POPULATION ASSESSMENT: OREGON COAST COHO SALMON ESU

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March 2001

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Abstract

The status of wild populations of coho salmon (*Oncorhynchus kisutch*) in the Oregon Coast ESU is examined. Populations are grouped into 12 units termed "population complexes." Trends of abundance of coho salmon of each complex are examined for the period 1990-2000 based on random surveys of spawners. Estimates of theoretical juvenile production for the 1997-99 broods are made for each complex. Probability of extinction is estimated for the major populations of most complexes. The relative health of each population complex is ranked relative to the other complexes based on metrics of abundance, viability, and productivity.

Introduction

Coho salmon in Oregon coastal basins are listed as threatened under the Endangered Species Act. Under the Section 4(d) of the Act, rules have been adopted to govern take. These rules require Hatchery and Gene Management Plans (HGMPs) for hatchery programs and Fisheries Management and Evaluation Plans (FMEPs) for fisheries that might impact listed coho salmon. Assessment of population status is an integral part of these plans. The purpose of this report is to provide assessments for populations within the Oregon Coast ESU.

There have been several reviews of the status of Oregon coastal coho salmon during the past decade. Nickelson et al. (1992) judged the populations of coho salmon in the Alsea, Siltcoos, Tahkenitch, Coos, and Coquille basins to be healthy. Huntington et al. (1994) concluded that coho salmon in the Siltcoos, Tahkenitch, Coos, Coquille, and Smith (Umpqua) river basins were healthy. Kostow (1995) examined the status of coastal coho salmon at a larger geographic scale of several basins combined but did not judge health. Finally, Weikamp et al. (1995) examined coho salmon at the scale of the entire Oregon Coast ESU and concluded that they were threatened.

This report, identifies twelve population units within the Oregon Coast ESU, describes their recent status, and ranks their health relative to one another. Although patterns of relative health were identified, no attempt is made to analyze their causes. This will come with future work.

Population Units

The first step in assessing salmonid populations is to identify independent population units. Population units can be viewed as a hierarchy of levels of complexity and geographic scope. The highest level in the hierarchy of population units for coho salmon on the Oregon Coast is the Evolutionarily Significant Unit (ESU) (Waples 1995), developed to help implement the Endangered Species Act for salmon. There are two ESUs identified on the Oregon Coast for coho salmon, the Oregon Coast ESU and the Southern Oregon/Northern California Coasts ESU (Weitkamp et al. 1995). Within the Oregon Coast ESU, which includes coastal basins south of the Columbia River to Cape Blanco, Kostow (1995) identified three Gene Conservation Groups (GCG): North/Mid Coast, Umpqua, and Mid/South Coast. For the purposes of fisheries management, the North/Mid Coast GCG was split into Northern and North Central sub-aggregates and the Umpqua and Mid/South Coast were combined into a South Central aggregate (PFMC 1999). For the purpose of designing monitoring programs, the Oregon Plan monitoring program adopted the split of the North/Mid Coast GCG because population trends in the two areas were different, but rejected the combining of the South Central aggregate (Jacobs et al. 2000). This resulted in four Gene Conservation Areas (GCA) within the Oregon Coast ESU: North Coast, Mid Coast, Umpqua, and Mid-South Coast.

McElhany et al. (2000) defines an independent population as "...any collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations." For the purpose of this population assessment, we have coined the term "Population Complex" to refer to these independent populations. A population complex is then comprised of smaller breeding units, which we term populations. These units are independent from each other at shorter scales of time.

ODFW (1995) lists 81 coastal coho salmon populations within the boundaries of the Oregon Coast ESU. This list includes a few large basins, subbasins of large basins, and many small direct ocean tributaries that are probably too small to support independent populations.

The approach used to identify population complexes for this analysis was to start with the major basins and then estimate the probable sphere of influence of populations in these larger basins on populations in smaller nearby streams [See Labelle (1992) for information on straying between streams]. Because the rate of genetic interchange among streams is unknown and is probably not "black and white," assignment of groups was, to some extent, arbitrary. However, some guiding principles were used in this process.

1. Groupings were primarily based on geography, similarity of habitats, and potential similarity of life history types.

2. Small streams were grouped with nearby larger rivers.

3. Second, where available, abundance trend data were used to aid grouping. For example, peak spawner counts in Beaver Creek, which lies midway between the Yaquina and Alsea basins tends to track with the Alsea, and not the Yaquina, (Figure 1) and therefore was included in the Alsea Complex.

4. Where possible, coastal headlands were used as boundaries between adjacent groups.

Ultimately, 12 population complexes were identified (Table 1 and Figure 2). Within some complexes, primary populations were also identified (Table 2). Most complexes also contain secondary populations; streams which, based on the results of a population viability model (Nickelson and Lawson 1998), are too small (<40 miles of habitat) to sustain a viable population (Figure 3). Populations in streams with less than 40 miles of habitat have increasingly greater probabilities of experiencing very low abundances and thus depensatory effects on the populations and greater probabilities of extinction. That is not to say that these populations are not important to the abundance and diversity of coho salmon of the complex. However, they are not demographically independent as defined by McElhany et al. (2000). These secondary populations are included in ODFW (1995).

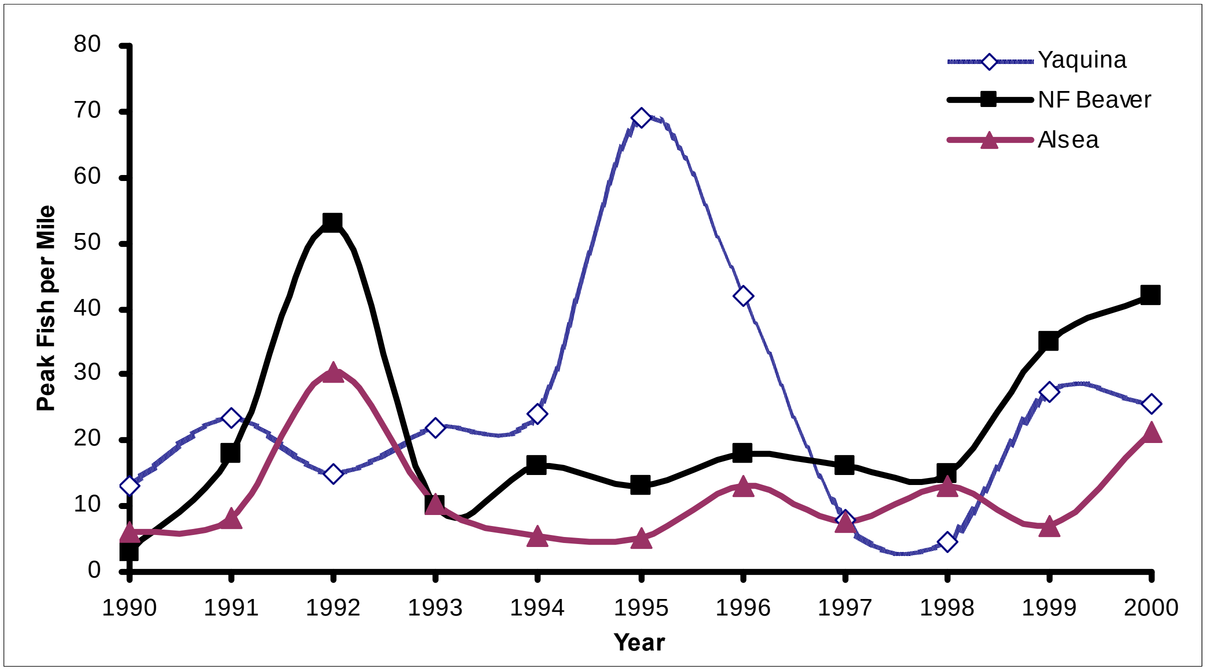

Figure 1. Trend of peak counts of spawning coho salmon in standard index sites of mid coast streams of the Oregon Coast ESU.

Table 1. Population complexes for coho salmon for the Oregon Coast ESU

Population Complex	**Description**	**Major Headland**
Necanicum	Necanicum River - Arch Cape Creek	
		Cape Falcon
Nehalem	Short Sands Creek - Spring Creek	
Tillamook	Watseco Creek - Netarts Bay	
		Cape Lookout
Nestucca	Rover Creek - Neskowin Creek	
		Cascade Head
Siletz	Salmon River - Rocky Creek	
		Cape Foulweather
Yaquina	Spencer Creek - Thiel Creek	
Alsea	Beaver Creek - China Creek	
		Heceta Head
Siuslaw	Cape Creek - Siuslaw River	
Lakes	Siltcoos, Tahkenitch, & Tenmile Lakes	
Umpqua	Entire Umpqua basin	
Coos	Coos River - Big Creek	
		Cape Arago
Coquille	Coquille River - Sixes River	

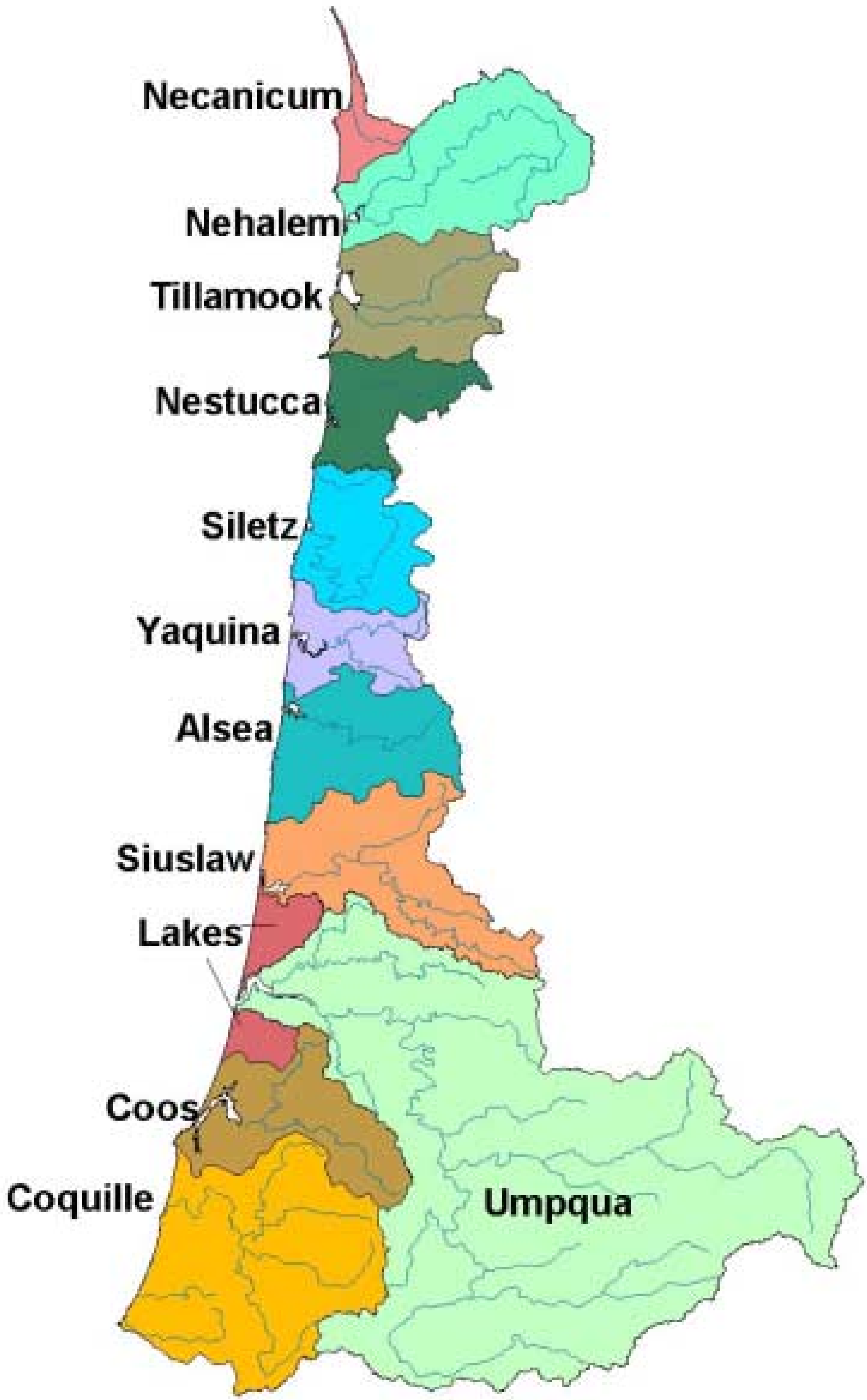

Figure 2. Coho salmon population complexes of the Oregon Coast ESU.

Table 2. Individual coho salmon populations within population complexes for the Oregon Coast ESU.

Gene Conservation Area	Population Complex	Primary Populations
North Coast	Necanicum	Necanicum River
	Nehalem	North Fork Nehalem River Nehalem River
	Tillamook	Kilchis River Wilson River Trask River Tillamook River
	Nestucca	Little Nestucca River Nestucca River
Mid Coast	Siletz	Salmon River Siletz River
	Yaquina	Yaquina River
	Alsea	Drift Creek Alsea River Yachats River
	Siuslaw	North Fork Siuslaw River Siuslaw River
Umpqua	Umpqua	Smith River Umpqua River
Mid-South Coast	Lakes	Siltcoos Lake Tahkenitch Lake Tenmile Lakes
	Coos	Coos River
	Coquille	Coquille River

Coho Salmon Life History

Adult coho salmon migrate into fresh water in the fall to spawn. Spawning of wild coho salmon usually occurs from mid-November through February. Adult spawning coho salmon are typically 3 years old and they are often accompanied by 2-year-old jacks (precocious males) from the next brood. Jacks typically comprise about 5-10% of a brood return except in lake systems where they have averaged 24% over the past 10 years. The abundance of jacks is an indicator of brood strength. The number of hatchery jacks is used to predict abundance of 3-year-old adults the following year

(Sharr et al. 2000). However, while this general trend appears to hold for numbers of spawning wild fish, a similar predictor has yet to be developed, probably because of the error associated with counting jacks on the spawning grounds.

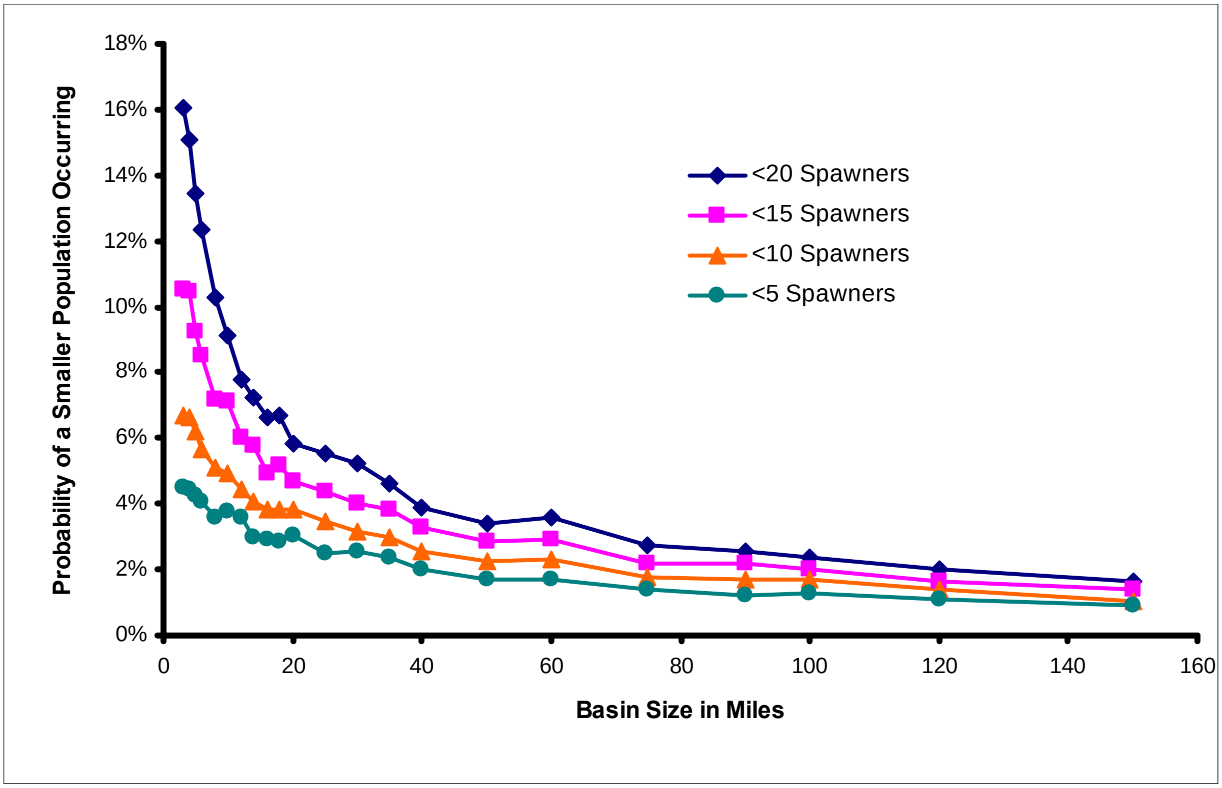

Figure 3. The relationship between basin size and probability of a smaller population of coho salmon occurring within 10 generations.

Spawning occurs primarily in small tributaries located throughout coastal basins. The parents normally exhibit strong homing to their natal stream. The female digs a nest (redd) in the gravel and lays her eggs, which are immediately fertilized by accompanying adult males or jacks. The eggs are covered by digging and displacing gravel from the upstream edge of the nest. Each female lays about 2,500 eggs. The adults die soon after spawning. Sex ratios of spawning adults tend to average around 50:50 at most locations (Table 3). However, Moring and Lantz (1975) observed 77% males in three small Alsea River tributaries over a period of 14 years. They concluded that males tend to move around a lot and visit multiple streams.

The eggs hatch in about 35-50 days, depending upon water temperature (warm temperature speeds hatching). The alevins remain in the gravel 2 or 3 weeks until the yolk is absorbed and emerge as fry to actively feed in the spring. Most juvenile coho salmon spend 1 summer and 1 winter in fresh water. The following spring, approximately 1 year after emergence, they undergo physiological changes that allow them to survive in seawater. They then migrate to the ocean as silvery smolts about 10-12 cm in length.

The smolts undergo rapid growth in the ocean, reaching about 40-50 cm by fall. Little is known of the ocean migrations of juvenile coho salmon from Oregon coastal streams, however based on what is known, it appears migrations are mostly limited to coastal waters. Initial ocean migration appears to be to the north of their natal stream (Fisher and Pearcy 1985; Hartt and Dell 1986). After the first summer in the ocean, a small proportion of the males attain sexual maturity and return to spawn as jacks. Migration patterns during the fall and winter are unknown. Those fish remaining at sea grow little during winter but feed voraciously during the next spring and summer, growing to about 60-80 cm in length. During this second summer in the ocean, a substantial percentage of these maturing adults are caught in ocean troll and sport fisheries, usually to the south of their natal stream (Lewis 2000). The survivors return to their home streams or neighboring streams where they spawn and die to complete the life cycle.

Table 3. Observations of coho salmon sex ratio at adult traps.

Population complex	**% males**	**% females**	**Location**	**Run years**	**Data source**
Nehalem	52%	48%	North Fork trap	1998-1999	Life Cycle Monitoring
Siletz	50%	50%	Mill Cr. trap	1997-1999	Life Cycle Monitoring
Yaquina	51%	49%	Mill Cr. trap	1997-1999	Life Cycle Monitoring
Alsea	77%	23%	Drift Cr. tributaries	1959-1972	Moring & Lantz (1975)
	50%	50%	Cascade Cr. trap	1997-1999	Life Cycle Monitoring
Umpqua	55%	45%	Smith River trap	1999	Life Cycle Monitoring
Coos	63%	37%	Winchester Cr., S. Coos R., & Fall Cr.	1999	Life Cycle Monitoring

Habitat Use and Freshwater Distribution

Spawning and rearing of juvenile coho salmon generally take place in small low gradient (generally <3%) tributary streams, although rearing may also take place in lakes where available. Coho salmon require clean gravel for spawning and cool water temperatures (53-58°F preferred, 68°F maximum) for rearing (Reiser and Bjornn 1979). Fry emerge from February to early June (Moring and Lantz 1975) and occupy backwater pools and the stream margins (Mundie 1969; Lister and Genoe 1970; Nickelson et al. 1992a). During summer, coho prefer pools in small streams, whereas during winter, they prefer off-channel alcoves, beaver ponds, and dam pools with complex cover (Nickelson et al. 1992a, 1992b). Complexity, primarily in the form of large and small wood is an important element of productive coho salmon streams (Nickelson et al. 1992b; Rodgers et al. 1993). Little is known about residence time or habitat use of estuaries during seaward migration. It is usually assumed that coho salmon spend only a short time in the estuary before entering the ocean. However, recent research is finding that rearing in the upper ends of tidal reaches can be extensive.

