NPPC - Sandy R.

PART IV. ANADROMOUS FISH PRODUCTION PLANS

COHO SALMON

Fisheries Resource

Natural Production

History and Status

Early-returning coho salmon in the Sandy Subbasin are produced at the Sandy Hatchery and managed as a hatchery stock. They also produce naturally in numerous tributaries and the upper mainstem. Numbers for early-run coho that return to spawn naturally are represented best by Marmot Dam counts. Although some spawning habitat for coho exists below Marmot Dam, the optimum tributaries are above the dam in upper tributaries and side channels of the mainstem.

Construction of Marmot Dam and the Bull Run Reservoir system has reduced the available habitat historically used by coho salmon. Although Marmot Dam is laddered, flows for many years after construction were not adequate to attract or allow passage above the dam. Minimum flow agreements now maintain flows adequate for fish passage and attraction. The Bull Run River remains blocked for anadromous fish passage above the dam for Reservoir 2; the city of Portland mitigates for the loss of habitat by funding the release of juvenile fish elsewhere in the subbasin.

Wild late-run coho are native to small streams in the subbasin. They once spawned and reared in nearly every tributary of the subbasin and in the upper mainstem. At present, naturally produced late-run coho are nearly extinct in the tributaries of the Sandy River (ODFW and WDF 1987). Supplementation of the Sandy River coho run with early-run fish has been made for many years, to the extent that it is difficult to separate the stocks in the run. Supplementation with hatchery early-run coho is one of many factors that have led to a depletion of the wild runs. Other factors that have led to this decline include poor logging practices in the past, overharvest by fisheries, and poor ocean upwelling trends. Current management of coho in the subbasin is intended to provide adults for various sport and commercial fisheries. Despite record high coho returns to the Columbia River, wild spawning populations in tributary streams have reached all time lows in recent years (Hirose 1983).

Recent data on late-run coho is restricted to spawning ground counts that are conducted on 10 Lower Columbia index tributaries totaling 9.2 miles; this level of surveying has been in effect since 1975. Data specifically for late-run coho in the Sandy River is extremely limited.

In the late 1950s and early 1960s, the Oregon Fish Commission conducted studies on Lower Columbia River tributaries, which focused on natural production factors of salmon. A weir was built on Gnat Creek to monitor adult and juvenile salmonid passage, and operated from October 1955 to June 1962 (Willis 1962). All returning jacks and adults were counted prior to passage above the weir. Juvenile salmonids and kelt steelhead were counted and sampled prior to passage downstream of the weir.

Trapping and tagging studies on Cedar Creek in the Sandy River system, Big Creek, and on the North Fork of the Klaskanine River were conducted from 1961 to 1963 to gain juvenile life history information for natural and hatchery-reared coho salmon (Niska and Willis 1963).

References to "El Niño" in this report refer to a condition of warm ocean temperatures and poor upwelling that occurs periodically, and that occurred in the early 1980s, resulting in poor survival and condition factor in maturing salmonids. Coho were affected to a greater extent than other salmonids, due to the shorter ocean period in their life cycle, and a southerly ocean migration pattern.

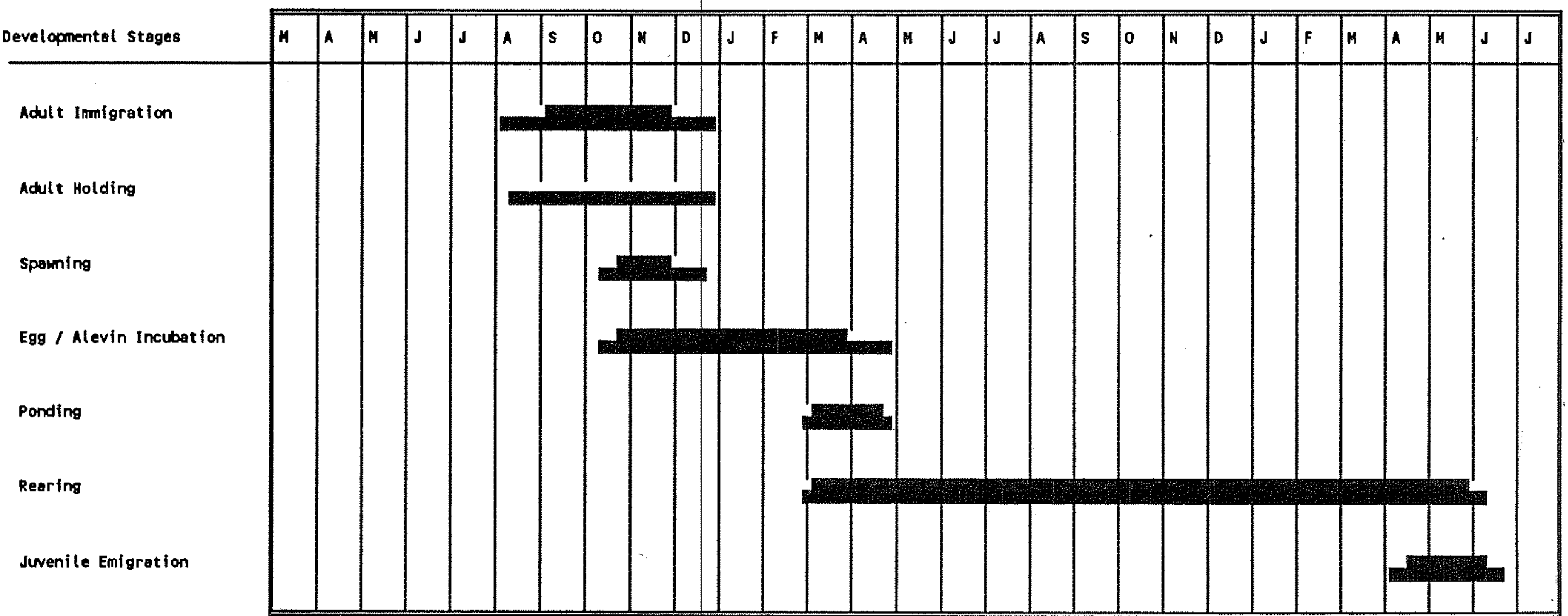
Life History and Population Characteristics

The timing of life history stages in the life cycle of early-returning coho is shown in Table 12. Table 13 shows the timing of late-run coho.

Adult coho enter the Sandy system in August and September, and continue to be found in the basin through February. Peak counts over Marmot Dam occur in September, October, and November, representing the early run. Another small peak in the dam counts appears in February, and probably represents movement of the remnant late-run coho. Figure 7 shows counts of coho over Marmot Dam by month. Salmon angling for coho is closed in August; most coho are caught in September and October. Because of their condition and declining abundance, few coho are retained and recorded on angler catch-record cards (punch cards) after November 1.

Data specifically for late-run coho in the Sandy Subbasin is unavailable. Apportioning the run between late-run and early-run fish in December and January is difficult due to the extent to which supplementation with early run fish has occurred (Fig. 7).

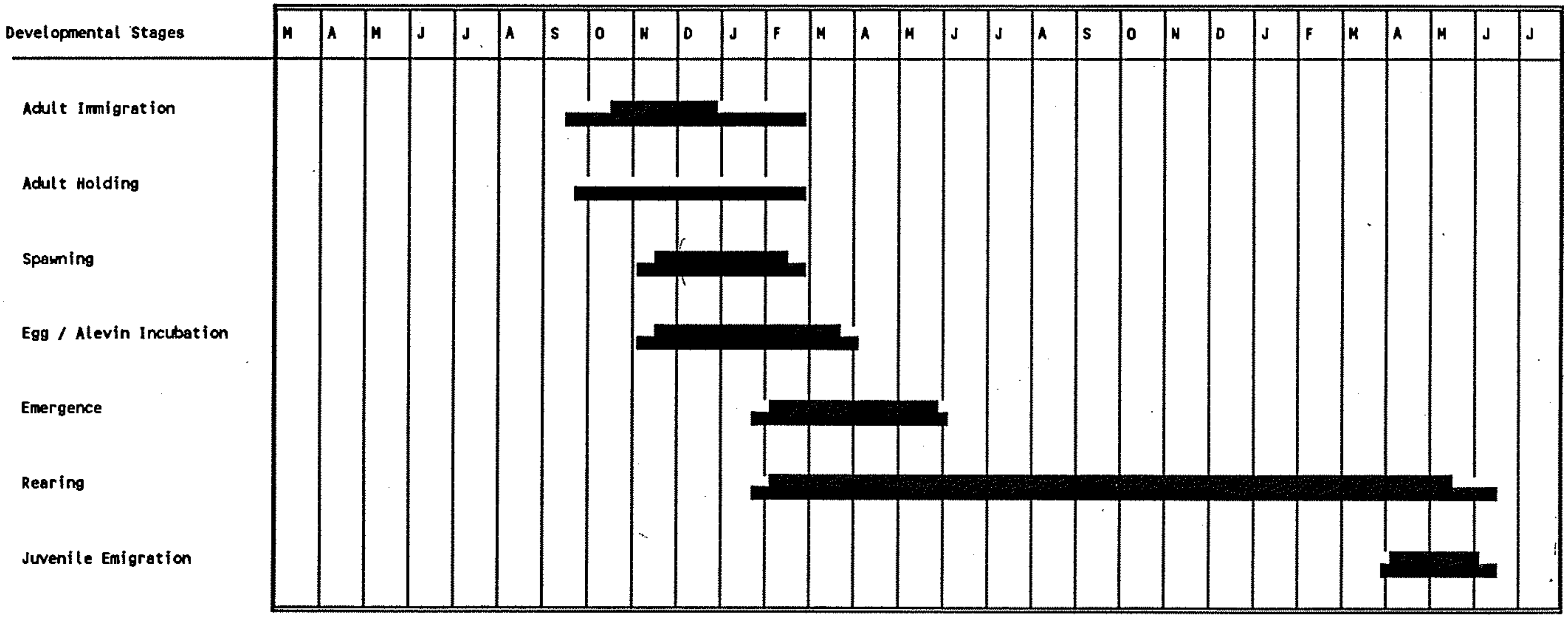
Table 12. Freshwater life history of early run coho in the Sandy Subbasin.



