THE OREGON PLAN for Salmon and Watersheds

Status of Oregon Coastal Stocks of Anadromous Salmonids, 1999-2000

Report Number: OPSW-ODFW-2001-3

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CONTENTS

EXECUTIVE SUMMARY

This report provides an assessment of the status of adult anadromous salmonids inhabiting coastal basins of Oregon. Status is monitored through spawning surveys. Species or races monitored through these surveys are fall chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*) and steelhead (*O. mykiss*). Assessments cover through the 1999 brood year for salmon and the 2000 brood year for steelhead. Status is generally assessed along two levels of geographic aggregation: Evolutionary Significant Units (ESUs) and Gene Conservation Areas (GCAs). ESUs were defined by the National Marine Fisheries Service in conducting reviews for protection under the federal Endangered Species Act. GCAs are usually subsets of populations within ESUs and were defined by the Oregon Department of Fish and Wildlife either as part of the implementation of the Wild Fish Management Policy or as part of monitoring associated with implementation of the Oregon Plan for Salmon and Watersheds.

Fall Chinook

The Oregon Coastal ESU includes fall chinook inhabiting coastal basins south of the Columbia River mouth through the southern portion of Cape Blanco. Indices of spawner abundance in this ESU show a significant increase over the past 50 years. There are four GCAs within the Oregon Coastal ESU. Spawner abundance trends are available for each GCA over a 13-year period form 1986-99. Overall, counts of spawners in all GCAs show healthy levels of abundance, however there are some differences in the patterns of trends. Fall chinook in the Nehalem/Ecola and Mid-South Coast GCAs have remained stable. Fall chinook in the North-Mid Coast GCA have declined 5% per year during this period, whereas fall chinook in the Umpqua GCA increased dramatically. The declining trend of fall chinook in the North-Mid Coast GCA is primarily attributed to declines in populations inhabiting the Tillamook and Nestucca Basins.

The Southern Oregon ESU and South Coast GCA are identical in Oregon, and include all coastal basins south of Cape Blanco, as well as the entire Rogue Basin. Trends of spawner abundance differ among coastal and interior populations of fall chinook within this ESU. Over the 40-year period that coastal populations of this ESU have been monitored, spawner abundance has shown a significant decline. Spawner populations of interior stocks of the Rogue Basin have fluctuated between two general levels of abundance during the 23-year period of record. During 1977-84 and during the 1990s the abundance index was fairly stable, averaging about 150 spawners per mile. In contrast, during the period of 1985-89, the index of spawner abundance averaged about five times higher, peaking in 1988 at over 1,300 fish per mile. Despite the substantial reductions in ocean fishery harvest that have persisted since 1990, spawner abundances of South Coast fall chinook have not shown significant increases.

Coho

Two ESUs have been defined for Oregon coastal coho. The Oregon Coastal ESU includes all basins north of Cape Blanco. There are four GCAs within the Oregon Coastal ESU. The South Coast GCA is identical to the Oregon portion of the Southern Oregon/Northern California ESU and includes all basins south of Cape Blanco, beginning with Elk River.

Long-term trends of total pre-harvest abundance and spawner escapement are available for the Oregon Coastal ESU. Both of these indices show significant declining trends over the 50-year period of record. The level of both spawner escapement and pre-harvest abundance observed in 1999 was slightly improved from the record low levels observed in 1997 and 1998. Indexes of adult recruits per spawner are available for the 1950-95 brood years. This index measures the overall survival of coastal coho from egg deposition to adulthood. These values range from eight to less than one. Survival rates of coastal coho stocks have shown a steady decline over about the last 20 brood years. Spawner replacement failed to occur for the three most recent brood years. Estimates of the abundance of adult coho spawners within the four GCAs that comprise the Oregon Coastal ESU are available back through 1990. Spawner abundance in the Oregon Coastal ESU has ranged from about 20,000 adults in 1990 to near 80,000 adults in 1996. In 1999, an estimated 47,400 adult coho spawned in the Oregon Coastal ESU. Among the four GCAs, spawner abundance has generally been lowest in the North Coast GCA and highest in the Mid-South Coast GCA. In the North Coast GCA, spawner abundance has averaged about 3,700 adults, and has ranged from about 2,200 adults to about 9,300 adults. Conversely, in the Mid-South Coast GCA, spawner abundance has averaged more than 14,000 adults and been as high as 28,000 adults in 1996. The most productive basins in this GCA have been the Coos, Tenmile Lakes and Siltcoos Lake Basins.

Production of coho salmon in the Southern Oregon ESU overwhelmingly occurs in the Rogue Basin. Run size estimates of naturally produced adult coho are available for a 19-year period beginning in 1980. During this period, run size has ranged from about 300 adults in 1993 to near 8,000 adults in 1997. Accounting for ocean fishery harvest shows a somewhat different pattern of Rogue coho abundance. Significant harvest occurred during 1980-90. Given this, total stock abundance peaked at about 14,000 adults in 1981. In 1999, an estimated 1,440 adult coho naturally spawned in the in the Rogue Basin. This is the lowest natural spawning run observed since 1993.

