EA1398

ENGLISHMAN RIVER WATERSHED RECOVERY PLAN

Prepared for

Pacific Salmon Endowment Fund Society

September 2001

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1 Introduction

The Englishman River has been selected by the Pacific Salmon Endowment Fund Society as the first watershed to receive attention in the Georgia Basin salmon recovery planning process for coho and steelhead (PSEF Technical Committee 2001). The Englishman River is an important salmon-producing stream on the mid-east coast of Vancouver Island. The watershed has all species of salmon, including steelhead and is designated a sensitive stream by the BC government under the Fish Protection Act. Forestry, agriculture, and urban development are the primary land uses in the watershed.

The development of a comprehensive recovery plan is the first step in the recovery of coho and steelhead in the Englishman River watershed.

1.1 Purpose of a Recovery Plan

The primary purpose of a recovery plan is to identify and set priorities for activities required to achieve the recovery goals for a specific watershed and its fish stocks. Consequently, the recovery plan must focus on what is good for the fish and these plans must be permitted to evolve as new information is collected. Section 2 of this recovery plan summarizes the available information on the selected watershed and stocks. Sections 3 and 4 are a synthesis of this information and identifies information gaps and the potential for recovery. Section 5 identifies realistic recovery goals and priority activities required to achieve the recovery goals. Specific goals, strategies and recovery activities regarding habitat, stock use, land use and water use will focus on what is good for the fish while taking into consideration competing uses within the watershed. Section 6 provides the framework for monitoring and assessing the effectiveness of the overall recovery plan, specific recovery projects/activities and the processes used to implement the recovery plan. Section 7 defines the priorities and implementation schedule for each set of activities. Section 8 contains a list of projects and approximate funding requirements.

1.2 Watershed Selection Criteria and Rationale

At a meeting with regional biologists from Department of Fisheries and Oceans (DFO) and Ministry of Environment, Lands, and Parks (MELP), a number of watersheds were discussed as potential candidates for initial salmon recovery activities in the Georgia Basin. The following watersheds were recommended for further discussion: Englishman, Cowichan, Chemainus, Oyster, Kanaka, Salmon and Alouette (PSEF Technical Committee 2001).

Of the Vancouver Island watersheds, the Englishman River was identified as a good starting point for the Pacific Salmon Endowment Fund (PSEF) initiatives in this region owing to its manageable size, unique mix of anadromous species, development concerns, and relatively low level of enhancement activity. Initial PSEF efforts on the Englishman will hopefully attract the support and commitment required to initiate comprehensive recovery programs on other high priority streams along the east coast of Vancouver Island.

1.3 Guiding Principles for Recovery Planning

In the US, the National Marine Fisheries Service (NMFS 1996) identified three primary components of a successful fisheries recovery strategy as:

- substantive protective and conservation elements;
- a high level of certainty that the strategy will be properly implemented, including necessary authorities, commitments, funding, staffing, and enforcement measures; and
- a comprehensive monitoring program.

NMFS then identified nine components of a conservation or recovery plan which have been adopted by the PSEF:

- identify, at appropriate scales, the factors that have contributed to the species or stock declines;
- establish clear objectives and time frames for eliminating or reducing all major factors for population decline and for achieving desired population characteristics;
- establish quantifiable criteria and standards by which progress toward each objective will be measured;
- establish priorities for action;
- adopt measures needed to achieve the explicit objectives. A plan should include actions to protect and restore habitat wherever habitat condition is a factor of decline, whether on private or public lands;
- provide high levels of certainty that identified measures and actions will be implemented;
- establish a comprehensive monitoring/reporting program, including methods to measure whether objectives are being met, and to detect stock declines and increases in each area of concern;
- as much as possible, integrate federal, state, tribal, local, corporate and non-government activities/projects that are designed to recover salmon populations and the habitat upon which they depend; and
- use an adaptive management approach that actively shapes recovery/management actions to produce needed information.

The PSEF also endorses the notion that recovery plans for Pacific salmon stocks adhere to the principles laid out in the draft Wild Salmon Policy:

- Principle 1 - Wild Pacific salmon will be conserved by maintaining diversity of local populations and their habitats;
- Principle 2 - Wild Pacific salmon will be managed and conserved as aggregates of local populations called Conservation Units;
- Principle 3 - Minimum and target levels of abundance will be determined for each conservation unit;
- Principle 4 - Fisheries will be managed to conserve wild salmon and optimize sustainable benefits;

- Principle 5 - Salmon cultivation techniques may be used on strategic intervention to preserve populations at greatest risk of extirpation; and
- Principle 6 - For specified conservation units, when genetic diversity and long term viability may be affected, conservation of wild salmon populations will take precedence over other production objectives involving cultivated salmon.

1.4 Recovery Planning

The PSEF approach to recovery planning is similar to Stage II of the Watershed-based Fish Sustainability Planning Guidelines (WFSP; draft November 2000). In Stage II of the WFSP, a watershed profile is developed which describes the current condition of the watershed and fish stocks. Objectives, targets and strategies are then developed to guide recovery. Finally, a monitoring and assessment framework is established. Throughout the process of developing the plan, public involvement is integrated into the planning. This recovery plan for the Englishman River includes each of these components.

1.5 Public Participation

Local stewardship groups with an interest in the Englishman River watershed and its salmon stocks were involved throughout the planning process. Public meetings were held on five occasions (26 March, 12 April, 10 May, 21 June, and 22 August) to provide input to the planning process and review drafts of the plan. Appendix A contains a list of participants in the planning process.

2 Stock/Watershed Profile

The Englishman River is located in the mid-east area of Vancouver Island at Parksville and drains roughly 324 km^2. The river originates on the eastern slopes of Mt. Arrowsmith (1820 m) and Mount Moriarty Ridge and flows in an easterly direction for 40 km, entering Strait of Georgia adjacent to Rathtrevor Beach Provincial Park (Figure 1). It is a community watershed, providing water to residents of Parksville and the Parksville East Water District.

The Englishman River watershed lies in the Coastal Western Hemlock biogeoclimatic zone. The generalized bedrock geology of the Englishman River watershed includes the following major bedrock types: Karmutsen Formation (basalt) from the Late Triassic, Sicker Group (volcanic) from the Paleozoic Period, and Nanaimo Group (sand, gravel, coal) from the Late Cretaceous. Surficial deposits are of glacial origin. The soils within the lower watershed are predominantly loamy sands and sandy clay loams (Boom and Bryden 1993).

For this recovery plan, the watershed has been partitioned into five main basins: Englishman River, South Englishman River, Center Creek, Morison Creek and Shelly Creek (Figure 1). Each of these basins contains habitat for anadromous salmonids. The anadromous section of the mainstem Englishman, below a barrier falls, is 15.85 km long. The anadromous section of the South Englishman, below the falls, is 4.5 km. The three smaller salmon-bearing tributaries of Center Creek, Morison Creek and Shelly Creek have anadromous lengths of 5.2, 2.1, and 1.0 km, respectively. Map 1 in Appendix B shows the distribution of salmonids within the watershed.

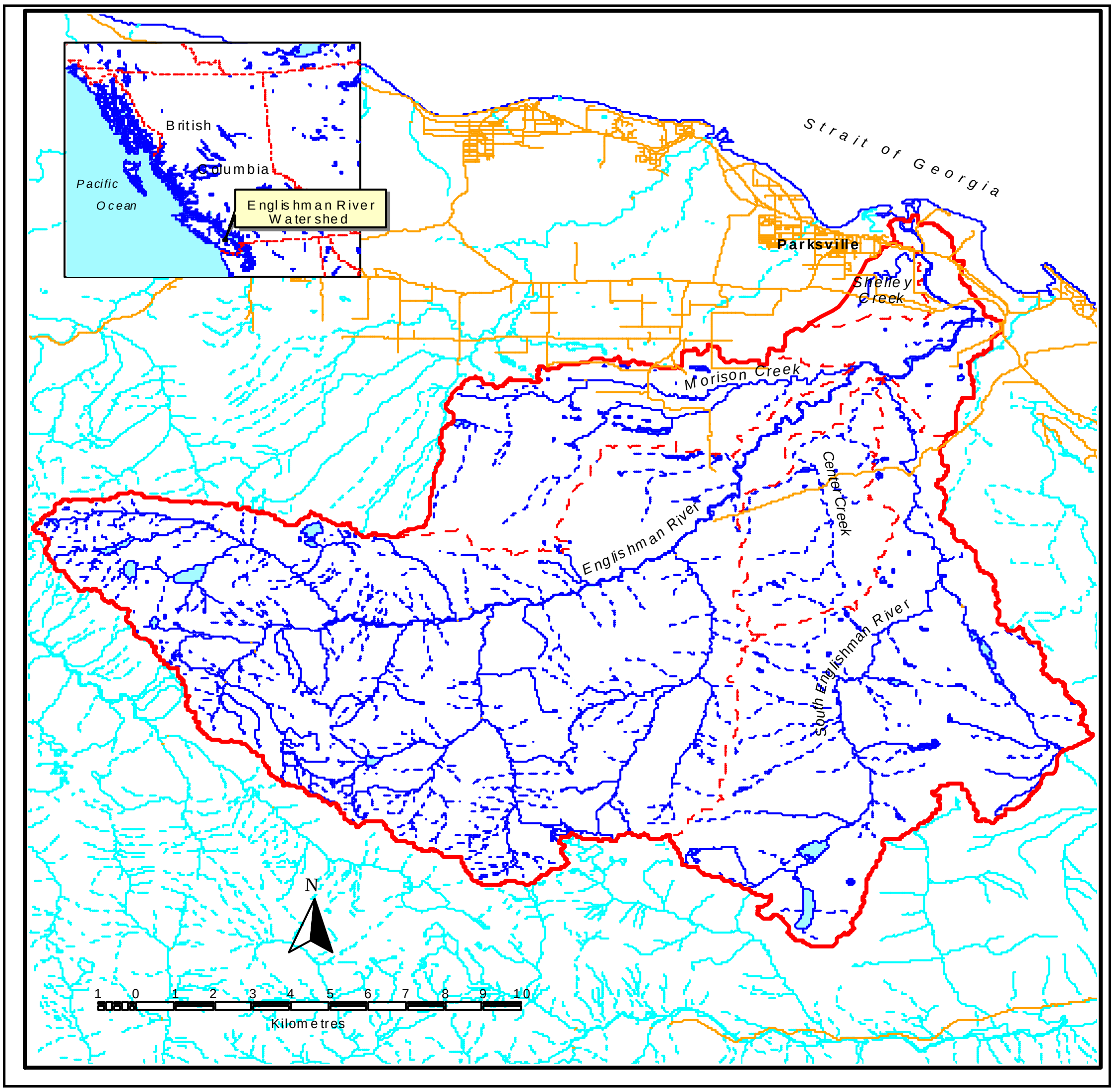


Figure 1. Englishman River watershed and sub-basins.

2.1 Fish Population Status and Trends

The Englishman River supports significant populations of salmon. Chum are the dominant species followed by coho. Steelhead, cutthroat, chinook, pink and sockeye are also present. Resident game species include rainbow and cutthroat trout. Hamilton and Kosakoski (1982) provide a good description of each salmon stock and life history timing. Table 1 shows when the various life stages for each species are present within the Englishman River and estuary.

2.1.1 Adult Abundance

Coho

Escapement records for salmon in the Englishman River date back to 1953. These estimates are from Fishery Officer observations as recorded on BC16s. Prior to 2000, the historical maximum estimate for coho was 3,500 spawners recorded in 1957 (Figure 2). Since then, escapements have not exceeded 1,500 with a mean of 960. However, in 2000, a record number of coho returned to the Englishman River (5,200), perhaps due to improved marine survival (see below).

Steelhead

Winter-run steelhead salmon abundances have declined considerably since 1985 (Figure 3). Historical abundances of wild steelhead ranged from 500 to 2,000 adult returns to the river. During this period, Englishman River steelhead were enhanced and it is difficult to discern the population size of the wild stock (Figure 4). Current abundances of steelhead in the Englishman River are at critically low levels (Wightman et al. 1998).

Table 1. Life history timing for anadromous salmonids within the Englishman River and estuary.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coho	Eggs	Eggs	Eggs								Eggs	Eggs
	Fry	Fry	Fry	Fry	Fry	Fry	Fry	Fry	Fry	Fry	Fry	Fry
				Smolts	Smolts	Smolts						
									Adults	Adults	Adults	Adults
Chinook	Eggs	Eggs	Eggs								Eggs	Eggs
		Fry	Fry	Fry	Fry							
				Smolts	Smolts	Smolts						
								Adults	Adults	Adults		
Pink	Eggs	Eggs	Eggs								Eggs	Eggs
			Fry	Fry								
									Adults	Adults		
Chum	Eggs	Eggs	Eggs								Eggs	Eggs
			Fry	Fry	Fry	Fry						
									Adults	Adults	Adults	
Sockeye	Eggs	Eggs	Eggs								Eggs	Eggs
			Fry	Fry	Fry	Fry						
					Smolts	Smolts						
							Adults	Adults	Adults	Adults		
Steelhead		Eggs	Eggs	Eggs								
	Fry	Fry	Fry	Fry	Fry	Fry	Fry	Fry	Fry	Fry	Fry	Fry
				Smolts	Smolts	Smolts						
	Adults	Adults	Adults	Adults								Adults

Eggs Fry Smolts Adults

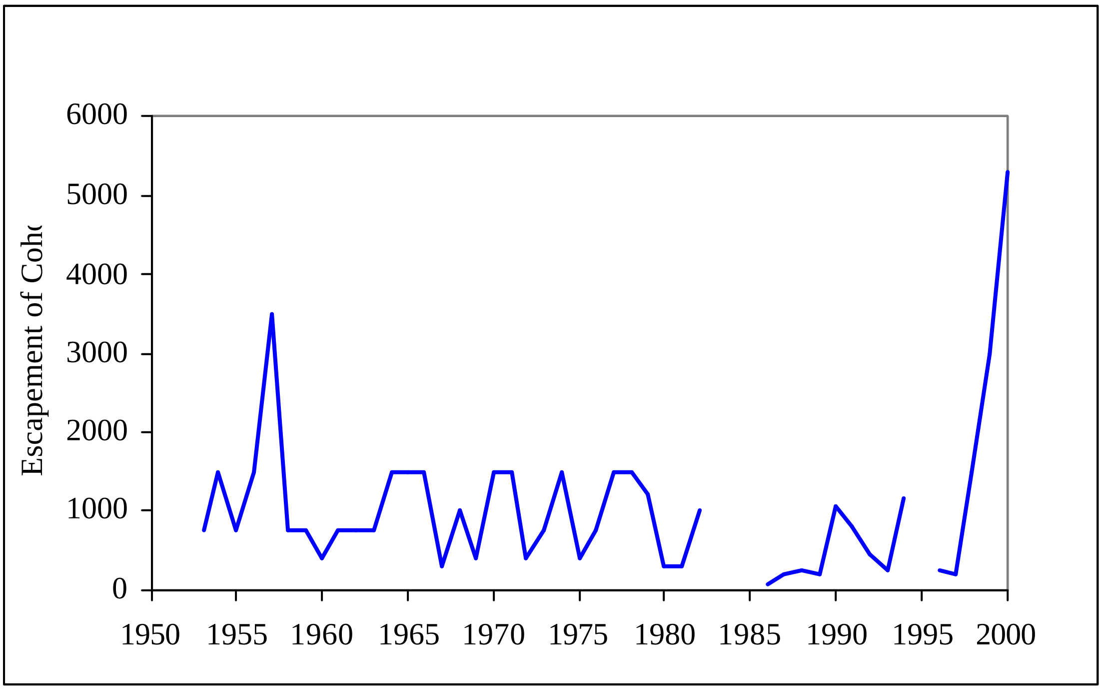


Figure 2. Coho escapements to the Englishman River (from DFO database). Counts prior to 1998 were from Fishery Officer counts; 1998-2000 are Area-Under-the-Curve estimates from swim counts.