The distribution of coho salmon within a basin is primarily determined by two factors: marine survival, and the distribution of freshwater habitat of different levels of quality. When marine survival has been very poor as in recent years, coho will be found in only the highest quality habitats. Coast-wide, these habitats comprise about 22% of the habitat (Nickelson 1998). When marine survival increases, as could occur with a changing climate regime, coho will redistribute into freshwater habitats of lower quality. Thus coho salmon population dynamics function with a classic “source-sink” relationship among stream reaches.

Estimates of Theoretical Juvenile Production and Adult Equivalents

A theoretical estimate of the number of eggs, fry, parr, and smolts was calculated for each population complex for the 1997-1999 broods (Table 4). Number of eggs deposited was estimated by assuming a 50:50 sex ratio and 2,500 eggs per female. Number of fry was assumed to be 65% of egg deposition. To estimate parr, adults were assumed to spawn in high quality habitat Nickelson (1998) until fully seeded. Any adults in excess of full seeding were assumed to spawn in moderate quality habitat. Egg to parr survival was then based on the relative seeding level of each habitat category and the equations of Nickelson and Lawson (1998). Parr abundance was estimated by multiplying survival rate by egg deposition. Smolt abundance was estimated by multiplying number of summer parr by an overwinter survival rate of 0.34 for high quality habitat and 0.20 for moderate quality habitat as calculated from the equations of Nickelson and Lawson (1998).

Conversion rates were calculated to determine the number of adults expected from a known number of individuals at a given juvenile life stage. Actual adult equivalents are influenced by many factors the most important being: 1) marine survival, 2) freshwater habitat quality, and 3) freshwater juvenile density. For the purpose of this exercise, conversion rates were calculated for juvenile fish rearing in fully seeded moderate quality habitat (Nickelson 1998) based on the equations of Nickelson and Lawson (1998) and the estimated rates of adults per smolt from Sharr et al. (2000). Table 5 presents conversion rates for a range of marine survival and the 1990-99 average.

Critical and Viable Population Levels

McElhany et al. (2000) identify two numeric populations levels that delineate categories of risk for salmonid populations. These are: “a *viability threshold* above which populations have negligible risk of extinction due to local factors” and “a *critical threshold* below which populations are at relatively high risk of extinction in the near future.”

Table 4. Estimates of abundance of juvenile life stages based on spawner abundance.

Population	1997 Brood (millions)				1998 Brood (millions)				1999 Brood (millions)			
Complex	Eggs	Fry	Parr	Smolts	Eggs	Fry	Parr	Smolts	Eggs	Fry	Parr	Smolts
Necanicum	0.32	0.21	0.05	0.02	1.18	0.77	0.23	0.06	0.89	0.58	0.11	0.03
Nehalem	1.47	0.95	0.59	0.20	1.49	0.97	0.60	0.20	4.35	2.83	1.15	0.39
Tillamook	0.42	0.28	0.11	0.04	0.34	0.22	0.10	0.03	2.72	1.77	0.29	0.09
Nestucca	0.42	0.27	0.11	0.04	0.21	0.14	0.08	0.03	2.69	1.75	0.32	0.09
Siletz	0.83	0.54	0.30	0.10	0.49	0.32	0.19	0.07	1.43	0.93	0.36	0.12
Yaquina	0.48	0.31	0.19	0.07	0.46	0.30	0.18	0.06	3.25	2.11	0.59	0.20
Alsea	1.40	0.91	0.56	0.19	1.78	1.16	0.71	0.24	6.95	4.52	1.23	0.42
Siuslaw	0.84	0.54	0.33	0.11	1.36	0.88	0.54	0.18	3.50	2.27	1.19	0.40
Lakes	10.75	6.99	0.81	0.27	13.89	9.03	0.88	0.30	15.89	10.33	0.92	0.31
Umpqua	3.70	2.41	1.40	0.47	11.41	7.41	2.03	0.69	9.78	6.36	1.93	0.65
Coos	1.41	0.92	0.39	0.13	3.96	2.57	0.55	0.19	6.01	3.91	0.63	0.21
Coquille	7.15	4.65	1.19	0.30	3.40	2.21	0.35	0.12	3.98	2.59	0.37	0.13

Table 5. Adult equivalent conversion rates for each juvenile life stage of coho salmon.

	Survival to smolt	Survival to adult based on:		
Life Stage	in moderate quality habitat	Maximum observed smolt to adult survival	Minimum observed smolt to adult survival	1990-99 average smolt to adult survival
Smolt		0.1200	0.0090	0.0210
Summer Parr	0.203	0.0243	0.0018	0.0043
Fry	0.025	0.0030	0.0002	0.0005
Egg	0.016	0.0019	0.0001	0.0003

Critical Threshold

The habitat-based, life cycle model of Nickelson and Lawson (1998) was used to determine risk of extinction as a function of population size. The model includes algorithms to address the depensatory influence of random events on spawning success at low densities. These effects include skewed sex ratios and asynchronous spawning timing. These factors can prevent spawners from finding mates and results in reduced productivity when spawner numbers are extremely small.

The model was run using actual 1994 population sizes as the starting point. Four broods were simulated with 10% marine survival to fill each basin with fish, and then 16 generations were simulated with stochastic marine survival averaging 1%. Fishery exploitation rate was modeled as zero. This very severe set of conditions was modeled to insure a relatively high frequency of extinction to facilitate differentiating the effect of population size. All major coastal basins were modeled, and 1,000 iterations of each simulation were run. To assess risk of extinction as a function of population size, spawner abundance was converted to fish per mile by dividing total spawners by the number of miles in each basin. Then for the 16 generations of very low survival, the probability of extinction (defined as <0.05 fish/mile) within four generations was estimated when population densities were 0.1-1.0, 1.1-2.0, ... 9.1-10.0, 10.1-20.0, and >20.0 fish per mile.

The results of this analysis were that probability of extinction increased rapidly when spawner densities were less than four fish per mile (Figure 4). This result was consistent across basins. Critical populations levels were therefore defined for each population complex at the abundance that would equate to four fish per mile on the spawning grounds (i.e. miles of spawning habitat times four).

Viable Threshold

Figure 4 demonstrates that above the critical threshold, population size has little or no affect on probability of extinction. Nickelson and Lawson (1998) also found that above a critical level there was no relationship between abundance and probability of extinction in 100 years. They found that the most important factor determining the viability of the population was the quantity of high quality habitat. Each population must have access to an adequate quantity of high quality habitat [i.e. habitat that can sustain populations at abundances above the critical threshold through periods of poor (defined as 3%) marine survival]. The model of Nickelson and Lawson (1998) was used to determine the quantity of high quality habitat needed to sustain populations.

Figure 5 suggests that when a population has access to less than 15 miles of high quality habitat, the probability of extinction increases rapidly. Therefore, a viability threshold was defined as the availability of at least 15 miles of high quality habitat. Using the methods of Nickelson (1998), these values can be calculated for each population complex.

Assessment of the Status of Population Complexes

Population assessments were completed at the level of the 12 population complexes. The presentations of the analyses have been standardized, as much as possible, to facilitate the making of comparisons. However, the level of information available for a population complex is not always comparable to that available for others.

Abundance of wild coho salmon spawners in Oregon coastal streams has been estimated annually since 1990 using stratified random surveys (Jacobs and Nickelson 1998), and is maintained in an ODFW database. Surveys were originally designed to estimate populations at the coast-wide level. Thus, 95% confidence intervals at the coast-wide level averaged ±28%, while those at the basin level averaged ±99%. With the advent of the Oregon Plan for Salmon and Watersheds in 1997 (OPSW 1997), the sampling rate was increased from 240 sites to 480 sites, with the goal of estimating populations at the level of the Gene Conservation Area (GCA) within about ±30%. This level of effort should result in confidence intervals at the basin level being ±50-60%. Further implementation of Oregon Plan monitoring in 1998 resulted in the adoption of an integrated rotating panel sampling design based on EPA's GIS-based Environmental

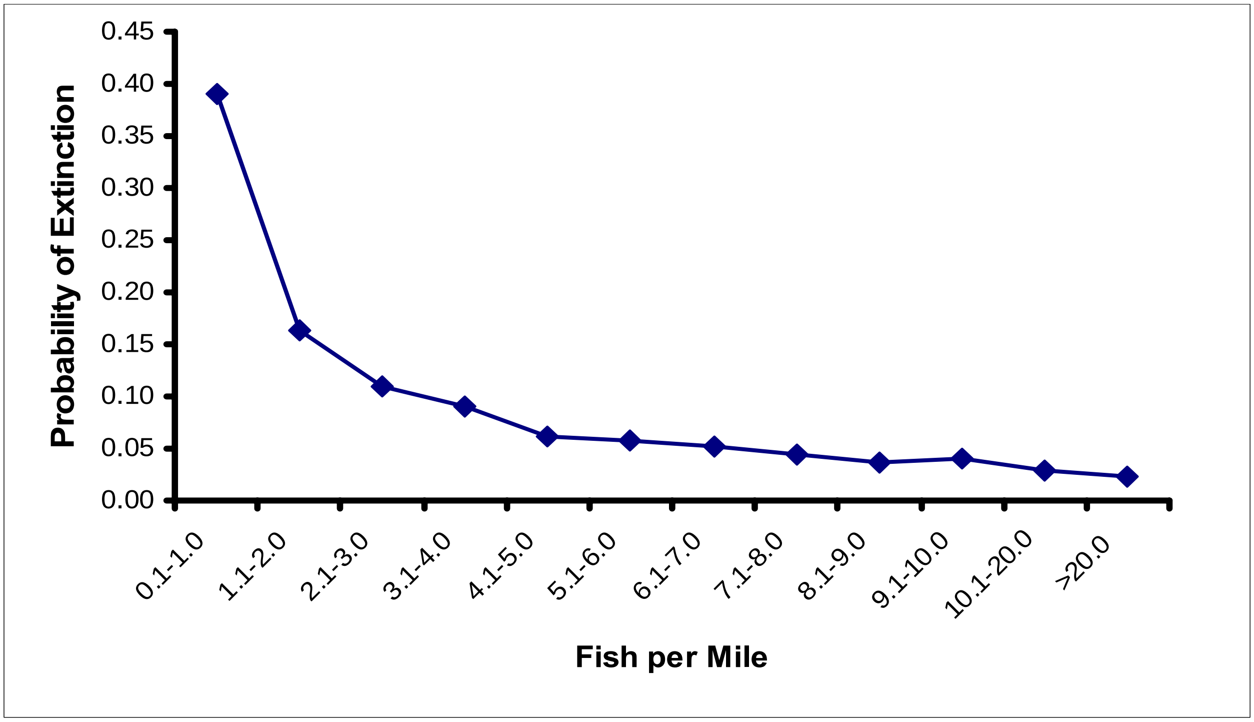

Figure 4. Probability of extinction of basin level populations as a function of spawner density. Data are combined for all major coastal basins. After Sharr et al. (2000).

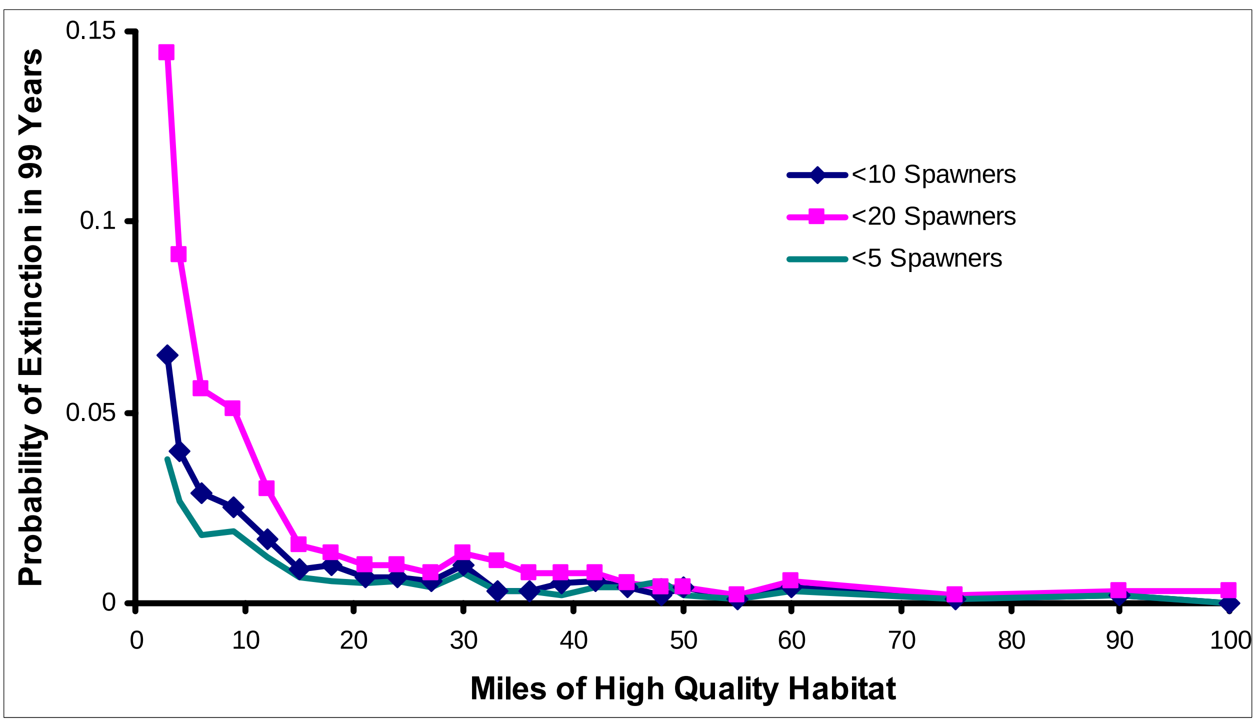

Figure 5. The relationship between the quantity of high quality habitat (habitat that will support populations of coho salmon when marine survival is 3%) and probability of extinction defined as <20, <10, or <5 spawners.

Monitoring and Assessment Program (EMAP) (Stevens 1997) site selection procedure (Jacobs et al. 2000). Estimates of spawner abundance in the Lake systems (Siltcoos, Tahkenitch, and Tenmile) are based on extrapolation of estimates in standard index areas to the rest of each basin (Jacobs et al. 2000). Estimates for the Umpqua Complex are the sum of counts at Winchester Dam on the North Umpqua River and estimates from spawning surveys in the rest of the basin.

Estimates of spawner abundance during fall and winter 2000-01 were influenced by extremely dry conditions and low stream flows. These conditions affected the population estimates in a variety of ways. Some factors, such as improved viewing conditions could lead to overestimation of the populations. Other factors, such as mainstem spawning, extended spawner life-span, and spawning after the termination of surveys (which were extended past the normal date of termination) would lead to underestimation of populations. The problem of late spawning was particularly noted in the Yaquina, Alsea, and Coos complexes.

Estimates of pre-harvest abundance of adult coho salmon were made for each population complex by dividing spawner abundance by one minus exploitation rate. Exploitation rates were acquired from ODFW IJ Unit databases (Curt Melcher, personal communication, October 2000).

Prior to 1998, the number of hatchery fish on the spawning grounds was estimated from the proportion of recovered carcasses found to have “hatchery” scale patterns. The scale analysis has a subjective element and can be problematic because of the lack of adequate samples from known wild fish. It is possible for wild fish, particularly if there is a lake in the system, to have scale patterns similar to hatchery fish. Beginning with adults returning in 1998, almost all hatchery fish have been marked by the removal of their adipose fin. As a result, the subjectivity has been taken out of the estimation of the number of hatchery strays. All estimates of spawner abundance reported here have had hatchery fish removed and therefore represent our best estimate of the abundance of wild spawners.

Necanicum Complex

The Necanicum Complex consists of coho salmon inhabiting the Necanicum River and a few small direct oceans tributaries to its south. There is an estimated 70 miles of spawning habitat available to the coho salmon of this complex. The critical population level for the Necanicum Complex is 300 adult spawners. However, given the current state of the habitat, this complex is not viable because high quality habitat is estimated to be present in only 3 miles of stream, well below the 15-mile threshold needed to support a viable population.

The abundance of coho salmon spawners of the Necanicum Complex has ranged from about 200 to about 1,100 and has averaged about 600 since 1990 (Figure 6 and Table 6). In four of those years, spawner abundance fell below the critical threshold of 300 fish. In two additional years, the 95% confidence intervals of the population estimate fell below the critical level. Recruits per wild spawner have been highly variable, with four of the last eight broods falling to one or below (Table 6 and Figure 7). Hatchery fish have been observed on the spawning grounds. Of 60 scale samples collected during 1990-99, 19 (32%) had hatchery scale patterns.

Smolt production was estimated for the 1997 through 1999 broods. Estimated smolt abundance ranged from 15 thousand to 55 thousand for the Necanicum Complex (Table 4).

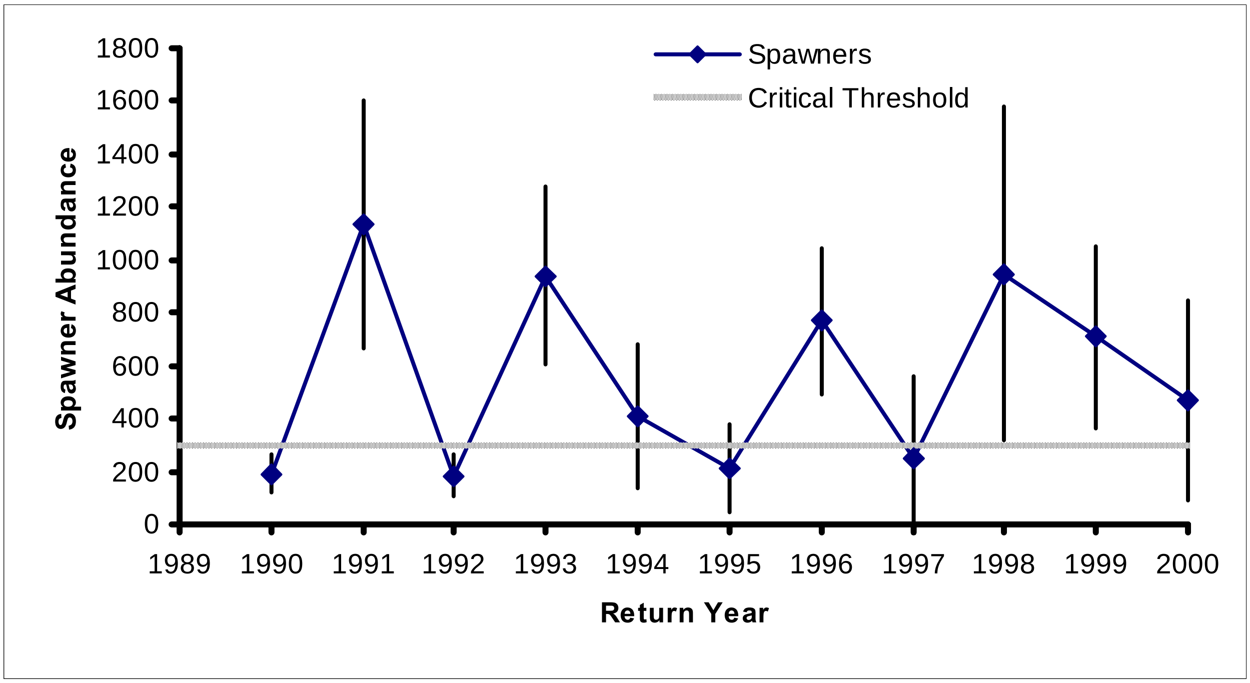

Figure 6. Trend in adult coho salmon abundance relative to the critical population level for the Necanicum Complex. Error bars are 95% confidence limits.

Nehalem Complex

The Nehalem Complex consists of coho salmon inhabiting the Nehalem Basin, one small direct ocean tributary to the north and a few to the south. There is an estimated 470 miles of spawning habitat available to the coho salmon of this complex. The critical population level for the Nehalem complex is 1,900 adult spawners. The habitat of this complex has the potential to support a viable population because high quality habitat is estimated to be present in 110 miles of stream, well above the 15-mile threshold.

The population of wild coho salmon spawners of the Nehalem Complex has ranged from about 1,000 to about 14,500 and has averaged about 3,100 since 1990 (Figure 8 and Table 7). In six of those years, spawner abundance fell below the critical threshold of 1,900 fish. In only two years since 1990 has the lower 95% confidence limit not extended below the critical threshold. Recruits per wild spawner have been highly

Table 6. Population parameters for the Necanicum Complex coho salmon.