Notes:

1. The developmental stage timing represents basin wide averages, local conditions may cause some variability.
2. Narrow bars indicate periods of light to moderate activity for a given life history stage.
3. Wide bars indicate periods of heaviest activity for a given life history stage.
4. Sources for life history stages were hatchery fish adult and rearing data (Sheldon, 1988) and personal communications with hatchery personnel.

Table 13. Freshwater life history of late run coho in the Sandy Subbasin.



Notes:

1. The developmental stage timing represents basin wide averages, local conditions may cause some variability.
2. Narrow bars indicate periods of light to moderate activity for a given life history stage.
3. Wide bars indicate periods of heaviest activity for a given life history stage.
4. Sources for immigration, spawning, rearing and emigration were Willis, 1962, and Niska and Willis, 1963. Incubation and emergence were derived using average subbasin water temperatures and S.T.E.P. temperature unit guidelines.

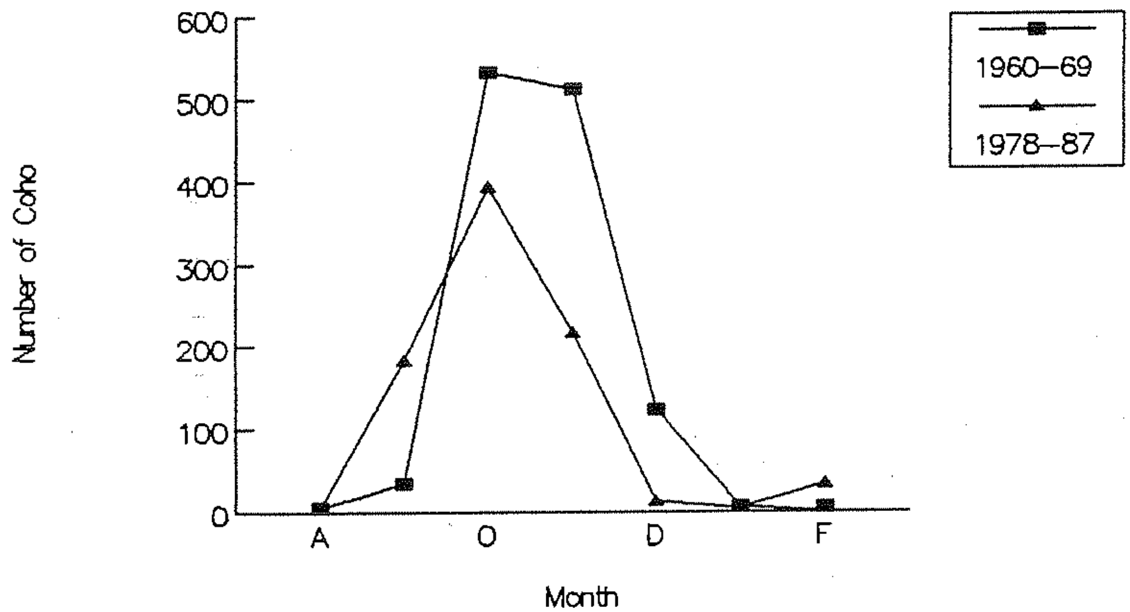


Figure 2. Average monthly counts of coho over Marmot Dam for two ten-year periods (ODFW and PGE Marmot Dam Counts).

As an example of late run timing in Lower Columbia tributaries, adult late-run coho entered Gnat Creek from mid-September to mid-February with a peak in late October. Large numbers were counted through the weir in October, November, and December (Willis 1962).

Because supplementation with early-run coho has been so extensive, most of the coho returning to the Sandy Subbasin are early-run stock, either hatchery or naturally produced (J. Massey, Oregon Department of Fish and Wildlife, pers. commun.). An estimate of run size for coho in the subbasin can be made from hatchery returns, sport catch, and Marmot Dam counts. Differentiating early-run from late-run fish in the dam counts and sport catch is difficult to accomplish with available data. The sport catch of coho above the dam is minimal, so the dam counts reflect an estimate of natural spawning for habitat above Marmot. Table 14 shows an estimate of the minimum run size of coho in the Sandy Subbasin.

Surveys by the Oregon Department of Fish and Wildlife (and by Oregon Fish Commission) reveal a drastically declining trend in natural spawning counts since 1960. Summarized counts are shown in Table 15.

These counts are for the 9.2 miles of stream used to index escapement of natural spawning coho in lower Columbia River tributaries; included are 3.5 miles on two tributaries of the Clackamas River. The counts on five of the 10 streams have been influenced by pre-smolt releases and releases of surplus hatchery adults since 1981 (P. Hirose, Oregon Department of Fish and Wildlife, pers. commun.), although these releases haven't had much effect on adult returns.

Coho return to fresh water as 2-year-old jacks or 3-year-old adults, with only a rare occurrence of 4-year-olds. Marmot Dam counts of jacks and adults from 1979 through 1987 shows an annual average of 40 jacks and 777 adults. This is an indication of the age structure of coho returning to spawn naturally in the subbasin, although data specifically for late-run coho in the Sandy Subbasin is lacking. Jacks averaged 56 percent of the coho run over the seven-year course of the Gnat Creek Weir studies, when virtually all returning salmonids were handled before being passed above the weir.

Table 14. Minimum estimated coho run in the Sandy Subbasin. The asterisk (*) designates counts which are missing from available data. (Sport catch from ODFW; Marmot Dam Counts from ODFW and PGE; Hatchery returns from ODFW, Columbia River Management. No counter was in operation at Marmot Dam in 1975, 1976, and 1977.)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Sport Catch	1115	1801	962	1967	1130	831	1014	2259	398	1884	730	1238
Marmot Count	*	*	*	411	682	632	654	722	*	872	1472	1594
Hatchery Return												
Adults	5695	8409	5359	8751	8692	9500	6884	13944	4756	12290	8145	25872
Jacks	2504	2186	1276	324	590	204	265	1234	705	279	3024	833
Minimum Run Size Estimate	9314	12396	7597	11453	11094	11167	8817	18159	5859	15325	13371	29537

Table 15. Summary of coho counts (modified from Oregon Department of Fish and Wildlife and WDF 1987).

Period	High Count	Low Count	Avg. Fish/mile
1960-69	324	116	22.8
1970-79	248	15	6.7
1980-84	81	11	3.2
1985	3		0.3
1986	51		5.5
1987	7		0.8

The sex ratio for early-run coho spawning naturally in the subbasin is not available. It is available for hatchery returns, however (see "Hatchery Production").

Data specifically for late-run coho in the Sandy Subbasin is unavailable. The adult male-to-female ratio in Gnat Creek from 1955 to 1962 averaged 1-to-1, with an average run size of 32 males, 84 jacks, and 33 females.

The adult length-weight relationship is not available for early-run coho spawning naturally in the subbasin. Adult lengths and weights from late-run coho in the Sandy River are unavailable. Lengths from coho captured at the Gnat Creek Weir showed females ranging from 23 inches to 32 inches with a peak around 28 inches. Males ranged from 10 inches to 35 inches with a peak for jacks around 18 inches, and a peak for adults between 25 inches and 30 inches (Howell et al. 1985).

Time of spawning for naturally producing early-run coho is not documented by spawning ground surveys done on a regular basis.

Observations by private individuals and by Oregon Department of Fish and Wildlife biologists indicate that spawning occurs from October to late November, not unlike the hatchery spawning time (J. Massey, Oregon Department of Fish and Wildlife, pers. commun.). A small number of early-run fish may persist into December, but differentiation between early and late runs is difficult due to the extent of supplementation and the length of time such supplementation has been practiced.

Data for late-run coho specifically in the Sandy Subbasin is lacking. Wild coho generally spawn from late November to early January, with a few stragglers spawning into February. Most of the females handled at the Gnat Creek Weir were not ripe until November 20 (Table 13).

Wild coho generally spawn higher in the system than chinook, in reaches where gravels are smaller, gradients are higher, and pool-to-riffle ratios are lower. They share many of the tributaries with steelhead.

Coho spawn and rear in virtually all of the subbasin's tributary reaches that are below impassable barriers (J. Massey, ODFW, pers. commun.). Lower tributaries such as Beaver Creek have a low gradient and general lack of quality gravel, which makes them only fair to poor coho habitat. Flow regimes and a lack of small gravel in the lower Bull Run are also poor for salmonids. Most of the other tributaries of the Sandy have good to excellent coho habitat up to impassable barriers of falls or extreme gradient.

In the mainstem Sandy River, coho spawn mainly above the mouth of the Salmon River and use the lower mainstem primarily for rearing area.

Data for fecundity of female early-run coho spawning naturally in the Sandy River and for female late-run coho is unavailable (see "Hatchery Production").

Fecundity was measured in female coho harvested from a mixed-stock run by Columbia River gill nets. Females carried from 1,800 to 4,800 eggs with a majority in the 2,000 to 3,500 range. A definite correlation between length and fecundity was observed (Howell et al. 1985).

The Oregon Department of Fish and Wildlife Comprehensive Coho Plan (ODFW 1981) cites an estimated average fecundity of 2,500 eggs per female for Oregon coho.

The development of fish eggs can be predicted using an indicator called temperature units (TU). For each 24-hour period, an egg receives one TU per degree Fahrenheit above 32 degrees of the surrounding water. Coho eggs hatch after receiving 750 TUs to 800 TUs, according to the Oregon Department of Fish and Wildlife's Salmon and Trout Enhancement Program (STEP) information. At 45 F, this translates to about 60 days from fertilization to hatching. Emergence takes place around the "button-up" period (transformation from alevin to fry, with final absorption of the yolk sac), which occurs at 1,250 TUs to 1,300 TUs, or about 98 days. In this subbasin, where water temperatures from November to February range from 40 F to 45 F, fry should emerge from about late February to early April. Emergent coho fry have been identified at Marmot Dam as late as June 1 (D. Cramer, Portland General Electric, pers. commun.).

