creek) are incubated at Minter Creek Hatchery, reared at Coulter Creek Hatchery, and transferred to Agate Pass Seapens as yearlings in January of each year. Weight at transfer is 15 g/fish (30 fish/lb). Freshwater is replaced by ambient saltwater (28 g/L or 28 ppt salinity) during the 45 minute tow to the Agate Pass aboard the transport barge.

The Agate Pass Seapens consist of four 8.5 m (28 ft) square pens that are 5 m (16 ft) deep and are suspended from wooden surface floats. The full rearing volume of each pen is 361 m³ (12,500 ft³) at slack or low current, but is reduced by 50% during full ebb or current flow. Maximum current velocity is 2 knots. The coho are usually feed a frozen diet at 1.2% body weight daily. Hand feeding spans a 3-hour period in the morning and again in the afternoon. Average food conversion is 1.4:1. Loading densities are kept below 1.5 kg/m³ (1 lb/ft³) at full volume, with rearing density adjusted by early releases.

Mortalities are removed two to three times weekly by scuba diver, which permits enumeration of adipose fin clipped fish. The diver inspects the fish, repairs nets, and examines the seabed below the pens for food wastage. If necessary, adjustments are made in feeding rates to avoid wastage. The fish are inspected monthly by Northwest Indian Fisheries Commission (NWIFC) pathologists, or more often during epizootics or other events. Target release weight is 45-57 g/fish (8-10 fish/lb) by mid June or earlier if daily surface water temperature exceeds 13⁰ C. Feeding information, growth rates, mortality, water quality, fish health data, and related operational data are entered into a hatchery management database.

Fish Health and Marine Rearing Mortality

Coho held at Agate Pass Seapens have experienced cumulative mortality levels ranging from a low of 0.3% in the 1981 brood to a high of 27.4% in the 1991 brood (Figure 1). Bacterial kidney disease (BKD), abdominal distention syndrome (Bloat), and the inability to adapt to the saltwater environment at the time of transfer have been the three major causes of mortality. Additional complications have been associated with anemia due to unexplained causes (BY 91).

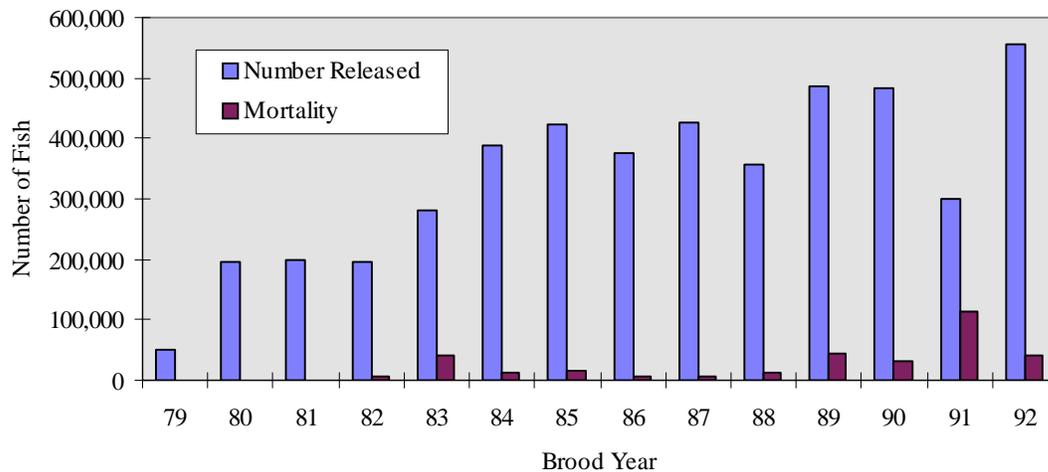


Figure 1. Agate Pass Seapens total coho release and marine mortality by brood year

The level of severity of these conditions has varied over the years. Mortality due to osmoregulatory problems at the time of saltwater transfer has been as high as 16% (BY 91). The condition known as bloat has been a chronic problem and a significant contributor to mortality levels. This condition results in fish with fluid filled stomachs and distended abdomens. Fish with bloat can be found throughout the rearing cycle and do not seem to recover. Bacterial kidney disease progresses rapidly once the fish enter the saltwater netpen environment and ultimately becomes the primary cause of mortality. Mortality due to BKD can be quite devastating. In an effort to reduce the severity of BKD infections, the 1989 and 1990 brood were experimentally treated with the antibiotic oxytetracycline. Fish were fed medicated feed (4g oxytetracycline/45.4 kg fish/day for 21 days) shortly after saltwater transfer. BKD levels were analyzed using the Quantitative Fluorescent Antibody Technique (Cvitanich, Fish Health Lab), which indicated some degree of benefit. Projected mortality due to BKD after release was estimated to be from 1 to 3%.