Return Year	Wild spawners	Pre-harvest wild population	Recruits per spawner
1990	191	614	
1991	1,135	2,079	
1992	185	378	
1993	941	1,631	8.5
1994	408	438	0.4
1995	211	241	1.3
1996	768	838	0.9
1997	253	289	0.7
1998	946	1,026	4.9
1999	728	788	1.0
2000	468	506	2.0
Annual mean	567	803	2.5

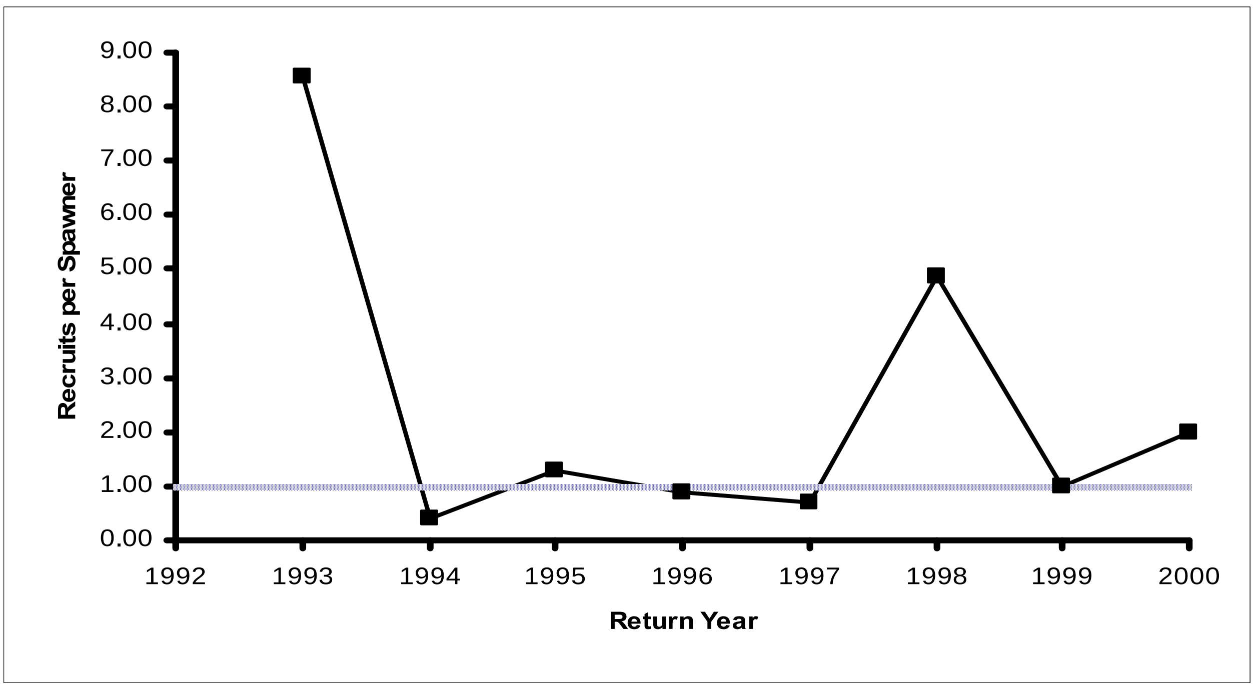

Figure 7. Trend in recruits per spawner for Necanicum Complex wild coho.

variable, with four of the last eight broods falling below one (Table 7 and Figure 9). However, the 1997 brood was very productive: a parent stock of about 1,200 producing an estimated 15,700 adults and 14,500 spawners in the 2000-2001 run.

Hatchery strays have comprised a significant portion of the spawning population in most years. However, the occurrence of stray hatchery fish has been concentrated in the North Fork Nehalem near the hatchery where 90% of the spawners (444 of 491 samples collected in 1990-99) have been of hatchery origin, compared to 35% (68 of 194) in the rest of the basin.

Results of past surveys in the North Fork Nehalem suggested little natural production of coho salmon was taking place in that subbasin, which was heavily influenced by hatchery fish. However, since the North Fork above Waterhouse Falls became a Life-Cycle Monitoring Site in 1998 (Solazzi et al. 2000) and most of the hatchery fish are now marked, we have found that significant natural production is occurring. Wild adult spawning populations were estimated to be 657 in 1998 and 737 in 1999 (Table 8), and have averaged 52% males. Since 1998, all hatchery fish captured in the Waterhouse Falls trap have been removed from the system. As a result, the proportion of hatchery fish in the spawning population above the falls has been reduced to about 30% (fish are able to avoid the trap by jumping the falls), down from 90% in previous years. Another factor in the reduction of hatchery fish on the spawning grounds is the reduction in smolt releases from Nehalem Hatchery from 800,000 to 200,000.

Estimated wild smolt production in the North Fork has been 42,000, 22,000, and 32,000 in 1998, 1999, and 2000, respectively (Solazzi et al. 2001). Estimates of smolt production for the entire Nehalem Complex for the 1997-1999 broods range from about 200 thousand to about 400 thousand (Table 4).

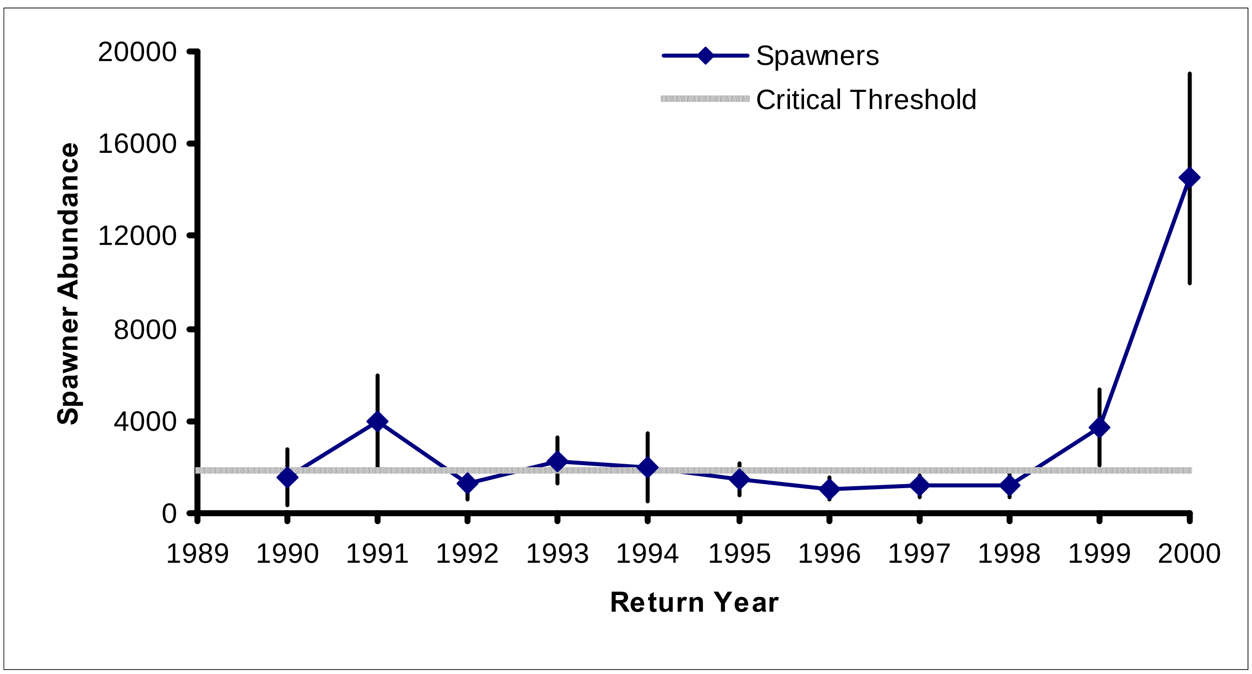

Figure 8. Trend in adult coho salmon abundance relative to the critical population level for the Nehalem Complex. Error bars are 95% confidence limits.

Table 7. Population parameters for the Nehalem Complex coho salmon.

Return Year	Wild spawners	Pre-harvest wild population	Recruits per spawner
1990	1,552	4,990	
1991	3,975	7,280	
1992	1,268	2,593	
1993	2,265	3,925	2.5
1994	2,007	2,153	0.5
1995	1,463	1,670	1.3
1996	1,057	1,153	0.5
1997	1,173	1,339	0.7
1998	1,190	1,291	0.9
1999	3,713	4,018	3.8
2000	14,508	15,701	13.4
Annual mean	3,106	4,192	3.0

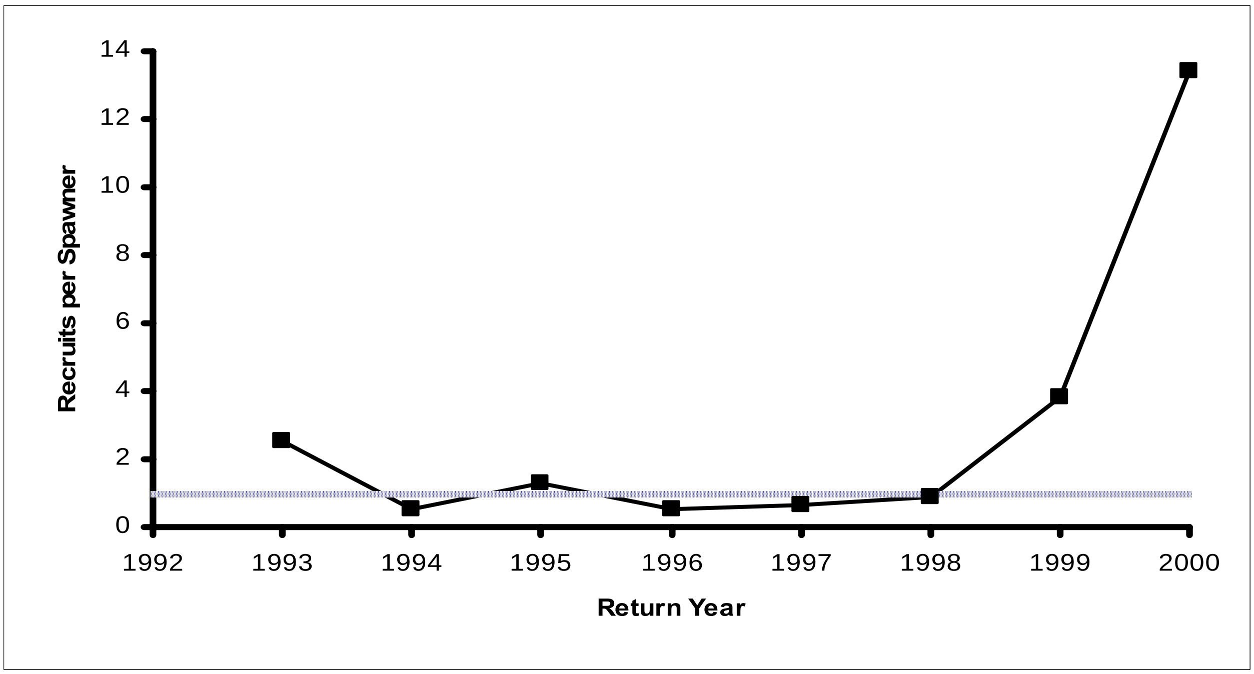

Figure 9. Trend in recruits per spawner for Nehalem Complex wild coho.

Tillamook Complex

The Tillamook Complex consists of coho salmon inhabiting the tributaries to Tillamook and Netarts bays and one small direct ocean tributary to the north of Tillamook Bay. There is an estimated 250 miles of spawning habitat available to the coho salmon of this complex. The critical population level for the Tillamook Complex is 1,000 adult spawners. However, given the current state of the habitat, this complex is not viable because high quality habitat is estimated to be present in only 12 miles of stream, below the 15-mile threshold needed to support a viable population.

The abundance of coho salmon spawners of the Tillamook Complex has ranged from about 300 to 3,000 and has averaged about 1,000 since 1990 (Figure 10 and Table 8). In eight of those years, spawner abundance fell below the critical threshold of 1,000 fish and in all years the lower 95% confidence limit extended below the critical threshold. Recruits per wild spawner have been highly variable, with four of the last eight broods falling to one or below (Table 8 and Figure 11).

Hatchery strays have comprised a significant portion of the Tillamook Complex coho salmon population. During the period 1990-99, 285 out of 401 (71%) of fish sampled on the spawning grounds had hatchery scale patterns. However, they were restricted primarily to spawning streams in close proximity to the hatchery facility (Jacobs et al. 2000). Since 1997, the number of stray hatchery fish on the spawning grounds has declined considerably, undoubtedly in response to eliminating releases from East Fork Trask pond (in 1995) and reducing total releases to 200,000 (also in 1995).

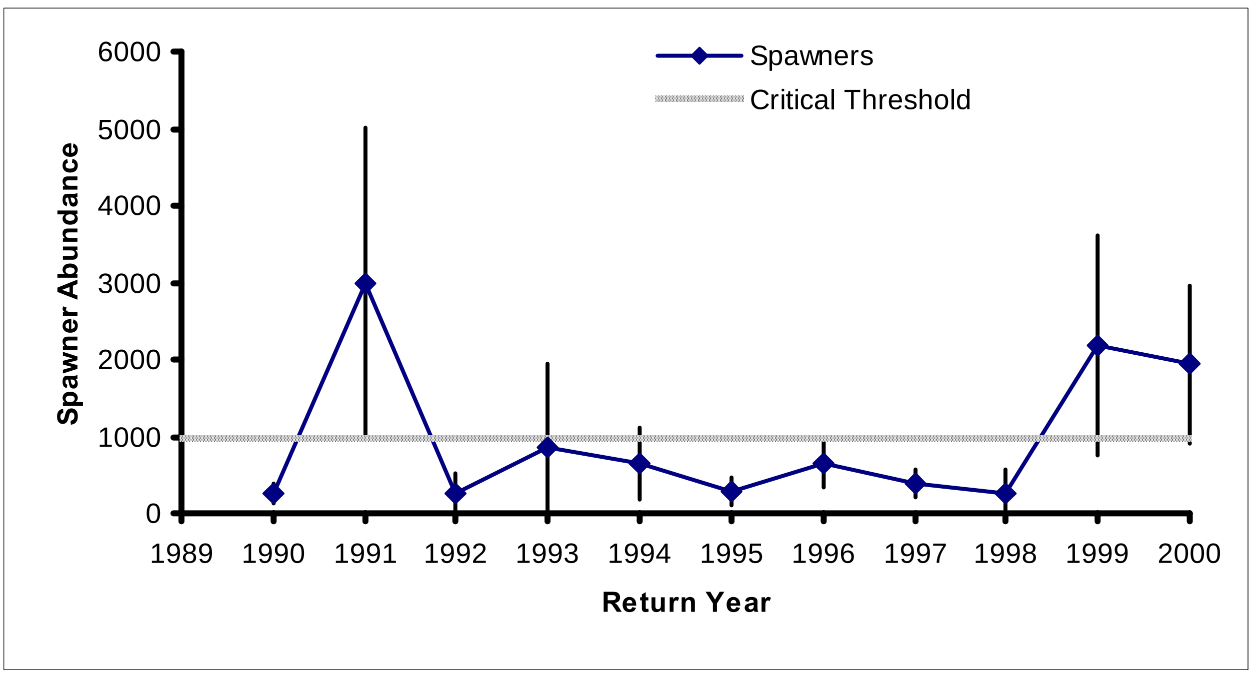

Figure 10. Trend in adult coho salmon abundance relative to the critical population level for the Tillamook Complex. Error bars are 95% confidence limits.

Wild smolt production was estimated for the 1997 through 1999 broods. Estimated smolt abundance ranged from 34 thousand to 85 thousand for the Tillamook Complex (Table 4).

Table 8. Population parameters for the Tillamook Complex coho salmon.

Return Year	Wild spawners	Pre-harvest wild population	Recruits per spawner
1990	265	852	
1991	3,000	5,495	
1992	261	534	
1993	860	1,490	5.6
1994	652	700	0.2
1995	289	330	1.3
1996	661	721	0.8
1997	388	443	0.7
1998	271	294	1.0
1999	2,175	2,354	3.6
2000	1,942	2,102	5.4
Annual mean	979	1,392	2.3

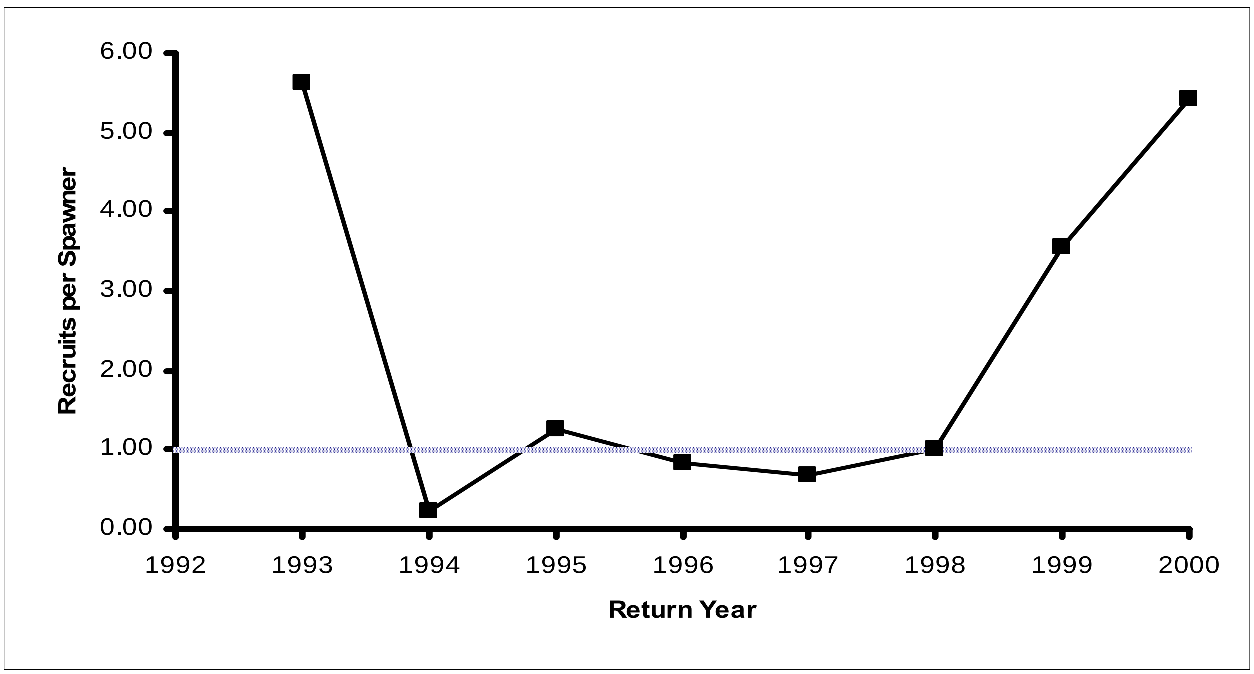

Figure 11. Trend in recruits per spawner for Tillamook Complex wild coho.

Nestucca Complex

The Nestucca Complex consists of coho salmon inhabiting streams located between Cape Lookout on the north and Cascade Head on the south. These include the Nestucca River, Sand Lake tributaries, and Neskowin Creek. There is an estimated 190 miles of spawning habitat available to the coho salmon of this complex. The critical population level for the Nestucca Complex is 800 adult spawners. However, this complex is not viable because high quality habitat is estimated to be present in only 14 miles of stream, slightly below the 15-mile threshold needed to support a viable population.

The abundance of coho salmon spawners of the Nestucca Complex has ranged from less than 200 to about 2,200 and has averaged about 800 since 1990. (Figure 12 and Table 9). In seven of those years, spawner abundance fell below the critical threshold of 800 fish and in all years the lower 95% confidence limit extended below the critical threshold. Recruits per wild spawner have been highly variable, with three of the last eight broods falling to one or below (Table 9 and Figure 13). Hatchery fish have been observed at times on the spawning grounds. Of 66 scale samples collected during 1990-99, 8 (12.1%) had hatchery scale patterns.

Smolt production was estimated for the 1997 through 1999 broods. Estimated smolt abundance ranged from 29 thousand to 89 thousand for the Nestucca Complex (Table 4).