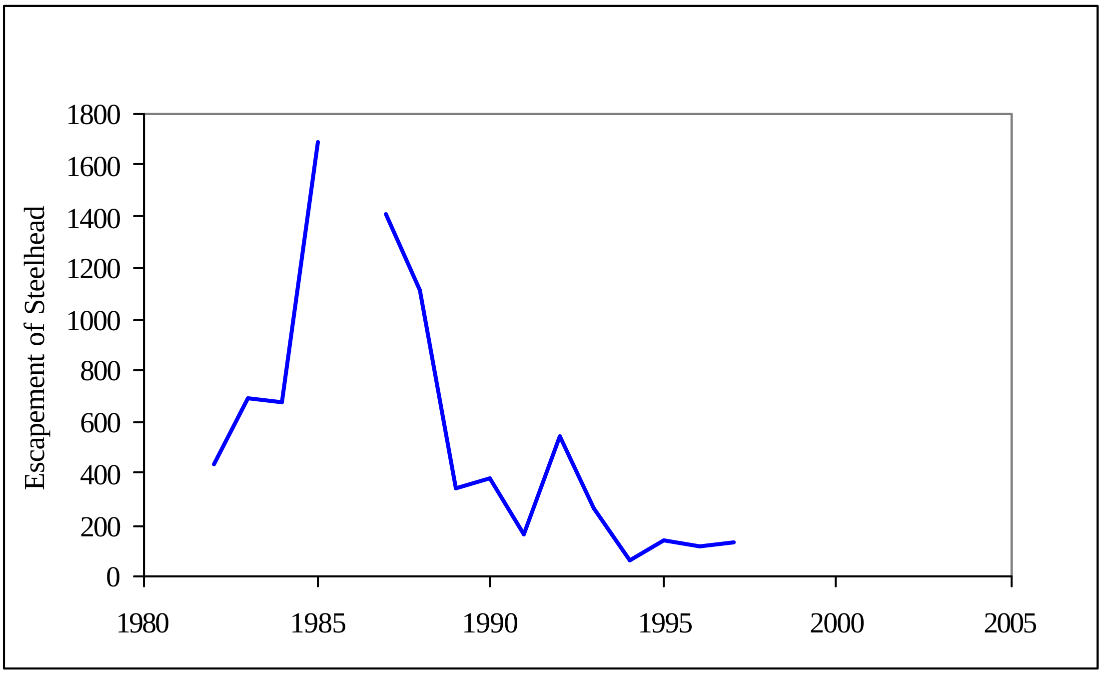
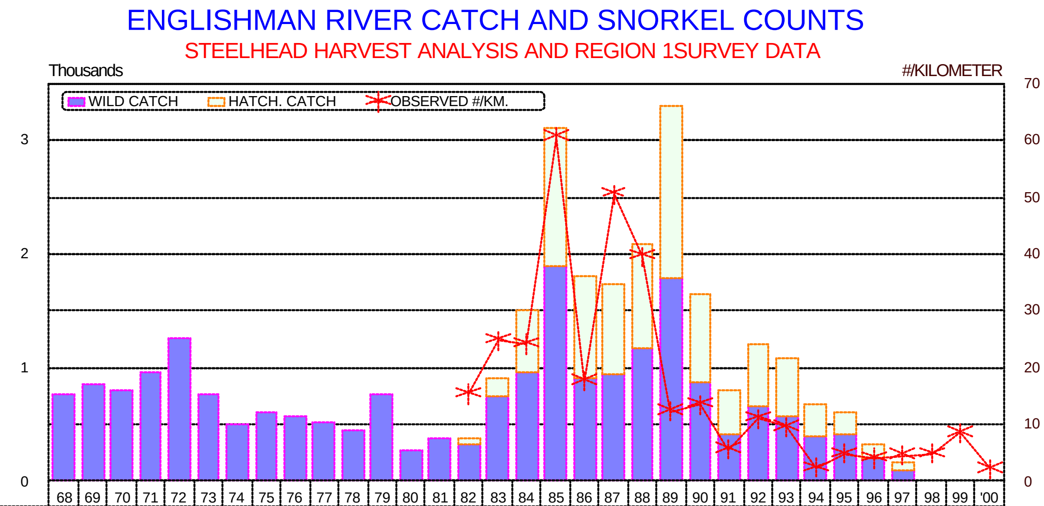


Figure 3. Estimated steelhead escapements to the Englishman River (Ministry of Environment, Lands and Parks, Nanaimo).



	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
OBSERVED #/KM.															15.3	24.8
HATCH. CATCH															0.048	0.153
WILD CATCH	0.77	0.847	0.809	0.952	1.259	0.757	0.501	0.61	0.569	0.527	0.445	0.761	0.277	0.382	0.329	0.75

	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	'00
OBSERVED #/KM.	24.1	60.6	17.5	50.5	39.6	12.3	13.5	5.6	11.1	9.6	2.3	4.8	4	4.5	4.8	8.5	2.1
HATCH. CATCH	0.545	1.219	0.907	0.782	0.919	1.516	0.78	0.38	0.559	0.515	0.283	0.196	0.114	0.073			
WILD CATCH	0.952	1.886	0.907	0.948	1.169	1.785	0.866	0.413	0.651	0.567	0.393	0.405	0.202	0.089			

Figure 4. Englishman River catch and trends in abundance indexed by number per kilometer of stream surveyed (Ministry of Environment, Lands and Parks).

Chum

Chum escapements to the Englishman were as high as 15,000 historically, then declined to less than 2,000 (Figure 5). Over the past five years, the number of chum has increased steadily to the record return in 1999 of 25,000 chum. Coho and chum salmon abundances appear to have tracked each other fairly closely. The catch of Inner South Coast chum stocks declined sharply in the 1950's and mid-1960's (DFO 1999). The rapid decline in the 1960's prompted the complete closure of commercial chum fisheries. The stock recovered in the 1970's but declined into the 1980's.

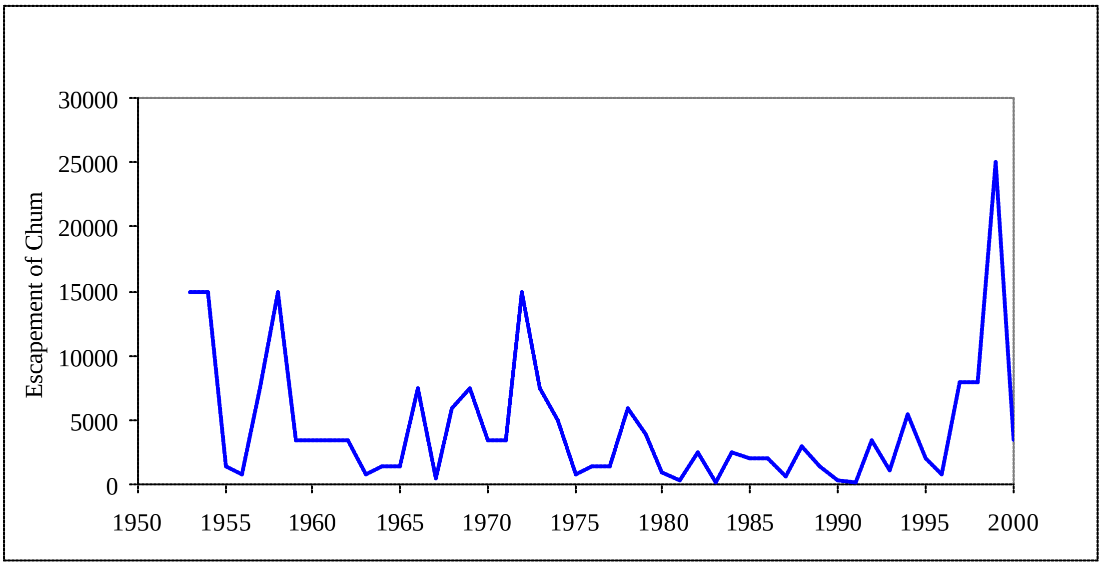


Figure 5. Chum escapements to the Englishman River (from DFO database). Estimates prior to 1998 are from Fishery Officer counts; after 1998 estimates are from swim counts.

Less than average returns in the late 1990's suggest that Inner South Coast chum stocks suffered from lower than expected marine survival (DFO 1999). Commencing in 1998, chum stocks began to rebound, probably due to increased marine survival.

Other Salmon
Abundances of pink, chinook and sockeye have always been lower than chum or coho (<500 average). There is no evidence of a decline in chinook abundances from historical levels (Figure 6). Chinook salmon in the Englishman are now predominantly of Qualicum River stock due to enhancement efforts over the past six years. In 2000, an estimated 1,500 spawners returned to the river.

However, Englishman River pink salmon declined precipitously from 1958-1962 to near extinction levels (Figure 7). In 1992, attempts were made to re-establish the pink run in the Englishman River. These efforts appear to be succeeding.

There is just a small population of stream-type sockeye in the Englishman River. Little is known about this population and to the extent that additional data on this species can be obtained through assessments of the target species, this should be explored. Care must also be taken to ensure that recovery efforts on coho or steelhead do not negatively impact sockeye.

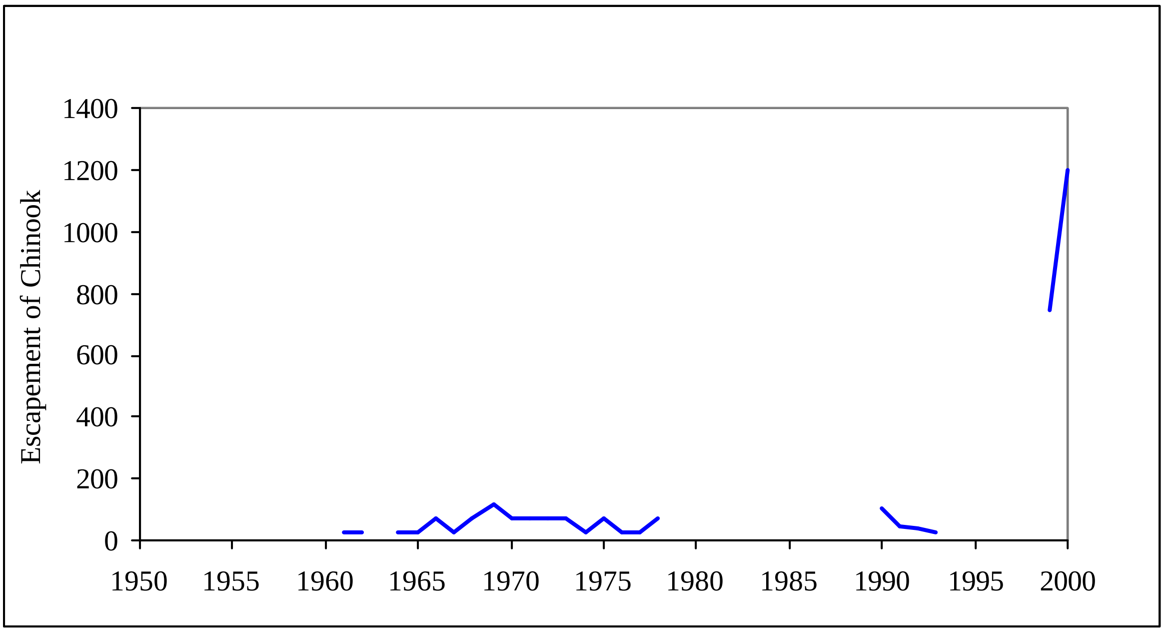


Figure 6. Chinook salmon escapements in the Englishman River (from DFO database). Estimates prior to 1998 are from Fishery Officer counts; after 1998 estimates are from swim counts.

2.1.2 Juvenile Abundance

Coho
There has been sporadic monitoring of juvenile abundances for coho salmon in the Englishman River since the mid 1980's. Blackburn and Hurst (1988) documented fry densities for the

watershed in 1987. Densities of between 0.5 and 3 fry per m^2 were observed in side channels and mainstem areas of the Englishman River. These densities were considerably lower than for other systems and applying a 7.6% fry-smolt survival (Bradford 1995) would suggest that smolt production at that time was quite low (between 10,000 and 20,000 smolts) given the available and useable habitat during late summer.

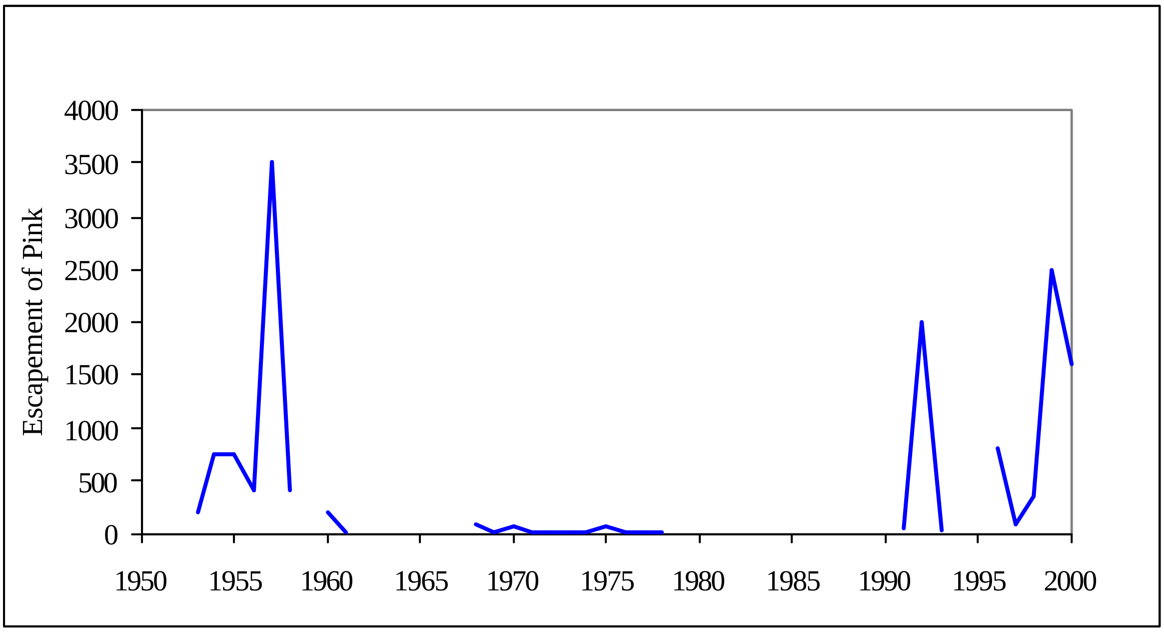


Figure 7. Pink salmon escapements to the Englishman River (from DFO database). Estimates prior to 1998 are from Fishery Officer counts; after 1998 estimates are from swim counts.

Recent monitoring of smolt production from the system in 1998 and 1999 has generated estimates of 27,000 and 46,000 smolts, respectively (Decker et al. 2000). Between 17% and 20% of the smolt production came from the two constructed side-channels and the remainder came from the natural watercourses. In 2000, a total of 7,000 smolts were counted out of Center Creek.

Steelhead
Estimates of juvenile fry densities are available for 1998-2000 (Figure 9). Densities of steelhead fry in the Englishman River (as for many other Vancouver Island streams) appear to be well below predicted levels based on habitat capability (Ptolemy 1993) and abundance data collected during the 1980's when there was relatively high spawner abundance and catch rates.

2.1.3 Enhancement History

Enhancement of Englishman River coho began in earnest in 1987 with the coho colonization program of DFO. This program was developed as a means to augment coho production in a watershed by outplanting coho fry into non-anadromous areas of watersheds. The program on the Englishman River lasted six years and by 1993 all enhancement of coho in the Englishman River using hatchery means had stopped (Figure 8a; Appendix C Table 1).

After the termination of the coho colonization program, subsequent enhancement efforts on the Englishman focused on recovery of pink stocks and on the establishment of a run of Qualicum River chinook in the Englishman River (Figure 8b; Appendix C Table 2) commencing in 1982.

Pink salmon enhancement on the Englishman River began in 1993 with Quinsam River pinks as the donar stock (Figure 8c; Appendix C Table 4).

Steelhead enhancement on the Englishman River began in 1979 and continued to 1997 (Figure 8d; Appendix C Table 4). Sea run cutthroat trout have also been enhanced on the Englishman River from 1991 to 1999 using Little Qualicum stock.

To our knowledge, there are no documented enhancement goals or objectives (in terms of establishment of naturally spawning abundance) established for any species in the Englishman River. Currently, several million pink eggs from the Quinsam hatchery (data to be provided) are released into the Englishman River along with 250,000 chinook smolts from the Big Qualicum hatchery. There are also 30,000 coho fry from Englishman River broodstock being reared at the Englishman River hatchery for release as fed fry in 2001.

2.1.4 Survivals

Coho

There are no direct measures of freshwater survival for Englishman River salmon or steelhead. Black Creek is the closest wild stock of coho with estimates of freshwater survival. Freshwater (egg-smolt) survivals at Black Creek have ranged from 0.14% to 3.8% since 1988 (Figure 10). Over the entire period, freshwater survivals have averaged around 2% and have not shown any trend towards decline. However, marine (smolt-adult) survivals of coho at Black Creek have declined significantly beginning in 1993. Marine survivals for the enhanced Big Qualicum coho stock show a similar trend (Figure 11). It should be noted that Labelle et al. (1997) found little correlation in marine survival among East Coast of Vancouver Island coho stocks. There was considerable variability in marine survivals among the nine stocks examined and between 1986 and 1988 marine survivals ranged from 0.5% to 23.1%.

Of particular interest is that Big Qualicum coho consistently had a lower marine survival than all of the other systems included in the study. The Little Qualicum River wild stock had a considerably higher marine survival than did the Big Qualicum enhanced stock. The work of Labelle et al. (1997) demonstrating variability in marine survival rates among East Coast Vancouver Island streams emphasizes the need to have stock specific monitoring of recovery efforts.

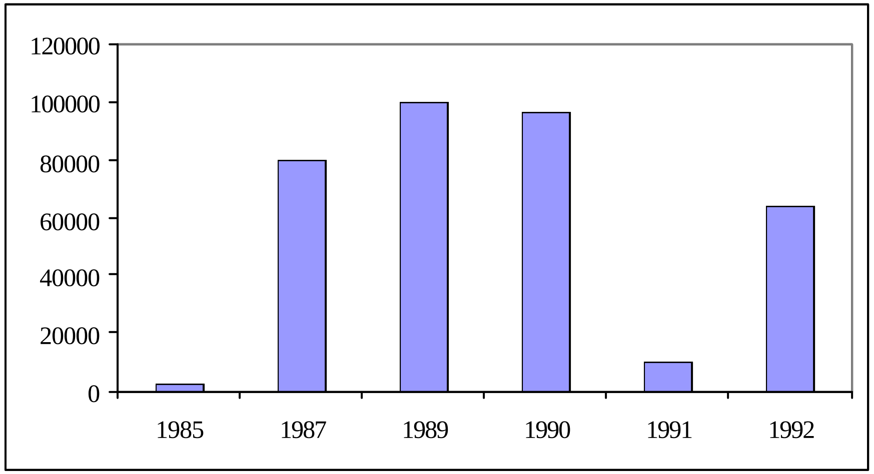


Figure 8a. Fed fry coho releases to Englishman River from Big Qualicum River stock.