After emergence from the gravel, juvenile coho begin to feed just prior to full absorption of the yolk sac. Optimum stream characteristics (McGie 1986) for rearing coho are as follows.

Percentage pools	50-80 percent
Gradient	<3 percent
Stream Order	2-5
Maximum temperature	<65 F

The typical life cycle has coho juveniles rearing to the yearling stage, although some migrate out of the subbasin prior to receiving their first annulus. Percentages of brood year coho in the Sandy Subbasin that migrate as fingerlings, as opposed to yearlings, are not available. Such numbers are available from the Gnat Creek Weir studies (Willis 1962).

Juvenile coho migrate out of the subbasin and into the Columbia River at 12 to 14 months of age for yearling smolts, the most common age class for coho outmigration. Analysis of scales from returning adults indicates that young-of-the-year outmigrants do not contribute significantly to adult returns, a fact blamed on early mortality (Willis 1962). Coho smolts from headwater tributaries farther from salt water tend to migrate earlier than those from streams closer to salt water. Smolt migration timing from study streams is shown in Table 16. Smolt sizes for Big Creek, Gnat Creek, and the North Fork Klaskanine River averaged 4.6 inches. Smolts averaged 4 inches in Cedar Creek (Sandy Subbasin) (Willis 1962, Niska and Willis 1963).

Table 16. Smolt migration timing from study streams in the Sandy Subbasin.

Stream	Peak Migration Period
Gnat Creek	71 percent in May, 90 percent in April and May
Big Creek	Early May to mid-June
Cedar Creek	Early April to early June
N. Fk. Klaskanine	Mid-April to late May

Egg-to-smolt survival for naturally produced early-run coho is unavailable for the Sandy Subbasin. The Oregon Department of Fish and Wildlife Coho Plan (ODFW 1981) estimates a potential egg-to-smolt survival rate of 3 percent for wild coho naturally spawned and reared.

From the weir and trapping studies, estimates were developed for wild coho production factors, such as length and fecundity, potential egg deposition, and resultant outmigrant smolts from known adult numbers. Based on these values, egg-to-smolt survival rates of 4.6 percent for Cedar Creek (Sandy Subbasin), 0.5 percent for Big Creek, 1.4 percent for the North Fork Klaskanine, and 1.5 percent for Gnat Creek were estimated. The Gnat Creek figure appears to be conservative, based on the fact that smolts may have been allowed to pass over the weir uncounted in times of high flow. The actual egg-to-smolt survival may have been closer to 2 percent if all smolts had been accounted for.

An optimistic smolt-to-adult survival rate of 7.5 percent was offered by Salo and Bayliff as referenced in the Oregon Department of Fish and Wildlife Coho Plan. Estimates can be derived from data presented in the Gnat Creek Weir studies for smolt-to-adult, smolt and fingerling-to-adult, smolt-to-jack and adult, or smolt and fingerling-to-jack and adult rates. The smolt outmigrant rates are probably best, based on the assumption (which has some research basis) that fingerling outmigrants do not contribute significantly to adult returns (Willis 1962). Estimates for survival rates for brood years 1955 through 1958 are shown in Table 17.

Table 17. Survival rates estimates for brood years 1955 through 1958 (in percent).

Brood Year	Smolt-to-Adult	Smolt-to-Jack and Adult
1955	2.34	5.31
1956	3.19	8.61
1957	1.68	6.02
1958	2.26	8.86
AVG.	2.37 percent	7.20 percent

The Northwest Power Planning Council's smolt production model estimates smolt production for each species in a subbasin, based on the best available data on a reach-by-reach basis. Values for species presence, type of use (spawning and rearing versus rearing only), habitat quality, total length of reach, low flow width of reach, and length of reach used by a species are entered into the data base for each reach. The model then calculates the potential smolt production at full seeding of the habitat.

The original Northwest Power Planning Council model estimated the total subbasin smolt production based on this standard estimation method at 971,011 fish. The model appeared to overestimate production on a large scale and was revised to more closely approximate the Oregon Department of Fish and Wildlife method (see below). The revised Northwest Power Planning Council estimate for full seeding smolt production at the current habitat condition is 143,763 smolts.

An estimate developed by Oregon Department of Fish and Wildlife personnel estimated the carrying capacity or smolt production to be 92,567 fish for the Sandy Subbasin. This methodology incorporates stream width and gradient into calculations for coho production, and associates a quality value for each reach based these parameters. Narrower streams with a favorable gradient produce more coho than streams over 90 feet or those with a gradient too low or too high, according to this model.

The Mount Hood National Forest estimates the coho smolt production potential within the forest boundaries on the Sandy to be 316,700 fish. This estimate was developed with the assistance of the Oregon Department of Fish and Wildlife and other agencies with fish management expertise. Mount Hood National Forest and Portland General Electric biologists believe that the estimates generated by the Oregon Department of Fish and Wildlife and Northwest Power Planning Council methods are low for coho smolt production. The ODFW method uses a smolt density approximately half that of observed smolt densities in Fish Creek of the Clackamas system, a drainage that has been extensively studied for the pre- and post-project effects of habitat improvement. The national forest and Portland General Electric do realize that the Northwest Power Planning Council estimate is a standardized method used throughout the Columbia Basin to estimate the benefits of actions and strategies, and may not reflect actual smolt capacity. The smolt densities used in the Northwest Power Planning Council estimate were offered by the Monitoring and Evaluation Group (MEG) from studies in other drainages. Depending on the degree to which the study streams differ physically and morphologically from the Sandy Subbasin, there is a potential for the model's estimate to deviate from the true value.

A lack of subbasin-specific data for many natural production factors used in the estimates may limit the model's reality. Through use of the fitting parameter, the System Planning Model baseline files can be calibrated to simulate "real" adult return numbers. While the estimate of smolt production may not reflect accurate numbers, the model's calibration step should allow for use of the estimated smolt numbers in the process of evaluating the benefits of proposed strategies.

Supplementation History

Oregon Department of Fish and Wildlife hatcheries and the Salmon and Trout Enhancement Program (STEP) have stocked early-run coho as fry and pre-smolts to supplement natural spawning in tributaries of the Sandy River. An average of 450,000 fry were released annually in the 1960s. Fry and pre-smolt releases in the 1970s were done infrequently using surplus fish. In the 1980s, campaigns were launched to again supplement natural spawning (in the wake of the "El Nino" years) with releases of fry and pre-smolts. Pre-smolt releases in 1981 through 1984, and in 1986 averaged 257,500 fish annually. Fry releases in 1980 and from 1982 through 1986 averaged 179,000 fish annually. Release data are shown in Appendix D.

Marmot Dam counts have risen in the last few years, and spot surveys of juveniles in stream reaches that normally do not hold many rearing coho have revealed large rearing populations (J. Massey, ODFW, pers. commun.). These positive results cannot be completely attributed to the pre-smolt and fry releases, due to the regulated ocean harvest that has occurred in the 1980s, but off-station releases certainly could be a contributing factor. Fry and pre-smolts are not marked for evaluation of such releases.

Anticipated facilities and supplementation actions for coho in the Sandy Subbasin include remodeling the adult ponds at Sandy Hatchery for additional rearing, and adding new wells for hatchery water source. The Oregon Department of Fish and Wildlife's Restoration and Enhancement Program identifies supplementation and habitat enhancement actions to be addressed further and implemented in the next six years. Projects for the Sandy Subbasin have only been proposed at this time. Further planning and implementation will take place in the near future, in cooperation with the Columbia Basin system planning effort.

Fish Production Constraints

Major constraints to the natural production of early-run coho in the subbasin are listed in Table 18. They include impassable barriers, low flow, siltation of spawning gravels, gradient, and pool-to-riffle ratio. Specific examples include the barriers of the Bull Run water supply system, the low flows below Marmot and Little Sandy diversion dams, siltation in Beaver Creek and the lower mainstem, and high gradients with a lack of pools found in upper tributaries such as the Zigzag River (see also Part II).

Hatchery Production

The first hatchery on the Sandy was operated at a facility at the mouth of Boulder Creek on the Salmon River from 1898 to 1912. Originally intended as a steelhead hatchery, spring chinook were more readily available and were raised in greater numbers than steelhead. After Marmot Dam was built, flows below the dam no longer attracted fish, and the operation of the Salmon River Hatchery was discontinued. From 1913 to 1925, other facilities were operated to raise spring and fall chinook. Their locations and dates are somewhat unclear, but records indicate activities at "Lower Sandy River Hatchery," "Big Sandy River Hatchery," and the "Bull Run Feeding Ponds." From 1938 to 1948, a small hatchery was active immediately below Marmot Dam, but by 1948 was only operated for taking eggs (Wallis 1966). Presently two hatcheries are producing fish in the subbasin, although one is strictly for educational and not production purposes.

Late-run coho are not produced by Oregon hatcheries or released in the subbasin. They are, however, raised at Washington hatcheries on the Lewis and Cowlitz rivers (Howell et al. 1985). Coho produced for release in the subbasin are of the early-run stock.

Sandy Hatchery (ODFW)

Sandy Hatchery, built in 1950, is located 1.5 miles north of the town of Sandy in Clackamas County. The site is 0.5 miles up Cedar Creek from its confluence with the Sandy River. The Sandy Hatchery raises strictly early-run coho salmon with brood stock from adult hatchery returns. Historically, hatcheries on the Sandy once raised fall chinook and winter steelhead, but these species have been discontinued from production at this facility.

Table 18. Sandy Subbasin constraints to natural production of coho. (NPPC Fish and Wildlife Data Base 1988).