Other pathogens isolated from fish held in the pens have been *Aeromonas salmonicida* (causative agent of furunculosis) and *Vibrio anguillarum*. In both cases, no signs of disease occurred. Starting with brood year 1987 the coho have received a one hour immersion vaccination against *Vibrio anguillarum* during truck transport to the dock (maximum of 136 kg fish/L of vaccine at a dilution of 1:1000).

Predation accounts for less than 0.5% total mortality. Coho mortality from river otters predation is controlled by electric fences around the perimeter of the floats. Avian predation is restricted by the use of bird nets. Prompt removal of mortalities from the pens alleviates scavenger fish damage to the nets.

The mortality at Agate Pass Seapens follows an annual pattern as represented by brood year 1992 (Figure 2). Early season mortality is characterized by high initial losses due to inability to adapt to saltwater or injury during transfer. Mortality rates decrease to 0.1%/week until water temperatures rise in late April and through May. The increased temperature stress accelerates mortality in diseased or non-smolted fish. The weekly mortality rates continue to increase until release. The late season mortality rates in Figure 2 decline due to a partial release in week 20. The mortality rate for week 22 represents one day.

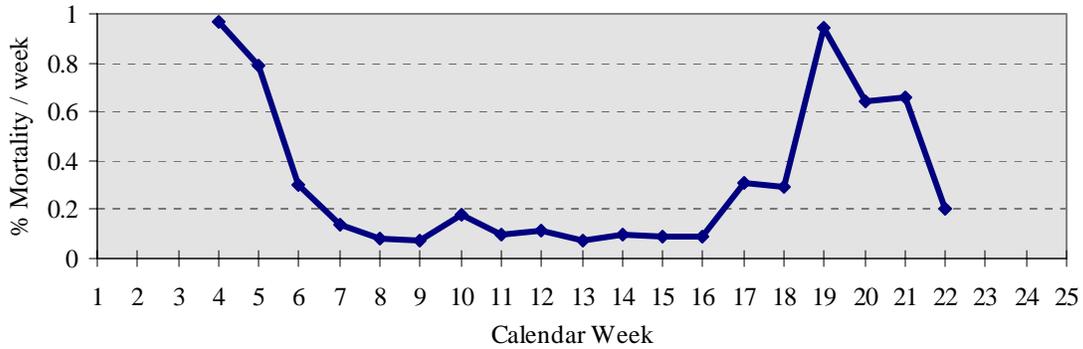


Figure 2. Brood year 1992 Agate Pass Seapens coho mortality by calendar week

Contribution to All Fisheries

Coho releases from Agate Pass Seapens have been represented by CWT groups of 29,000 to 50,000 fish per year, except for three brood years (1979, 1984, and 1991) (Figure 3). The CWT groups ranged from 8.0% (BY 90) to 24.6% (BY 80) of the total release.