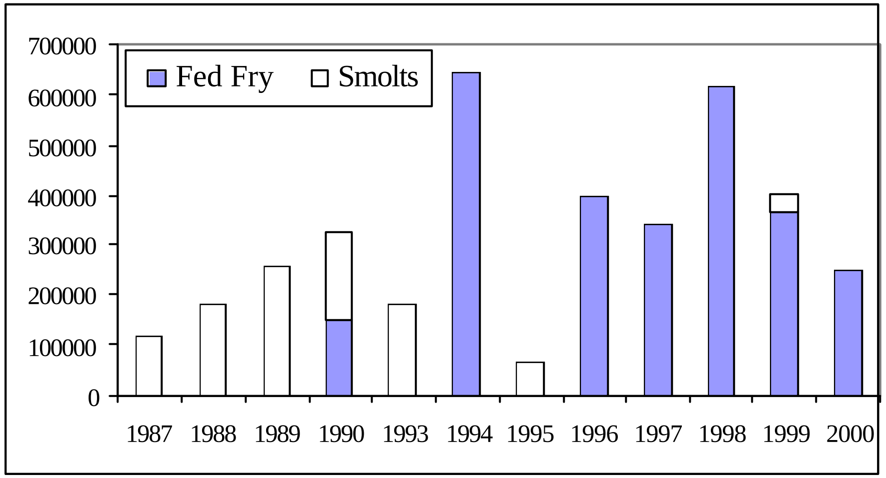


Figure 8b. Chinook salmon releases to Englishman River using Big and Little Qualicum River stock.

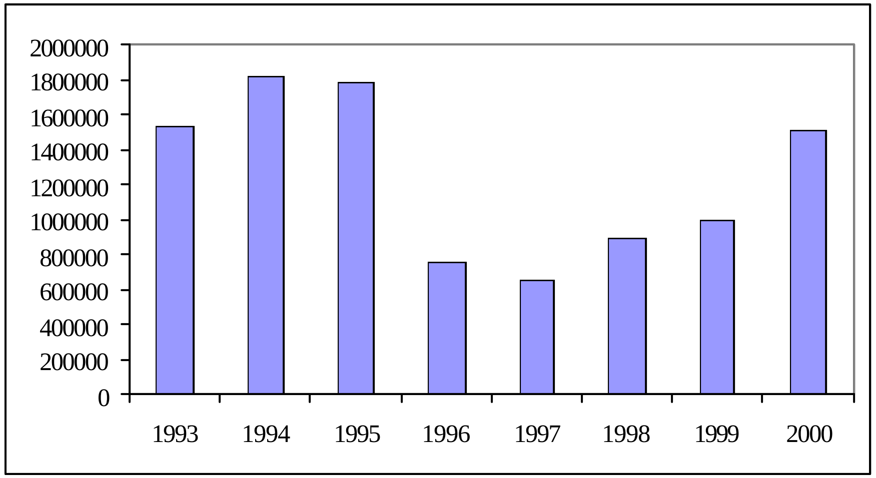


Figure 8c. Pink salmon egg transfers to Englishman River from Quinsam River stock.

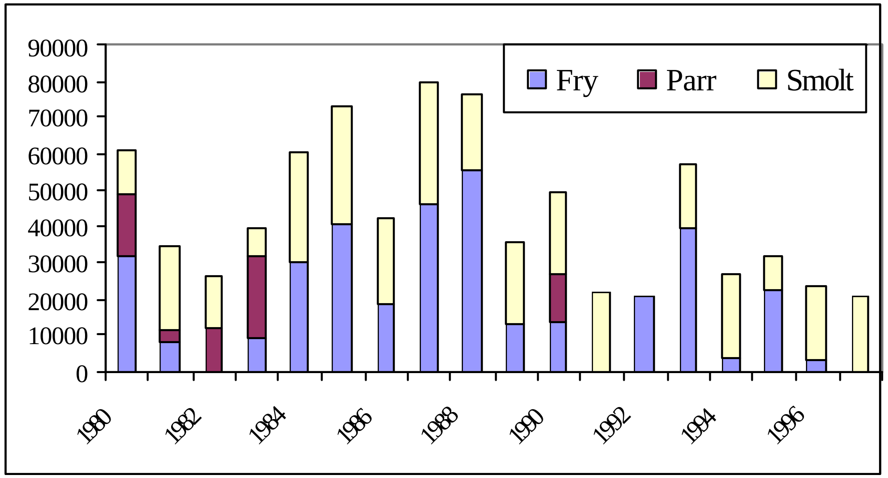


Figure 8d. Steelhead releases to Englishman River using Englishman River stock.

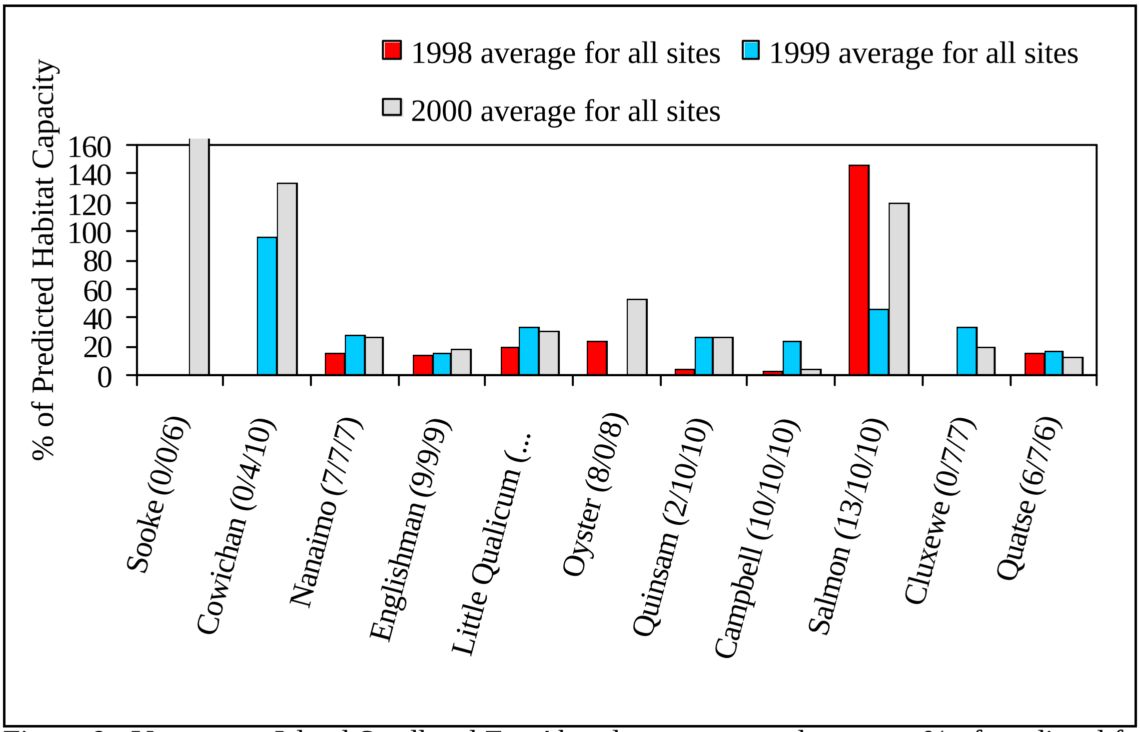


Figure 9. Vancouver Island Steelhead Fry Abundance expressed as mean % of predicted fry per unit area (FPU) for 1998, 1999, 2000 (depth/velocity adjusted, based on Ptolemy, 1993). In parentheses are the sample sizes in each year.

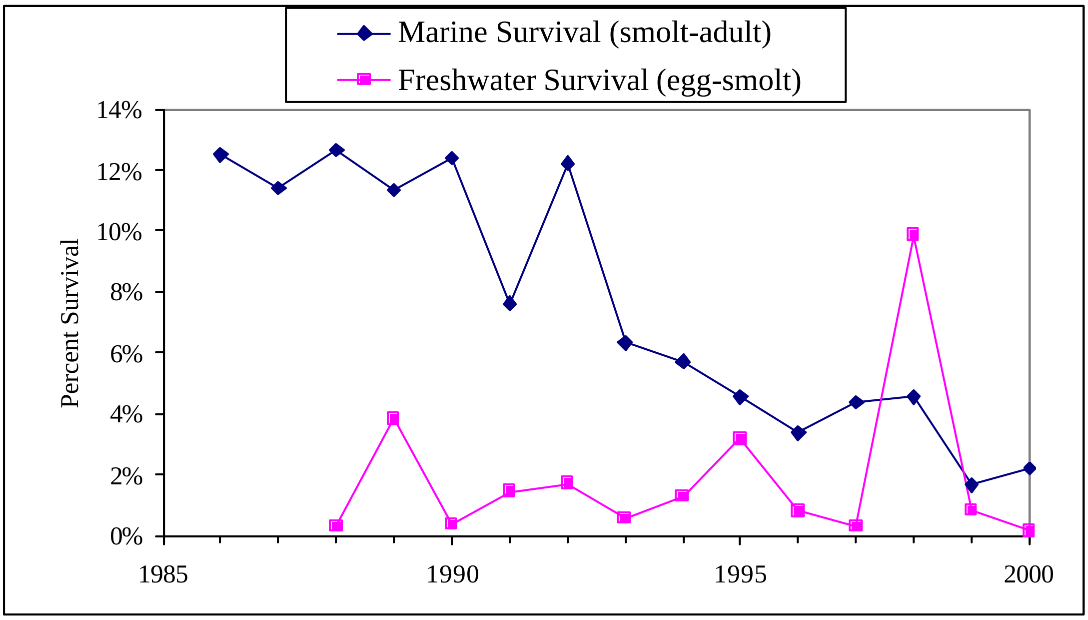


Figure 10. Freshwater and marine survival estimates for Black Creek (data from Simpson et al. 2001).

Improved estimates of smolt abundance and adult escapements in 1998-2000 for Englishman River coho have allowed the first direct measurements of marine survival for this stock (Table 2). Smolt-adult survivals for the 1996 and 1997 broods were estimated to be 9.4% and 11.1%, respectively. These are considerably higher than marine survival estimates for other Georgia basin stocks (Simpson et al. 2001).

Steelhead
There are no direct measures of freshwater or marine survivals for Englishman River steelhead. However, freshwater survival in the Keogh River as measured by smolts per spawner declined significantly in the late 1990's (Ward 2000). Smolts per spawner from 1992 to 1994 were, on average, 70% lower than previous estimates for similar spawner abundances. There is no clear evidence that Englishman River steelhead have experienced similar declines in freshwater survival.

Table 2. Number of smolts and spawners, by brood year for Englishman River coho and estimates of marine survival (smolt-adult), 1996 and 1997 brood years.

Brood Year	Return Year	Smolts (Decker et al. 2000)	Spawners (DFO escapement database)	Catch Mortality (assumed to be zero)	Smolt-Adult Survival (%)
1996	1999	31,549	2978	0	9.4
1997	2000	47,608	5280	0	11.1

Marine survivals for Keogh River steelhead have also been declining since the early 1990's (less than 4% compared to 15% in previous decade) (Ward 2000). Wightman et al. (1998) provide a good summary of possible reasons for the decline in marine survivals of Strait of Georgia steelhead. It is reasonable to assume that Englishman River steelhead may be experiencing similar low marine survivals.

2.2 Salmon Resource Use

Coho
Overall exploitation rates on Georgia Basin coho remained very high through the early 1990's even though marine survivals were in serious decline (Figure 11).

2.2.1 Commercial Fisheries

There are no direct measures of harvest distribution for Englishman River coho. However, Figure 12 shows the proportion of Big Qualicum coho harvested in various fisheries. If Englishman River coho co-migrate with Big Qualicum coho, then a similar harvest distribution would be expected. Unfortunately, there is no data to confirm or refute this hypothesis.

Since 1990, the troll and saltwater recreational fisheries have harvested the majority of Big Qualicum coho, in roughly equal proportions (Figure 12). Since 1997, only a few Big Qualicum coho have been harvested in recreational fisheries.

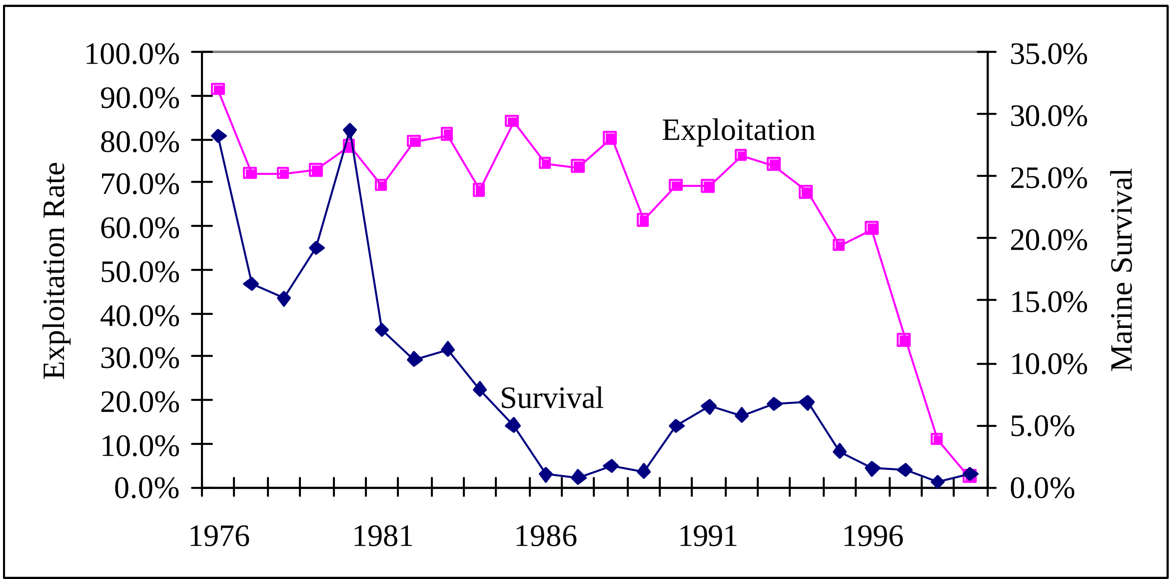


Figure 11. Marine survival and exploitation rates for Big Qualicum coho (Simpson et al. 2001).

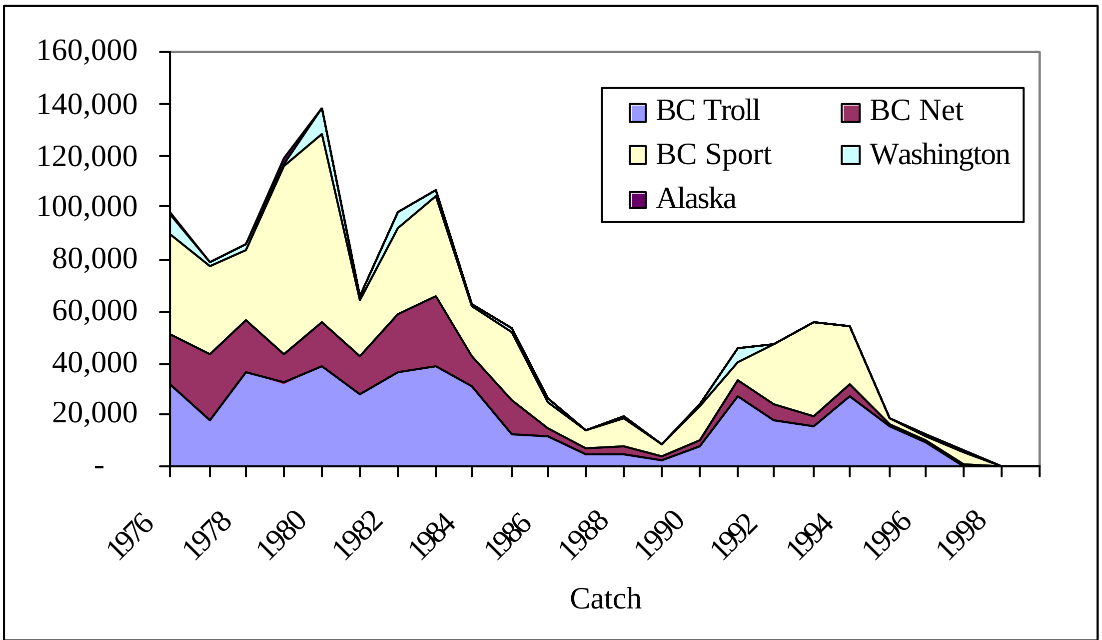


Figure 12. Catch distribution for Big Qualicum coho (Simpson et al. 2000).

Steelhead
No information is available on the distribution of catch among commercial fisheries for Englishman steelhead. However, since winter run steelhead return to coastal streams after the end of the commercial salmon season, there is a low likelihood of them being taken in commercial fisheries. Accordingly, it is safe to assume that most Englishman River winter steelhead were harvested in freshwater recreational fisheries.

Chum
Englishman River chum salmon are fall type and are harvested in net fisheries in Johnstone Strait and in terminal net fisheries in the Strait of Georgia. Englishman River chum are passively managed, meaning that they are taken in fisheries that are directed at the more abundant stocks such as the Puntledge, Big Qualicum, and Little Qualicum. These stocks are enhanced.