NAME	FROM	TO	TRIBUTARY TO	HABITAT QUALITY	COHO CONSTRAINTS			
BEAVER CR	MOUTH	KELLY CR	SANDY R	3	FLO	SED	TEM	
KELLY CR	MOUTH	HEADWATERS	BEAVER CR	3	FLO	SED	TEM	PSB
BEAVER CR	KELLY CR	BEAVER CR, N FK	SANDY R	3	FLO	SED	TEM	
BEAVER CR, S FK	MOUTH	BEAVER CR, S FK, M FK	BEAVER CR	3	FLO	SED	TEM	
BEAVER CR, N FK	MOUTH	HEADWATERS	BEAVER CR	3	FLO	SED	TEM	
BIG CR	MOUTH	POUNDER CR	SANDY R	3	PSB	PTR	GQN	
BULL RUN R	MOUTH	LAUGHING WATER CR	SANDY R	3	FLO	OTH		
BULL RUN R	LAUGHING WATER CR	BOWMAN CR	SANDY R	3	FLO	GQN		
BULL RUN R	BOWMAN CR	LITTLE SANDY R	SANDY R	3	FLO			
LITTLE SANDY R	MOUTH	SIEVERS CR	BULL RUN R	4	FLO	PSB		
BULL RUN R	LITTLE SANDY R	BULL RUN RES 2	SANDY R	3	FLO	GQN		
SANDY R	BULL RUN R	KOTZMAN CR	COLUMBIA R	2	FLO			
SANDY R	KOTZMAN CR	CEDAR CR	COLUMBIA R	2	FLO			
SANDY R	CEDAR CR	BADGER CR	COLUMBIA R	2	FLO			
SANDY R	BADGER CR	WHISKY CR	COLUMBIA R	2	FLO			
ALDER CR	MOUTH	HEADWATERS	SANDY R	2	PSI			
WILDCAT CR	MOUTH	HEADWATERS	SANDY R	2	PTR	PSB		
BOULDER CR	MOUTH	HEADWATERS	SALMON R	2	PTR			
CHEENEY CR	MOUTH	LITTLE CHENEY CR	SALMON R	3	PTR	CVR	PSI	
SALMON R, S FK	MOUTH	MACK HALL CR	SALMON R	3	PTR	GQN		
BIGHORN CR	MOUTH	HEADWATERS	SALMON R	3	PTR	PSI		
COPPER CR	MOUTH	HEADWATERS	SALMON R	2	PTR	PSI		
SANDY R	SALMON R	HACKETT CR	COLUMBIA R	3	SED	CHN	CVR	PTR
HACKETT CR	MOUTH	HEADWATERS	SANDY R	2	SED	CHN		
SANDY R	HACKETT CR	BEAR CR	COLUMBIA R	3	SED	CHN	CVR	
BEAR CR	MOUTH	HEADWATERS	SANDY R	2	SED	CHN		
SANDY R	BEAR CR	ZIGZAG R	COLUMBIA R	3	SED	CHN		
ZIGZAG R	MOUTH	ROCKWOOD CR	SANDY R	3	PTR			
ZIGZAG R	ROCKWOOD CR	HENRY CR	SANDY R	3	PTR			
HENRY CR	CALDWELL CR	HEADWATERS	ZIGZAG R	2	PTR	PSI		
ZIGZAG R	HENRY CR	STILL CR	SANDY R	3	PTR			
COOL CR	MOUTH	HEADWATERS	STILL CR	3	PTR	PSI		
STILL CR	COOL CR	HEADWATERS	ZIGZAG R	2	PTR	PSI		
ZIGZAG R	STILL CR	CAMP CR	SANDY R	3	PTR			
CAMP CR	MOUTH	BRUIN RUN CR	ZIGZAG R	3	GQN	PTR		
BRUIN RUN CR	MOUTH	HEADWATERS	CAMP CR	2	PTR			
CAMP CR	BRUIN RUN CR	WIND CR	ZIGZAG R	3	GQN	PTR		
CAMP CR	WIND CR	HEADWATERS	ZIGZAG R	2	GQN	PSI	SED	

(continued)

Table 18 continued. Coho constraints.

NAME	FROM	TO	TRIBUTARY TO	HABITAT QUALITY	COHO CONSTRAINTS		
ZIGZAG R	CAMP CR	DEVIL CANYON	SANDY R	3	GQN	SED	PTR
DEVIL CANYON	MOUTH	HEADWATERS	ZIGZAG R	2	GQN	PTR	PSB
ZIGZAG R	DEVIL CANYON	LADY CR	SANDY R	3	PTR		
ZIGZAG R	LADY CR	LITTLE ZIGZAG CANYON	SANDY R	3	PTR		
SANDY R	ZIGZAG R	CLEAR CR	COLUMBIA R	3	SED	GQN	
CLEAR CR	MOUTH	LITTLE CLEAR CR	SANDY R	2	CVR		
CLEAR CR	LITTLE CLEAR CR	HEADWATERS	SANDY R	3	PSI		
SANDY R	CLEAR CR	HORSESHOE CR	COLUMBIA R	2	SED	GQN	PTR
HORSESHOE CR	MOUTH	HEADWATERS	SANDY R	2	PSI	PTR	
SANDY R	HORSESHOE CR	LOST CR	COLUMBIA R	2	GQN	SED	PTR
LOST CR	MOUTH	CAST CR	SANDY R	2	PTR		
SANDY R	LOST CR	SANDY R, CLEAR FK	COLUMBIA R	3	GQN	SED	PTR
SANDY R	SANDY R, CLEAR FK	SANDY R, MUDDY FK	COLUMBIA R	3	SED		
SANDY R, MUDDY FK	MOUTH	HEADWATERS	SANDY R	3	SED		

KEY: FLO = LOW FLOW; SED = SEDIMENT; TEM = TEMPERATURE; GQN = GRAVEL QUANTITY; CVR = INADEQUATE COVER; PSB = PASSAGE BLOCKED; PSI = PASSAGE IMPEDED; PTR = UNFAVORABLE POOL-TO-RIFFLE RATIO; CHN = CHANNELIZATION; OTH = OTHER

HABITAT QUALITY: 1 = EXCELLENT 4 = POOR

Water for incubating eggs, rearing juveniles, and holding adults is drawn from Cedar Creek in the range of 5 cfs to 20 cfs; a nearby spring provides water for the personnel residences at the rate of 50 to 75 gallons per minute (gpm). The water supply is obtained by way of a concrete dam 50 feet long and 3 feet high. A 1,285-foot pipeline delivers water to the facility through two headboxes.

For incubating eggs and fry, the hatchery has 24 troughs 16 inches deep, 16 feet long, and 14 inches wide. Sandy Hatchery has 20 raceways, each 20 feet wide and 80 feet long, and are arranged in two batteries of 10 raceways each. (Wallis 1966). They are approximately 4 feet deep and are concrete lined. Water depth is approximately 3.5 feet. Each raceway is partially divided lengthwise by a concrete center wall, which can be extended at both ends to form 40 raceways 10 feet wide. The center wall design provides a circular flow in the pond.

The adult holding pond was constructed in 1959. It is built of concrete, and is 35 feet by 78 feet with a 4.5-foot depth (Wallis 1966). A rack across Cedar Creek prevents adult fish from passing upstream of the hatchery and diverts them into the ponds through a 68-foot fish ladder. Water for the holding ponds comes from the main water supply or from the effluent of the rearing ponds.

The Sandy Hatchery currently raises only early-run coho salmon, the majority of which are released on-station as smolts. Production of fall chinook, spring chinook, and steelhead have not occurred at Sandy Hatchery since brood years 1976, 1975, and 1974, respectively.

Sandy Hatchery was built under the Columbia River Fishery Development Program, financed by the U.S. Fish and Wildlife Service. The original purpose of the facility was to produce additional fish for the Sandy River runs, and to rehabilitate fish runs in Sandy River tributaries above Marmot Dam. Under this program, Sandy Hatchery was also used to develop and expand fisheries in the Willamette system. In the late 1970s, production was shifted to exclusively raise coho salmon.

The present facility goal is to produce 1 million coho smolts annually, which eventually contribute to ocean and Columbia River harvest, subbasin sport harvest, and escapement for hatchery returns. Off-station releases of excess adults, fry, and pre-smolts supplement natural early-run coho production in tributaries. Compensation for steelhead and spring chinook production lost to Portland General Electric and city of Portland projects is accomplished at Clackamas Hatchery in the Willamette Subbasin, and at Gnat Creek Hatchery on the lower Columbia River.

Studies conducted in 1959 and 1960 indicated that the capacity of each pond was 70,000 yearlings, or a total of 1.4 million smolts. Low flows and high water temperatures in the fall and summer often limit production, however. With adequate flow, each raceway is capable of producing about 4,500 pounds of fish (0.9 pounds per cubic foot of rearing space), but seldom is this level of flow available in the summer and fall critical period. Smolts are raised to about 15 fish per pound; typically 66,700 pounds are produced. Incubation troughs are available for a capacity of 5 million eggs and 3.5 million fry. Appendix E shows annual production at Sandy Hatchery.

Walters' (1989) hatchery evaluation indicates that Sandy Hatchery exceeded theoretical production levels during the study period. Theoretical flow requirements were 112 percent to 244 percent of the available flow during the summer and fall low-flow period. The study also indicates that any attempted increases in production will require new rearing technology such as oxygen supplementation. Water supply limits annual production to about 1 million smolts (J. Massey, Oregon Department of Fish and Wildlife, pers. commun.). The raceway water supply often dips to 2,000 gpm in the late summer or early fall (K. Bourne, Sandy Hatchery manager, Oregon Department of Fish and Wildlife, pers. commun.).

Presently, biologists collect coho brood stock only at the hatchery trap. In the past, brood stock of coho, steelhead, and chinook were collected at stations such as Marmot, Lake Oswego, and on the Bull Run (Wallis 1966).