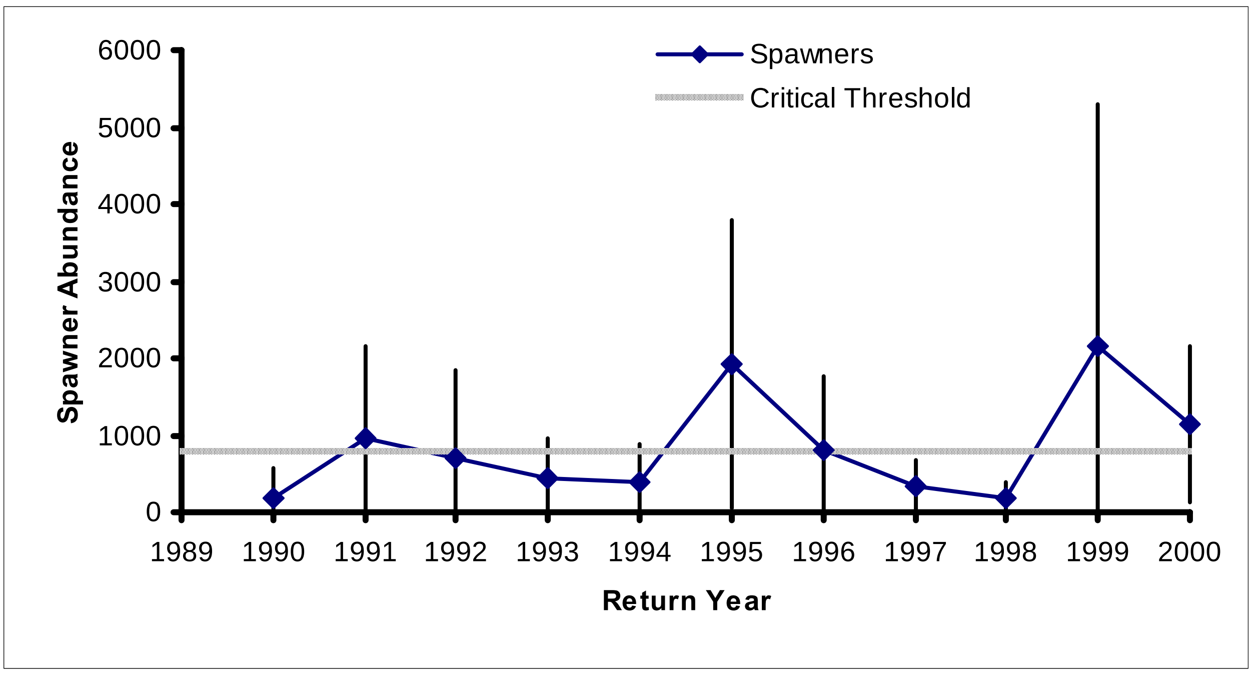

Figure 12. Trend in adult coho salmon abundance relative to the critical population level for the Nestucca Complex. Error bars are 95% confidence limits.

Siletz Complex

The Siletz Complex consists of coho salmon inhabiting mid-coast streams located between Cascade Head on the north and Cape Foulweather on the south. These include Salmon River, Devils Lake tributaries and Siletz River. There is an estimated 170 miles of spawning habitat available to the coho salmon of this complex. The critical population level for the Siletz Complex is 700 adult spawners. The habitat of this complex has the potential to support a viable population because high quality habitat is estimated to be present in 51 miles of stream, more than the 15-mile threshold.

The abundance of coho salmon spawners of the Siletz Complex has ranged from about 400 to about 3,000 and has averaged about 1,300 since 1990 (Figure 14 and

Table 9. Population parameters for the Nestucca Complex coho salmon.

Return Year	**Wild spawners**	**Pre-harvest wild population**	**Recruits per spawner**
1990	189	608	
1991	968	1,773	
1992	708	1,448	
1993	442	766	4.1
1994	390	418	0.4
1995	1,919	2,191	3.1
1996	794	866	2.0
1997	332	379	1.0
1998	169	183	0.1
1999	2,248	2,433	3.1
2000	1,155	1,250	3.8
Annual mean	847	1,120	2.2

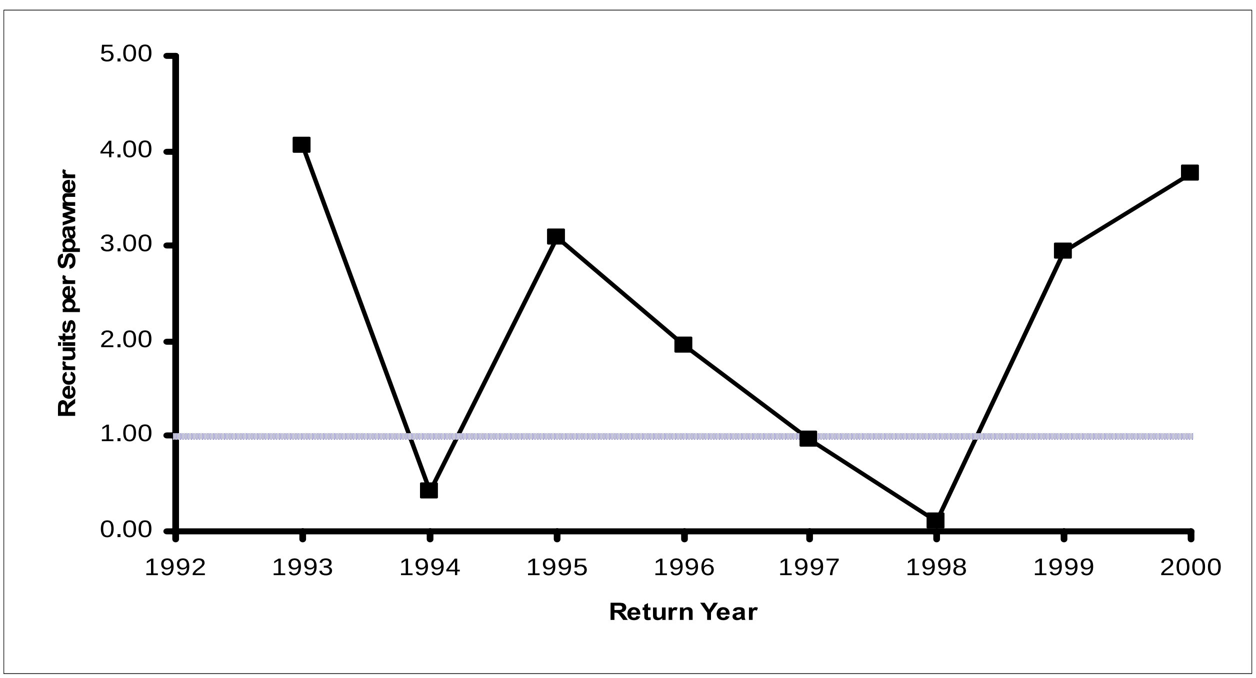

Figure 13. Trend in recruits per spawner for Nestucca Complex wild coho.

Table 10). In only two of those years, spawner abundance fell below the critical threshold of 700 fish. However, every year except 1992 and 2000 the lower 95% confidence limit extended below the critical threshold. Recruits per wild spawner have been highly variable, with four of the last eight broods falling to below one (Table 10 and Figure 15). However, the 1997 brood was very productive: a parent stock of about 700 producing an estimated 3,300 adults and 3,000 spawners in the 2000-2001 run.

Hatchery fish have been very common in the spawning population since 1990, with 1343 of 1569 (85.6%) of scales samples collected in 1990-99 having hatchery scale patterns. Over 90% of the spawners in the Salmon River portion of this complex have been hatchery fish, whereas 66% of the spawners in the Siletz River have been hatchery fish. The number of hatchery smolts that could potentially interact with this complex was gradually reduced from 1.5 million to 250,000 between the 1991 and 1997 brood years.

A Life-Cycle Monitoring Site is located at Mill Creek, a Siletz River tributary. Adult abundance in Mill Creek since 1997 has ranged from 55 to 147 (Solazzi et al. 2001) and has averaged 50% males. Smolt production has ranged from about 4,300 to about 9,500. Estimated smolt abundance for the entire Siletz Complex ranged from 66 thousand to 121 thousand for the 1997-99 broods (Table 4).

Table 10. Population parameters for the Siletz Complex coho salmon.

Return Year	**Wild spawners**	**Pre-harvest wild population**	**Recruits per spawner**
1990	831	2,672	
1991	1,023	1,874	
1992	2,641	5,401	
1993	874	1,515	1.8
1994	1,584	1,700	1.7
1995	819	935	0.4
1996	1,329	1,449	1.7
1997	667	761	0.5
1998	388	421	0.5
1999	1,147	1,241	0.9
2000	3,036	3,286	4.9
Annual mean	1,304	1,932	1.5

Yaquina Complex

The Yaquina Complex consists of coho salmon inhabiting mid-coast streams located from Cape Foulweather to Thiel Creek, just north of Yaquina Bay. The Yaquina River is the primary watershed, the remainder being small ocean tributaries. There is an estimated 140 miles of spawning habitat available to the coho salmon of this complex. The critical population level for the Yaquina Complex is 600 adult spawners.

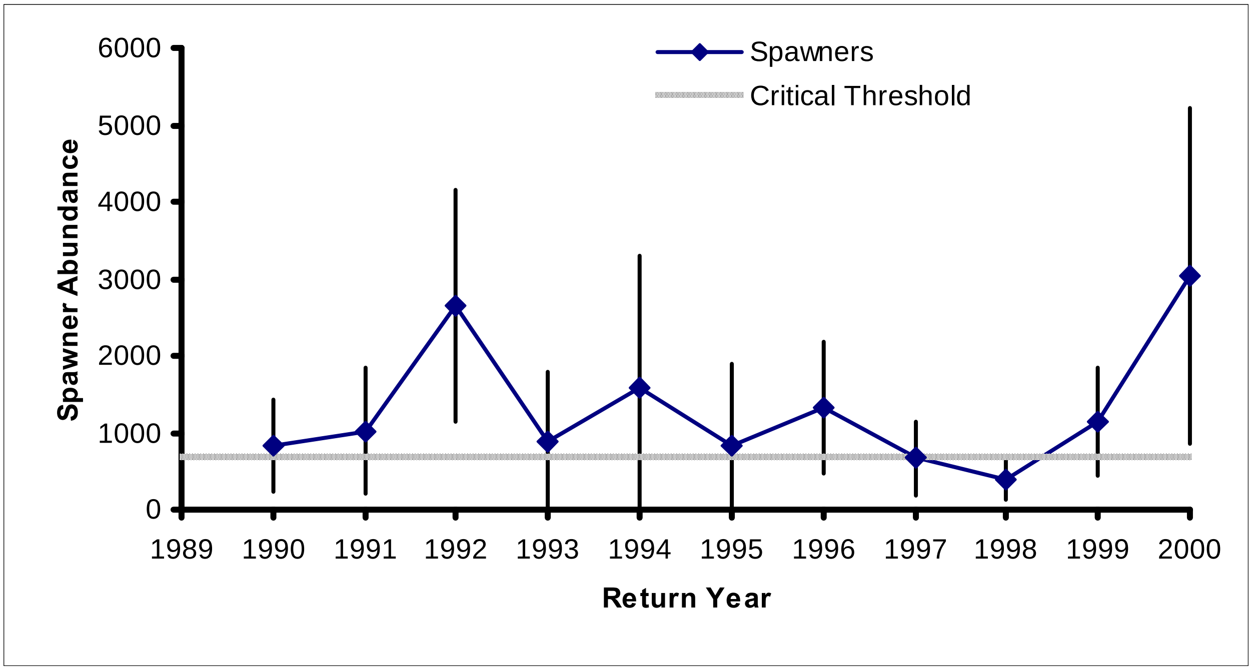

Figure 14. Trend in adult coho salmon abundance relative to the critical population level for the Siletz Complex. Error bars are 95% confidence limits.

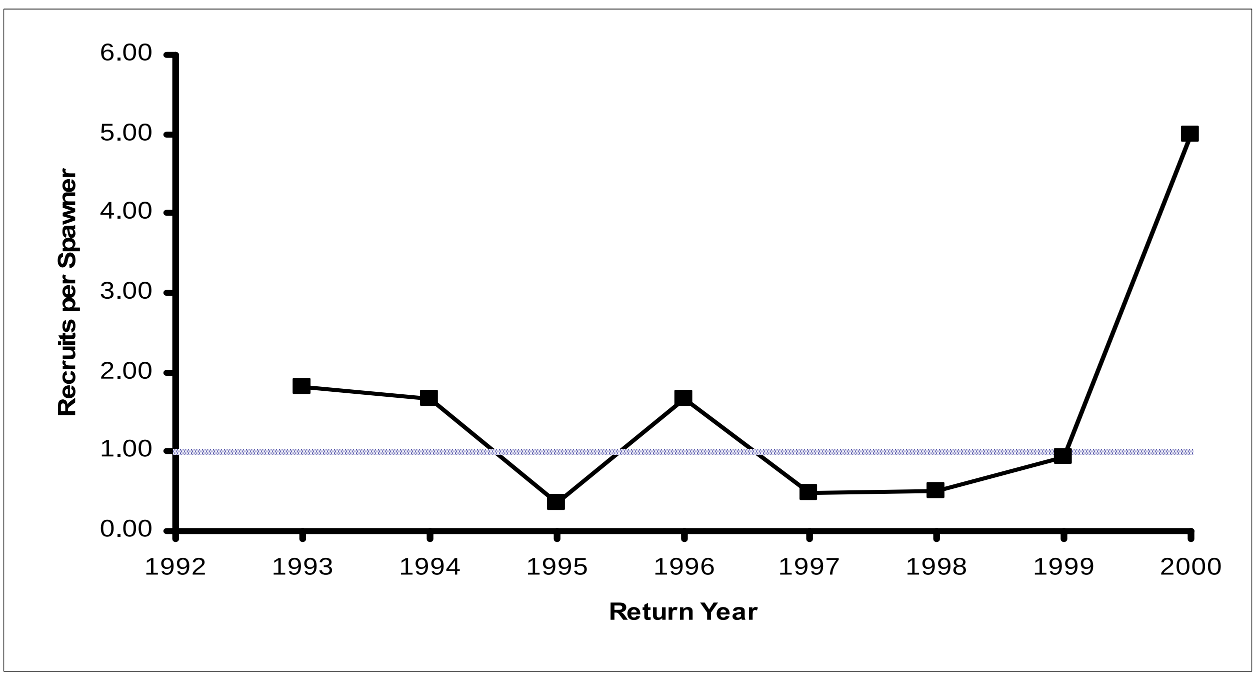

Figure 15. Trend in recruits per spawner for Siletz Complex wild coho.

The habitat of this complex has the potential to support a viable population because high quality habitat is estimated to be present in 58 miles of stream, more than the 15-mile threshold.

The Yaquina coho salmon population has experienced a boom or bust in abundance over the past decade. The abundance of coho salmon spawners of the Yaquina Complex has ranged from about 400 to about 5,700 and has averaged about 1,700 since 1990 (Figure 16 and Table 11). In five of those years, spawner abundance fell below the critical threshold of 600 fish and in two additional years the spawning population was only slightly above the threshold. Recruits per wild spawner have been highly variable over the last eight years (Table 11 and Figure 17). The1991-93 broods experienced excellent survival, producing seven to ten recruits per spawner. Unfortunately, the offspring of those returns faired much poorer and recruits per spawner fell below one.

Hatchery fish originating from a private hatchery comprised about 53% of the spawning population in the 1980s (Jacobs and Cooney 1997). During the 1990s, the percentage dropped to about 21%. However, the hatchery programs that contributed to these strays have now been eliminated.

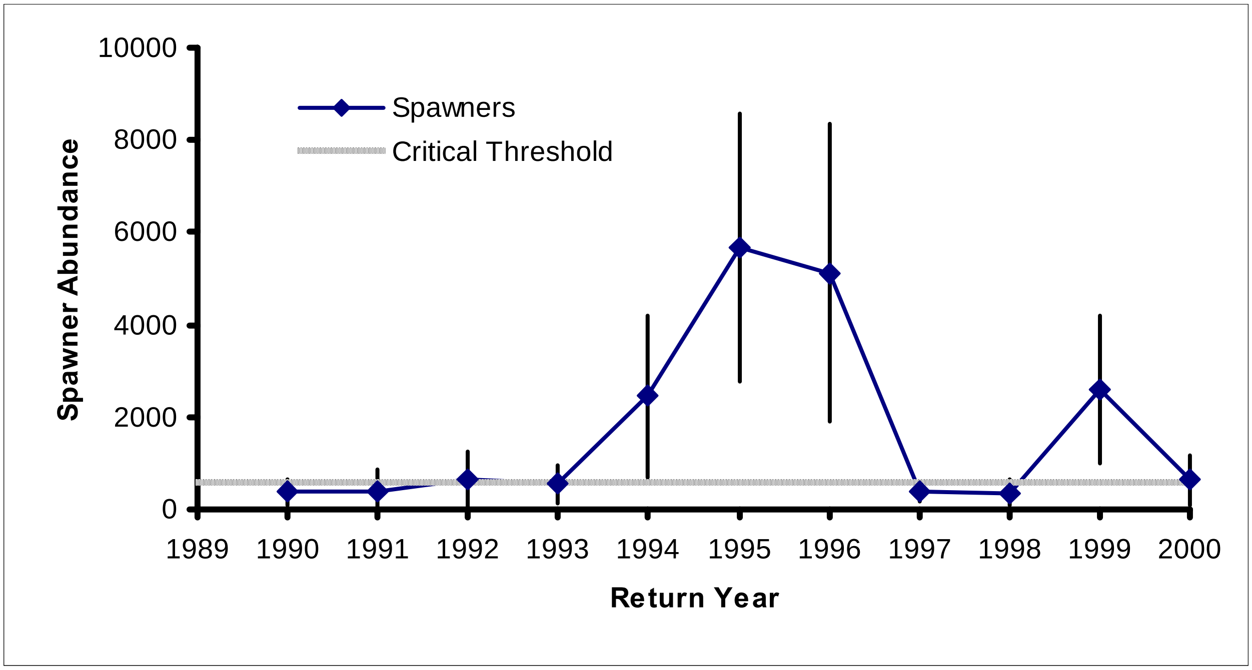

Figure 16. Trend in adult coho salmon abundance relative to the critical population level for the Yaquina Complex. Error bars are 95% confidence limits.

A Life-Cycle Monitoring Site is located at Mill Creek, a Yaquina River tributary. Adult abundance in Mill Creek since 1997 has ranged from 92 to 138 (Solazzi et al. 2001) and has averaged 51% males. A reservoir located within the Mill Creek watershed provides rearing habitat and in some years produces large smolts that apparently survive well. Estimated marine survival of the 1995 brood was 10%. Smolt production has ranged from about 1,400 to about 6,700. Estimated smolt abundance for the entire Yaquina Complex ranged from 62 thousand to 201 thousand for the 1997-99 broods (Table 4).

Table 11. Population parameters for the Yaquina Complex coho salmon.

Return Year	Wild spawners	Pre-harvest wild population	Recruits per spawner
1990	381	1,225	
1991	380	696	
1992	633	1,294	
1993	549	951	2.5
1994	2,448	2,627	6.9
1995	5,668	6,470	10.2
1996	5,127	5,591	10.2
1997	384	438	0.2
1998	364	395	0.1
1999	2,596	2,810	0.6
2000	628	680	1.8
Annual mean	1,742	2,107	4.0

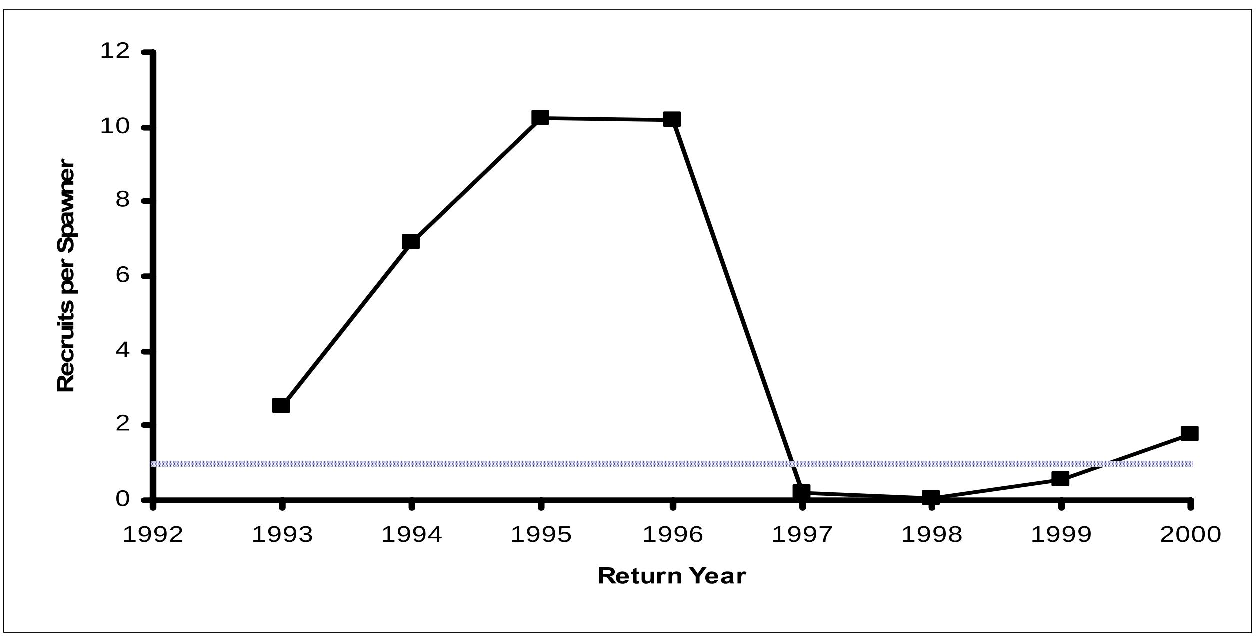

Figure 17. Trend in recruits per spawner for Yaquina Complex wild coho.