The average catch of Inner South Coast chum stocks for eight regions within Johnstone and Georgia straits is summarized in DFO (1999). Catches in terminal fisheries in the Qualicum area averaged around 50,000 in the 1950's and 1970's with a major decline to less than 5,000 in the 1960's. Qualicum area catch of chum in the 1980's and 1990's averaged over 200,000, largely due to enhancement of the above mentioned stocks. The catch of Englishman River chum is not known from these mixed stock fisheries.

Other Salmon
Little information is available on the harvest of chinook, sockeye or pink stocks in the Englishman. Given their historical low abundance, there were likely no directed fisheries on chinook or sockeye. Pink were taken in net fisheries until their severe decline in the late 1950's (Figure 7). The reason for the sudden decline of pink salmon is not known.

2.2.2 Recreational Fisheries

Coho
There are no data for coho catches within the Englishman River. Englishman River coho (and chinook) were also harvested in saltwater recreational fisheries. Estimates of Englishman River catches are not available.

Steelhead (and cutthroat)
There used to be significant in-river fisheries for cutthroat and steelhead on the Englishman River. In the 1960's and 1970's, steelhead sport fisheries were minimally regulated (Wightman et al. 1998). Sport fisheries harvest rates were likely in excess of sustainable levels, even during the period of hatchery enhancement (Figure 4) (Lirette et al. 1987). By 1996-1997, wild winter steelhead returns to many east coast Vancouver Island streams had declined to the extent that angler catch success was, on average, three times lower than that experienced in the 1980's (Wightman et al. 1998). On the Englishman, catch rates decreased by 53%. By late 1997, emergency sport fishing closures were put into effect on six Vancouver Island streams, including the Englishman.

2.2.3 First Nation Fisheries

Coho
Few Englishman coho are harvested in directed First Nations fisheries.

Steelhead
First Nation fisheries have not taken large numbers of steelhead from the Englishman River. Some of the Nanoose First Nation members have angled in the past for steelhead.
Chum
Englishman River chum salmon are harvested by the Nanoose First Nation.

2.3 Land Use

Map 2 in Appendix A shows land title in the Englishman River watershed. The watershed includes parts of the Cameron, Dunsmuir, and Nanoose Land Districts and is within the traditional territories of the Qualicum and Nanoose First Nations.

The majority of the watershed is within privately held forestlands with logging as the primary activity. Table 3 shows the percentage of holdings within the watershed for each sub-basin.

Weyerhaeuser and Timberwest are the primary forestry operators in the watershed. Weyerhaeuser operations are primarily in the South Englishman River, upper Englishman River and upper Center Creek sub-basins, while Timberwest operates primarily in lower Center Creek and Upper Morison Creek sub-basins.

Table 3. Percent of land in Englishman River watershed held by major land use type.

Basin	Weyerhaeuser	Timberwest	Private Other	Park/Protected Area	Crown	Right of Way
Englishman River Mainstem	82.0%	6.3%	4.7%	1.9%	4.8%	0.3%
South Englishman River	68.3%	31.7%	0%	0%	0%	0%
Center Creek	75.9%	24.0%	0%	0.1%	0%	0%
Morison Creek	16.7%	45.7%	32.6%	5.0%	0%	0%
Shelly Creek	11.8%	1.1%	84.5%	0.2%	0%	2.4%
Total	51.0%	22.0%	24.0%	1.4%	1.0%	0.6%

2.3.1 Protected Areas

There are a number of protected areas within the Englishman River watershed. Englishman River Falls Park is located at the main falls on the mainstem Englishman River. Portions of the lower river riparian area are designated as Conservation Area as is 65 ha in estuary.

2.3.2 Forestry

Much of the Englishman River watershed was logged in the early 1900's, as inferred from tree height data obtained from Weyerhaeuser (Map 3). There was a significant second cut rotation in the 1950's and 1960's. Since that time, cut levels have been greatly reduced and primarily restricted to headwater areas of the watershed, Morison Creek and Center Creek. Virtually the entire watershed has been logged at least once. There are few intact, old growth riparian areas within the drainage.

2.3.3 Agriculture

Agriculture use is prevalent in the Morison Creek drainage as well as Shelly Creek. The primary uses in these areas are forage crops such as corn or grasses.

2.3.4 Rural Residential

Rural residential is a rapidly growing land use within the Englishman River watershed, primarily in Morison Creek, Shelly Creek and lower Englishman River. Many of these properties are hobby farms with horses being a major activity.

2.3.5 Urban

There is very little urban property within the watershed except for a small area of Parksville along the lower 1 km of the river.

2.3.6 Industrial

There is very little industrial activity in the watershed.

2.4 Water Use

East Coast of Vancouver Island watersheds experience extreme fluctuations in flow, primarily resulting from rain events. Late in the summer, flows often reach critically low levels for salmonids rearing (coho, steelhead, cutthroat, chinook). As for many East Coast Vancouver Island streams, there is potential for water withdrawals from some of the sub-basins within the Englishman watershed to negatively impact rearing fish.

The Englishman River is a community watershed supplying drinking water during the summer months to Parksville and surrounding areas via an intake in the lower Englishman River. There are currently 37 water licences (October 1994) within the Englishman River Water Allocation

Plan Area (Boom and Bryden 1993). These licences are concentrated in the lower part of the Englishman River and Morison Creek. About 85% of the drinking water for the area currently comes from wells.

In 1998, the Arrowsmith Dam was completed to improve fish habitat and domestic water supply. The dam is a joint venture with Arrowsmith Water Service, City of Parksville, Town of Qualicum Beach and the Regional District of Nanaimo.

The City of Parksville, which has long used the Englishman River to augment its groundwater supplies during peak summer demand, is now assured of increased withdrawals because of the dam and Arrowsmith Lake reservoir. Half of the water stored will be used to increase or maintain flows for fisheries purposes.
Qualicum Beach is not expected to need water from Arrowsmith Dam for another ten years (Arrowsmith Water Service News Release, 2000).

2.4.1 Agricultural

Irrigation is the primary water use by farmers in the Englishman River watershed. In 1994, seven of the 37 water licences in the watershed were for the purpose of irrigation. Most of these are in Morison Creek. However, in terms of water demand (13.0 l/sec estimated average annual licenced demand), irrigation accounts for only 2.4% of the total demand for the watershed (Boom and Bryden 1993).

2.4.2 Domestic (Rural/Urban)

In 1994, four of the 37 water licences were held by Waterworks Departments, accounting for 54.3% of the total annual licenced demand or 72.7 l/sec. The primary intake from the Englishman is in the lower river near the old Island Highway bridge. The construction of the Lake Arrowsmith Dam has enabled water storage which should enable improved maintenance of minimum flows in the Englishman River mainstem which are estimated at 10% of Mean Annual Discharge (MAD) or 1.37 cms for the summer low period. Ideal rearing flows are near 20% MAD or 2.74 cms based on BC Fisheries standards (R. Ptolemy, pers. comm.). Similar flow requirements can be calculated for tributaries to the Englishman.

There were 15 domestic water licences as of 1994 for rural residential use. These licences accounted for only 0.1% of the annual licenced demand. However, as for agricultural use, this percentage may be higher on a sub-basin basis (e.g. Morison or Shelly Creek).

2.4.3 Industrial

Industrial activities such as trailer parks, motels, mobile home parks account for four of the 37 water licences and 1.4% of the annual licenced demand (2.0 l/sec). On a sub-basin basis, this could be higher.

2.4.4 Conservation

Fisheries and Oceans maintains several water licences in conjunction with the constructed side channels on the Englishman River. The estimated average annual licenced demand for these side channels is 28.3 l/sec (Boom and Bryden (1994).

2.5 Freshwater Habitat Description and Condition

There have been few comprehensive habitat assessments for the Englishman River. Hamilton and Kosakoski (1982) completed a biophysical inventory of the lower 8 km of the Englishman River, Morison Creek, and the South Englishman River. Additional habitat assessments were conducted by Lirette et al. (1987) and BC Fisheries Branch in 1992. Recorded information included: wetted width, substrate composition, bank cover, occurrence of secondary channels, pool/riffle ratios and juvenile salmon distribution. Instream habitat was surveyed again in 1987 by Blackburn and Hurst (unpublished). While these reports documented available habitat, they did not address habitat quality from a restoration perspective.

In 1999, the Mid-Vancouver Island Habitat Enhancement Society conducted an Urban Salmon Habitat Assessment of Shelly Creek.

The following sections summarize what is currently known about critical salmon habitats in the Englishman River watershed.

2.5.1 Spawning Habitat

Blackburn and Hurst (unpublished) quantified available spawning habitat in the Englishman River and South Englishman River. They determined 69,000 m^2 of spawning habitat in the Englishman and 2,750 m^2 in the South Englishman, 1,100 m^2 in Center Creek, and 225 m^2 in Morison Creek, for a total of 73,000 m^2. Not withstanding flow concerns, these data suggest that coho and steelhead production in the mainstem is not spawning-limited.

However, available spawning habitat is limited in Shelly Creek primarily because of barriers to access. Coho and chum have been observed spawning on limited gravel just below the Martindale Road culverts, approximately 200 m upstream from the creek mouth. These culverts present a barrier to adult coho. Coho fry observed above the culverts are likely transported from the Englishman River and lower Shelly Creek during flooding. Spawning habitat is also somewhat limited in Morison Creek and the lower South Englishman due to the prevalence of a bedrock streambed. There appear to be no spawning limitations in Center Creek.

2.5.2 Summer Rearing Habitat

Summer rearing habitat is considered one of the primary limiting factors of coho, cutthroat and steelhead production within the watershed. Summer flows are extremely low and many off-channel areas become dry. Instream cover in the mainstem and Morison Creek is poor. The condition of rearing habitat in Center Creek is not known.

2.5.3 Over-wintering Habitat

Winter rearing conditions in the mainstem of the Englishman can be characterized as unstable in gravel bed reaches due to extreme high winter flows. Fry and pre-smolts are likely flushed from the system due to inadequate refuge from the high flows. Accordingly, in some years with severe precipitation, winter rearing may become the limiting factor over summer rearing.

2.5.4 Flow Regime

MAD measured in the lower Englishman has increased by 50% since the early 1900's (Figure 13). However, only five years of data were available for the early 1900's period.

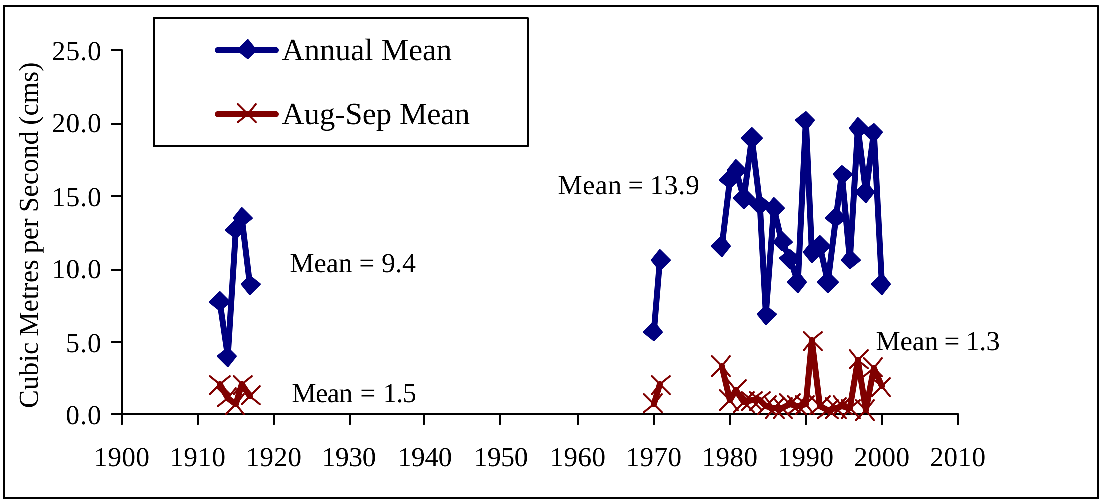


Figure 13. Mean annual discharge and August-September mean discharge for Englishman River.

Frequent periods of extreme low flow in August and September have likely limited available rearing habitat in the mainstem Englishman while extreme high flows in some years likely resulted in flushing of fry and parr from the system. The flow regime and loss of complex instream habitat in the Englishman River mainstem are likely the most critical factors affecting smolt production. However, the recent construction of the Arrowsmith Dam and capacity for water storage could help to ameliorate problems; at least with low flows in late summer. The water licence to operate the dam requires minimum flows of 1.6 cms (Provisional Operation Rule under Conditional Water Licence for Arrowsmith Dam). These levels have been exceeded in three of the past four years (two of which were pre-dam).

Stream flows have also been assessed in Shelly Creek by the Mid-Vancouver Island Habitat Enhancement Society (1999). Low summer flows is considered one of the limiting factors affecting fish populations in the creek.

Extreme winter flows in the Englishman River have likely also contributed to poor freshwater survival in many years, particularly during the flood events of 1980-1983, 1990 and 1992 (Figures 14, 15, and 16).

The Arrowsmith Dam is expected to provide significant improvements to fish habitat in the Englishman River through increased flows during low flow periods.

The large floods in 1980-1983 and 1990 resulted in significant changes to the stream channel; channel destabilization and infilling with fine material (Craig Wightman, Bob Hooton, Dave Clough, pers. comm.). These flows likely resulted in channel widening, riparian damage, and large-scale reduction in large woody debris (LWD). The river is still in a state of recovery from these events.

Overall, since 1980, there has been a declining trend in the maximum discharge during the winter period (Figure 16). However, in any given year there could be extreme flooding again.

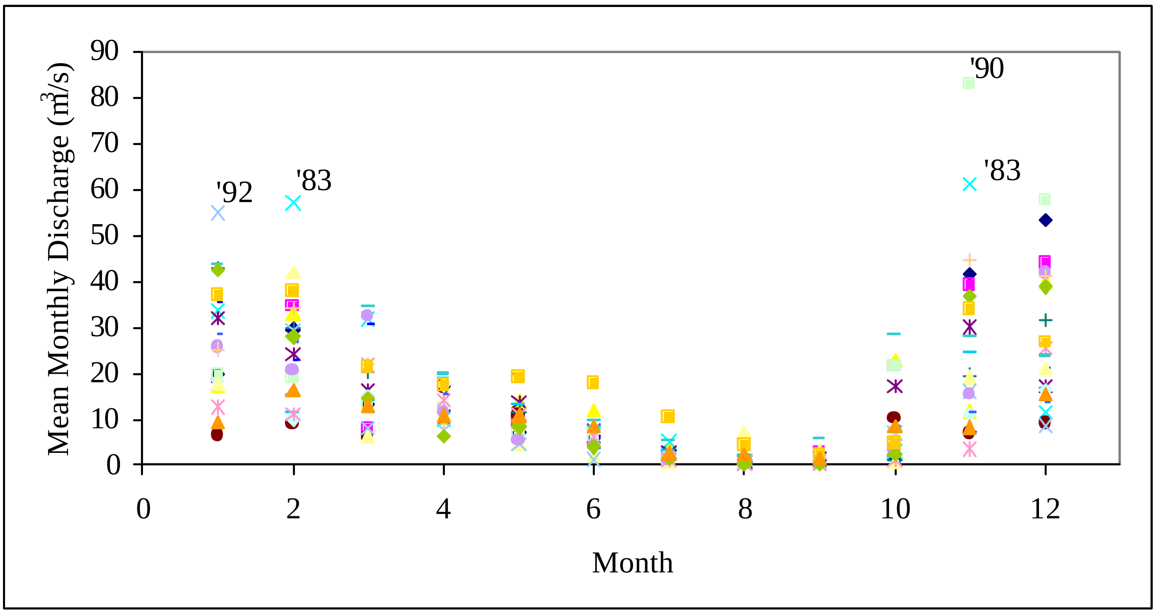


Figure 14. Mean monthly discharge at Englishman River, 1980-2000.

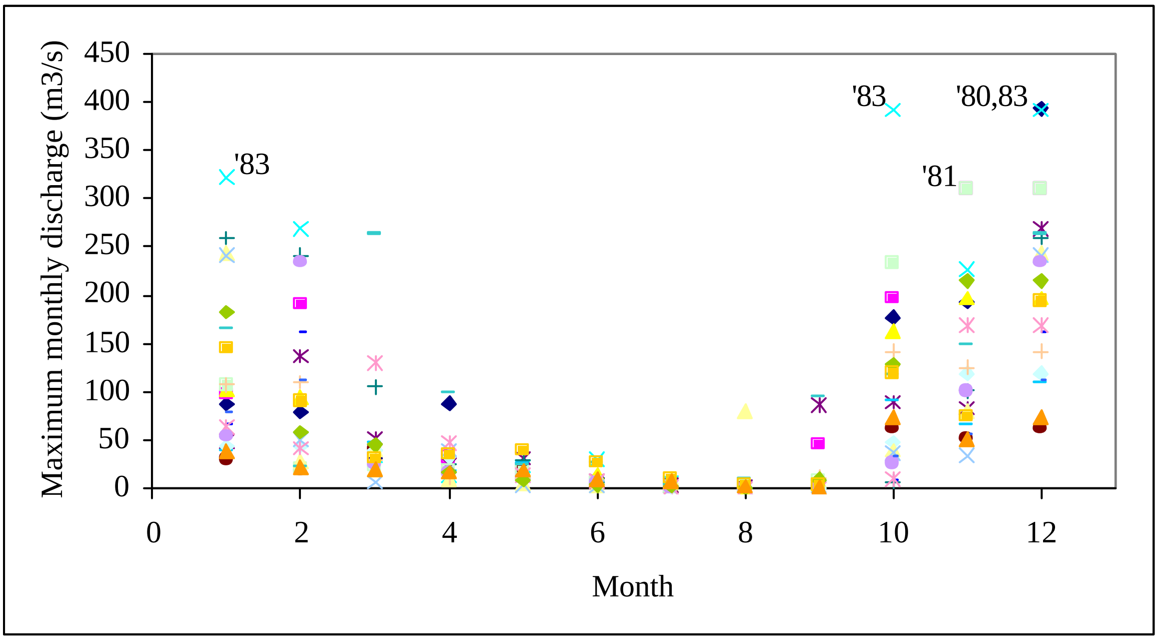


Figure 15. Maximum monthly discharge at Englishman River, 1980-2000.