In the early part of the run (prior to October 10), fish that enter the trap and holding ponds at Sandy Hatchery are not ripe and generally contract fungus and die before they ripen. The current practice is to sell these fish as surplus until after October 10 (R. Whitlatch, ODFW, pers. commun.). If indications are that the coho run may be low for a given year, the early-returning adult coho are held in an attempt to use every fish for spawning, even though most of them die. Ripe fish are used as they come in, and fish in the pond are used as they ripen. In an attempt to spawn randomly, males and jacks are stripped of milt into a common bucket, forming a sperm pool. A scoop of this sperm pool is then used to fertilize a bucket of eggs, stripped from a number of females.

Mount Hood Community College Hatchery (MHCC)

A small hatchery facility is operated by the students and faculty of Mount Hood Community College, near Gresham in Multnomah County. Beaver Creek and Kelly Creek are water sources for propagation activities. The goal of this program is strictly educational, and no effort is made to evaluate adult returns from releases (J. Graybill, Instructor, MHCC Fishery Program, pers. commun.). The program raises chinook or coho salmon from eggs obtained from Bonneville or Sandy hatcheries; 5,000 to 10,000 fish are produced annually. None are marked for later recognition.

The facility consists of 32 circular tanks of 3 feet in diameter, and three circular tanks of 6 feet in diameter, in addition to troughs and egg incubators for about 10,000 fish. In recent years, the program at Mount Hood Community College has been incorporated into STEP.

Life History and Population Characteristics

Hatchery return size is available for Sandy Hatchery for the years 1978 through 1986 (Table 19). Returns over those years averaged 6,384 males, 4,598 females, and 829 jacks. Hatchery contribution to the sport catch in the Sandy is unknown. The contribution of hatchery-raised fish that stray to spawn naturally is also unknown.

Trapping activities at Sandy Hatchery indicate adult timing of entry into the subbasin. In general, coho are trapped from mid-September through December, although low water flows or production needs may affect the starting and ending dates. For Sandy Hatchery data from 1978 through 1987, trapping has started as early as September 10 and as late as October 22; the trap has been closed as early as November 29 and as late as January 10 (egg and fry data, rearing data, and adult data tables provided by R. Sheldon, ODFW Columbia Region Hatchery Coordinator, August 1988).

Peak sport catch occurs in September and October. The first coho probably enter the Sandy in August, but angling for salmon is closed through August 31.

Returning coho are 2-year-old jacks or 3-year-old adults. Of the hatchery returns that entered Sandy Hatchery in 1978 through 1986, adults averaged 93 percent of the total run (egg and fry data, rearing data, and adult data tables provided by R. Sheldon, ODFW Columbia Region Hatchery Coordinator, August 1988).

Of 3-year-old adults returning to the Sandy Hatchery each year from 1978 through 1986, an average of 42 percent were females. The range in that time period was from 36 percent to 49 percent (Table 19).

Table 19. Sandy Hatchery early-run coho salmon returns (ODFW unpublished data).

YEAR	OCEAN AGE	NUMBER MALES	NUMBER FEMALES	TOTAL NUMBER	FRACTION FEMALES	EGGS PER FEMALE
1978	1	324		324	0.00	
	2	5,023	3,728	8,751	0.43	2,981
1979	1	590		590	0.00	
	2	5,565	3,127	8,692	0.36	2,947
1980	1	204		204	0.00	
	2	5,368	4,132	9,500	0.43	2,281
1981	1	265		265	0.00	
	2	3,790	3,094	6,884	0.45	2,495
1982	1	1,234		1,234	0.00	
	2	8,263	5,681	13,944	0.41	2,575
1983	1	705		705	0.00	
	2	2,873	1,883	4,756	0.40	1,638
1884	1	279		279	0.00	
	2	6,300	5,990	12,290	0.49	2,714
1985	1	3,024		3,024	0.00	
	2	5,072	3,073	8,145	0.38	2,771
1986	1	833		833	0.00	
	2	15,198	10,674	25,872	0.41	2,042
AVERAGE	1	829	0	829	0.00	0
78-86	2	6,384	4,598	10,982	0.42	2,494

Data for the length/weight relationship of hatchery coho in the subbasin is unavailable.

The time of spawning at Sandy Hatchery, like the time of trapping, is also widely variable and depends on production needs, water flow, and return numbers. In data from 1978 to 1987, the first spawning date has been as early as October 15 and as late as November 9. The last spawning date of the season has been as early as November 1 and as late as December 19.

Fecundity was measured in female coho harvested from a mixed-stock run by Columbia River gill nets. Females carried from 1,800 to 4,800 eggs with a majority in the 2,000 to 3,500 range. A definite correlation between length and fecundity was observed (Howell et al. 1985).

The average fecundity of female coho at Sandy Hatchery from 1978 through 1986 was 2,494 eggs per female. The annual averages ranged from 1,638 to 2,947 eggs per female (egg and fry data, rearing data, and adult data tables provided by R. Sheldon, ODFW, Columbia Region Hatchery Coordinator, August 1988). The low figure represents fecundities from fish that returned after maturing in the ocean under the effects of "El Niño." Length and weight figures were also low in that year.

The Oregon Department of Fish and Wildlife Comprehensive Coho Plan (ODFW 1981) cites an estimated average fecundity of 2,500 eggs for Oregon coho females.

Incubation begins immediately after spawning and fertilization of the eggs, which occurs at Sandy Hatchery from mid-October to mid-December.

The development of fish eggs can be predicted using an indicator called TUs, or temperature units (see Natural Production, above). The 10-year average (ending with 1987) for Sandy Hatchery coho is 758 TUs at hatching (egg and fry data, rearing data, and adult data tables provided by R. Sheldon, Oregon Department of Fish and Wildlife Columbia Region Hatchery Coordinator, August 1988). Initial feedings in a hatchery environment take place prior to the "button-up."

Mean water temperatures at Sandy Hatchery are shown in Figure 4 (in Part II). The average temperature for November through February is 42 F, which would translate into 78 days from fertilization to hatching and 128 days to "button-up." At these rates, hatching should take place at Sandy Hatchery in January and February, with "button-up occurring in March and April. Coho are ponded in March or April.

Coho smolts are reared until they are 12 to 14 months of age, and are released in late April or early May. The target size at release is 10 to 15 fish to the pound (J. Massey, Oregon Department of Fish and Wildlife, pers. commun.). Hatchery smolts are assumed to emigrate to the Columbia River immediately after release from the ponds.

Egg-to-smolt survival for early-run hatchery coho averaged 0.82 between 1978 and 1981, and 0.88 for 1982 through 1985. The overall average was 0.85 (egg and fry data, rearing data, and adult data provided by R. Sheldon, ODFW, Columbia Region Hatchery Coordinator, August 1988)(Table 20).

Table 20. Sandy Hatchery early-run coho juvenile survival rates (ODFW, unpub. data).

YEAR	RATE OF EGG LOSS	ESTIMATED RATE OF EGG-FRY SURVIVAL	RATE OF FRY LOSS	RATE OF MORTALITY IN THE POND	ESTIMATED RATE OF FRY-SMOLT SURVIVAL	ESTIMATED RATE OF EGG-SMOLT SURVIVAL
1978	0.078	0.922	0.016	0.047	0.938	0.865
1979	0.134	0.866	0.026	0.061	0.915	0.792
1980	0.071	0.929	0.015	0.098	0.888	0.825
1981	0.064	0.936	0.011	0.132	0.858	0.803
1982	0.054	0.946	0.015	0.030	0.955	0.904
1983	0.089	0.911	0.013	0.046	0.941	0.858
1984	0.064	0.936	0.010	0.022	0.968	0.906
1985	0.145	0.855	0.010	0.014	0.976	0.834
1986	0.140	0.860	0.015			
Average						
'78-81		0.91			0.90	0.82
'82-85		0.90			0.96	0.88
'78-85		0.91			0.93	0.85

Smolt-to-adult survival for early-run hatchery coho has been estimated in propagation evaluation projects using coded-wire tag data compiled by the Pacific Marine Fisheries Commission. The commission's mark recovery program evaluates releases of tagged lots of fish by reporting the number of tags recovered in ocean and inland fisheries, along with hatchery returns. The results of propagation evaluations for coho from brood years 1975 through 1983 is shown in Table 21. Hatchery returns averaged 1.1 percent of the total release, while inland sport catch accounted for less than 0.5 percent for all of those brood years.

Table 21. Results of propagation evaluation studies using tagged coho salmon from Sandy Hatchery (ODFW unpublished data).

BROOD YEAR	RELEASE YEAR	NUMBER TAGGED	TOTAL RELEASE	1_/ OREGON: CATCH AND HATCHERY RETURNS		2_/ OREGON: COLUMBIA AND INLAND SPORT		3_/ PERCENT ACCOUNTED FOR IN OREGON		4_/ PERCENT ACCOUNTED FOR -- TOTAL	
				Jack	Adult	Jack	Adult	Jack	Adult	Jack	Adult
1975	1977	438,342	940,256	925	38,062	0	0	0.10	4.05	0.11	6.56
1976	1978	300,294	623,928	472	26,107	0	35	0.08	4.18	0.12	6.45
1977	1979	110,345	907,050	584	22,301	0	0	0.06	2.46	0.06	3.32
1978	1980	201,966	987,242	118	18,561	0	0	0.01	1.88	0.01	2.38
1979	1981	284,394	1,128,127	389	24,574	0	139	0.03	2.18	0.04	2.62
1980	1982	269,755	996,831	1,405	18,256	0	0	0.14	1.83	0.14	2.27
1981	1983	163,049	304,537	98	10,395	0	0	0.03	3.41	0.03	3.61
1982	1984	209,246	1,038,938	133	13,472	0	0	0.01	1.30	0.01	1.42
1983	1985	289,273	786,185	1,594	64,696	0	1,549	0.20	8.23	0.20	9.01
AVERAGES:		251,852	857,010	635	26,269	0	191	0.07	3.28	0.08	4.18

1_/ Includes ocean and inland catch, sport and commercial, and hatchery returns.
2_/ Includes only those fish caught in Columbia River mainstem or tributaries. (Excludes estuary)
3_/ Includes sport and commercial catch, ocean and inland, and hatchery returns.
4_/ Includes all fish from total release accounted for in OR, WA, CA, AK, and B.C.