Alsea Complex

The Alsea Complex consists of coho salmon inhabiting mid-coast streams located from Beaver Creek south to China Creek, just north of Heceta Head. Populations include Beaver Creek, Drift Creek, Alsea River and Yachats River. There is an estimated 360 miles of spawning habitat available to the coho salmon of this complex. The critical population level for the Alsea Complex is 1,400 adult spawners. The habitat of this complex has the potential to support a viable population because high quality habitat is estimated to be present in 97 miles of stream, well above the 15-mile threshold.

The abundance of coho salmon spawners of the Alsea Complex has ranged from about 1,000 to over 8,600 and has averaged about 3,000 since 1990 (Figure 18 and Table 12). Twice in the past decade, spawner abundance fell below the critical threshold of 1,400 fish. However, every year except 1999 the lower 95% confidence limit extended below the critical threshold (Figure 18) and the Alsea River population, the largest in the complex fell to about 200 fish in 1998. Recruits per wild spawner have been highly variable over the last eight years (Table 12 and Figure 19), but have been below one only twice.

Hatchery fish have been common in the spawning population in some years of the last decade, particularly in Beaver Creek and the Alsea River. Of 424 scale samples collected during 1990-99, 84 (19.8%) had hatchery scale patterns. However, the hatchery programs that contributed to the strays have now been eliminated.

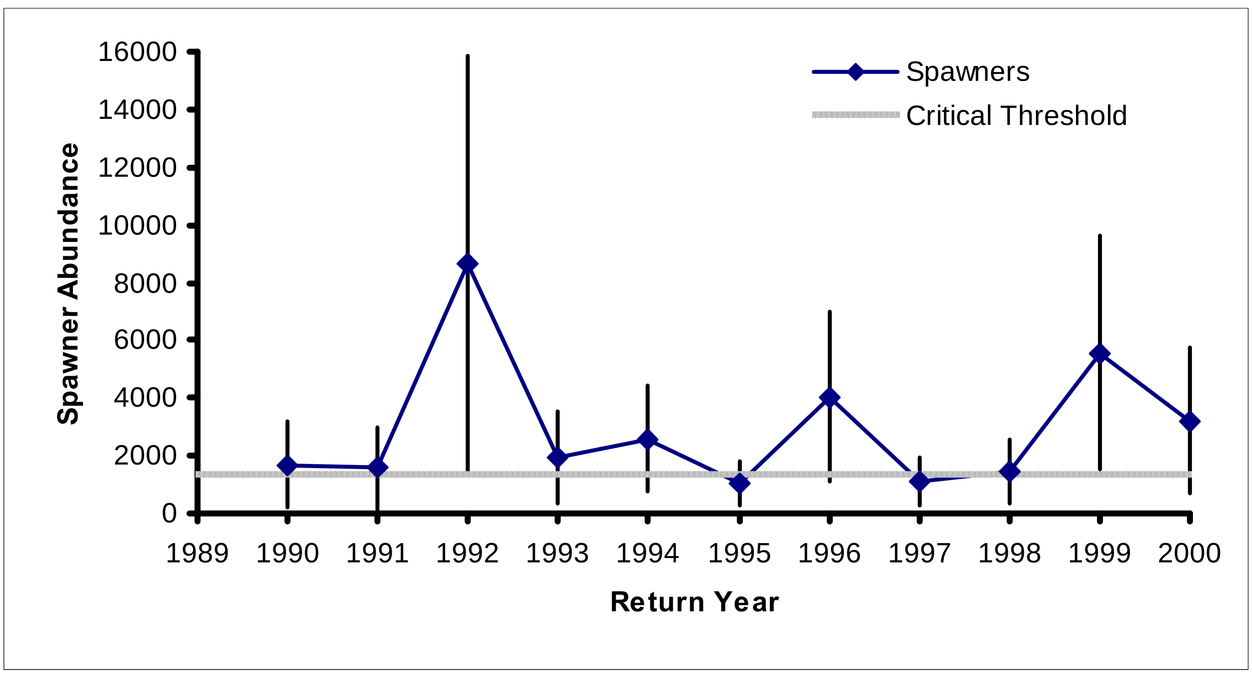

Figure 18. Trend in adult coho salmon abundance relative to the critical population level for the Alsea Complex. Error bars are 95% confidence limits.

Table 12. Population parameters for the Alsea Complex coho salmon.

Return Year	Wild spawners	Pre-harvest wild population	Recruits per spawner
1990	1,694	5,447	
1991	1,589	2,910	
1992	8,656	17,701	
1993	1,928	3,341	2.0
1994	2,578	2,766	1.7
1995	1,029	1,175	0.1
1996	4,046	4,412	2.3
1997	1,123	1,282	0.5
1998	1,423	1,543	1.5
1999	5,563	6,021	1.5
2000	3,219	3,484	3.1
Annual mean	2,986	4,553	1.6

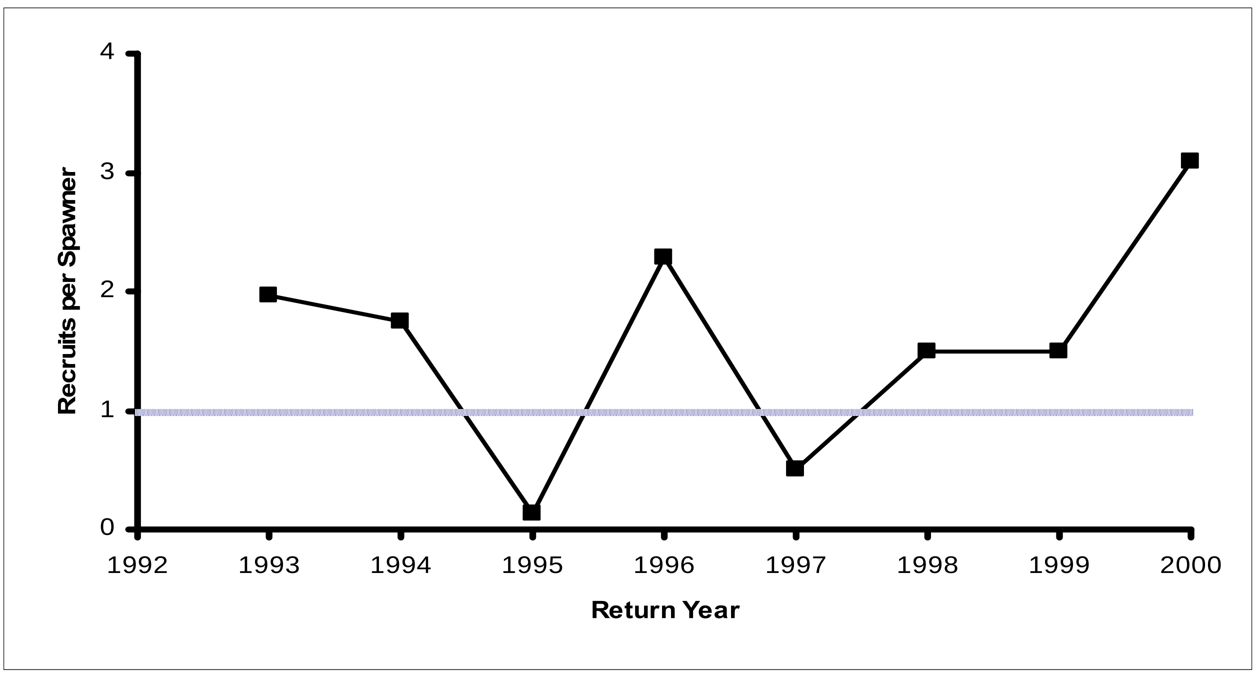

Figure 19. Trend in recruits per spawner for Alsea Complex wild coho.

A Life-Cycle Monitoring Site is located at Cascade Creek, an Alsea River tributary. Adult abundance in Cascade Creek since 1997 has ranged from 6 to 39 (Solazzi et al. 2001) and has averaged 50% males. Smolt production has ranged from 13 to about 1,400. Smolt production has also been monitored for many years in four other Alsea Complex streams: upper Lobster and East Fork Lobster creeks in the Alsea Basin and Cummins and Tenmile creeks, direct ocean tributaries (Figure 20).

Estimated smolt abundance for the entire Alsea Complex ranged from 190 thousand to 416 thousand for the 1997-99 broods (Table 4).

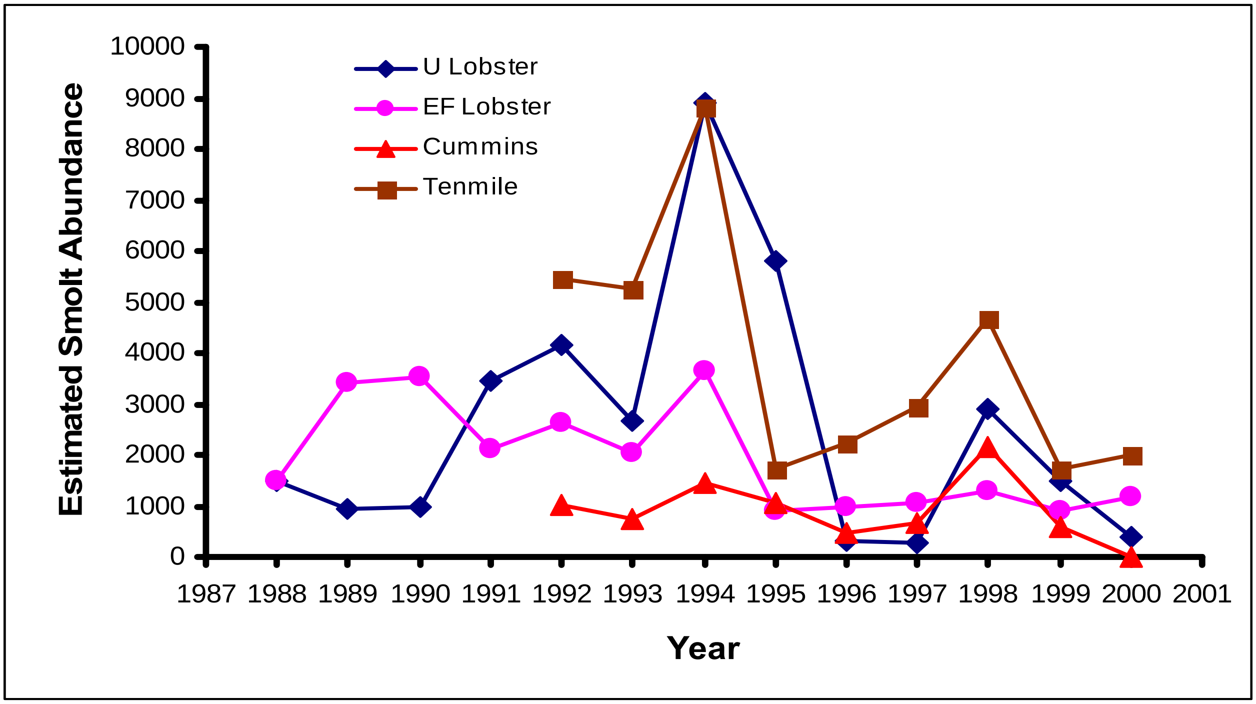

Figure 20. Estimated smolt production from four Alsea Complex streams.

Siuslaw Complex

The Siuslaw Complex consists of coho salmon inhabiting the Siuslaw Basin and small ocean tributaries north to Heceta Head. There is an estimated 580 miles of spawning habitat available to the coho salmon of this complex. The critical population level for the Siuslaw Complex is 2,300 adult spawners. The habitat of this complex has the potential to support a viable population because high quality habitat is estimated to be present in 158 miles of stream, well above the 15-mile threshold. It should be noted however, that the estimate of habitat quality is based on a sample size of only 15% of the available stream miles, much less than any other complex.

The abundance of coho salmon spawners of the Siuslaw Complex has ranged from less than 700 to more than 7,600 and has averaged about 3,800 since 1990 (Figure 21 and Table 13). Twice in the past decade, spawner abundance fell below the critical threshold of 2,300 fish and in 5 other years the lower 95% confidence limit extended below the critical threshold. Recruits per wild spawner exhibited a downward trend from 1993 to 1999, which was dramatically reversed in 2000, when the 1997 brood produced about 7,100 adults and 6,500 spawners from about 700 parent spawners (Table 13 and Figure 22).

Hatchery fish have been common in the spawning population in some years of the last decade, although they have primarily been concentrated in one or two tributaries just below Lake Creek Falls, the result of a hatchery program to introduce coho salmon into the watershed above the falls, which has been discontinued. In other parts of the basin, of 302 scale samples collected in 1990-99, 84 (27.8%) had hatchery scale patterns.

Table 13. Population parameters for the Siuslaw Complex coho salmon.

Return Year	Wild spawners	Pre-harvest wild population	Recruits per spawner
1990	2,685	8,633	
1991	3,740	6,850	
1992	3,440	7,035	
1993	4,428	7,674	2.9
1994	3,205	3,439	0.9
1995	6,089	6,951	2.0
1996	7,625	8,315	1.9
1997	668	763	0.2
1998	1,086	1,178	0.2
1999	2,798	3,028	0.4
2000	6,549	7,088	10.6
Annual mean	3,847	5,541	2.4

Smolt production was estimated for the 1997 through 1999 broods. Estimated smolt abundance ranged from 113 thousand to 402 thousand for the Siuslaw Complex (Table 4).

Lakes Complex

The Lakes Complex consists of coho salmon inhabiting the three major coastal lake basins: Siltcoos, Tahkenitch, and Tenmile. There is an estimated 100 miles of spawning habitat available to the coho salmon of this complex. The critical population level for the Lakes Complex is 400 adult spawners. The habitat of this complex has the potential to support a viable population. The lakes provide excellent winter rearing habitat, which has the effect that all 100 miles of stream function as high quality habitat. As a result, this is one of the most productive complexes on the coast and trends in abundance reflect just that.

The abundance of coho salmon spawners of the Lakes Complex has ranged from about 2,000 to about 13,500 and has averaged about 9,000 over the past 10 years (Figure 23 and Table 14). Abundance during the past decade has never fallen below the critical threshold of 400 fish. Recruits per spawner have been variable over the last 8 years, with the only one year falling to below one (Table 14 and Figure 24). Hatchery

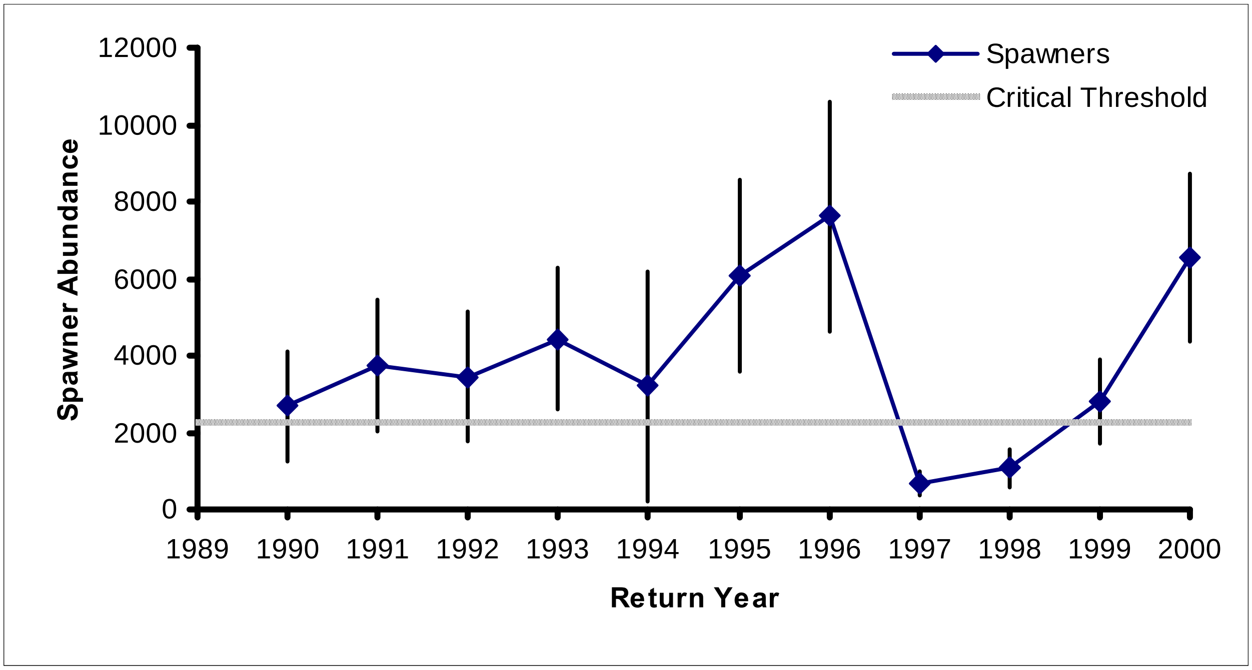

Figure 21. Trend in adult coho salmon abundance relative to the critical population level for the Siuslaw Complex. Error bars are 95% confidence limits.

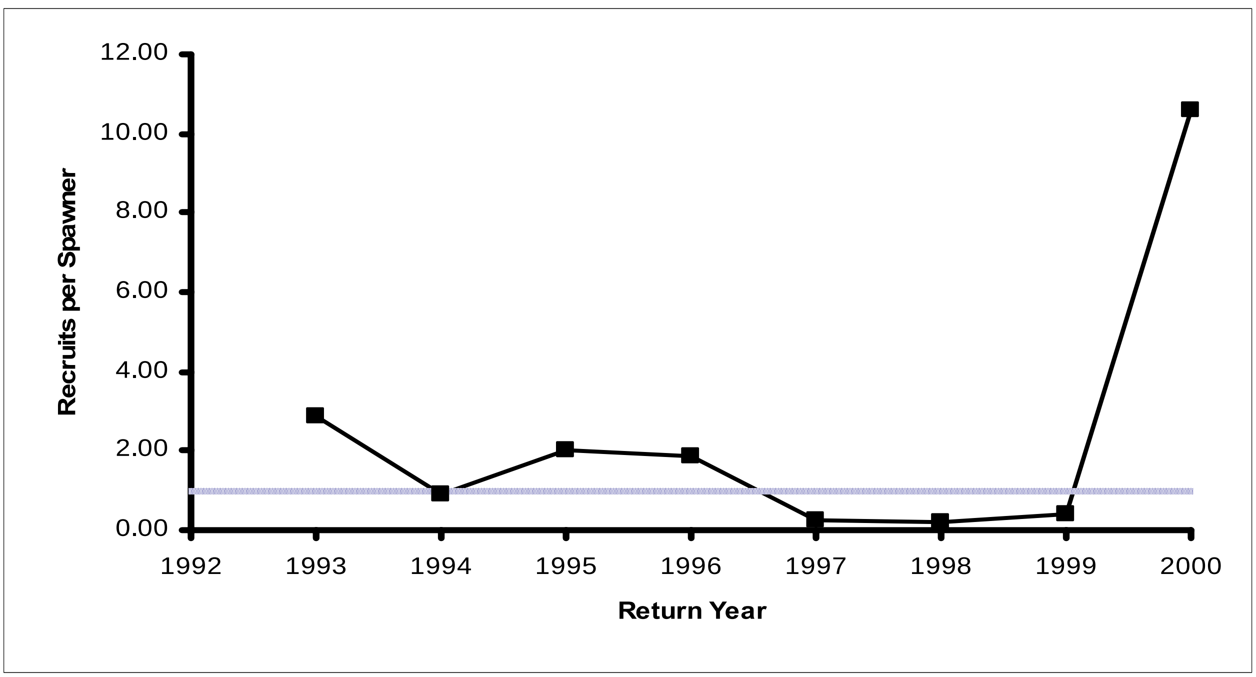

Figure 22. Trend in recruits per spawner for Siuslaw Complex wild coho.

fish have been rare in the spawning population with only 22 of 2,540 (0.9%) of scales sampled during 1990-99 having hatchery scale patterns.