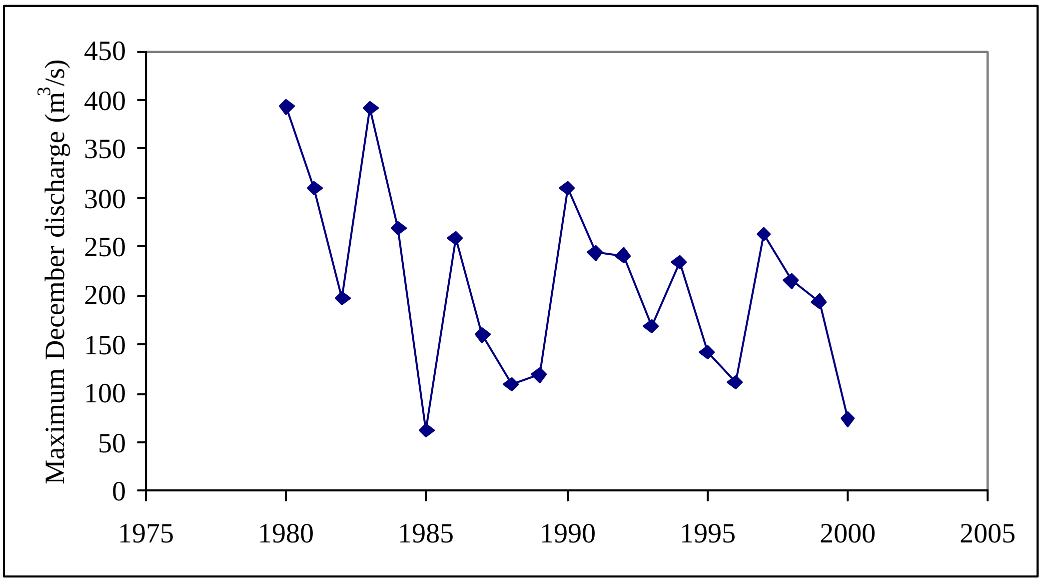


Figure 16. Maximum December discharge at Englishman River, 1980-2000.

2.5.5 Habitat Enhancement Projects

In the 1990's, two artificial side-channels were constructed by DFO with support of M&B (now Weyerhaeuser) and Timberwest on the Englishman River to increase the amount of off-channel rearing habitat for juvenile coho salmon (Decker et al. 2000). The Timberwest channel is located on the left bank of the river approximately 7 km upstream from the mouth, just below

Morison Creek confluence. The M&B channel is located about 1 km downstream of the Timberwest channel on the south (right) bank.

Each channel consists of approximately 80% rearing and 20% spawning habitat (Decker et al. 2000). The Timberwest channel is 1,300 m in length and consists of 17,700 m^2 of habitat. The M&B channel is 950 m in length and consists of 6,000 m^2 of habitat.

A proposal is currently in progress to lengthen the Timberwest channel by another 2,000 m. Once completed, this will bring the total length of constructed off channel habitat in the Englishman River to 4,300 m, or 15% of the total length of accessible riverine habitat. Construction of this side channel extension is now pending a sale of the land by Timberwest.

2.6 Estuary Habitat Description and Condition

The Englishman River estuary and the adjoining uplands consists of approximately 129.5 ha, 114 of which are in the Parksville/Qualicum Wildlife Management Area (Annand et al. 1993). The estuarine marsh of the Englishman River estuary covers an area of about 60 ha (Dawe and McIntosh 1993). Sixty-five hectares of the west side of the estuary is owned by the Nature Trust of BC.

The hydrology of the Englishman River estuary is influenced by both river discharge and tidal action. The constant interaction of the river and sea has created a complex sandbar river channel environment (Annand et al. 1993).

The first development in the estuary occurred in the 1950's when a portion of the estuary was dyked for use as a log sort (Dogleg Slough). There was little change until Aldergrove Enterprises purchased the flats for development. After series of studies, Aldergrove Enterprises elected to build a campground on the oceanfront. In March 1979, DFO breached one of the dykes and reopened 35.2 ha to tidal inundation. Approximately 23 ha on the most westerly portion of the flats remains privately owned by Surfside RV Resort.

All five species of salmon have been noted as using the Englishman River estuary; the primary species being chum and coho (Blood 1976, Tutty et al. 1983). Annand et al. (1993) found the highest densities of salmon in the Dogleg Slough area and found salmon present throughout the estuary. Abundances of salmon in the estuary were highest in May and June.

There are concerns that the estuary is not operating at its full biological potential. Reduced river flows in late summer have likely reduced the extent of freshwater inundation of tidal channels and sloughs. Storm sewer discharges into constructed ponds on the estuary may be impacting on water quality.

2.7 Productive Capacity

2.7.1 Coho

The average number of coho smolts produced annually by a particular stream is a measure of the stream's potential to produce coho salmon (Bradford et al. 1997). Coho production is primarily regulated by density-dependent factors, probably related to the quality and quantity of suitable rearing habitat in the stream (Bradford et al. 1997) and species choice for small streams.

Given this assumption of limited rearing space, Marshall and Britton (1990), using data collected up until 1979, developed predictive models for smolt yield from west coast streams. Marshall and Britton found a correlation between smolt abundance and stream area or stream length. Barnanski (1989) found a similar relationship for Washington State streams, as did Holtby et al. (1990) for 36 streams on the west coast of North America, and subsequently Bradford et al. (1997) for a larger data set for western North America. Of these relationships, the linear form model of Marshall and Britton (1990) was the best predictor in terms of the number of smolts produced per unit of stream length. A comparison of each of these models with actual smolt abundances for nine BC wild coho streams revealed that the Marshall and Britton (1990) model predicts smolt abundances that are within 82% of actual abundances (averages for the period 1980-1999) (Table 4, Figure 17).

Table 4. Coho smolt productivity models for streams in the Pacific Northwest.

Model	Relation	R	Sample Size
Marshall and Britton (1990)	$y=1924.6x-894.75$	0.94	24
Holtby et al. (1990)	$y=941.4x^{1.074}$	0.92	36
Bradford et al. (1997)	$Lny=6.90+0.97lnx$	0.84	83

x is stream length in kilometers; y is smolt abundance

In contrast, the Holtby et al. (1990) and Bradford (1997) models predicted smolt abundances that were 52% and 39% of actual abundances, respectively, and presumably because the larger data set (N>35) included streams from a much wider geographic area.

Two east Vancouver Island streams for which smolt productivity has been closely monitored (Black Creek and Big Qualicum) have produced, on average, 2,182 and 2,740 smolts per km, respectively (Bradford et al. 2000). Given the limited rearing habitat in the Englishman, one might expect the productivity of the Englishman River to be lower than these two streams.

Using the model of Marshall and Britton (1990), we estimated average coho smolt production at capacity for the Englishman River at 50,500 or 1,768 smolts/km (Appendix D). This is equivalent to approximately 1,800 smolts/km. Hamilton and Kosakoski (1982) also determined an expected smolt yield of 1,847 smolts/km based on observed fry densities and over-wintering survival of 30%. As this is a prediction of average smolt yield, we would expect actual numbers to fluctuate annually about this mean.

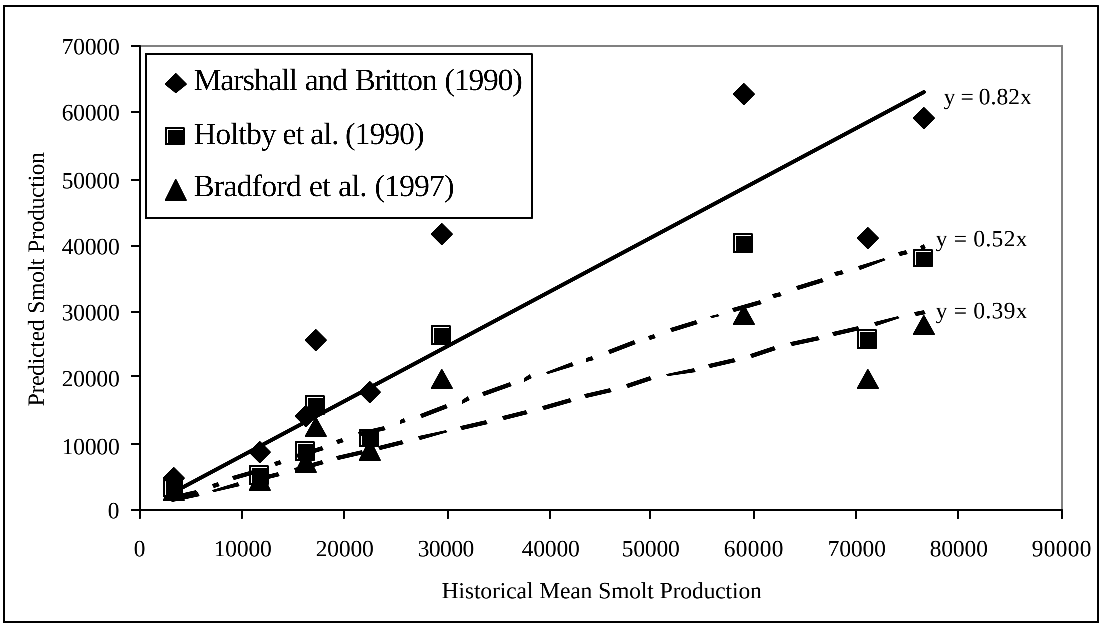


Figure 17. Relationship between predicted smolt abundance using three different models and historical mean-smolt production.

Determining the number of coho spawners required to fully seed the freshwater habitat of the Englishman River and produce 50,500 smolts requires an understanding of freshwater survival (egg-smolt). Survival of salmon eggs and juveniles in freshwater is related to the frequency of floods, droughts, and freezing in the river (Wickett 1958), the quality of gravel and density of spawners (Chapman 1988). Bradford (1995) found that, on average, coho egg-fry survival was higher than for the other species of salmon (19.8%) while fry-smolt survival for coho was generally lower (7.6%).

Using the Marshall and Britton (1990) model and applying Bradford (1995) mean survival estimates, approximately 2,400 coho spawners would be required to fully seed the freshwater coho habitat. Figure 18 shows the distribution of spawners required to seed the available habitat in each sub basin. Figure 19 shows the number of spawners required over a wide range of egg-smolt survivals.

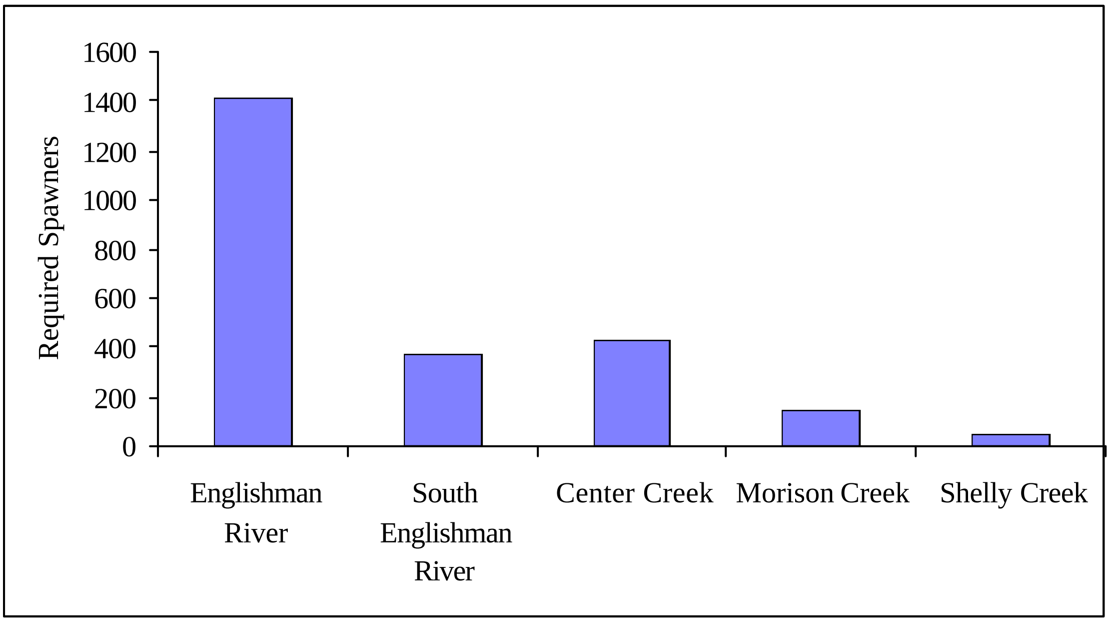


Figure 18. Distribution of required number of coho spawners within the Englishman River watershed.

2.7.2 Steelhead

Steelhead productive capability has been modeled using habitat parameters for several systems throughout BC (e.g. Tautz et al. 1992; Bocking and English 1992; Nelson et al. 1998; Bocking 2000; Bocking et al. 2000 (in prep)). Using the methods described in detail in Bocking and English 1992, we estimated 8,000 steelhead smolts could be produced from the available habitat area (6,000 from mainstem areas) (Appendix D). The model applies Keogh River smolt densities of 0.058 per m^2 of useable habitat area and adjusts this based on Englishman River alkalinity and mean-smolt age. The available habitat included the Englishman River, South Englishman River and Center Creek. These estimates of steelhead smolt capability are higher than those reported in Wightman et al (1998), Tredger (1986) and Lirette et al. (1987). The main reason for the higher production capability reported in this recovery plan is the additional habitat included from Center Creek.

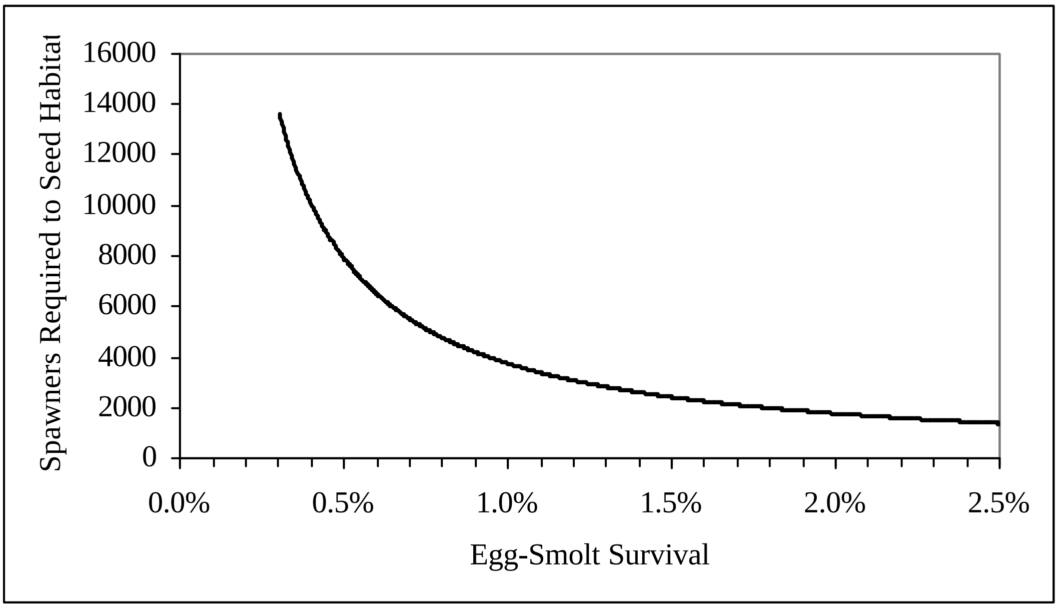


Figure 19. Relationship between freshwater survival (egg-smolt) and coho spawners required to fully seed available habitat.

Applying a fecundity of 4,047 for Englishman River steelhead and an assumed egg-fry survival of 10%, this translates to 220 adult steelhead spawners required to adequately seed the available habitat and produce 8,000 steelhead smolts. If egg-fry survival were as low as 5%, then 450 spawners would be needed to fully seed habitat. This equates to 20 adult spawners per km in the Englishman River. Twenty adults (10 females) per km has been suggested as the "safe" level of adult steelhead to achieve sufficient annual fry recruitment (Wightman et al. 1998).

We do not know what current freshwater survival is like for Englishman River steelhead. Ward (2000) documented a significant reduction in freshwater survival from spawner to smolt at the Keogh River from 1976 to 1994. As a minimum, accurate data on adult and smolt populations are required to measure freshwater survival. Counts of steelhead parr may be used as a surrogate for potential smolt yield and can be used to assess freshwater fry-parr survival.

2.7.3 Chum

The capacity of the Englishman to produce chum salmon can be approximated by the available spawning habitat. Assuming 1.5 spawners per m^2, the Englishman River could support 45,000 chum spawners on 70,000 m^2 of spawning habitat (Blackburn and Hurst, unpublished). This estimate is considerably higher than the maximum reported abundance of 25,000 in recent years.