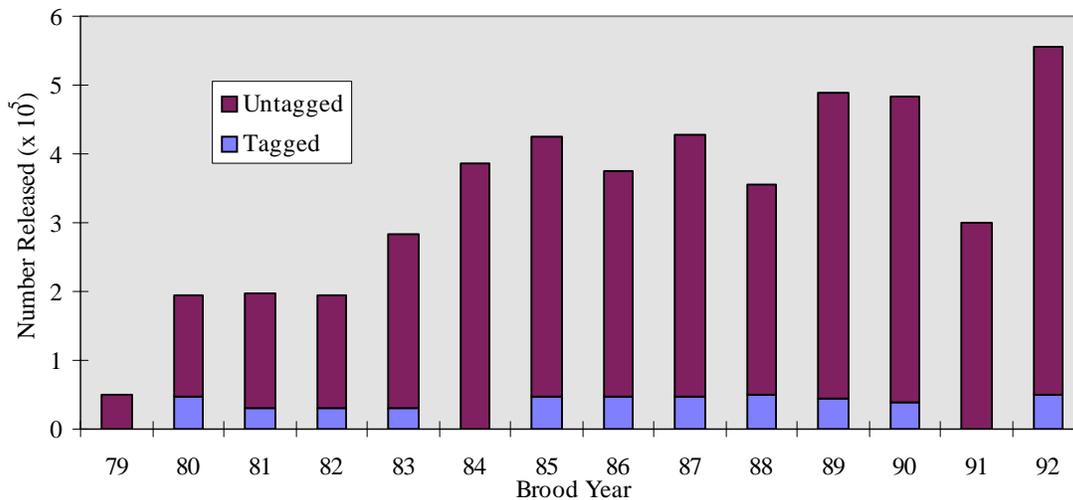


Figure 3. Coho Released by Agate Pass Seapens, showing tagged and untagged fish.

Estimates of total catch and fishery contribution rates (Table 1) and individual fishery catches (Table 2) were made from CWT recovery data obtained from the Pacific States Marine Fisheries Commission.

Brood Year	Number Tagged	Number Released	Estimated Contribution Rate by Area												
			Alaska	Canada	WA Coast and South	Strait Net and Troll	Strait Sport	Hood Canal	North Puget Sound Net	North Puget Sound Sport	Mid Puget Sound Net	Mid Puget Sound Sport	South Puget Sound Net	South Puget Sound Sport	All Freshwater
79	0	49,855	*	*	*	*	*	*	*	*	*	*	*	*	*
80	48,130	195,720	0.0	32.4	2.2	0.9	3.6	0.9	2.0	0.3	45.0	9.8	1.0	0.3	1.5
81	30,029	197,984	0.0	48.8	3.0	2.4	1.5	0.5	4.2	0.0	33.0	3.4	0.2	0.0	3.1
82	29,843	194,560	0.0	40.8	5.4	2.1	1.3	0.3	7.0	0.0	39.1	2.4	0.6	0.0	1.1
83	30,089	282,202	0.0	40.2	3.2	2.0	2.5	3.1	3.8	0.0	40.7	1.3	1.7	0.0	1.6
84	0	387,042	*	*	*	*	*	*	*	*	*	*	*	*	*
85	48,015	424,191	0.0	41.4	4.5	0.3	2.3	0.0	2.2	0.2	45.4	1.1	1.6	0.0	1.0
86	48,494	375,059	0.0	46.9	2.1	1.4	3.7	0.4	1.9	0.3	40.5	1.1	0.5	0.1	1.1
87	47,260	426,806	0.0	40.0	3.3	0.5	6.3	0.0	0.8	0.0	46.2	2.2	0.4	0.0	0.3
88	49,668	355,679	0.0	49.1	3.7	1.8	5.3	0.0	5.8	0.2	31.0	2.0	0.5	0.0	0.5
89	44,809	487,662	0.0	53.1	8.6	0.1	3.6	0.0	0.6	0.5	28.2	4.3	0.5	0.0	0.6
90	38,483	482,959	0.2	60.6	13.8	0.0	4.1	0.0	0.6	2.0	8.7	5.6	1.3	0.0	3.2
91	0	299,487	*	*	*	*	*	*	*	*	*	*	*	*	*
92	49,051	554,987	0.0	67.2	5.1	1.6	0.0	0.0	0.4	0.0	22.0	0.0	3.4	0.0	0.4
Average			0.0	47.3	5.0	1.2	3.1	0.5	2.7	0.3	34.5	3.0	1.1	0.0	1.3

Table 1. Agate Pass Seapens coho contribution rates by brood year and area (* = No CWT releases)