Smolt production was estimated for the 1997 through 1999 broods. Estimated smolt abundance ranged from 274 thousand to 311 thousand for the Lakes Complex (Table 4).

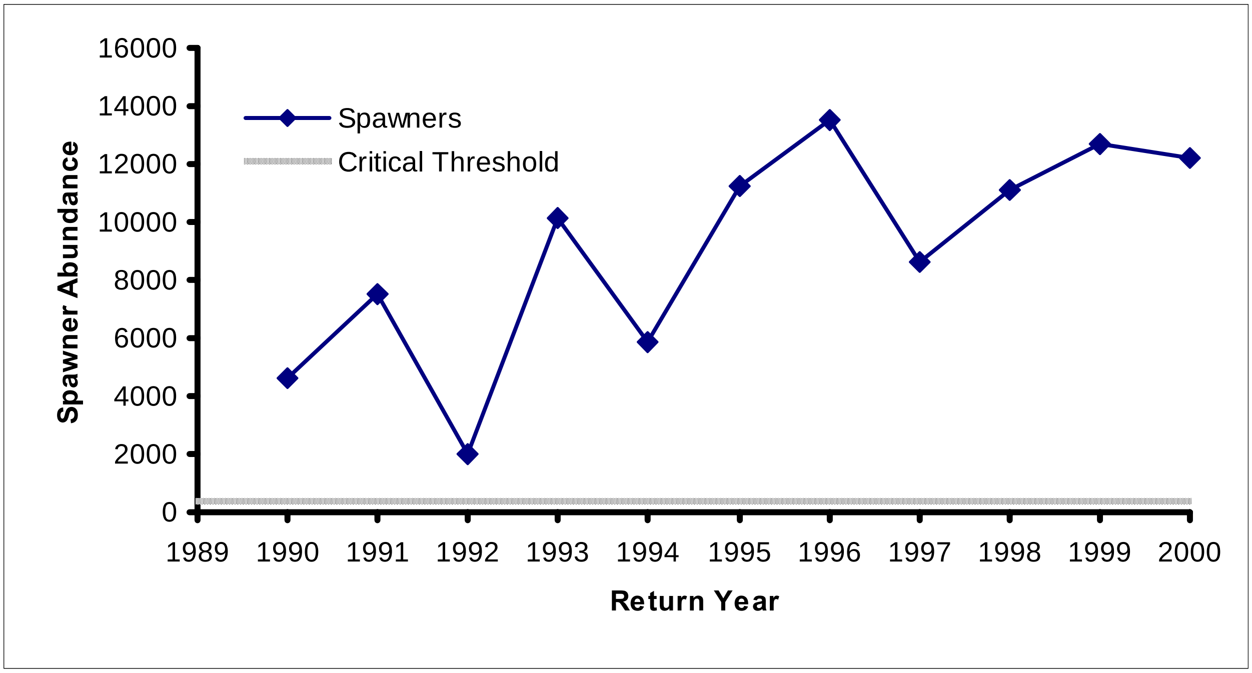

Figure 23. Trend in adult coho salmon abundance relative to the critical population level for the Lakes Complex. Population estimation methods do not allow calculation of confidence intervals.

Table 14. Population parameters for the Lakes Complex coho salmon.

Return Year	**Wild spawners**	**Pre-harvest wild population**	**Recruits per spawner**
1990	4,629	14,884	
1991	7,495	13,727	
1992	1,986	4,061	
1993	10,145	17,582	3.8
1994	5,841	6,267	0.8
1995	11,216	12,804	6.5
1996	13,493	14,714	1.5
1997	8,603	9,821	1.7
1998	11,108	12,048	1.1
1999	12,710	13,755	1.0
2000	12,178	13,180	1.5
Annual mean	9,037	12,077	2.2

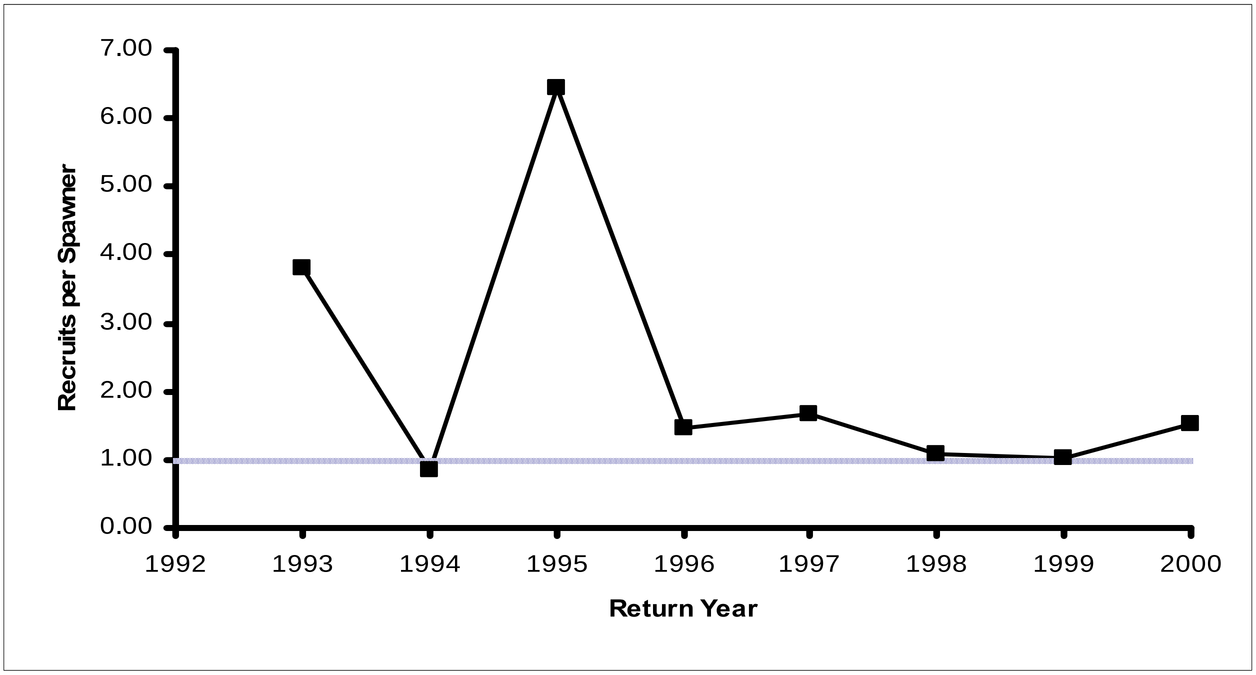

Figure 24. Trend in recruits per spawner for Lakes Complex wild coho.

Umpqua Complex

The Umpqua Complex consists of coho salmon inhabiting the Umpqua Basin. Populations are found in Smith River, lower basin tributaries, and the North Fork and South Fork subbasins. There is an estimated 1,230 miles of spawning habitat available to the coho salmon of this complex. The critical population level for the Umpqua Complex is 4,900 adult spawners. The habitat of this complex has the potential to support a viable population because high quality habitat is estimated to be present in 169 miles of stream, well above the 15-mile threshold.

The abundance of coho salmon spawners of the Umpqua Complex has ranged from about 3,000 to about 12,800 and has averaged about 7,500 since 1990 (Figure 25 and Table 15). In four of those years, spawner abundance fell below the critical threshold of 4,900 fish. Recruits per wild spawner have been variable, with three of the last four broods falling to below one (Table 15 and Figure 26). Hatchery fish have been common in the spawning population in most years though in low numbers – 112 of 943 (11.9%) scale samples collected during 1990-99 exhibiting hatchery patterns.

A Life-Cycle Monitoring Site is located at West Fork Smith River. Adult abundance in West Fork Smith River in 1999 was estimated to be 264 fish (Solazzi et al. 2001). In addition, a mark-recapture estimate for adult coho salmon crossing Smith River Falls yielded an estimate of 1,541, of which 55% were males. Smolt production in the West Fork Smith River has ranged from about 10,900 to about 22,400. Estimated smolt abundance for the entire Umpqua Complex ranged from 472 thousand to 686 thousand for the 1997-99 broods (Table 4).

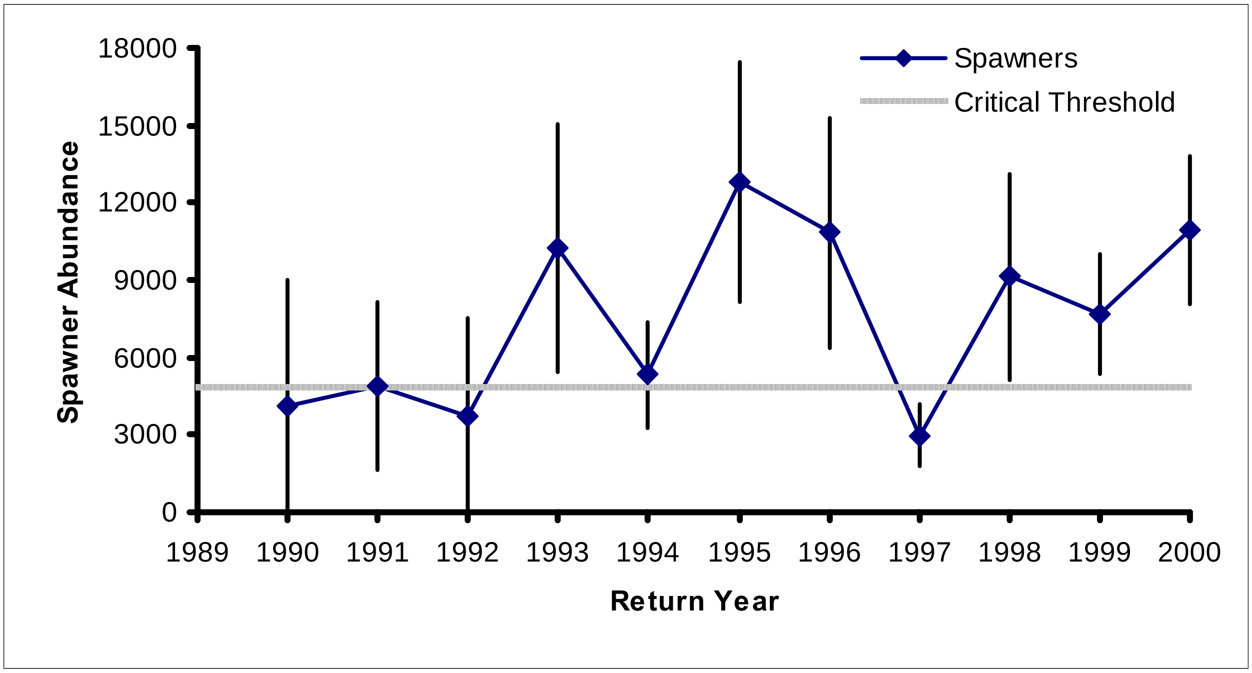

Figure 25. Trend in adult coho salmon abundance relative to the critical population level for the Umpqua Complex. Error bars are 95% confidence limits.

Table 15. Population parameters for the Umpqua Complex coho salmon.

Return Year	Wild spawners	Pre-harvest wild population	Recruits per spawner
1990	4,113	13,225	
1991	4,875	8,929	
1992	3,759	7,687	
1993	10,244	17,754	4.3
1994	5,338	5,727	1.2
1995	12,809	14,622	3.9
1996	10,824	11,804	1.2
1997	2,960	3,379	0.6
1998	9,153	9,927	0.8
1999	7,685	8,317	0.8
2000	10,947	11,847	4.0
Annual mean	7,519	10,293	2.1

Coos Complex

The Coos Complex consists of coho salmon inhabiting the Coos Basin. There is an estimated 220 miles of spawning habitat available to the coho salmon of this complex. The critical population level for the Coos Complex is 900 adult spawners. The habitat of this complex has the potential to support a viable population because

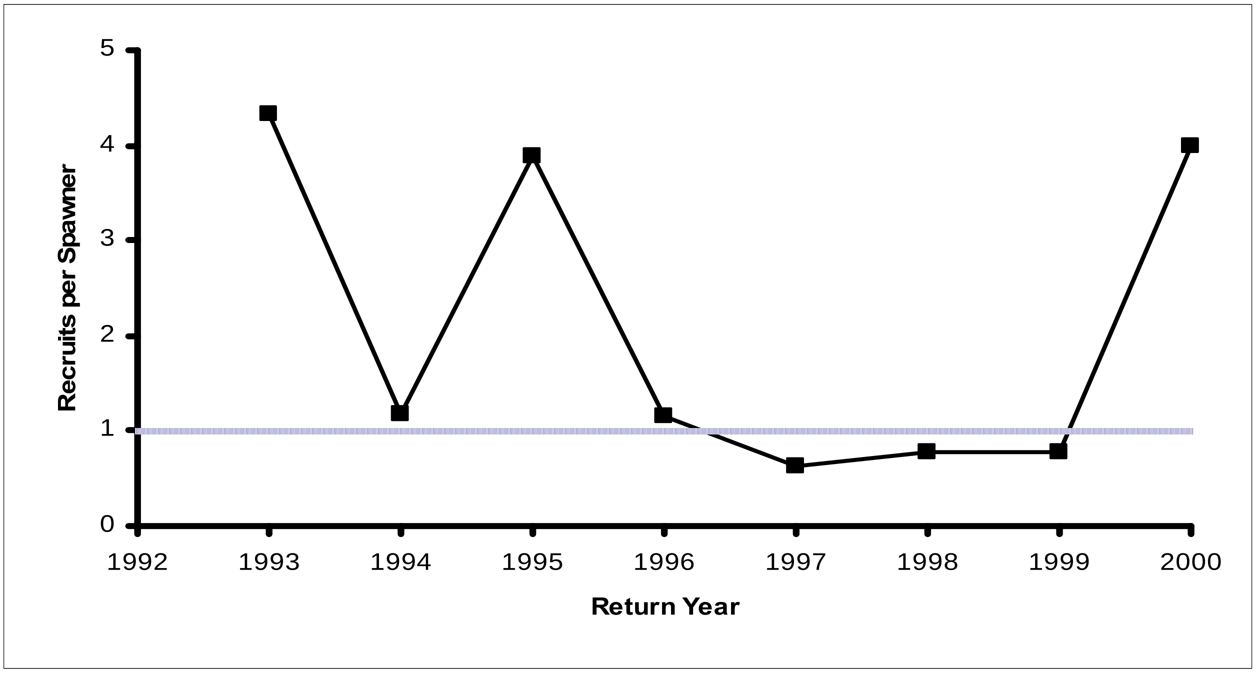

Figure 26. Trend in recruits per spawner for Umpqua Complex wild coho.

high quality habitat is estimated to be present in 56 miles of stream, more than the 15-mile threshold.

The abundance of coho salmon spawners of the Coos Complex has ranged from about 1,100 to about 15,300 and has averaged about 8,100 since 1990 (Figure 27 and Table 16). Abundance during the past decade has never fallen below the critical threshold of 900 fish and in only four years has the lower 95% confidence limit fallen below the critical threshold. Hatchery fish have been found on the spawning grounds in some years of the last decade but for the period 1990-99, have averaged only 5.1% of the population (53 of 1,032 scale samples having hatchery patterns).

Recruits per wild spawner exhibited a downward trend from 1993 to 1999, with 1995 to 1999 falling to below one (Table 16 and Figure 28). This is the result of a series of five consecutive extremely strong broods not replacing themselves. During the mid 1990s, marine survival of coho salmon of this complex was much higher than most of the complexes to the north. At the end of the 1990s, survival came down to the level that the other complexes had been experiencing. The downward trend in recruits per spawner reversed in 2000, when the 1997 brood produced about 5,800 adults and 5,400 spawners from about 1,100 parent spawners.

Life-Cycle Monitoring Sites are located at Fall Creek, a South Fork Coos River tributary and at Winchester Creek, the major tributary to South Slough. Adult abundance in Fall Creek in 1999 was 35 fish (Solazzi et al. 2001). Smolt production in Fall Creek was about 1,700 in 1999 and about 300 in 2000. Adult abundance in Winchester Creek in 1999 was estimated to be 44 fish (Solazzi et al. 2001). Smolt production in Winchester Creek was about 2,200 in 1999 and about 3,100 in 2000. Estimated smolt abundance for the entire Coos Complex ranged from 133 thousand to 214 thousand for the 1997-99 broods (Table 4). Returns to the two streams in 2000 were very low, at least partially due to extremely low streamflows during the migration period.

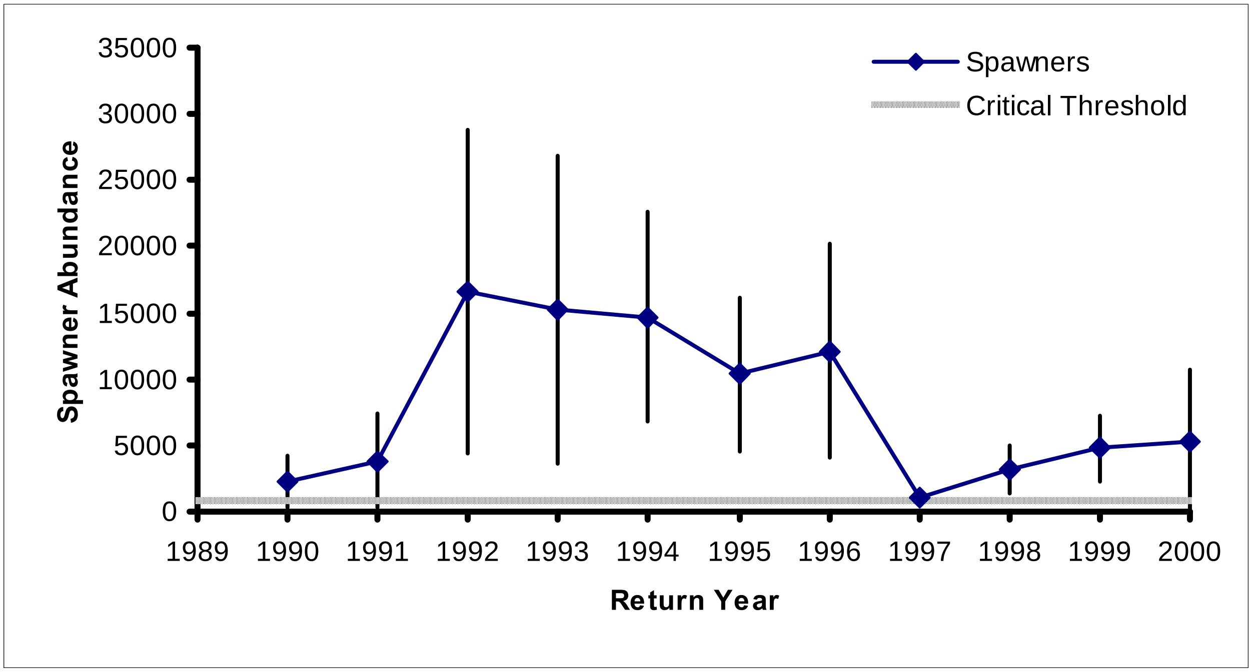

Figure 27. Trend in adult coho salmon abundance relative to the critical population level for the Coos Complex. Error bars are 95% confidence limits.

Table 16. Population parameters for the Coos Complex coho salmon.