2.7.4 Chinook

The chinook population in the Englishman River is entirely enhanced. To our knowledge, abundance goals have not been set and the capacity of the Englishman River to support chinook has not been quantified. Because of the potential for significant interactions between juvenile chinook and steelhead, abundance goals should be established for chinook. DFO is the process of establishing enhancement objectives for South Coast streams.

2.7.5 Pink

The pink population in the Englishman River is currently enhanced. As for chinook, the capacity of the Englishman to produce pink has not been rigorously assessed. Abundance goals need to be established for pink salmon along with a strategy to reach self sustainability.

3 Information Needs

3.1 Stock Condition

Coho
Sufficient data has been collected in the past two years to provide a baseline for coho abundance in the watershed. This program utilizes smolt fences on Centre Creek, and the two side channels to capture and mark coho smolts. These smolts are then recaptured in two rotary traps positioned in the lower Englishman River. A mark-recapture estimate of the system-wide smolt population is then obtained. The current smolt assessment project (now in its third year) should be continued and expanded to include a smolt fence on Morison Creek as well as coded-wire tagging of all wild coho smolts.

The current Area-Under-The-Curve (AUC) procedures for estimating adult spawner abundance should be reviewed and improved upon where possible. Currently, annual estimates of stream life (a parameter critical to the AUC calculation) are not obtained from study, but rather are guesstimates. Multiple swims of the entire anadromous section of the watershed are conducted each year.

There are some other options for enumerating adult salmon in the Englishman. These include: 1) a weir or resistivity counter on the lower Englishman, and 2) weirs or resistivity counters on the main tributaries. The appropriateness and feasibility of these two approaches should be examined.

Steelhead
There is little doubt that Englishman River steelhead have been in a state of decline, based on standardized swim counts of adults and fry densities. However, absolute measures of adult abundance are not available. Swim counts by MELP support the conclusion that the stock is in serious decline. Recently, captures of steelhead smolts emigrating from Center Creek and at the rotary screw traps in the lower Englishman in 2001 are providing the first indication of smolt numbers for portions of the system. Total abundance estimates of smolts and adults are required for the system as part of a recovery program. We recommend that the current smolt enumeration program for coho should be expanded to include steelhead.

Because of the inherent difficulties with counting winter run steelhead, different methods of enumerating adult steelhead should be explored. As a minimum, the current swim counts should be expanded to include the entire mainstem system.

Chum

Escapement estimates for chum salmon have been based on repeated swim counts since 1998. These are considered sufficient to monitor trends in abundance.

3.2 Freshwater Habitat Condition

A comprehensive channel and fish habitat assessment of Englishman River, South Englishman, Center Creek and Morison Creek is required to properly determine habitat condition. Although the fish habitat assessment will concentrate on the anadromous sections, channel and sediment source assessments will be undertaken throughout the watersheds. Further assessment of Shelly Creek in the vicinity of Martindale Road would help to determine if coho habitat can be improved immediately downstream of the barrier culverts at Martindale Road.

A comprehensive riparian assessment is required for the entire drainage as are water quality and quantity monitoring. Some water quality monitoring has already taken place in the watershed by BC Fisheries and the mid-Vancouver Island Habitat Enhancement Society. Timberwest also conducts routine monitoring of water quality within its forestlands.

3.3 Marine Survival

Low marine survival in the 1990's is believed to be one of the most important factors affecting the returns for coho and steelhead to the Englishman River. There are recent indications that the marine survival rates for coho salmon in the Strait of Georgia are substantially higher in 2001 than in previous years. Data from 2001 trawl surveys and zooplankton sampling in the Strait of Georgia have revealed a coincident increase in coho and euphausiid abundance (Richard Beamish, DFO, pers. comm. 2001). While these and similar findings from Barkley Sound (Ron Tanasichuk, DFO, pers. comm. 2001) suggest that poor marine survival is related to inadequate food supply for juvenile salmon, there remains considerable uncertainty regarding the location and time period when the majority of marine mortalities occur. On 6 July 2001, the Pacific Salmon Endowment Fund sponsored a meeting to discuss alternative proposals for addressing these marine survival questions. The current plan is to prepare and evaluate several research and monitoring options over the next few months and identify what role, if any, the PSEF should play in research, monitoring and the definition of management options related to the marine survival of salmon.

4 Prognosis

The prognosis for recovery of coho, cutthroat and steelhead stocks in the Englishman River is good. Indeed, coho are already showing signs of recovery, in terms of abundance, primarily because of apparently improved marine survival of the 1996 and 1997 broods. The construction of the Arrowsmith Dam should help to ensure sufficient rearing and spawning flows for coho.

4.1 Biological Factors Influencing Recovery

The primary factors limiting the recovery of coho and steelhead stocks in the Englishman River are poor marine survival and degraded freshwater habitat (summer and winter rearing). Marine survival is for the most part beyond our control, and appears to be improving based on recent evidence. Freshwater survival of coho and steelhead is primarily a function of available good quality habitat for incubation and rearing, and adequate stream flow.

The recent ability to store water to maintain adequate summer flows will go along way to improving summer rearing conditions. The current and proposed side channels also contribute greatly to rearing habitat for coho.

Measures to stabilize channel bars (and promote vegetation), improve cover, pool depth, and pool frequency as well as rehabilitate stream processes (i.e., sediment and flow regimes, riparian and floodplain functions) will also benefit recovery.

4.2 Socio-economic Factors Influencing Recovery

4.2.1 Land Use

The main concern regarding socio-economic factors influencing recovery is continued development pressures that may lead to further damage to riparian habitats and increased demand on water. Currently, these are primarily occurring in Morison Creek, Shelly Creek, and the lower Englishman River. Forestry activities in Center Creek, Englishman River and South Englishman River are the main concerns for those sub-basins.

4.2.2 Fisheries

Severe restrictions on the harvest of Georgia Basin coho have been in place since 1998. Near zero exploitation rates have been maintained over this period. DFO has not yet announced its 2001 fishing plan for these stocks, but it is anticipated that exploitation on coho will still be significantly curtailed. It is also generally acknowledged that there will not be a return to the 80%-90% exploitation rates that these stocks suffered in the 1980's.

Similar restrictions on steelhead harvests have been imposed on the Englishman River which has been re-designated as a wild steelhead stream. This means that there will not be a return to enhancement of the Englishman for steelhead. Strict fishing regulations are likely to continue on the Englishman.

4.2.3 Water Use

The demand for water from the Englishman River is certain to increase over time. A water management plan will be required to ensure that salmon recovery efforts are not compromised by the lack of sufficient water for salmon use. This includes ensuring that the water intake remains in the lower river during critical low flow periods. The short-term maintenance flow requirements for the Englishman River is 10% of MAD or 1.44 m^3/s (MELP). The Provisional Operation Rule for Arrowsmith Dam requires that flow releases be sufficient to maintain flow in the Englishman above 1.6 m^3/s. Optimum rearing flow is calculated to be 20% of MAD or 2.88 m^3/s (30-d average in August or September; Ron Ptolemy pers. comm.). Flows of 60% MAD or 8.6 m^3/s (Ron Ptolemy, pers. comm..).

5 Recovery Objectives, Targets, Strategies and Options

A recovery strategy for coho and steelhead salmon in the Englishman River must adhere to the PSEF principle of being holistic and comprehensive. To that end, the strategy should address the following:

- Maintenance of low exploitation rates until sufficient numbers of adults have returned to fully seed available habitat;
- Maintenance of adequate flows during summer rearing period;
- Provision (rehabilitation/protection) of adequate quality coho and steelhead rearing habitat including mainstem habitats; and
- Measures (rehabilitation/protection) to ensure long term stability of spawning habitats.

5.1 Abundance Goals

The following production goals are recommended as preliminary recovery targets. They are species-specific. These targets will be refined as additional information on stock productivity, habitat condition, and interaction between species is collected.

We recommend that smolt output be the primary measure of recovery success for coho and steelhead as it best represents stock productivity. Adult returns are highly variable depending on marine conditions.

Coho
The habitat-based production capability model for coho suggests that the Englishman River is capable of producing, on average, 52,500 smolts. This was determined using linear relationship of Marshall and Britton (1990). 95% confidence limits on the slope of this relationship were ± 302.6. Accordingly, one would expect the smolt capacity of the Englishman River to be somewhere between 41,875 and 59,170. Using an average egg-smolt survival of 1.5%, 2,400 coho spawners would be required to reach this smolt production level with a range of 1,900 to 2,800.

These estimates of average productive capacity for coho are based on model relationships developed using data from the 1970's and 1980's (Marshall and Britton 1990). We have generally no information on what productive capacity for a watershed might have been pre-development. Nor can we assume that we can hope to restore freshwater productive capacity to what it was in a pristine watershed. There are several approaches one can take:

1. Assume that there has been no loss of smolt productive capacity except in the obvious instances where man-made barriers have cut off stream habitat.
2. Assume that the smolt productivity models of the last two decades are underestimating historical productivity.

Given the loss of off-channel habitat and mainstem pool habitat, assumption Number 2 seems more plausible. Beechie et al. (1994) estimated that habitat alteration on the Skagit River has resulted in a 24% to 34% loss of smolt production. At Keogh River, habitat rehabilitation measures including LWD complexing, off-channel habitat creation, and nutrient additions have resulted in increased smolt production for both coho and steelhead.

We recommend that between 40,000 and 60,000 coho smolts be established as the recovery target range for Englishman River coho. The Weyerhaeuser and Timberwest channels currently account for approximately 20% of the total coho smolt production from the Englishman River. Adult spawning abundances of between 2,000 - 3,000 adult coho would allow for adequate smolt production depending on freshwater survivals.

Steelhead
The steelhead habitat-based production capability model for steelhead suggests that the Englishman River (mainstem, South Englishman and center Creek) is capable of producing, on average, 8,000 steelhead smolts. Using an established relationship between mean-smolt age and fry-smolt survival and a 5% egg-fry survival, 450 steelhead spawners would be required to reach this smolt production level. This equates to 20 adults (10 females) per km which has been suggested as the "safe" level of adult steelhead to achieve sufficient annual fry recruitment (Wightman et al. 1998).

There is some uncertainty as to the contribution that Centre Creek and South Englishman River make to steelhead smolt production in the Englishman watershed. Excluding these two systems reduces the smolt production capacity estimate to 6,025 smolts. This is within the range of 5,738 to 6,859, estimated by Tredger (1986) and by Lirette et al. (1987).

We recommend a target range of 6,000 to 8,000 steelhead smolts for the Englishman. Assuming a 5% egg-fry survival, this equates to a required spawning abundance of between 400 and 470. Between 400 and 500 returning adult steelhead spawners along with good marine survivals would allow for a re-opening of the traditional winter steelhead sport fishery, which has been closed for conservation reasons for the last three years (Craig Wightman, pers. comm.).

Chum
More and more researchers are pointing to the inter-relationship among salmonids within river systems. In particular, the role of nutrients arising from salmon carcasses in juvenile production is becoming well documented. Historically, chum salmon were abundant in the Englishman River and likely played an important nutrient role for coho and steelhead juveniles. Accordingly, maintenance of healthy chum runs to the Englishman will not only provide potential fishing opportunities but will also aid in the recovery of coho and steelhead stocks in the Englishman River.

There is considerable uncertainty regarding what the target abundance for chum should be. Until further study, we recommend a range of between 20,000 and 30,000 chum.

Pink
As for chum, pink salmon play an important role in the nutrient and food chain in streams such as the Englishman. Historically, pink salmon spawner abundances were in the 2,000-3,000

range. Recent enhancement efforts on the Englishman have resulted in returns in the 1,000-2,500 range. A target of around 3,000 - 5,000 pink salmon seems appropriate.

Chinook
Chinook salmon in the Englishman are enhanced. There are currently no clearly stated enhancement goals or objectives for chinook in the Englishman River. Given observations in other systems, the effect of chinook enhancement efforts on steelhead and coho recovery should be carefully assessed. On the Atnarko River, it was found that a successful enhancement program for chinook may be affecting the recovery of the local steelhead population (Nelson et al. 1998). Several studies have shown that competition between species occurs when there is size overlap and this competition tends to reduce the productive capacity of the habitat for each species (Chapman and Bjornn 1969; Bjornn 1978; Hartman 1965). Species competition for habitat space would be of particular concern along the margins of the mainstem Englishman and South Englishman.

Data collected in 1996 from juvenile surveys on the Atnarko River revealed size overlaps between 1+ steelhead/rainbow trout and chinook fry within the same habitat areas. Similar data compiled for the Dean River, a healthy steelhead population in the same region without any chinook enhancement, did not show any overlap between the size of steelhead/rainbow and chinook fry (Nelson et al. 1998). Because of the potential for interaction with the target species, the strategy of enhancing chinook in the Englishman River should be reviewed and abundance targets set.

Sockeye
No recovery plans or targets are required for the small stock of sockeye in the Englishman River. However, the abundance of this stock should be monitored where feasible to ensure that recovery actions for coho and steelhead do not negatively impact on sockeye.

5.2 Habitat Protection

Anadromous Sections of River
The mainstem of the Englishman River is the main spawning area for coho and steelhead. Maintenance of adequate flows in the mainstem will be critical to maintaining good egg-smolt survivals. Maintaining the water intake in the lower Englishman River will be critical to ensure this. Morison Creek and Center Creek are also very productive coho streams which need protection. Maintaining adequate flows in these streams is critical.

Protection of critical riparian habitats should be pursued within the watershed, particularly in Center Creek and the Englishman River mainstem. Working with private land owners and forest managers to protect small pockets of riparian habitats is a start toward ensuring that watershed integrity will be preserved.

Non-anadromous Sections of River
Activities occurring in the upper portions of the Englishman River watershed have the potential to impact directly on downstream fish habitat. Critical areas in the upper portions of each basin that are (or have potential) to contribute course sediments to the lower river sections need to be

protected and/or managed to ensure that such transport does not happen. This would include areas that are prone to sliding and/or severe bank erosion.

Estuary
The development of an estuary management plan with clear direction regarding development and rehabilitation needs to be undertaken if the whole Englishman River watershed is to be restored to its full potential. The plan should address issues such as:

- Protection of critical salmon habitats;
- Reductions in pollution discharges to the estuary;
- Maintenance of sloughs and smaller estuarine channels with adequate fresh and saltwater exchange;
- Controls on further development and alienation of critical habitat; and
- Etc.

5.3 Habitat Rehabilitation

It is premature to speculate on what specific habitat rehabilitation activities may take place. It is envisaged that rehabilitation prescriptions directed at riparian, sediment, channel and instream / off-channel habitat components will precipitate from the focused assessments (Table 5). Clearly, however, measures to improve rearing habitat in the Englishman River and estuary should be an essential component of the plan. It is important that rehabilitation activities be laid out in scientifically sound basis following the results and recommendations of the habitat assessments.

6 Monitoring and Evaluation Framework

Proper design and implementation of monitoring is a prerequisite to determining the success or failure of watershed recovery. Monitoring and evaluation of the recovery of Englishman River watershed and its coho and steelhead populations will consist of:

1. Stock recovery monitoring;
2. Physical works / activity effectiveness monitoring; and
3. An integrated evaluation of watershed recovery.

6.1 Stock Recovery Monitoring

Stock recovery monitoring is the monitoring of the progressive move towards full recovery as defined by the abundance targets established above. Clearly some semblance of ecological or watershed recovery will be critical to the successful recovery of the stocks. Monitoring of the watershed recovery is addressed in the next section – Physical Works / Activity Effectiveness.

Recovery monitoring will focus on the status of abundance of both smolt production and adult spawning populations. Accurate measures of smolt production are the most critical component of the monitoring program. Reasonably accurate measures of adults are also important, particularly if fisheries begin capturing a portion of the adult return. In the event that fisheries might occur, Englishman River coho smolts should be coded-wire tagged.

6.2 Physical Works / Activity Effectiveness

A hierarchical framework for effectiveness monitoring of restoration works and activities within watersheds has been proposed by Gaboury and Wong (1999). Effectiveness monitoring in the Englishman will involve two types or levels of monitoring: routine and intensive. Preliminary monitoring of physical works falls into the category of routine monitoring.

The main objectives of routine monitoring are to:

1. assess whether the works are functioning as intended using response indicators;
2. determine if remedial work is needed; and
3. identify specific areas which may warrant more detailed monitoring or specific investigation.

Intensive monitoring will rely on direct measures of physical and biological parameters for select projects or subsets of sites rather than response indicators. Intensive monitoring will be implemented to determine the inter-relationships of specific recovery activities, and their independent and combined effectiveness at restoring watershed processes and physical habitats.

6.3 Evaluation of Watershed Recovery

The overall success of implementing the various activities in the Englishman Recovery Plan should be evaluated in terms of attaining coho and steelhead population targets, and rehabilitating watershed processes in concert with addressing the habitat limitations to fish production. The evaluation will answer questions relating to the rate of recovery of watershed processes, and the combined effectiveness of watershed, hillslope, stream, and site-scale restoration treatments and protection activities on the recovery of limiting fish habitats and fish populations.

7 Implementation Plan Summary

Table 5 summarizes the overall implementation plan for the next three years. This plan is preliminary and will evolve as new information is acquired through 2001 projects. For 2001, the plan focuses primarily on:

1. Public Education;
2. Habitat Protection Measures; and
3. Rehabilitation Assessments to develop prescriptive measures.

The details of the plan are best described by way of project descriptions which are provided in the next and final section of this recovery plan.

Table 5. Implementation plan for Englishman River coho and steelhead.