Brood Year	Total Catch	Estimated Total Catch by Area													
		Alaska	Canada	WA Coast and South	Strait Net and Troll	Strait Sport	Hood Canal	North Puget Sound Net	North Puget Sound Sport	Mid Puget Sound Net	Mid Puget Sound Sport	South Puget Sound Net	South Puget Sound Sport	All Freshwater	
79	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
80	36,672	0	11,894	799	330	1,320	330	733	110	16,502	3,594	367	110	550	
81	19,476	0	9,496	585	467	292	97	818	0	6,427	662	39	0	604	
82	21,703	0	8,853	1,165	456	282	65	1,519	0	8,486	521	130	0	239	
83	45,685	0	18,345	1,478	891	1,142	1,416	1,713	0	18,571	594	777	0	708	
84	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
85	76,039	0	31,512	3,414	228	1,749	0	1,673	152	34,522	836	1,217	0	760	
86	61,540	0	28,846	1,288	862	2,277	246	1,169	185	24,924	677	308	62	677	
87	96,271	0	38,478	3,186	481	6,065	0	770	0	44,477	2,118	385	0	289	
88	44,915	0	22,055	1,654	808	2,380	0	2,605	90	13,924	898	225	0	225	
89	43,957	0	23,320	3,783	44	1,582	0	264	220	12,396	1,890	220	0	264	
90	23,682	41	14,350	3,278	0	971	0	142	474	2,060	1,326	308	0	758	
91	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
92	13,509	0	9,078	684	216	0	0	54	0	2,972	0	459	0	54	
Average		4	19,657	1,937	435	1,642	196	1,042	112	16,842	1,192	403	16	466	

Table 2. Agate Pass Seapens estimated total coho catch by brood year and area (* = No CWT releases)

Washington State Revenues and Benefits

Agate Pass Seapens coho contribute substantially to fisheries outside of Washington State as illustrated in Tables 1 and 2. However, Agate Pass Seapens operation is contingent upon benefits to Washington fishers exceeding the costs of providing these benefits. Revenues and benefits to Washington fisheries were calculated using values from Tables 10-12 in the 1988 Washington State Department of Community Development (DCD) Report "Economic impacts and net economic values associated with non-Indian salmon and sturgeon fisheries". Total revenue and benefit per coho to each fishery is shown in Table 3. These values are estimates and limited to non-Indian salmon harvested within Washington waters.

Fishery	Revenue and Benefit
NPS Sport	\$178.41
NPS Net	\$5.60
SPS Net	\$5.81
SPS Sport	\$245.53
Strait Net & Troll	\$6.42
Strait Sport	\$147.63
WCS Charter	\$115.53
WCS Net	\$13.09
WCS Private	\$70.06
WCS Troll	\$13.51

Table 3. Total Washington State revenue and benefits per fish by selected fishery (NPS=North Puget Sound, SPS=South Puget Sound, WCS=Wa Coast and South)

Commercial revenue was calculated as total revenue generated per area divided by catch. Recreational sport benefits were calculated as total recreational benefits per area divided by catch. The values were calculated for the period 1982-1985.

These revenue and benefit values are used for discussion purposes only. It is assumed that if these values were adjusted for the Agate Pass Seapen coho brood years 1980-1992 they would be different, but within the same order of magnitude. No argument is being made that one fishery should be favored over another fishery. In addition to not valuing Canadian harvests, no value is calculated for escapement.

Tribal net catches were added to the DCD report to calculate estimated revenues and benefits to selected Washington State fisheries (WDFW memo, 1996) (Table 4). These values do not include spiritual,

religious, and cultural attributes that increase the real value of salmon to Native American fishers.

Brood Year	NPS Sport	NPS Net	SPS Net	SPS Sport	Strait Net and Troll	Strait Sport	WCS Charter	WCS Net	WCS Private	WCS Troll	Total Value
80	\$306,227	\$12,090	\$91,253	\$325,329	\$3,655	\$187,816	\$7,914	\$0	\$3,154	\$661	\$938,099
81	46,978	5,355	36,760	81,179	2,923	41,798	2,287	181	4,577	5,429	227,467
82	40,611	9,022	46,610	57,801	2,934	36,479	19,555	0	10,086	9,776	232,876
83	25,211	11,927	59,970	41,355	3,555	76,075	9,730	0	2,600	10,778	241,199
83	40,058	8,880	48,208	20,887	2,166	85,857	4,350	730	1,954	4,935	218,026
85	54,331	10,957	191,402	106,524	1,553	252,512	17,832	819	9,645	31,555	677,130
86	129,811	9,347	140,910	24,864	5,609	333,335	9,099	589	3,153	9,625	666,341
87	219,558	23,385	245,992	183,381	2,696	905,305	20,591	0	12,487	26,196	1,639,592
88	105,970	14,919	80,644	79,469	5,205	369,146	15,615	0	15,947	12,683	699,599
89	93,092	2,813	70,097	347,229	344	218,865	38,874	0	32,114	27,797	831,226
90	109,427	2,326	14,221	252,574	0	136,898	75,325	0	31,805	15,917	638,492
92	1,980	2,611	19,371	21,802	1,247	23,761	6,412	0	3,110	4,723	85,017

Table 4. Estimated revenues and benefits to selected Washington State fisheries

Actual Agate Pass Seapens coho harvest and value to the Suquamish Tribal fishers is calculated from Salmon Management Area 10E Tribal fish ticket data (Zischke, 1996) (Table 5). Table 5 does not include the value of tribally caught Agate Pass Seapens coho harvested in mid Puget Sound.