Return Year	Wild spawners	Pre-harvest wild population	Recruits per spawner
1990	2,273	7,309	
1991	3,813	6,984	
1992	16,545	33,834	
1993	15,284	26,489	11.7
1994	14,685	15,756	4.1
1995	10,351	11,816	0.7
1996	12,128	13,226	0.9
1997	1,127	1,287	0.1
1998	3,167	3,435	0.3
1999	4,808	5,203	0.4
2000	5,312	5,749	5.1
Annual mean	8,136	11,917	2.9

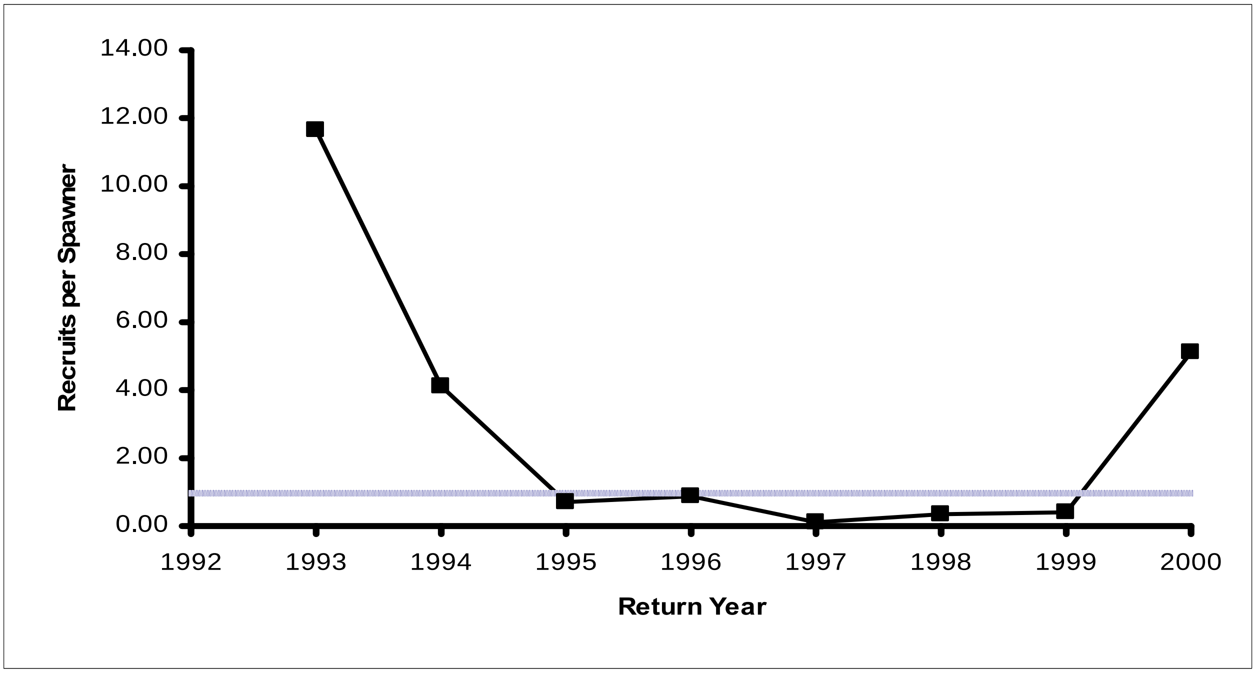

Figure 28. Trend in recruits per spawner for Coos Complex wild coho.

Coquille Complex

The Coquille Complex consists of coho salmon inhabiting streams from the Coquille Basin south to Sixes River. Populations are found in the Coquille River, New River, and Sixes River. There is an estimated 320 miles of spawning habitat available to the coho salmon of this complex. The critical population level for the Coquille Complex is 1,300 adult spawners. The habitat of this complex has the potential to support a viable population. Although high quality habitat is estimated to be present in only 21 miles of stream, only slightly greater than the 15-mile threshold, the lowland area of the Coquille Basin, much of which becomes a lake during winter, provides winter rearing habitat. In fact, recent research (Miller 1998) has documented a life history pattern in Coquille River coho salmon whereby large numbers of juveniles actively migrate to lowland reaches during spring and fall, presumably to take advantage of the over-wintering habitat.

The abundance of coho salmon spawners of the Coquille Complex has ranged from about 2,100 to about 16,200 and has averaged about 5,500 since 1990 (Figure 29 and Table 17). Since 1990, abundance has never fallen below the critical threshold of 1,300 fish and in only three years has the lower 95% confidence limit fallen below the critical threshold. Recruits per wild spawner have exhibited a general downward trend over the last eight years, but with only the 1996 brood falling below one (Table 17 and Figure 30). Hatchery fish have been uncommon on the spawning grounds with only 42 (5.3%) of 800 scales sampled from 1990-99 having hatchery patterns.

Smolt production was estimated for the 1997 through 1999 broods. Estimated smolt abundance ranged from 119 thousand to 296 thousand for the Coquille Complex (Table 4).

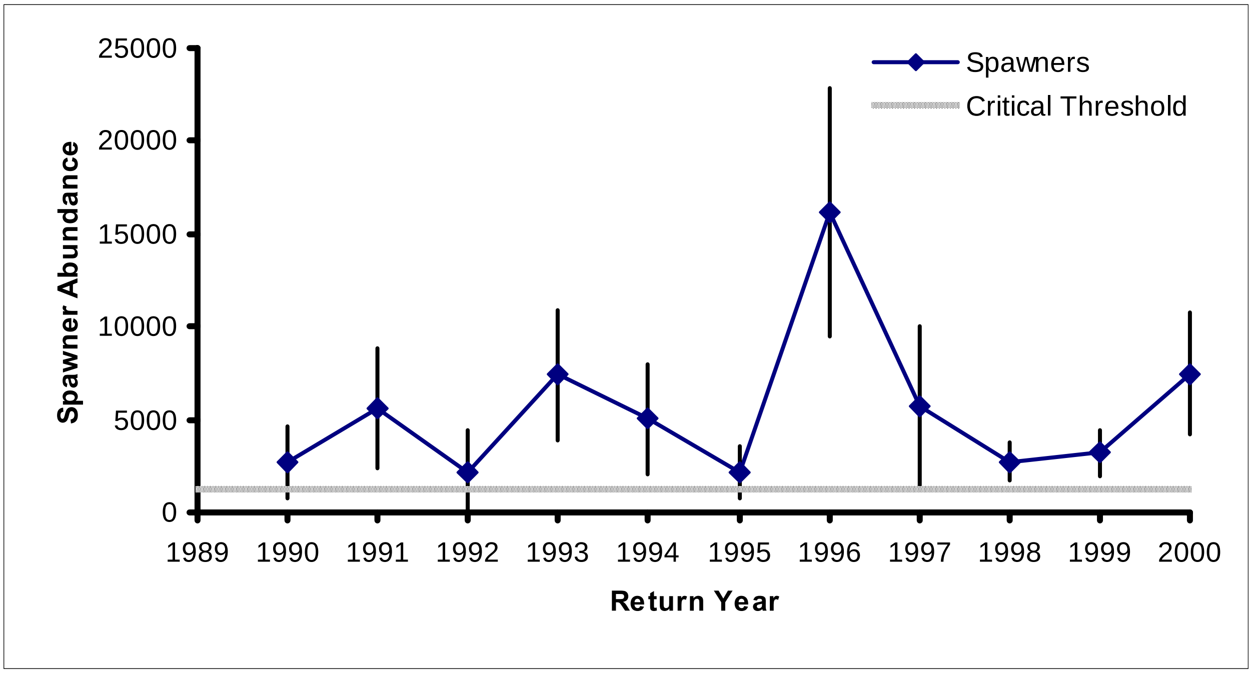

Figure 29. Trend in adult coho salmon abundance relative to the critical population level for the Coquille Complex. Error bars are 95% confidence limits.

Table 17. Population parameters for the Coquille Complex coho salmon.

Return Year	**Wild spawners**	**Pre-harvest wild population**	**Recruits per spawner**
1990	2,712	8,720	
1991	5,651	10,350	
1992	2,115	4,325	
1993	7,384	12,797	4.7
1994	5,035	5,402	1.0
1995	2,116	2,416	1.1
1996	16,169	17,632	2.4
1997	5,720	6,530	1.3
1998	2,718	2,948	1.4
1999	3,183	3,445	0.2
2000	7,478	8,093	1.4
Annual mean	5,480	7,514	1.7

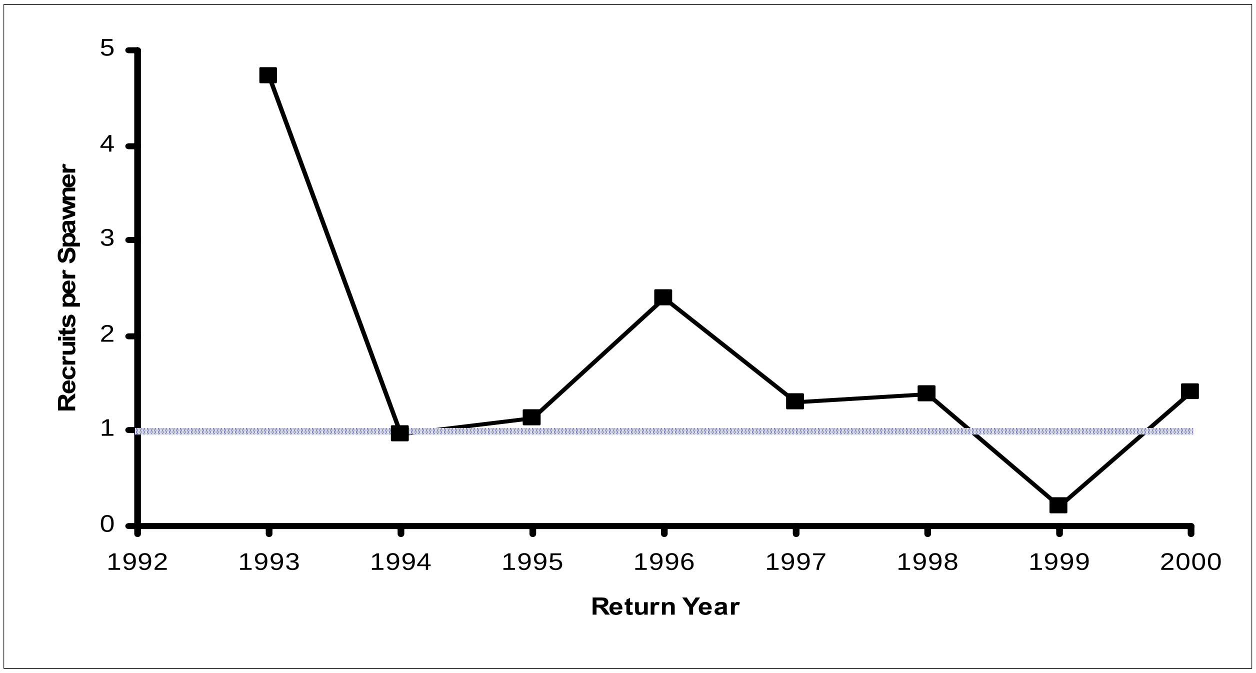

Figure 30. Trend in recruits per spawner for Coquille Complex wild coho.

Trends and Patterns of Abundance

Over the period of years examined (1990-2000), most populations varied independently from one another. This was true of both spawner abundance and pre-harvest abundance. Of 66 possible comparisons of abundance with each parameter, only six tracked together (Table 18), and were therefore significantly correlated ($p \leq 0.05$). One would expect to find at least three significant correlations just from random chance. It might also be expected that adjacent complexes would be more likely to be correlated than distant complexes. Examination of the shaded diagonal cells of Table 18 shows that of adjacent complexes, only the Umpqua and Lakes were significantly correlated. Only the Umpqua and Lakes, Umpqua and Siuslaw, and Siletz and Alsea exhibited significant correlations of both spawner abundance and pre-harvest abundance.

Whereas there were few correlations among population complexes, some distinct patterns of abundance are evident. The only population complex that experienced a significant trend in coho salmon spawner abundance was the Lakes (p=0.026), which increased at an average rate of 12 percent per year (Figure 23). The next closest to exhibiting a trend was the Umpqua, which increased an average 7% per year with p=0.163. For all other complexes, p ranged from 0.31 to 0.94. There were no significant trends in pre-harvest abundance because harvest impacts on coastal coho salmon decreased from a high of about 70% in 1990 to a low of about 7% in 1994 and have since remained low (Figure 31).

Populations in the various complexes tended to peak in different years. Over the 11-year period, only one pattern occurred in all of the complexes: the below average return in 1990 (Figure 32). A similar below average return occurred in 1997 in all complexes except the Coquille. In 1991, the populations in the North Coast GCA were above average while all other complexes except the Coquille were below average. In 1993 and 1996, complexes from the Siuslaw south and the Yaquina south had above average spawner populations whereas those to the north except the Necanicum were below average. In 2000, spawner populations were above average in nine of the twelve complexes and may have been underestimated in the other three. The Yaquina, and Coos had spawners observed after the end of the survey season, although they were all jacks and adult males in the Coos. The Necanicum is a small basin where mainstem spawning could have been a factor.

Because of the large decline in harvest impacts, the pattern of interannual variation in pre-harvest abundance was somewhat different from that of spawner abundance. For example, whereas 1990 was a below average year for spawner abundance coast wide, it was an above average year for pre-harvest abundance in seven of the twelve complexes (Figure 33). The below average spawner abundance resulted from the high harvest impacts. However, the below average spawner abundance observed in most complexes in 1997 and 1998 (Figure 32) was a reflection of the below average pre-harvest abundance in all complexes except the Necanicum in 1998 (Figure 33).

Comparative Health of Population Complexes

The relative health of the population complexes can be compared using three methods: 1) comparing spawner abundance to the critical threshold; 2) comparing the viability of the complexes; and 3) comparing relative productivity of the populations.

Abundance Relative to the Critical Threshold

The critical threshold “below which populations are at relatively high risk of extinction in the near future” (McElhaney et al. 2000) is defined as four spawners per mile. At abundances less than four fish per mile, modeling suggested that depensatory processes, such as spawners not finding one another, will result in higher probabilities of extinction. With the exception of the Siletz Complex, population complexes from the Yaquina north have experienced spawner abundances below the critical threshold more often in the 1990s than have population complexes to the south (Table 19). Of particular interest, the Nehalem, Tillamook, and Nestucca complexes were at or below the critical threshold most years from 1990 to 1998.

Viability

There are two aspects to viability: assessment of the habitat of a complex relative to the defined viability standard and estimated probability of extinction. Population viability analysis using the life-cycle model of Nickelson and Lawson (1998) demonstrated that above the critical threshold of four spawners per mile, abundance had little effect on population viability (Figure 4). However, for populations modeled in hypothetical river basins, the probability of extinction increased rapidly as the quantity of high quality habitat available to the population was decreased from 15 miles (Figure 5). Thus, 15 miles of high quality habitat was used as criteria to determine if a population was viable: i.e. has "negligible risk of extinction due to local factors" (McElhaney et al. 2000). Based on this criteria, three population complexes, the Necanicum, Tillamook, and Nestucca complexes, were judged not viable. This conclusion was reinforced when the Nickelson-Lawson life-cycle model was used to conduct population viability analysis on the primary populations of each complex using 1999 spawner abundances. Each of these populations had a much higher probability of extinction than any populations in

Table 18. Correlation matrices for spawner abundance and pre-harvest abundance among complexes. Significant ($p \leq 0.05$) correlation coefficients are shown in bold type.

Complex	Nec	Neh	Til	Nes	Sil	Yaq	Als	Siu	Lks	Ump	Coo
Necanicum	-		**Spawner Abundance**								
Nehalem	0.05	-									
Tillamook	0.57	0.56	-								
Nestucca	0.00	0.27	0.46	-							
Siletz	-0.30	**0.66**	0.20	0.15	-						
Yaquina	-0.14	-0.22	-0.17	0.55	-0.09	-					
Alsea	-0.19	0.04	0.04	0.25	**0.65**	0.02	-				
Siuslaw	0.04	0.38	0.17	0.39	0.44	**0.62**	0.13	-			
Lakes	0.44	0.30	0.27	0.46	-0.20	0.46	-0.28	0.41	-		
Umpqua	0.26	0.29	0.02	0.43	0.01	0.58	-0.18	**0.69**	**0.78**	-	
Coos	-0.09	-0.21	-0.28	0.00	0.37	0.35	0.46	0.44	-0.21	0.22	-
Coquille	0.34	0.12	0.12	-0.12	0.12	0.33	-0.01	**0.60**	0.48	0.33	0.20
Necanicum	-		**Pre-Harvest Abundance**								
Nehalem	0.15	-									
Tillamook	**0.74**	0.51	-								
Nestucca	0.06	0.21	0.45	-							
Siletz	-0.19	0.38	0.04	0.15	-						
Yaquina	-0.32	-0.37	-0.28	0.42	-0.23	-					
Alsea	-0.19	-0.04	-0.09	0.22	**0.86**	-0.11	-				
Siuslaw	0.20	0.33	0.20	0.27	0.50	0.30	0.30	-			
Lake Basins	0.53	0.24	0.31	0.11	-0.46	0.10	-0.52	0.35	-		
Umpqua	0.31	0.19	-0.01	0.15	-0.03	0.27	-0.14	**0.69**	**0.71**	-	
Coos	0.03	-0.20	-0.19	0.06	**0.61**	0.09	**0.69**	0.46	-0.32	0.26	-
Coquille	0.46	0.12	0.23	-0.24	0.00	0.09	-0.10	0.56	0.51	0.35	0.14

complexes that met the viability standard (Figure 34). It should be noted however, that with the exception of the Necanicum, all populations were well below the 5% probability of extinction in 100 years often used as a criteria for population sustainability (Thompson 1991; Allendorf et al. 1997; Goodman 1999)

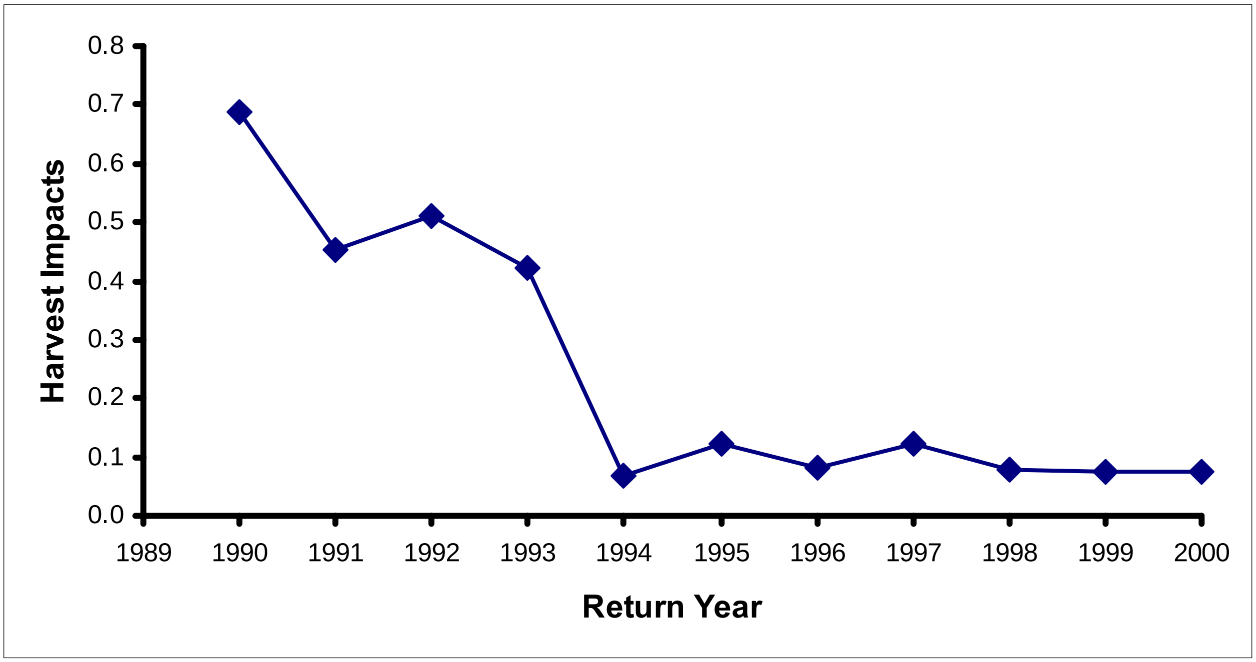

Figure 31. Harvest impacts on coastal coho salmon. Harvest impacts in 2000 were not available but were assumed similar to those in 1999 based on the fisheries planned.