Component	Activity	Target Species	Location	Year	Season	Description of Activity	Priority
1.Public Information	Dissemination of information regarding recovery process	All	All	2001 -	All	Production and distribution of education materials (e.g. meetings, newsletter)	High
2. Stock Assessment	Smolt enumeration	coho,steelhead	Center Creek, Morison Creek, Mainstem Englishman	2001 -	sprin g	Obtain an accurate estimate of smolt production using combination of tributary fences and rotary trap in lower Englishman. This is a continuation of project implemented in 1999.	High
	Adult enumeration	coho,steelhead, chum	system-wide	2001 -	spring-summer-fall	Obtain an accurate estimate of adults returning using a combination of visual counts (AUC) in the mainstem Englishman and fence count in the South Englishman, Centre Creek and Morison Creek. Feasibility and cost of a fixed point counting system on the Englishman mainstem should be explored.	High
3. Habitat Protection	Education, stewardship of land, water and resources	all	mainstem and tributaries	2001 -	all year	Develop a public education program to promote stream stewardship and wise land use practices to protect fisheries habitats (e.g. water retention ponds); include program of grants, loans, demonstration sites, etc.	High
	Flow Monitoring	all	mainstem and tributaries	2001 -	all year	Establish stream flow gauges on Morison, Centre, and South Englishman to monitor flows and temperatures and identify problems.	High
4. Habitat Rehabilitation	Riparian	all	mainstem and tributaries	2001 -2002	all year	Conduct riparian assessment of watershed to identify problem areas and prescribe works.	High
	Instream (including fish passage)	coho,steelhead	Center Creek, Morison Creek, South Englishman and Englishman	2001 -2002	summer/fall	Conduct channel and fish habitat assessment to identify problem areas and prescribe works	High
	Sediment	all	Upper Englishman, Morison	2001	summer/fall	Conduct sediment source survey to identify problem areas and prescribe works	High
	Riparian	all	TBA	2002 -	summer/fall	Implement Riparian works	High
	Instream	all	TBA	2002 -	summer/fall	Implement Instream works	High
	Sediment	all	TBA	2002 -	summer/fall	Implement Sediment remedial works	High
5. Monitoring	Activity Effectiveness	coho, steelhead	TBA	2003 -	all year	Conduct effectiveness monitoring as per FRBC guidelines for riparian and stream works, and on habitat protection activities	High
	Recovery Evaluation	all	All	2001 -	all year	Evaluate combined effectiveness of Recovery Plan component activities from the PSEF perspective and monitor recovery	High

8 Recommended Recovery Plan Projects

Table 6 contains a list of projects, objectives, timelines and approximate budget for each of the following recommended recovery projects.

8.1 Information and Coordination (Project #1)

Part of the process of watershed recovery is the coordination of projects and dissemination of information to progress towards recovery. This can take the form of a Watershed Recovery Newsletter, public meetings, and other forms of communication. During the recovery planning process, this has been quite informal. We recommend that this be established as a standalone project for the duration of the recovery plan implementation.

Estimated Project Duration *5 years*

8.2 Stock Assessment

A number of projects have been identified as essential, not only for determining current stock condition, but also for ongoing monitoring of the recovery effort. The following projects will satisfy much of the requirement for recovery monitoring as described in Section 6.1 of this plan.

8.2.1 Smolt Enumeration and Coded-Wire Tagging (Project #2)

Since 1998, DFO has operated a coho smolt enumeration program on the Englishman River. Reliable estimates of the total coho smolt production from the Englishman River have been obtained using a combination of tributary weirs and rotary traps in the Lower Englishman. Annual mark-recapture estimates of total coho smolt production are derived. Steelhead smolts have also been captured but not marked to allow for a mark-recapture estimate.

This project should be continued with the following objectives:

1. obtain a reliable mark-recapture estimate of total coho smolt production for the Englishman River;
2. coded-wire tag 20,000 coho smolts;
3. obtain a reliable mark-recapture estimate of total steelhead smolt production for the Englishman River; and
4. collect biological data for coho and steelhead, including size and freshwater age.

These objectives can be met by operating a total smolt weir on Center Creek and Morison Creek, marking all catch, and recapturing smolts in two rotary traps as they migrate through the lower Englishman River.

Existing weirs on two side channels (operated by DFO) do not form part of this study.

Proposals should be requested to conduct this work and must include a qualified biologist to direct the project. DFO staff have offered to coordinate this study with current stewardship groups.

Estimated Project Duration *5 years*

8.2.2 Adult coho enumeration (Project #3)

Adult coho are currently enumerated using near weekly snorkel swims and AUC estimation methods. While considerably better that traditional fishery officer estimates, uncertainty in the AUC escapement estimates remain due to assumptions regarding coho stream life (English et al. 1992) and observer efficiency.

We recommend that the current enumeration program be continued with the following augmentations to test some of the critical AUC assumptions:

1. annual estimates of coho stream life should be obtained using tagging and re-sighting methods;
2. annual estimates of observer efficiency should be made; and
3. adult weirs should be constructed and operated on Center Creek and Morison Creek.

It is presumed that matching funds will be available. This project will continue for the duration of monitoring pending the results of the feasibility assessment for a counting facility in the lower Englishman River.

Estimated Project Duration *5 years*

8.2.3 Adult steelhead enumeration (Project #4)

Adult steelhead are currently enumerated in the Englishman River using standardized swim counts along a portion of the river. A complete count is not obtained. We recommend expansion of the area covered by swim counts to include the entire anadromous portion of the watershed, particularly Centre Creek, South Englishman River, and Englishman River.

It is presumed that funding will continue to be available from other sources. PSEF provide sufficient funds to support the additional area covered. This project will continue for the duration of monitoring pending the results of the feasibility assessment for a counting facility in the lower Englishman River.

Estimated Project Duration *5 years*

8.2.4 Adult Weir in Lower River Feasibility Assessment (Project #5)

The development of a multi-species counting platform in the lower Englishman River that would provide reliable escapement estimates for all species is highly desirable from an operations and cost perspective. We recommend that a feasibility study be conducted to assess the establishment and operation of a permanent counting facility in the lower Englishman. Not only would such a facility provide superior data for monitoring recovery efforts, but would also establish the Englishman River as a key indicator stock for coho and steelhead.

The Request For Proposal (RFP) should be for qualified contractors to conduct the feasibility study.

Estimated Project Duration *1 year with possible expansion if feasible*

If the feasibility assessment results are positive, we estimate the cost of a permanent counting facility in the lower Englishman at $200,000 - $300,000 (construction costs). Annual operational costs would be around $50,000.

8.3 Habitat Protection

The establishment of habitat management plans, best practices for protection, and land/water stewardship programs will be critical to the ultimate success of the recovery plan.

8.3.1 Stewardship and Education (Project #6)

This project is implementation of a public education program on the Englishman River watershed to promote the wise use of water and improved land practices. This project should also include a component to assist landowners in acquiring grants, covenants, or other incentives to protect riparian areas and improve water use practices.

Estimated Project Duration *5 years*

8.3.2 Flow Monitoring (Project #7)

Water quantity and water quality stations should be established at the following locations for the purpose of monitoring changes in water quantity and quality:

- Outlet of Morison Creek;
- Outlet of Center Creek; and
- Outlet of South Englishman River.

Water quality and quantity should be measured on an appropriate time scale (e.g. quarterly or semi-annual).

The City of Parksville currently monitors water chemistry at the river intake in the lower Englishman for potable water requirements. Timberwest also monitors water chemistry in a number of locations within the Englishman River watershed. Recovery plan monitoring would augment these current studies and focus on nutrient levels and sediment levels in the water courses.

Estimated Project Duration *5 years*

8.4 Habitat Rehabilitation

This is a critical component to the recovery of coho and steelhead in the Englishman. The first year will be dedicated primarily to assessment of habitat condition and the development of a rehabilitation plan that is specific to rehabilitative measures to address watershed processes. This will include upslope, riparian and instream rehabilitation activities.

8.4.1 Riparian Assessments (Project #8)

Riparian assessments should be conducted during September of 2001 to identify areas where riparian ecological function is poor and can be improved using best riparian ecology practices. Procedures identified in the WRP Technical Circular will be followed. The approach should be comprehensive and strategic to address the following key aspects of riparian habitat:

1. bank stability;
2. shading of stream habitats;
3. future LWD recruitment; and
4. etc.

Results from the project will be riparian rehabilitation prescriptions for priority areas within the drainage. Priority areas will be those with direct influences on valued fish habitat. This project will require access to private land.

Estimated Project Duration *1 year with works to follow*

8.4.2 Channel Condition and Fish Habitat Assessment (Project #9)

This project is directed at determining channel and habitat condition within the Englishman River drainage and identifying rehabilitation measures which can be undertaken to improve valued fish habitat for coho and steelhead. Assessments must be conducted in September and October of 2001. Assessments will follow those of the Watershed Restoration Program and will be a combined Condition Assessment with Prescriptions.

This project will require access to private land.

Estimated Project Duration *1 year with works to follow*

8.4.3 Sediment Source Survey (Project #10)

This project will identify and prescribe rehabilitative measures for chronic sediment sources within the Englishman watershed that are contributing to negative impacts on downstream fish or riparian habitat. This project will require access to private land.

Estimated Project Duration *1 year with works to follow*

8.5 Monitoring

As described above, there are two components to monitoring. Neither of these require funding in 2001.

8.5.1 Activity Effectiveness (Project #11)

This project is intended to monitor the success of various rehabilitative measures undertaken as a result of Projects 8, 9 or 10. Effectiveness monitoring would commence in 2002 with pre-construction data collection at rehabilitation sites. For example, in the case of instream rehabilitation, juvenile densities and physical characteristics prior to construction will be critical.

Estimated Project Duration *4 Years (Year 2 – 5)*

8.5.2 Recovery Evaluation (Project #12)

This project is to monitor at a project level, whether PSEF goals and the recovery plan project goals are met. It also tracks and monitors progress toward recovery of coho and steelhead within the watershed. In other words, are the recovery objectives and targets being met. A key product of this Recovery Evaluation will be recommendations to the PSEF and the Pacific Salmon Foundation (PSF) regarding future projects and continuation of existing projects. A report that will serve as an addendum to the Englishman River Recovery Plan will be produced by March of each year.

Estimated Project Duration *5 years*

Table 6. Recommended recovery projects, objectives, timelines and approximate budget (includes 5% inflation factor).

Project	Objectives	Project Timing	Year 1	Year 2	Year 3	Year 4	Year 5
Information and Coordination	To keep public and recovery plan participants informed of progress and coordinate projects to maximize results	January – December	30,000	31,500	33,075	34,729	36,465
Smolt Enumeration and Coded Wire Tagging	To monitor freshwater productivity, marine survival, and exploitation for coho and steelhead	April – June	50,000	52,500	55,125	57,881	60,775
Adult Coho Enumeration	To monitor adult returns and spawner abundance, marine survival, and exploitation	September – December	60,000	50,000	52,500	55,125	57,881
Adult Steelhead Enumeration	To monitor adult returns and spawner abundance, marine survival, and exploitation	March – May	15,000	15,750	16,538	17,364	18,232
Adult Weir in Lower River (Feasibility Assessment)	To evaluate the feasibility of operating a counting weir or resistivity counter in the lower Englishman River to enumerate steelhead and coho spawners	August – May	10,000	Depends on results of feasibility assessments			
Stewardship and Education	To promote wise use of water and land use to protect salmon resource (includes fund for one-time grants to landowners to improve practices	January – December	75,000	15,000	15,750	16,538	17,365
Flow Monitoring	To monitor critical flow quantity, quality and temperature at key locations within the drainage	January – December	40,000				
Riparian Assessments	To assess condition of riparian habitats and recommend rehabilitation	September – October	20,000	Depends on results of assessments			
Channel Condition and Fish Habitat Assessment	To assess condition of stream channel and fish habitat and recommend rehabilitation	August – September	60,000	Depends on results of assessments			
Sediment Source Survey	To identify sediment sources that are or have the potential to negatively impact on fish habitat recommend rehabilitation	August – September	15,000	Depends on results of assessments			
Activity Effectiveness	To monitor the effectiveness of recovery measures and make recommendations	January – December	20,000	21,000	22,050	23,153	24,311
Recovery Evaluation	To monitor progress toward recovery and make recommendations	January - December	20,000	21,000	22,050	23,153	24,310
		Totals	415,000	Depends on extent of rehabilitation			

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APPENDIX A

List of Participants in the Englishman River Recovery Planning Process

Appendix A. List of participants in Englishman River Watershed Recovery Plan Process.

Name	**Affiliation**
Dan Bernard	The Nature Trust
Barbara Burns	Core Advisory Committee, Parksville-Qualicum Beach Wildlife Management Area
Bob Bocking	LGL Limited
Bob Brown	Community Fisheries Development Centre - Englishman River Enhancement
Ron Buechert	Parksville Stream Keepers
Don Cameron	
Bruce Carpenter	Land Owner
Rich Chapple	Pacific Salmon Foundation
Tim Clermont	Core Advisory Committee, Parksville-Qualicum Beach Wildlife Management Area
Dave Clough	Lantzville Stream Keepers
Carol Cornish	Parksville Stream Keepers
James Craig	BC Conservation Foundation
Neil K. Dawe	Environment Canada
Tony Dorling	Mid-Island Stewardship Trust Coordinator
John Dunn	Lantzville and Nanoose Stream Keepers
John Ebell	Fisheries and Oceans
John Eden	Weyerhauser, Northwest Bay Operations
Howie Edwards	Nanoose First Nation
Mike Edwards	Nanoose First Nation
Marc Gaboury	LGL Limited
Gary Gallinger	
Glen Jamiesen	Mount Arrowsmith Biosphere Foundation
Mark Johannes	Northwest Ecosystem Institute
Russ Jones	Haida Fisheries Program
Steve Lackey	Timberwest, Coast Timberlands
Marion Lightly	Fisheries and Oceans
Mike McCullich	BC Conservation Foundation
Matt McKay	Community Fisheries Development Centre - Englishman River Enhancement
Paul Mullen	Land Owner
Norm Mycock	Land Owner
John Pehowich	Core Advisory Committee, Parksville-Qualicum Beach Wildlife Management Area
Bert Reid	Arrowsmith Watershed Stewardship Team
Brigid Reynolds	Regional District of Nanaimo
Roy Roycroft, MCIP	City of Parksville
Norm Ryder	Arrowsmith Watershed Stewardship Team
Mel Sheng	Fisheries and Oceans
Kent Simpson	Fisheries and Oceans
Faye Smith	Qualicum Beach Stream Keepers
Roy Stewart	Parksville Stream Keepers
Patrick Walshe	Mid Vancouver Island Habitat Enhancement Society

Name	**Affiliation**
M.C. Warrior	Mid Vancouver Island Habitat Enhancement Society
Trevor Wicks	Arrowsmith Watershed Stewardship Team
Craig Wightman	Ministry of Water, Land & Air Protection
Herman Vanderbyl	Land Owner
Clinton Young	Community Fisheries Development Centre - Englishman River Enhancement

APPENDIX B

Maps

APPENDIX C

Salmon Stocking Records for Engishman River

Table C1. Coho salmon transplants from Big Qualicum hatchery to the Englishman River. (data provided by Big Qualicum Hatchery)

Brood Year	**Species**	**Stock**	**Number of Fish**			**Mark Type**	**Wt (gm)**	**Stage**	**Transport Date(s)**
			Mk	**Unmk**	**Total**				
1985	Coho	Big Qualicum		3,000	3,000		14.00	Fed fry	Jan 14/87
1987	Coho	Big Qualicum	20,256	19,412	39,668	LV clip	2.30	Fed fry	Jun 27 - Jul 4/88
1987	Coho	Big Qualicum	19,940	19,914	39,854	LV clip	1.92	Fed fry	Jun 27 - Jul 4/88
1989	Coho	Big Qualicum	16,528	60,346	76,874	L Max clip	1.41	Fed fry	May 10-14/90
1989	Coho	Big Qualicum	16,538	6,652	23,190	L Max clip	1.41	Fed fry	May 14-16/90
1990	Coho	Big Qualicum	16,383	39,700	56,083	LV clip	0.99	Fed fry	Jun 13-18/91
1990	Coho	Big Qualicum	6,188	34,000	40,188	LV clip	0.99	Fed fry	Jun 13-18/91
1991	Coho	Big Qualicum	10,112	0	10,112	L Max clip	2.00	Fed fry	Apr 4/92
1992	Coho	Big Qualicum		49,634	49,634		2.54	Fed fry	Aug 17/93
1992	Coho	Big Qualicum		15,000	15,000		2.54	Fed fry	Aug 20/93

Table C2. Chinook salmon transplants from Big Qualicum hatchery to the Englishman River. (data provided by Big Qualicum Hatchery)