Constraints to Hatchery Production

Descriptions of constraints and problems at Sandy Hatchery were obtained from Richard Whitlatch, hatchery manager, Oregon Department of Fish and Wildlife, in December 1988.

1. Diseases

   Cold water disease has been the most prevalent cause of mortality at Sandy Hatchery. It occurs in the first two months after the coho fry are ponded if average temperatures are below 40 F. Cold water disease affected brood years 1978 through 1984, and is present to some extent in most years. Mortalities in 1978 through 1984 broods ranged from 2.2 percent to 12.6 percent of ponded coho. Managers attempt treatment for this disease.

   Columnaris, an external bacteria, also affects rearing coho at Sandy Hatchery. It appears yearly with various extent, and treatment measures are attempted.

   Bacterial kidney disease and Costia outbreaks also occur on an occasional basis. They normally occur at minimal levels, and are generally not treated. Furunculosis occurs on an occasional basis and is normally treated.

2. Predation

   Predation at Sandy Hatchery is minimal, and cannot be considered a constraint on production. Occasional visits by blue herons, kingfishers, and mink occur, but not on a chronic basis.

3. Water Quality

   Water quality is generally good at Sandy Hatchery, aside from summer and fall temperatures and low flows, which limit production. Recirculation pumps are used to maintain flows through the rearing ponds from July until the first fall freshet, which usually occurs in mid-October. Without the reuse of water, the hatchery's production would be about half of present levels. Dissolved oxygen levels are well within desirable limits for propagation activities. An 80-foot by 24-foot concrete settling tank reduces turbidity of the water prior to use in the ponds and incubators.

Actions That Could Improve Production

Production at Sandy Hatchery is presently limited by summer flows; improvements should concentrate on that constraint. A new well has been suggested, but no proposal or feasibility study has been done at this time.

Harvest

The harvest of coho in the Sandy River occurs almost exclusively below Marmot Dam (J. Massey, Oregon Department of Fish and Wildlife, pers. commun.). Sport anglers harvested an average of 1,277 coho each year, from 1975 to 1986 (Oregon salmon and steelhead catch data, 1975-1987, Oregon Department of Fish and Wildlife Fish Division, Portland, Oregon, April 1989). Subbasin harvest is shown in Table 14 above.

Evaluations of Sandy Hatchery coho releases have been done using coded-wire tagged fish and reports of tag recoveries from the Pacific states and British Columbia. The results of harvest contributions from 13 tagged lots of coho smolts are shown in Table 22.

Few jacks are harvested in the ocean and mainstem fisheries, as opposed to higher adult contributions. The Oregon ocean commercial fisheries and non-Oregon ocean fisheries harvested an average of over 1 percent of the tagged fish each, while the freshwater and estuary commercial and ocean sport fisheries harvested between 0.5 percent and 1 percent each. The freshwater and estuary sport fisheries harvested an average of less than 0.1 percent, most of which was in the estuary (Buoy 10) fishery. The contribution to subbasin fisheries is very small compared to the ocean and mainstem fisheries.

No harvest management goals for early-run coho have been formulated for the Sandy Subbasin. Propagation evaluation studies using coded-wire tagged fish show a much greater contribution to the ocean and Lower Columbia River fisheries than to the Sandy River sport catch. Early-run coho from the Sandy River are managed primarily for their contribution to non-subbasin fisheries, although some harvest in the subbasin is desired by fall anglers.

Table 22. Harvest contributions of tagged coho salmon from Sandy Hatchery, in percent of number tagged (ODFW, unpublished data).

BROOD YEAR	RELEASE YEAR	NUMBER TAGGED	OREGON OCEAN SPORT CONTRIBUTION		OREGON OCEAN COMM. CONTRIBUTION		NON-ORE. SW[1] CONTRIBUTION	FRESHWATER AND ESTUARY SPORT CONTRIBUTION		FRESHWATER AND ESTUARY COMM. CONTRIBUTION	
			Jack	Adult	Jack	Adult	Comb.	Jack	Adult	Jack	Adult
1975	1977	141,592	0.0000	0.6060	0.0000	1.9147	2.4225	0.0000	0.0155	0.0254	0.1695
1975	1977	296,750	0.0020	0.6912	0.0000	2.2746	2.7171	0.0000	0.0074	0.0007	0.2945
1976	1978	301,564	0.0060	0.4208	0.0153	2.1243	2.3149	0.0000	0.0040	0.0023	0.2563
1977	1979	110,345	0.0000	0.4876	0.0000	0.8256	0.8772	0.0000	0.0000	0.0000	0.2266
1978	1980	201,623	0.0000	0.2296	0.0000	0.9850	0.5213	0.0000	0.0000	0.0000	0.0134
1979	1981	286,021	0.0000	0.2489	0.0000	0.7566	0.4895	0.0000	0.0388	0.0126	0.0325
1980	1982	270,055	0.0000	0.3677	0.0000	0.8891	0.6865	0.0000	0.0093	0.0133	0.0185
1981	1983	163,049	0.0018	0.3741	0.0000	0.0196	0.6464	0.0000	0.1907	0.0000	1.4309
1982	1984	209,266	0.0000	0.2346	0.0000	0.0702	0.2666	0.0000	0.0311	0.0000	0.3364
1983	1985	289,273	0.0014	0.4688	0.0000	1.0191	0.7422	0.0031	0.3875	0.0045	3.3598
1984	1986	326,835	0.0000	0.4932	0.0000	1.1694	0.5253	0.0058	0.0854	0.0000	0.9405
1985	1987	373,750	0.0008	0.5702	0.0000	1.5575	0.6440	0.0000	0.1926	0.0112	0.8321
1985	1987	30,776	0.0162	1.1470	0.0000	3.6067	1.1632	0.1950	0.3022	0.0520	1.3257
AVERAGES:			0.0022	0.4877	0.0012	1.3240	1.0782	0.0157	0.0973	0.0094	0.7105

1_/ Non-Oregon Saltwater (Ocean) Contribution includes WA, CA, AK, and B.C. sport and commercial harvest of adults and jacks.

An individual angler's harvest of salmon and steelhead is regulated by the catch record card limit in the Oregon sport fishing regulations. An angler is limited to 40 adult salmon and steelhead per year, in any combination. Daily and weekly limits are two and six fish, respectively. This weekly limit applies to any seven consecutive days. No quotas or other catch restrictions are in effect for total coho catch inside the subbasin. Many of the special regulations on the Sandy and its tributaries are designed to allow natural spawning to proceed without harassment or reduction from legal sport catch or snagging. Special regulations are in effect for the Sandy River, although not all are specifically for managing coho:

1. The Sandy River up to Brightwood Bridge (near the mouth of the Salmon River) is closed to salmon angling from July 15 to August 31. In addition, a marked zone around the mouth of Cedar Creek may be fished only with a single point hook of 5/8 inch or less, between September 1 and November 15. This regulation is in effect to prevent snagging. No angling is allowed from a floating device above the lower boundary to Oxbow Park. This regulation was developed to provide angling opportunities for bank anglers and to reduce conflicts between bank and boat anglers.

2. In the mainstem and tributaries above Brightwood Bridge, angling is closed all year for adult and jack salmon to allow for natural production, but open for steelhead angling from the fourth Saturday in May to December 31. Angling from a floating device is not allowed.

3. The Bull Run River up to the watershed boundary is open for salmon and steelhead angling all year, with the standard catch limits. A special closure above and below the Bull Run Powerhouse is in effect all year, for angler safety.

4. Cedar Creek is closed to angling from the hatchery dam to the Sandy River, to protect salmon returning to the hatchery.

5. The Salmon River up to Final Falls is closed for adult and jack salmon to protect holding and spawning fish, and open for steelhead angling from the fourth Saturday in May to December 31. Fly angling only is allowed from U.S. Forest Service Bridge 2618 up to Final Falls.

6. Tributaries not listed in the regulations are closed to salmon and steelhead angling. This is to protect naturally spawning fish.

The harvest of salmon and steelhead in Oregon streams is monitored by using catch record card data from angler returns.

Estimates of annual catch for the Sandy and major tributaries can be made from expansions of reported catch on the punch cards that are returned by anglers (Oregon salmon and steelhead catch data, 1975-1987, ODFW, Fish Division, Portland, Oregon, April 1989).

In Oregon, the game division of the Oregon state police has enforcement responsibility for administering fish and wildlife regulations set by the Oregon Legislature and by the Oregon Fish and Wildlife Commission. Officers make regular patrols and angler license checks, issuing citations to offenders of game regulations.

Specific Considerations

Coho are managed for hatchery stocks in the tributaries of the lower Columbia River. Approximately 1 million coho smolts are produced annually at Sandy Hatchery for release into the subbasin. Sandy Hatchery is currently raising only coho salmon. Coho smolts are released on-site from the facility on Cedar Creek. Pre-smolts and fry are released in and out of the subbasin by the hatchery and the STEP hatch box program.

The Sandy River up to Brightwood Bridge is closed to salmon angling from July 15 to August 31 to protect returning adults when the flows are low and the fish are vulnerable to snagging and vandalism. The Cedar Creek mouth area has a single-point hook regulation in the fall to prevent snagging. The mainstem Sandy and tributaries above Brightwood Bridge are closed all year to salmon angling.