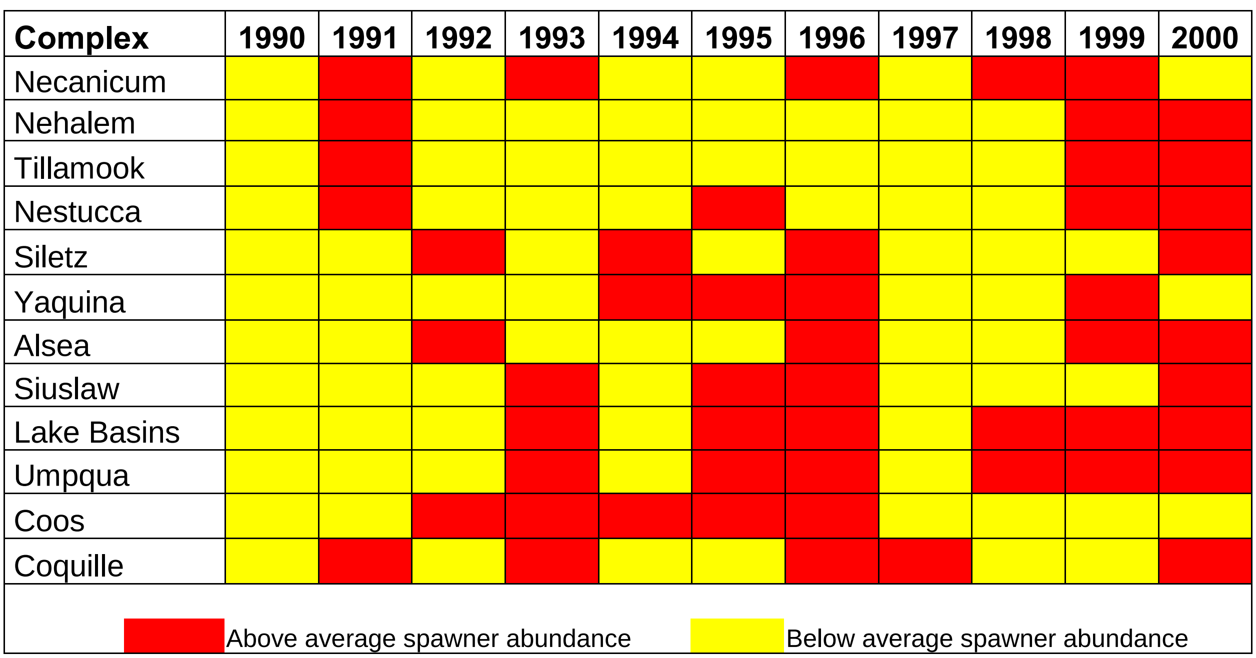

Figure 32. Patterns of spawner abundance relative to the eleven-year average.

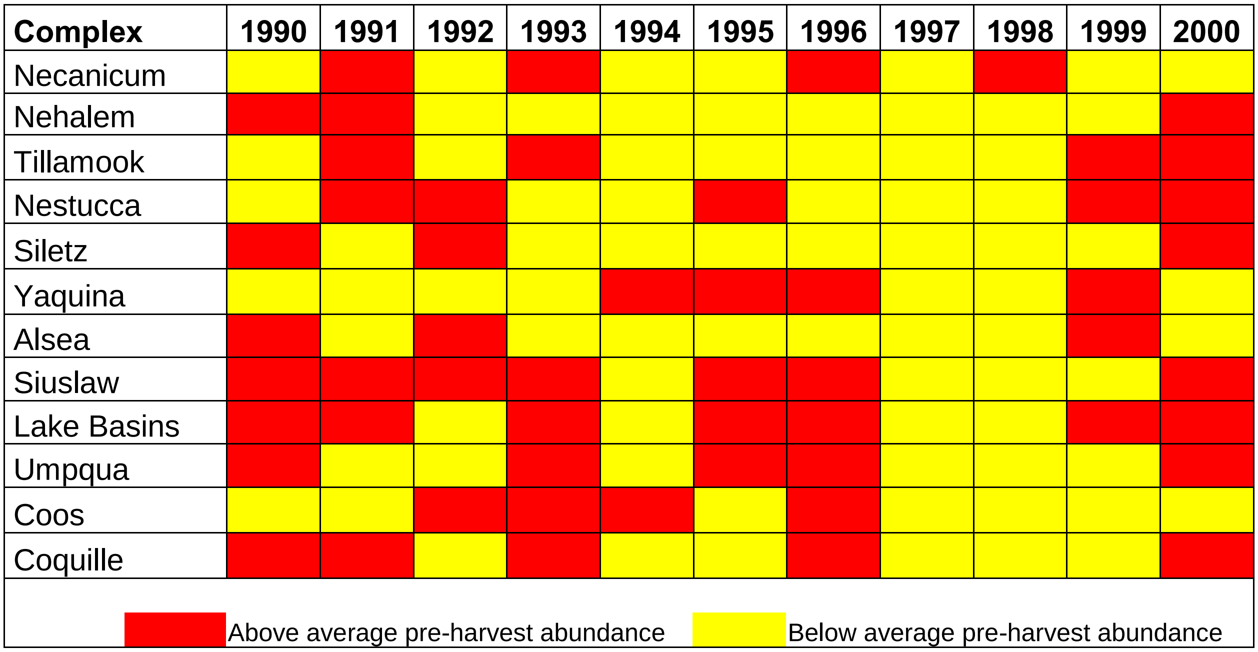

Figure 33. Patterns of pre-harvest abundance relative to the eleven-year average.

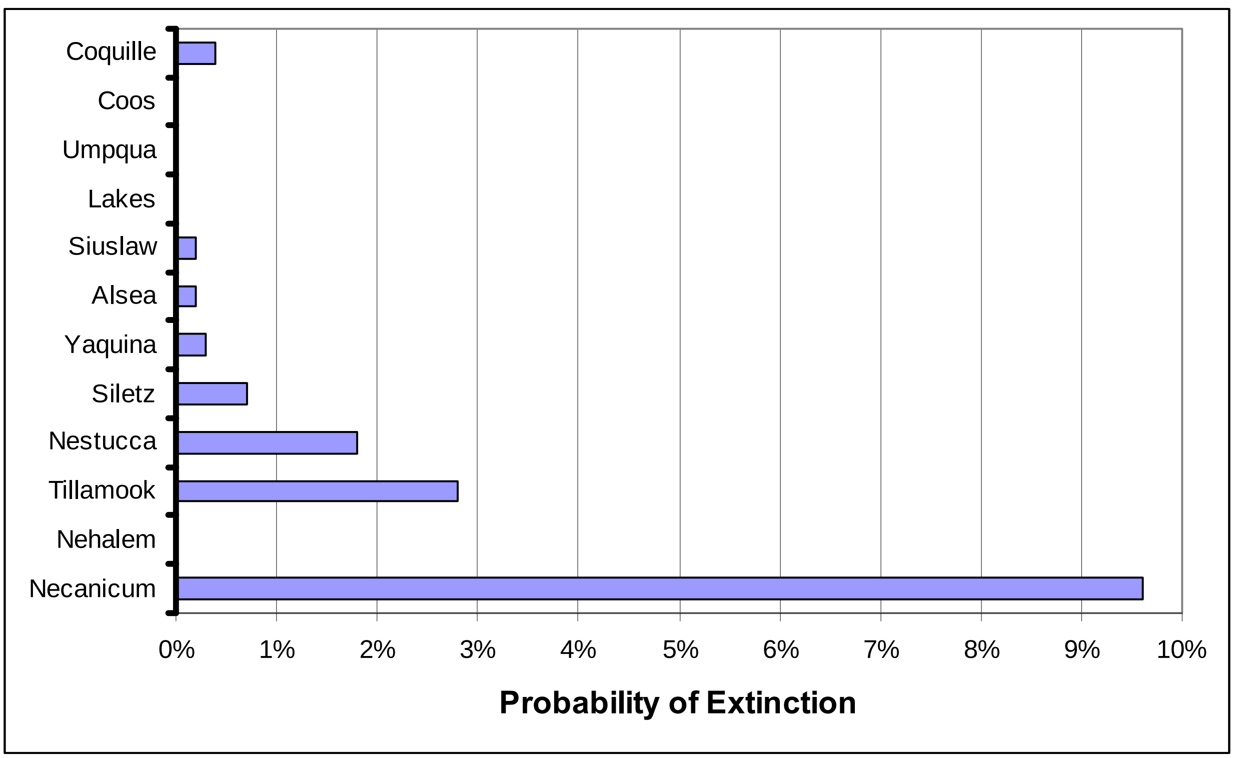

Figure 34. Probability of extinction in 99 years (defined as the occurrence of a minimum population of <2, adult spawners) estimated for each population complex in the Oregon Coast ESU, except for the Nestucca, Siletz, Alsea, and Coquille complexes, which were estimated for the largest primary population within the complex.

Productivity

Productivity is defined in the same way as Chilcote (2001): the number of recruits per spawner. It is expressed as the intercept in the regression of natural log of recruits per spawner on spawners, the **α** value in a Ricker recruitment function (Ricker 1975). Values of **α** were calculated for each population complex for brood years 1990-96. These values range from 0.84 for the Siletz Complex and 0.85 for the Tillamook Complex to 2.30 for the Coos Complex (Table 19). Unexpectedly, the Necanicum and Nestucca complexes, neither of which met the viability criteria, had higher **α** values than six complexes that met the viability criteria. All six complexes have a history of coho salmon hatchery programs.

Overall Ranking of Population Health

Each complex was ranked for viability, abundance, and productivity on a scale from one to twelve with ties. Viability was ranked based on the sum of ranking for quantity of high quality habitat as a percentage of the criteria of 15 miles and the ranking of probability of extinction. Abundance was ranked based on the sum of ranking for average spawner abundance as a percentage of the critical threshold for each complex and the ranking of the number of years above the critical threshold. Productivity was ranked based on the value of the Ricker **α** for each complex.

The larger complexes tended to rank highest in viability, with the Umpqua and Nehalem ranking one-two (Table 20). The three basins that failed to meet the viability criteria ranked 10-12. The complexes of the Mid-South Coast GCA ranked first through third in abundance. This was likely the result of a period of marine conditions during the mid 1990s that favored survival on the south coast but not the rest of the coast. Survival rates for coho salmon released from Cole Rivers Hatchery were high during this period, but were low elsewhere on the coast (Lewis 2000). Ranking of population complexes based on productivity produced no discernable pattern (Table 20).

Table 19. Summary of the status of coho salmon population complexes.

Complex	Population viable?	Ctitical threshold	Average spawner abundance	Number of years in last 11 above the critical threshold	Significant spawner trend?	Ricker α value
Necanicum	No	300	600	7	No	1.51
Nehalem	Yes	1,900	3,100	5	No	1.15
Tillamook	No	1,000	1,000	3	No	0.85
Nestucca	No	800	800	4	No	1.70
Siletz	Yes	700	1,300	9	No	0.84
Yaquina	Yes	600	1,700	6	No	1.96
Alsea	Yes	1,400	2,900	9	No	1.04
Siuslaw	Yes	2,300	3,800	9	No	1.25
Lakes	Yes	400	9,000	11	+12%/yr	1.77
Umpqua	Yes	4,900	7,600	7	No	1.29
Coos	Yes	900	8,100	11	No	2.30
Coquille	Yes	1,300	5,500	11	No	1.08

Table 20. Overall rankings of the relative health of population complexes.

Complex	Relative viability	Relative abundance	Ricker α value	Average rank	Overall rank
North Coast					
Necanicum	12	7	5	8.0	9
Nehalem	2	10	8	6.7	6
Tillamook	11	12	11	11.3	12
Nestucca	10	11	4	8.3	10
Mid-Coast					
Siletz	8	5	12	8.3	10
Yaquina	7	7	2	5.3	3
Alsea	6	4	10	6.7	6
Siuslaw	4	6	7	5.7	5
Umpqua					
Umpqua	1	9	6	5.3	3
Mid-South Coast					
Lakes	3	1	3	2.3	1
Coos	5	2	1	2.7	2
Coquille	8	3	9	6.7	6

With the exception of the Coquille and Nehalem complexes, the highest ranked complexes are located in the Mid-South GCA and the lowest ranked complexes are located in the North Coast GCA (Table 20). Overall, the relative health of populations by GCA follows a trend from high ranks in the south to low ranks in the north (Figure 35).

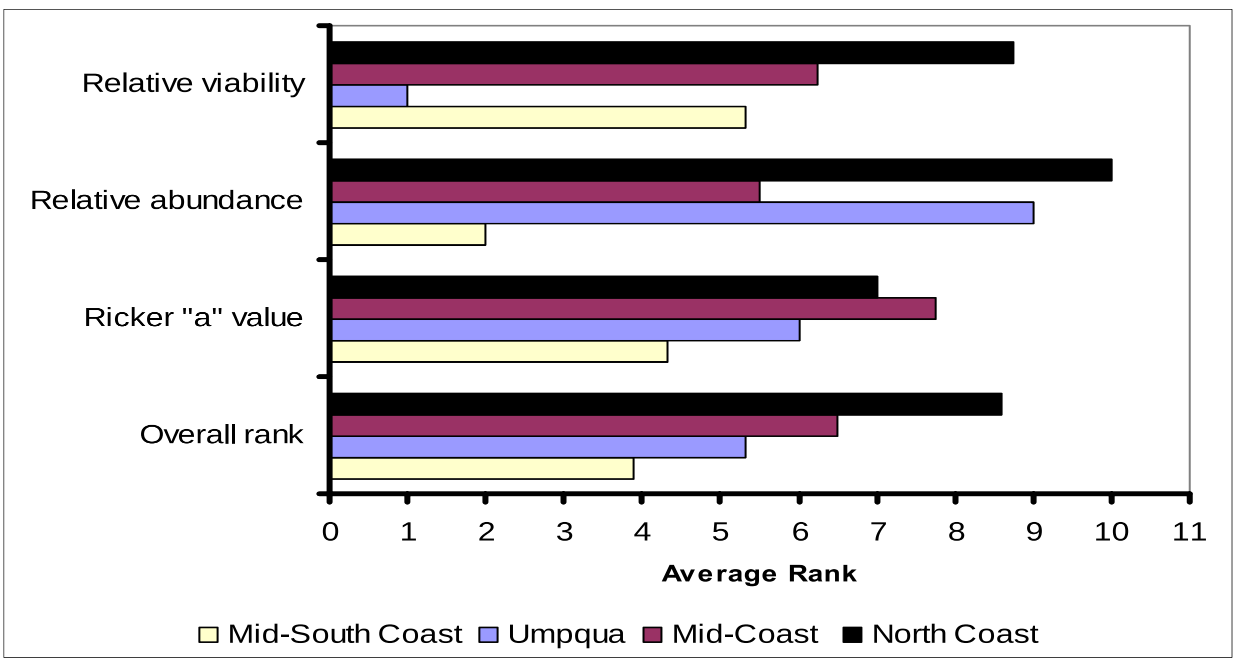

Figure 35. Average rankings of population parameters by GCA.

References

Allendorf, F.W., Bayles D., Bottom D.L., Currens K.P., Frissell C.A., Hankin D., Lichatowich J.A., Nehlsen W., Trotter P.C., and Williams T.H.. 1997. Prioritizing pacific salmon stocks for conservation. Cons. Biol. **11**: 140-152.

Chilcote, M.W. 2001. Conservation assessment of steelhead populations in Oregon. Oregon Department of Fish and Wildlife, Unpublished manuscript. Portland.

Fisher, J. P., and W. G. Pearcy. 1985. Studies of juvenile salmonids off the Oregon and Washington coast, 1985. Oregon State University Sea Grant College Program, ORESU-T-85-004, Corvallis.

Goodman, D. 1999. Population viability analysis: the risk assessment paradigm. *In* Workshop on assessing extinction risk for West Coast salmonids, Seattle, WA, November 13-15, 1996. NOAA Memo.

Hartt, A. C., and M. B. Dell. 1986. Early oceanic migrations and growth of juvenile Pacific salmon and steelhead trout. International North Pacific Fisheries Commission Bulletin 46:1-105.

Huntington, C.W., W. Nehlsen, and J. Bowers. 1994. Healthy native stocks of anadromous salmonids in the Pacific Northwest and California. Oregon Trout. Portland.

Jacobs, S.E. and C.X. Cooney. 1997. Oregon coastal salmon spawning surveys, 1994 and 1995. Oregon Department of Fish and Wildlife, Fish Information Report 97-5. Portland.

Jacobs, S.E. and T.E. Nickelson. 1998. Use of stratified random sampling to estimate the abundance of Oregon coastal coho salmon. Oregon Department of Fish and Wildlife, Final Reports (Fish) Project # F-145-R-09, Portland.

Jacobs S., J. Firman, G. Susac, E. Brown, B. Riggers and K. Tempel. 2000. Status of Oregon coastal stocks of anadromous salmonids. Monitoring Program Report Number OPSW-ODFW-2000-3, Oregon Department of Fish and Wildlife, Portland.

Kostow, K. (editor). 1995. Biennial report of the status of wild fish in Oregon. Oregon Department of Fish and Wildlife, Fish Division. Portland.

Labelle, M. 1992. Straying patterns of coho salmon (*Oncorhynchus kisutch*) stocks from southeast Vancouver Island, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 49:1843-1855.

Lewis, M.A. 2000. Stock assessment of anadromous salmonids, 1999. Oregon Department of Fish and Wildlife, Oregon Plan for Salmon and Watersheds, Annual Progress Report number OPSW-ODFW-2000-4, Portland.

Lister, D. B., and H. S. Genoe. 1970. Stream habitat utilization by cohabiting underyearlings of chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon in the Big Qualicum River, British Columbia. Journal of the Fisheries Research Board of Canada 27:1215-1224.

McElhaney, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42, 156 p.

Miller, B. 1998. Juvenile salmonid out-migration in the North Fork Coquille River in 1998. Oregon Department of Fish and Wildlife Life-Cycle Monitoring Project unpublished Report. Charleston.

Moring, J. R., and R. L. Lantz. 1975. The Alsea watershed study: Effects of logging on the aquatic resources of three headwater streams of the Alsea River, Oregon. Part I - Biological studies. Oregon Department of Fish and Wildlife, Fishery Research Report Number 9, Corvallis.

Mundie, J. H. 1969. Ecological implications of the diet of juvenile coho in streams. Pages 135-152. *In* T. G. Northcote [ed.] Symposium on salmon and trout in streams. H. R. MacMillan Lectures in Fisheries. University. of British Columbia, Vancouver, B.C.

Nickelson, T.E. 1998. A habitat-based assessment of coho salmon production potential and spawner escapement needs for Oregon coastal streams. Oregon Department of Fish and Wildlife, Fish Information Report 98-4. Portland.

Nickelson, T.E. and P. Lawson. 1998. Population viability of coho salmon *Ocorhynchus kisutch*, in Oregon coastal basins: Application of a habitat-based life-cycle model. Canadian Journal of Fisheries and Aquatic Sciences 55: 2383-2392.

Nickelson, T. E., J. D. Rodgers, S. L. Johnson, and M. F. Solazzi. 1992a. Seasonal changes in habitat use by juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49:783-789.

Nickelson, T. E., M. F. Solazzi, S. L. Johnson, and J. D. Rodgers. 1992b. Effectiveness of selected stream improvement techniques to create suitable summer and winter rearing habitat for juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49:790-794.

ODFW 1995. Biennial report on the status of wild fish in Oregon. Oregon Department of Fish and Wildlife, Portland.

OPSW. 1997. The Oregon plan for restoring salmon and watersheds. Governor's Office, Salem, OR.

PFMC. 1999. Final Amendment 13 to the Pacific Coast Salmon Plan. Fishery management regime to ensure protection and rebuilding of Oregon coastal natural coho. Pacific Fishery Management Council. Portland, Oregon.

Reiser, D. W., and T. C. Bjornn. 1979. Habitat requirements of anadromous salmonids. Ch. 1. *In* W. R. Meehan [tech. ed.] Influence of forest and rangeland management on anadromous fish habitat in the western United States and Canada. Pacific Northwest Forest and Range Experiment Station, USDA. Forest Service, Portland.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada No. 191. Ottawa.

Rodgers, J. D., S. L. Johnson, T. E. Nickelson, and M. F. Solazzi. 1993. The seasonal use of natural and constructed habitat by juvenile coho salmon (*Oncorhynchus kisutch*) and preliminary results from two habitat improvement projects on smolt production in Oregon coastal streams. *In* Proceedings of the coho workshop, May 26-28, 1992 at Nanaimo, B.C.

Sharr, S., C. Melcher, T. Nickelson, P. Lawson, R. Kope, and J. Coon. 2000. 2000 review of Amendment 13 to the Pacific Coast Salmon Plan. Pacific Fisheries Management Council. Portland.

Solazzi, M.F., S.L. Johnson, B. Miller, and T. Dalton. 2000. Salmonid Life-Cycle Monitoring Project 1998 and 1999. Monitoring Program Report Number OPSW-ODFW-2000-2, Oregon Department of Fish and Wildlife, Portland.

Solazzi, M.F., S.L. Johnson, B. Miller, and T. Dalton. 2001. Salmonid Life-Cycle Monitoring Project 1998 and 1999. Monitoring Program Report Number OPSW-ODFW-2001-2, Oregon Department of Fish and Wildlife, Portland.

Stevens D.L. 1997. Variable density grid-based sampling designs for continuous spatial populations. Environmetrics: 8 167-195.

Thompson, G.G. 1991. Determining minimum viable populations under the Endangered Species Act. NOAA Technical Memorandum NMFS F/NWC-198.

Waples, R.S. 1995. Evolutionarily significant units and the conservation of biological diversity under the Endangered Species Act. *In* Evolution and the aquatic ecosystem: Defining unique units in population conservation. Am. Fish. Soc. Symp. 17:8-27.

Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status review of coho salmon from Washington, Oregon and California. NOAA Technical Memorandom NMFS-NWFSC-24.