Brood Year	Species	Stock	Number of Fish Mk	Unmk	Total	Mark Type	Wt (gm)	Stage	Transport Date(s)
1987	Chinook	Big Qualicum	3,783	51,686	55,469	Ad/CWT	5.11	Smolt	May 18-20/88
1987	Chinook	Big Qualicum	61,745	0	61,745	Ad/CWT	7.50	Smolt	May 24-27/88
1988	Chinook	Big Qualicum	48,719	42,000	90,719	Ad/CWT	3.00	Smolt	Apr 20-25/89
1988	Chinook	Big Qualicum	54,313	36,000	90,313	Ad/CWT	5.00	Smolt	May 12-17/89
1989	Chinook	Big Qualicum	80,500	50,000	130,500	Ad/CWT	3.00	Smolt	May 14-18/90
1989	Chinook	Big Qualicum	53,087	75,000	128,087	Ad/CWT	5.00	Smolt	May 23-24/90
1990	Chinook	Big Qualicum	83,738	93,000	176,738	Ad/CWT	5.00	Smolt	May 21 - Jun 5/91
1990	Chinook	Big Qualicum		150,000	150,000		0.57	Fed fry	Apr 18/91
1993	Chinook	Big Qualicum		79,949	79,949		2.55	Smolt	May 20/94
1993	Chinook	Big Qualicum		102,309	102,309		5.21	Smolt	May 20/94
1994	Chinook	Big Qualicum		52,521	52,521		2.80	Fed fry	May 15/95
1994	Chinook	Little Qualicum		594,178	594,178		0.88	Fed fry	May 30/95
1995	Chinook	Big Qualicum		65,800	65,800		4.48	Smolt	May 29/96
1996	Chinook	Little Qualicum		261,432	261,432		1.50	Fed fry	May 15/97
1996	Chinook	Little Qualicum		137,978	137,978		2.25	Fed fry	May 21-22/97
1997	Chinook	Little Qualicum		150,000	150,000		1.51	Fed fry	Apr 14/98
1997	Chinook	Little Qualicum		91,828	91,828		2.08	Fed fry	Apr 20/98
1997	Chinook	Little Qualicum		100,000	100,000		2.58	Fed fry	Apr 29/98
1998	Chinook	Big Qualicum		100,400	100,400		2.22	Fed fry	Apr 7/98
1998	Chinook	Big Qualicum		519,889	519,889		2.77	Fed fry	Apr 15/99
1999	Chinook	Big Qualicum		48,059	48,059		3.06	Fed fry	Apr 27/00
1999	Chinook	Big Qualicum		38,688	38,688		3.59	Fed fry	May 3/00
1999	Chinook	Big Qualicum		35,351	35,351		4.16	Smolt	May 9/00
1999	Chinook	Little Qualicum		280,816	280,816		2.50	Fed fry	Apr 17-18/00
2000	Chinook	Little Qualicum		250,000	250,000		2.73	Fed fry	May 2-3/01

Table C3. Pink salmon transplants from Quinsam hatchery to the Englishman River. (data provided by Quinsam Hatchery)

Brood Year	Species	Stock	Number of Fish			Mark Type	Wt (gm)	Stage
			Mk	Unmk	Total			
1993	Pink	Quinsam River		1,530,002	1,530,002			Egg
1994	Pink	Quinsam River		1,823,476	1,823,476			Egg
1995	Pink	Quinsam River		1,791,742	1,791,742			Egg
1996	Pink	Quinsam River		750,012	750,012			Egg
1997	Pink	Quinsam River		651,624	651,624			Egg
1998	Pink	Quinsam River		899,587	899,587			Egg
1999	Pink	Quinsam River		1,000,050	1,000,050			Egg
2000	Pink	Quinsam River		1,505,736	1,505,736			Egg

Table C4. Steelhead stocking record for the Englishman River.

Release			Total			
Date(s)	**Species**	**Stock**	**Number**	**Wt (gm)**	**Stage**	**Location**
May 8, 1980	steelhead	Englishman	17000	14	parr	Englishman
May 28, 1980	steelhead	Englishman	12082	40	smolt	Englishman
July 1, 1980	steelhead	Englishman	31850	4	fry	Englishman
April 8, 1981	steelhead	Englishman	13400	47	smolt	Englishman
May 20, 1981	steelhead	Englishman	9435	29.7	smolt	Englishman
May 20, 1981	steelhead	Englishman	3316	16.6	parr	Englishman
September 1, 1981	steelhead	Englishman	8126	2.7	fry	Englishman
May 1, 1982	steelhead	Englishman	3511	50	smolt	Englishman
May 20, 1982	steelhead	Englishman	8885	53.8	smolt	Englishman
May 20, 1982	steelhead	Englishman	2182	53.8	smolt	Englishman
June 2, 1982	steelhead	Englishman	9320	20.2	parr	Englishman
June 2, 1982	steelhead	Englishman	2286	20.1	parr	Englishman
April 18, 1983	steelhead	Englishman	17489	12.1	parr	Englishman
April 18, 1983	steelhead	Englishman	5212	5.8	parr	Englishman
May 18, 1983	steelhead	Englishman	7855	63.1	smolt	Englishman
September 21, 1983	steelhead	Englishman	8848	5.6	fry	Englishman
April 16, 1984	steelhead	Englishman	12270	72.5	smolt	Englishman
May 10, 1984	steelhead	Englishman	18411	48.8	smolt	Englishman
September 27, 1984	steelhead	Englishman	25587	3.18	fry	Englishman
September 27, 1984	steelhead	Englishman	4233	0.3	fry	Englishman
May 13, 1985	steelhead	Englishman	9788	9.5	parr	Englishman
May 13, 1985	steelhead	Englishman	4927	43.5	smolt	Englishman
May 30, 1985	steelhead	Englishman	10355	24.2	smolt	Englishman
September 18, 1985	steelhead	Englishman	40482	2.9	fall fry	Englishman
September 18, 1985	steelhead	Englishman	22396	7.9	parr	Englishman
April 18, 1986	steelhead	Englishman	10241	65.4	smolt	Englishman
May 14, 1986	steelhead	Englishman	10807	75.98	smolt	Englishman
May 28, 1986	steelhead	Englishman	2588	43.7	smolt	Englishman
October 2, 1986	steelhead	Englishman	18855	2.2	fall fry	Englishman
May 11, 1987	steelhead	Englishman	22024	67.6	smolt	Englishman
May 20, 1987	steelhead	Englishman	12102	32.13	smolt	Englishman
July 17, 1987	steelhead	Englishman	45858	0.6	fall fry	Englishman
April 22, 1988	steelhead	Englishman	18023	72.5	smolt	Englishman

Release			Total			
Date(s)	**Species**	**Stock**	**Number**	**Wt (gm)**	**Stage**	**Location**
May 10, 1988	steelhead	Englishman	3155	58.8	smolt	Englishman
August 17, 1988	steelhead	Englishman	55609	3.7	fall fry	Englishman
May 4, 1989	steelhead	Englishman	13349	59.5	smolt	Englishman
May 5, 1989	steelhead	Englishman	5167	60.6	smolt	Englishman
May 11, 1989	steelhead	Englishman	4076	37.9	smolt	Englishman
September 27, 1989	steelhead	Englishman	12659	5.9	fall fry	Englishman
May 1, 1990	steelhead	Englishman	13423	74.6	smolt	Englishman
May 7, 1990	steelhead	Englishman	9575	56.5	smolt	Englishman
August 17, 1990	steelhead	Englishman	13204	2.3	fry	Englishman
October 18, 1990	steelhead	Qualicum	13316	10	parr	Englishman
April 26, 1991	steelhead	Englishman	10268	78.2	smolt	Englishman
April 26, 1991	steelhead	Englishman	11861	73.2	smolt	Englishman
June 10, 1992	steelhead	Englishman	20836	1.46	fry	Englishman
April 26, 1993	steelhead	Englishman	9897	81.31	smolt	Englishman
April 24, 1993	steelhead	Englishman	7541	54.48	smolt	Englishman
July 24, 1993	steelhead	Englishman	27295	0.96	fry	Englishman
July 24, 1993	steelhead	Englishman	11673	2.42	fry	Englishman
August 24, 1993	steelhead	Englishman	824	1.74	fry	Englishman
April 11, 1994	steelhead	Englishman	15606	74.63	smolt	Englishman
May 5, 1994	steelhead	Englishman	7491	76.93	smolt	Englishman
August 8, 1994	steelhead	Englishman	3702	3.65	fry	Englishman
April 24, 1995	steelhead	Englishman	9496	75.76	smolt	Englishman
July 13, 1995	steelhead	Englishman	22311	1.55	fry	Englishman
April 19, 1996	steelhead	Englishman	9960	67.57	smolt	Englishman
April 22, 1996	steelhead	Englishman	10400	68.49	smolt	Englishman
September 10, 1996	steelhead	Englishman	2983	5.23	fry	Englishman
April 24, 1997	steelhead	Englishman	11162	76.46	smolt	Englishman
April 24, 1997	steelhead	Englishman	9886	62	smolt	Englishman

Table C5. Cutthroat stocking record for the Englishman River.

Release Date	Species	Stock	Total Number	Wt (gm)	Stage	Location
April 22, 1991	cutthroat	Qualicum	8614	65.4	smolt	Englishman
April 23, 1992	cutthroat	Qualicum	5000	75.2	smolt	Englishman
May 6, 1993	cutthroat	Qualicum	5100	58.4	smolt	Englishman
May 3, 1994	cutthroat	Qualicum	4662	60.4	smolt	Englishman
April 25, 1995	cutthroat	Qualicum	3584	50.9	smolt	Englishman
May 8, 1996	cutthroat	Qualicum	1296	90.27	smolt	Englishman
May 9, 1997	cutthroat	Qualicum	2662	71.73	smolt	Englishman
May 4, 1998	cutthroat	Qualicum	4408	94.63	smolt	Englishman
May 5, 1998	cutthroat	Qualicum	4408	94.63	smolt	Englishman
April 21, 1999	cutthroat	Qualicum	1900	77.97	smolt	Englishman

APPENDIX D

Coho and Steelhead Productivity Models

Table D1. Watershed area, Mean Annual Discharge, stream order and accessible length for Englishman River coho and steelhead.

	Watershed	Area (km^2)	MAD (m^3/s)	Stream Order	Accessible length[1] (<8% gradient) (m)
1	Englishman River	325.0	13.7		15850
2	South Englishman River	82.8	3.5		4475
3	Center Creek	20.8	0.9		5200
4	Morison Creek	35.6	1.5		2050
5	Shelly Creek	4.4	0.2		1000

Table D2. Coho fry useable area predicted from MAD and September low flow stage.

	Watershed	Area (km^2)	MAD (m^3/s)	Stream Order	Actual [1] Width (m)	Pred. Width (Main Order)	Low Flow Stage	Theoretical % Useable Width (m)	Theor.Useable Width (m)	Theor.Useable Width (m)	Theoretical Useable Area (m^2)	Theoretical[8] Useable Area (m^2)
							%MAD		(predicted width)	(actual width)	(pred. width)	(actual width)
1	Englishman River	325.0	13.7			21.3	71.9	20%	4.3		67816	
2	South Englishman River	82.77	3.5			10.4	71.9	28%	2.9		13154	
3	Center Creek	20.82	0.9			5.1	71.9	36%	1.8		9510	
4	Morison Creek	35.6	1.5			6.7	71.9	33%	2.2		4577	
5	Shelly Creek	4.35	0.2			2.2	71.9	41%	0.9		919	

Table D3. Smolt population estimates for Englishman watersheds using relations from Marshall and Britton (1990).

(Model 1 = Marshall and Britton 1990 (Linear); Model 2 = Marshall and Britton 1990 (Areal);

(Model 3 = Holtby et al. (1990) (Linear); Model 4 = Bradford et al. 1997.

	Watershed	Area (km^2)	Stream Order	Useable Length (m)	Useable Area (m^2)	Total Smolts[3]	Total Smolts	Total Smolts	Total Smolts	Total Smolts
						Model 1	Model 2	Model 3	Model 4	Historical Max
1	Englishman River	325.0		15850	67816	29610	20307	18307	14476	26200
2	South Englishman River	82.8		4475	13154	7718	5559	4707	4245	7397
3	Center Creek	20.8		5200	9510	9113	4303	5530	4911	8596
4	Morison Creek	35.6		2050	4577	3051	2415	2035	1991	3389
5	Shelly Creek	4.4		1000	919	1030	679	941	992	1653

Table D4. Estimate of the required number of coho spawners to fully seed available habitat assuming Marshall and Britton linear model (Model1).

Model1

	Watershed	Area (km²)	Stream Order	Smolts[1] Produced	Fry[2] Produced	Required[3] Eggs	Female[5] fecundity	Required[6] Spawners	Spawner/ km	Percent of Total escapement
					egg-fry =	19.8%				
				fry-smolt =	7.6%	1.50%				
1	Englishman River	325.0		29610	390635	1972906	2800	1409	89	58.61%
2	South Englishman River	82.8		7718	101818	514234	2800	367	82	15.28%
3	Center Creek	20.8		9113	120227	607205	2800	434	83	18.04%
4	Morison Creek	35.6		3051	40246	203265	2800	145	71	6.04%
5	Shelly Creek	4.4		1030	13586	68618	2800	49	49	2.04%
	Total	**469**		**50522**	**666513**	**3366228**		**2404**		

[1]Number of smolts at maximum production for specified model
[2]Number of fry required to fully seed habitat and produce maximum smolts
[3]Number of eggs required to fully seed habitat given specified egg to fry survival
[4]Female length from either tributary specific data or average
[5]Female fecundity
[6]Required number of spawners calculated

Table D5. Steelhead smolt population estimates for Englishman River, applying Keogh River smolt densities (Tautz et al. 1992).

		Accessible Stream Order =	4		Keogh densities =	*300*	*0.058*
	Watershed	Area (km^2)	Stream Order	Useable[1] Length (m)	Theoretical[2] Useable Area (m^2)	Smolts[3] per km	Smolts[4] per sq m
						Model 1	Model 2
1	Englishman River	325.0		15850	67816	4755	3933
2	South Englishman River	82.8		4475	13154	1343	763
3	Center Creek	20.8		5200	9510	1560	552
4	Morison Creek	35.6		2050	4577	615	265
5	Shelly Creek	4.4		1000	919	300	53
	Total			28575	95975	8573	5567

[1]Useable length of accessible stream portion

[2]Theoretical useable area determined as sum of product of accessible length and useable width

[3]Smolts per kilometre using Keogh density of 300 smolts per linear kilometre

[4]Smolts per square kilomtre using Keogh density of 0.058 smolts per km^2

Table D6. Table of adjustment factors for alkalinity and mean smolt age using Tautz et al. (1992).

	Watershed	Area (km^2)	Stream Order	Total[1] Alkalinity (mg/l)	Standing[2] Crop (kg/ha)	Adjust[3] 1	Smolt[4] Age (yr)	Smolt[5] Age (yr)	Smolt[6] Age (yr)	Space[7]	Adjust[8] 2
							(7d)	(avg)	(data)		
	Keogh			16.00	1.45			2.96		2.36	
1	Englishman River	325.0		18.7	1.57	1.08	2.40			1.67	1.42
2	South Englishman River	82.8		18.7	1.57	1.08	2.40			1.67	1.42
3	Center Creek	20.8		18.7	1.57	1.08	2.40			1.67	1.42
4	Morison Creek	35.6		18.7	1.57	1.08	2.40			1.67	1.42
5	Shelly Creek	4.4		18.7	1.57	1.08	2.40			1.67	1.42

[1]Alkalinity derived from field measurements

[2]Late summer fry standing crop predicted from alkalinity

[3]Adjustment factor 1: ratio of Englishman River standing crop to Keogh standing crop

[4]Mean smolt age predicted from growing season temperature

[5]Mean smolt age (Ptolemy, pers. comm.)

[6]Tributary specific mean smolt age from ageing (not available)

[7]Space requirements for smolts as determined from mean smolt age

[8]Adjustment factor 2: ratio of Keogh smolt space requirement to Englishman River smolt space requirements

Table D7. Smolt estimates adjusted for nutrients and mean smolt age using Keogh smolt densities.

	Watershed	Area (km^2)	Stream Order	Total[1] Alkalinity (mg/l)	Adjust1[2]	Smolt[3] Age (yr)	Adjust2[4]	Smolts[5] per km	Smolts[6] per m^2
								Model 3	Model 4
1	Englishman River	325.0		18.7	1.08	2.40	1.42	7283	6025
2	South Englishman River	82.8		18.7	1.08	2.40	1.42	2056	1169
3	Center Creek	20.8		18.7	1.08	2.40	1.42	2389	845
4	Morison Creek	35.6		18.7	1.08	2.40	1.42	942	407
5	Shelly Creek	4.4		18.7	1.08	2.40	1.42	460	82
	Total							13130	8526

[1] Alkalinity from Column J of Alkalinity Model Sheet

[2] Adjustment factor 1: ratio of Englishman River standing crop to Keogh standing crop

[3] Mean smolt age using actual or pooled mean data

[4] Adjustment factor 2: ratio of Keogh smolt space requirement to Englishman River smolt space requirements

[5] Smolts per kilometre x adjustment 1 x adjustment 2

[6] Smolts per km^2 x adjustment 1 x adjustment 2

Table D8. Estimate of the required number of steelhead spawners to fully seed available fry habitat.

Model4

	Watershed	Length (m)	Area (km^2)	Stream Order	Steelhead/Rainbow present (confirmed)	Smolts Produced[1]	Fry Produced[2]	Required Eggs[3]	Female Length[4]	Female fecundity[5]	Required Spawners[6]
							egg-fry =	0.10			
1	Englishman River	15850	325.0		Y	6025	33704	674078	610	4047	333
2	South Englishman River	4475	82.8		Y	1169	6538	130754	610	4047	65
3	Center Creek	5200	20.8		Y	845	4726	94526	610	4047	47
4	Morison Creek	2050	35.6		Y	407	2275	45492	610	4047	22
5	Shelly Creek	1000	4.4			82	457	9130	610	4047	5
	Total					8526	47699	953980			471

[1]Number of smolts at maximum production for specified model
[2]Number of fry required to fully seed habitat and produce maximum smolts
[3]Number of eggs required to fully seed habitat given specified egg to fry survival
[4]Female length from either tributary specific data or average
[5]Female fecundity predicted from female length
[6]Required number of spawners calculated