The annual harvest of coho in the Sandy River averaged 1,277 fish from 1975 to 1986. This harvest in the subbasin is relatively low, when compared to the harvest of subbasin-produced coho in the ocean and the Columbia River fisheries. To maintain the hatchery production at current levels, Sandy Hatchery needs an adult return of about 5,120 fish (2,150 females). Returns have met or exceeded this number for all but one year from 1975 to 1986.

The production of hatchery fish is limited by the low water supply in the fall. Sandy Hatchery often operates at or near capacity of the current water supply system, and any proposed increases in fish production will require an increase in the water supply.

Natural spawning by late-run coho is at extremely low levels in the tributaries of the lower Columbia River, according to Oregon Department of Fish and Wildlife Columbia River Management surveys; the Sandy River is no exception.

The city of Portland's Bull Run water supply dams have blocked passage to many miles of historic coho spawning habitat. The city mitigates for such loss by funding the hatchery production of other species, which are released elsewhere in the system.

Factors that limit natural production in the subbasin include low summer flow, sedimentation, and high temperatures in the lower tributaries. The upper subbasin coho production is limited by constraints such as blocked passage, pool-to-riffle ratio, lack of stream cover, channelization and loss of habitat diversity, and a lack of spawning gravel. Sedimentation in some of the upper tributaries is also a problem.

The subbasin has been stocked intensively with early-run coho for many years, probably to the detriment of the late-run native coho. Competition between naturally spawned and planted early-run juveniles may affect the survival or growth of late-run juveniles. The pure native stock may not exist in the Sandy River or other lower Columbia tributaries, due to the fact that coho have a propensity for straying into non-natal streams.

Critical Data Gaps and Uncertainties

1. Adult run size, especially for late run. The late-run stock is at extremely low levels, and considered to be a remnant run if it exists at all. Marmot Dam counts indicate very few fish passing above the dam in January and February.

2. Juvenile emigrant numbers.

3. Egg-to-smolt survival rate.

4. Smolt-to-adult survival rate.

5. Genetic integrity of late run. The genetic integrity of the late-run stock may not be intact. The release of early-run stock in the upper basin has taken place for many years.

6. Emergence timing.

7. Length/weight relationship.

8. Fecundity.

9. Sex ratio.

10. Spawning time.

Objectives

Management Policies

1. Management of coho in the Sandy Subbasin will be primarily for natural and hatchery production of early-run stock.

2. The production of coho in the subbasin is aimed primarily at providing fish for harvest in ocean and Columbia River fisheries, both commercial and sport. In addition, subbasin sport catch and hatchery returns will be maintained.

Biological Objectives

1. Provide a spawning escapement of 1,100 early stock adults passing over Marmot Dam.

   Rationale: The Oregon Department of Fish and Wildlife's smolt estimate for coho production above the dam is 42,537 smolts. Based on a 3 percent egg-to-smolt survival (ODFW Coho Plan), a fecundity of 2,500 eggs per female, and a 1-1 sex ratio of adults, 1,134 adults are needed to produce this many smolts. The average Marmot Dam count for 18 years between 1960 and 1986 (no counter was in operation in some years) is 1,063 fish. The average in recent years (1978 to 1986) has dropped to 880 fish, however. ODFW estimates that 1,100 adults would approach full seeding for habitat above Marmot Dam.

2. Determine whether the late-run still exists as a genetically distinct stock. Evaluate the status of the stock.

   Rationale: The early-run stocking program may have eliminated the true late-run stock, based on the dwindling counts of late fish over Marmot Dam. The few fish that return late may be mixed early-run and late-run stock, due to the extent of stocking that has taken place for many years. Unlike the winter steelhead management for the Sandy Basin, hatchery coho have been stocked in the upper subbasin extensively.

3. Maintain an annual hatchery return of 1,400 adults for Sandy Subbasin production. (Actually, 5,600 adults or more are needed to meet the average egg collection needs if Sandy Hatchery is to be used as an egg collection facility for production at Wahkeena Pond, Cascade Hatchery, and other facilities.) The number females needed is 500 to 600 for Sandy River production; up to 2,000 for total production and transfers.

Rationale: Egg needs for releases into the subbasin total 1.2 million eggs. The hatchery provides 5 million eggs or more to other facilities annually. The average fecundity is approximately 2,500 eggs per female. The average fraction of females in the hatchery return is 0.42. The average egg-to-smolt survival is 0.85.

Utilization Objective

Maintain an average annual sport catch of 1,300 fish in the subbasin.

Rationale: This is slightly higher than the 1975 through 1986 average of 1,277 caught per year, and appears to meet angler demand. The popularity of the fishery is dependent on the rainfall and flow conditions each fall, which subsequently determine whether the fish enter the subbasin in bright or dark condition.

Alternative Strategies

Modeling results for each strategy are presented in Tables 23a and 23b as fish produced at "maximum sustainable yield" (MSY). The sustainable yield of a fish population refers to that portion of the population that exceeds the number of fish required to spawn and maintain the population over time. Sustainable yield can be "maximized," termed MSY, for each stock at a specific harvest level. The MSY is estimated using a formula (Beverton-Holt function) that analyzes a broad range of harvest rates. Subbasin planners have used MSY as a tool to standardize results so that decision makers can compare stocks and strategies.

In MSY management, managers set a spawning escapement level and the remaining fish (yield) could theoretically be harvested. In practice, a portion of the yield may be reserved as a buffer or to aid rebuilding. Thus, managers may raise the escapement level to meet a biological objective at the expense of a higher utilization objective.

The amount of buffer appropriate for each stock is a management question not addressed in the subbasin plans. For this reason, the utilization objective, which usually refers to harvest, may not be directly comparable to the MSY shown in Tables 23a and 23b. At a minimum, a strategy should produce an estimated MSY equal to or greater than the utilization objective. A MSY substantially larger than the subbasin utilization objective may be needed to meet subbasin biological objectives.

Estimated costs of the alternative strategies below are summarized in Table 23c.

STRATEGY 1: Maintain current releases of smolts in the lower subbasin and release STEP fry, surplus hatchery fry and pre-smolts, and excess hatchery adults in the upper and lower subbasin.

The STEP hatch box program is popular in the Sandy Subbasin and cooperators have released coho in the system since the 1982 brood year. The number of cooperators has increased from three (1982 brood) to 13 (1986). Because of the popularity of this volunteer program, the cooperators wish to continue their involvement in the hatch box program. In recent years, fry and pre-smolts were part of the annual production at lower Columbia River hatcheries, and some were released in the Sandy. A surplus of hatchery coho fry and pre-smolts occurs in some years, and the typical strategy has been to release them into the upper subbasin in habitat believed to be underseeded. In addition, a surplus of hatchery adults occurs quite often, and have typically been released in tributaries above Marmot Dam. If surplus juveniles and adults are not released in the subbasin, alternate release or disposal destinations will need to be developed.

ACTIONS: 1-6

1. Continue to release 1 million early-run coho smolts from Sandy Hatchery.

2. Continue to improve juvenile bypass facility at Marmot Dam to reduce mortality and diversion to Roslyn Lake.

3. Continue fish habitat restoration and enhancement in the upper subbasin to increase natural carrying capacity.

4. Transport excess early-run hatchery adults to areas of the upper basin deemed underseeded.

5. Continue STEP releases of coho fry in the upper and lower subbasin.

6. Continue surplus fry and pre-smolt releases in the upper subbasin.

STRATEGY 2 (Recommended Strategy): This strategy is similar to Strategy 1 except that releases of hatchery fish would not be made above Marmot Dam and excess hatchery adult fish would not be released. This strategy would reserve the upper basin for natural production of early and late-run coho, much like the current management of winter steelhead in the subbasin (preferred by the Public Advisory Committee).

The release of STEP fry and hatchery surplus juveniles may not be increasing production to any great extent, and in fact, may be harmful in the long run to naturally produced coho. The released fish may also provide competition to naturally produced juvenile steelhead. If the limiting factor in coho production is survival from fry to smolt, the release of STEP and surplus fry will not benefit production. If, however, production is limited by egg-to-fry survival, then the program should show benefits. By releasing surplus early-run juveniles and adults in the upper subbasin, the production of late-run fish may be reduced or eliminated. The release of hatchery stock coho is probably at the cost of reduced production of natural coho, both early and late-run.

ACTIONS: 1-3, 7, 9, 10

1. --
2. --
3. --

7. Discontinue releases of fry, pre-smolts, and excess hatchery adults above Marmot Dam. Release juveniles in mainstem and tributaries below the dam. Sell or bury the excess adults from Sandy Hatchery.

9. Investigate the existence of the late-run stock through electrophoretic, morphometric, meristic, and life history studies. Compare latest running Sandy River coho with natural and hatchery produced Sandy River early-run coho, and with Clackamas River late-run coho.

10. Survey potential streams for late-run coho spawning activity above and below Marmot Dam to estimate the run's condition.

STRATEGY 3: This strategy is similar to Strategy 2, except that releases of Clackamas late-run coho would be made above Marmot Dam to supplement native late-run coho. (This strategy would only work if surplus late-run stock were available at North Fork Trap. There is no surplus at the current time, and Clackamas objectives call for increases in late-run production above North Fork Dam.)

ACTIONS: 1-3, 7-10

1. --
2. --
3. --
7. --

8. Supplement the late-run stock with annual releases of up to 100,000 smolts or surplus adults from suitable stock, such as Clackamas late-run coho. Release surplus pre-smolts and fry also, if available. The smolt release numbers would be dependent on available brood stock from the Clackamas subbasin. For estimated costs, see Appendix C.

9. --
10. --

Table 23a. System Planning Model results for early-run coho in the Sandy Subbasin. Baseline value is for pre-mainstem implementation, all other values are post-implementation.

Utilization Objective:
- Maintain an average annual sport catch of 1,300 fish in the subbasin.
- Maintain an annual hatchery return of 1,400 adults for subbasin needs, 5,600 total for all needs.
- Females needed: 500 to 600 for Sandy River production; up to 2,000 for production and transfers.