<u>Brood Year</u>	<u># Coho Caught</u>	<u>Coho Value</u>
80	1,314	\$3,626
81	2,084	\$11,085
82	1,927	\$13,084
83	8,411	\$13,251
84	18,032	\$141,842
85	14,368	\$299,741
86	7,957	\$93,131
87	8,685	\$139,174
88	2,720	\$64,164
89	1,634	\$44,812
90	2,298	\$12,743
91	8,676	\$54,216

Table 5. Suquamish Tribal Area 10E commercial coho harvest and value

Observed Straying

The Agate Pass Seapen coho CWT data provide an opportunity to observe straying patterns. Straying is defined for this paper as freshwater recoveries outside of Washington Salmon Management Area 10E. These coho were Wallace River, Minter Creek, or George Adams Hatchery stock, transferred to Coulter Creek Hatchery for freshwater rearing. Coulter Creek Hatchery is now part of the Minter Creek Hatchery Complex. Minter Creek Hatchery stock is now the dedicated stock for the Agate Pass Seapens. Recovery locations of Agate Pass Seapens coho strays are enumerated in Table 6.

	<u>Distance from Agate Pass (km)</u>	<u>Wallace River Stock</u>	<u>Minter Creek Stock</u>	<u>Minter + George Adams Stock</u>
<u>Mid and South Puget Sound</u>				
Grovers Creek Hatchery	6	62	1	93
Cowling Creek Hatchery	6	13		
Blackjack Creek	20	1		
Seattle Aquarium	25	1		
Univ of WA Hatchery	25	3		
Garrison Springs Hatchery	55	5		3
Soos Creek Hatchery	70	1		1
Minter Creek Hatchery	75	38	1	25
<u>North Puget Sound</u>				
Tulalip Hatchery	50	4		
Wallace River Hatchery	130	237		
<u>Hood Canal</u>				
Big Beef Creek Research Hatchery	80	56		1
Quilcene National Fish Hatchery	95	1	1	
Hoodsport Hatchery	120	4		1
George Adams Hatchery	125			9
Total Number of Tagged Recoveries		50,576	1,194	9,018

Table 6. Freshwater recovery locations of Agate Pass Seapen coho by broodstock, brood years 80-92 combined, including distance from the Agate Pass Seapens

The recovery patterns of Agate Pass Seapen coho observed in Table 6 cannot be used to determine straying rates because (1) each tagged fish does not have an equal probability of being recovered during spawning ground surveys and (2) each fish in a run can not be classified as a home or stray recovery. The data support observations of Vander Haegen and Doty (1995) that hatchery salmon do not stray randomly, but return to their natal hatchery or another hatchery. The two nearest hatcheries, Grovers Creek Hatchery and Cowling Creek Hatchery, together received proportionally more strays than any other recovery locations, except for Wallace River Hatchery. All Agate Pass Seapens coho straying to Wallace River Hatchery were of Wallace River origin, suggesting the genetic component of hatchery straying. Similar results are observed for George Adams Hatchery strays from Agate Pass Seapens-- the only recoveries at that hatchery were of the single year that George Adams Hatchery broodstock was used.

Survival and contribution rate analyses

The Agate Pass Seapens estimated survival rate and estimated total fishery contribution rate was compared to three similar net pen facilities and the parent broodstock hatcheries (Figure 4). The results are based on a computer model and show that extended marine rearing may have a positive effect on survival and fishery contribution over freshwater releases. The high estimated survival of Agate Pass Seapens coho, relative to the other net pens, may be in part due to better quantification of CWT mortalities in the pens.