Biological Objective:
- Provide a spawning escapement of 1,100 adults passing over Marmot Dam.
- Determine whether the late-run still exists as a genetically distinct stock. Evaluate the status of the stock.

Strategy[1]	Maximum[2] Sustainable Yield (MSY)	Total[3] Spawning Return	Total[4] Return to Subbasin	Out of[5] Subbasin Harvest	Contribution[6] To Council's Goal (Index)
Baseline[7]	7078 -C	5,559	12,639	51,720	0(1.00)
All Nat	7078 -C	5,559	12,639	51,720	0(1.00)
2*	7005 -C	5,073	12,078	49,423	- 2,857(0.96)
3	7005 -C	5,073	12,078	49,423	- 2,857(0.96)

*Recommended strategy.

[1] Strategy descriptions:

For comparison, an "all natural" strategy was modeled. It represents only the natural production (non-hatchery) components of the proposed strategies plus current management (which may include hatchery production). The all natural strategy may be equivalent to one of the alternative strategies below.

2. Maintain current releases of smolts in the lower subbasin and release STEP fry, surplus hatchery fry and pre-smolts, and excess hatchery adults in the upper and lower subbasin. Pre Mainstem Implementation.

3. Strategy 1 except no releases of hatchery fish above Marmot Dam and no releases of excess hatchery fish. Reserves upper basin for natural production. Pre Mainstem Implementation.

[2] MSY is the number of fish in excess to those required to spawn and maintain the population size (see text). These yields should equal or exceed the utilization objective. C = the model projections where the sustainable yield is maximized for the natural and hatchery components combined and the natural spawning component exceeds 500 fish. N = the model projection where sustainable yield is maximized for the naturally spawning component and is shown when the combined MSY rate results in a natural spawning escapement of less than 500 fish.

[3] Total return to subbasin minus MSY minus pre-spawning mortality equals total spawning return.

[4] Total return to the mouth of the subbasin.

[5] Includes ocean, estuary, and mainstem Columbia harvest.

[6] The increase in the total return to the mouth of the Columbia plus prior ocean harvest (as defined by the Northwest Power Council's Fish and Wildlife Program), from the baseline scenario. The index () is the strategy's total production divided by the baseline's total production.

[7] The baseline and Strategy 1 are the same for this species/stock.

Table 23b. System Planning Model results for late-run coho in the Sandy subbasin. Baseline value is for pre-mainstem implementation, all other values are post-implementation.

Strategy[1]	Maximum[2] Sustainable Yield (MSY)	Total[3] Spawning Return	Total[4] Return to Subbasin	Out of[5] Subbasin Harvest	Contribution[6] To Council's Goal (Index)
Baseline[7]	0 -N	0	0	0	0(0.00)
All Nat	0 -N	0	0	0	0(0.00)
2*	0 -N	16	16	65	80(0.00)
3	18 -N	871	890	3,640	4,529(0.00)

*Recommended strategy.

1 Strategy descriptions:

For comparison, an "all natural" strategy was modeled. It represents only the natural production (non-hatchery) components of the proposed strategies plus current management (which may include hatchery production). The all natural strategy may be equivalent to one of the alternative strategies below.

2. Maintain current releases of smolts in the lower subbasin and release STEP fry, surplus hatchery fry and pre-smolts, and excess hatchery adults in the upper and lower subbasin. Pre Mainstem Implementation.
3. Strategy 1 except no releases of hatchery fish above Marmot Dam and no releases of excess hatchery fish. Reserves upper basin for natural production. Pre Mainstem Implementation.

2 MSY is the number of fish in excess to those required to spawn and maintain the population size (see text). These yields should equal or exceed the utilization objective. C = the model projections where the sustainable yield is maximized for the natural and hatchery components combined and the natural spawning component exceeds 500 fish. N = the model projection where sustainable yield is maximized for the naturally spawning component and is shown when the combined MSY rate results in a natural spawning escapement of less than 500 fish.

3 Total return to subbasin minus MSY minus pre-spawning mortality equals total spawning return.

4 Total return to the mouth of the subbasin.

5 Includes ocean, estuary, and mainstem Columbia harvest.

6 The increase in the total return to the mouth of the Columbia plus prior ocean harvest (as defined by the Northwest Power Council's Fish and Wildlife Program), from the baseline scenario. The index () is the strategy's total production divided by the baseline's total production.

7 The baseline and Strategy 1 are the same for this species/stock.

Table 23c. Estimated costs of alternative strategies for Sandy coho. Cost estimates represent new or additional costs to the 1987 Columbia River Basin Fish and Wildlife Program; they do not represent projects funded under other programs, such as the Lower Snake River Compensation Plan or a public utility district settlement agreement. (For itemized costs, see Appendix C.)

	Proposed Strategies		
	1	2*	3
Hatchery Costs			
Capital[1]	0	0	164,220
O&M/yr[2]	0	0	1,785
Other Costs			
Capital[3]	0	0	0
O&M/yr[4]	0	0	0
Total Costs			
Capital	0	0	164,220
O&M/yr	0	0	1,785

* Recommended strategy.

[1] Estimated capital costs of constructing a new, modern fish hatchery. In some subbasins, costs may be reduced by expanding existing facilities. For consistency, estimate is based on $23/pound of fish produced. Note that actual costs can vary greatly, especially depending on whether surface or well water is used and, if the latter, the number and depth of the wells.

[2] Estimated operation and maintenance costs per year directly associated with new hatchery production. Estimates are based on $2.50/pound of fish produced. For consistency, O&M costs are based on 50 years.

[3] Capital costs of projects (other than direct hatchery costs) proposed under a particular strategy, such as enhancing habitat, screening diversions, removing passage barriers, and installing net pens (see text for specific actions).

[4] Estimated operation and maintenance costs per year of projects other than those directly associated with new hatchery production. For consistency, O&M costs are based on 50 years.

Recommended Strategy

The recommended strategy for coho is Strategy 2, calling for discontinuing early-run coho releases above Marmot Dam. Modeling and SMART analysis were done separately for early and late-run coho. Modeled production factors and output are shown in Tables 24 and 25. Natural production alone would not meet the objectives for the subbasin and a suitable brood stock is not currently available for supplementation of the late run. Therefore, a continuing hatchery program with the protection of spawning and rearing habitat above Marmot Dam was chosen as the recommended strategy.

Strategy 2 has the highest discount value for both the early and late-run stocks in SMART analysis (Tables 26 and 27). Supplementation with late-run coho ranks lower in the SMART analysis because of the genetic disadvantage of importing a stock from another subbasin, and because it scored low in the feasibility of acquiring brood stock from another subbasin. The Clackamas late run, one of the only "healthy" late-run coho stocks in the area, is probably suitable, but Clackamas Subbasin objectives call for increases in production above North Fork Dam, which may preclude taking brood stock for the Sandy in the near future.

Modeled production of early-run coho decreases slightly for Strategy 2 because of the reduced surplus stocking above the dam, but late-run coho production increases. Note that the MSY for early-run terminal harvest is much higher than the typical annual harvest in the Sandy Subbasin. In-subbasin coho harvest is highly dependent on the water conditions, angler effort, and run timing. In some years, the fish may not enter the Sandy until they are dark, holding in the Columbia River and awaiting the first fall freshets. In these years, harvest and angler demand (effort) for coho are low.

Because of the way lower Columbia River tributaries are managed through the ODFW Coho Plan, the hatchery return portion of the biological objective takes precedence in the current and recommended strategies. An increasing concern for wild stocks of fish, however, will place greater importance on actions aimed at rebuilding wild stocks in future management of the subbasin.

With the recent public call for protection and enhancement of native stocks, Strategy 2 is further supported as the recommended coho strategy. Reserving the upper subbasin for natural production would be consistent with the strategy that has been in practice for winter steelhead. Hatchery winter steelhead juveniles and excess adults are not stocked above Marmot Dam under the current management regime, reserving the upper basin for natural production.

Table 24. Percent and absolute increase in selected natural production and subbasin harvest parameters associated with each early-run coho strategy (SPM modeling).

	Strategy		
	1 *	2	3
Percent Increase			
Pre-spawning survival	0.0	0.0	0.0
Egg-smolt survival	0.0	0.0	1.5
Smolt-smolt survival	0.0	0.0	0.1
Natural smolt carrying capacity	0.0	0.0	-14.4
Maximum sustainable yield run size	0.0	-4.4	-4.4
Maximum sustainable yield harvest	0.0	-1.0	-1.0
Absolute increase			
Maximum sustainable yield run size	0	-561	-561
Maximum sustainable yield harvest	0	-73	-73

* Baseline or current situation.

Table 25. Percent and absolute increase in selected natural production and subbasin harvest parameters associated with each late-run coho strategy (SPM modeling).

	Strategy		
	1 *	2	3
Percent Increase			
Pre-spawning survival	0.0	0.0	0.1
Egg-smolt survival	0.0	8.0	8.0
Smolt-smolt survival	0.0	0.0	0.1
Natural smolt carrying capacity	0.0	385.9	385.9
Maximum sustainable yield run size	0.0	750.0	41850.0
Maximum sustainable yield harvest	0.0	0.0	--
Absolute increase			
Maximum sustainable yield run size	0	15	837
Maximum sustainable yield harvest	0	0	461

* Baseline or current situation.

Table 26. Total value, discount value, and confidence value developed for each early-run coho strategy through SMART analysis.

STRATEGY	TOTAL VALUE	DISCOUNT VALUE	CONFIDENCE VALUE
1	500	270	0.54
2*	540	342	0.63333333
3	320	114	0.35625

*Recommended strategy

Table 27. Total value, discount value, and confidence value developed for each late-run coho strategy through SMART analysis.

STRATEGY	TOTAL VALUE	DISCOUNT VALUE	CONFIDENCE VALUE
1	400	210	0.525
2*	640	330	0.515625
3	560	186	0.33214286

* Recommended strategy