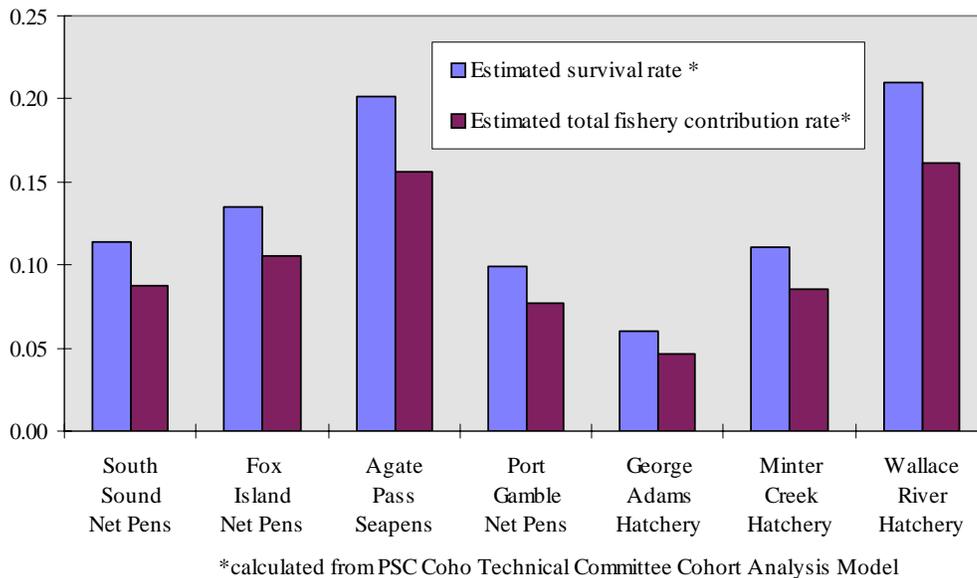


Figure 4. Survival and contribution rates of 7 selected Puget Sound and Hood Canal coho facilities.

Summary

WDFW has determined the average direct cost of salmon smolts produced in Washington State to be \$3.00/lb. The cost to produce 500,000 smolts is therefore \$50,000. SIT has determined the Agate Pass Seapens program direct cost to be \$35,000. WDFW provides \$30,000 for fish food during the extended marine rearing period. These figures total \$115,000. The revenue and benefit to selected Washington fisheries ranged from \$85,017 to \$1,639,592 and averaged \$591,255 for brood years 1980 to 1992. Given the assumptions of this simple analysis, the Agate Pass Seapens have a benefit costs ratio of 5:1 for the Washington fisheries alone.

Planned Facility Modifications

The SIT plans to replace the wood surface floats of the current Agate Pass Seapen facility with an Ocean Spar three-pen complex in the near future (Figure 5). The SIT and the Muckleshoot Indian Tribe own and operate an Ocean Spar complex in Elliott Bay, adjacent to downtown Seattle. These systems provide a constant rearing volume and more protection from predators and storms, thereby reducing stress and promoting fish health. The new Agate Pass Seapens will operate at half the rearing density of the existing system.

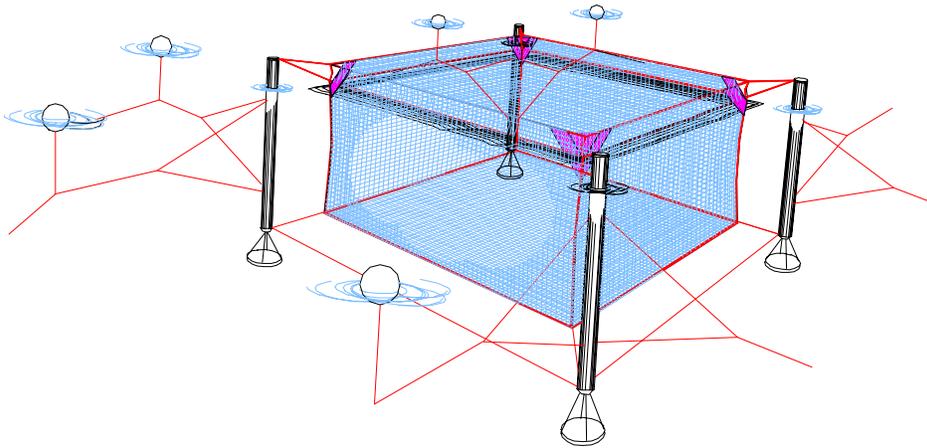


Figure 5. Schematic of an Ocean Spar net pen. The new Agate Pass Seapens will consist of three in series.

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