Estimates of the occurrence of hatchery coho in natural spawning populations are available through the analysis of scale patterns collected on spawning surveys over the last nine years. Three major conclusions can be drawn from this analysis: (1) hatchery strays have occurred in essentially every major coastal basin, (2) in some basins natural spawning has been dominated by hatchery strays, and (3) although hatchery strays were widespread, they comprised a minor portion of the natural spawners in the most productive GCAs. Beginning in 1998, returns of adult coho originating from Oregon hatcheries were essentially 100% marked with adipose fin-clips. This mass marking enables the proportion of natural spawning hatchery fish to be estimated from recovery of fin-marked carcasses. In 1999, hatchery fish comprised less than 10% of the natural spawners in any of the five coastal GCAs. Estimates based on scales were generally consistent with estimates derived from mark-recoveries in terms of distinguishing areas having high levels of hatchery influence from areas where little or no straying occurred, however, the two methods did not always agree relative to the magnitude of hatchery straying.

Chum

All Oregon coastal stocks of chum salmon are part of the Pacific Coast ESU. This ESU encompasses all coastal chum stocks in the U. S., from Washington through California. GCAs have not yet been described for Oregon chum populations. Recent sampling indicates that chum populations occur along the Oregon Coast as far south as Coos Bay. Coastal stocks are most abundant in North coastal basins, particularly Tillamook Bay. Spawner abundance of Oregon coastal chum stocks has varied widely since 1948. Despite this variability, there has been a declining trend in overall spawner abundance during this 52-year period. Coastal chum abundance reached record low levels in 1996 and have yet to show any significant increases since then.

Steelhead

Oregon Coastal steelhead have traditionally been monitored through a combination of dam passage counts and angler harvest records. However, since 1992, restrictions in the harvest of wild steelhead essentially eliminated the utility of angler harvest records for assessing the status of coastal winter steelhead stocks. New strategies were initiated for monitoring coastal winter steelhead in 1997, including research into the applicability of spawner surveys for monitoring abundance.

We completed our first year of the evaluation of spawner surveys in Smith River. We estimated that 1,440 wild adult winter steelhead passed the trap site at Smith River Falls. We used a modified random sampling design to estimate the total number of steelhead redds in the basin upstream from Smith River Falls. Based on this method, we estimated that there were 1,438 $\pm$ 447 redds in this portion of the basin. Applying an estimate of the redd:adult ratio to the estimated total number of redds yielded an estimate of 1,672 $\pm$ 646 adult steelhead upstream from the falls.

We found a highly significant relationship between steelhead spawner abundance and the number of redds counted upstream from four calibration sites over the last three years. This relationship suggests that redd counts may provide a reliable means of indexing the abundance of Oregon Coastal steelhead. We plan to continue our calibration studies at Smith River to verify this finding. However, because no monitoring for coastal steelhead is currently in place, we recommend initiating systematic redd counts in Oregon coastal basins immediately.

INTRODUCTION

Status assessment of fishery resources is a fundamental function of the Oregon Department of Fish and Wildlife (ODFW). Status assessments of anadromous salmonids feed directly into marine and freshwater harvest management, implementation of ODFW's Wild Fish Management Policy, development of basin management plans and the planning and evaluation of restoration and enhancement activities. More recently, status assessment of Oregon stocks of anadromous salmonids has been an integral component of state and federal Endangered Species Act reviews (ODFW 1995, Weitkamp et al. 1995, Busby et al. 1996, Johnson et al. 1997, Myers et al. 1998). With the development and implementation of the Oregon Plan for Salmon and Watersheds (OPSW 1997) as the region's principal recovery strategy for salmon, status assessment was identified as the primary tool for gauging the success of this recovery effort. In response to monitoring needs of the Oregon Plan, ODFW augmented its monitoring programs for fishery and habitat resources (OPSW 1997, Firman and Jacobs 2001). A major component of this effort is the monitoring of adult spawner populations. Results of spawner monitoring and assessment of population status relative to Oregon Plan recovery efforts were first reported in Jacobs et al. (2000).

Spawning salmon (*Oncorhynchus* spp.) have been counted in Oregon coastal streams since 1948 to assess the status and trends of naturally produced spawning stocks. The history of this monitoring program is chronicled in Jacobs and Cooney (1997). Spawning surveys have been the Department's primary tool for assessing the status and trends of naturally produced salmon stocks. This effort has focused on three species: chinook salmon (*O. tshawytscha)*, coho salmon (*O. kisutch)*, and chum salmon (*O. keta*). Results for chinook and chum salmon have been reported through the 1995 return year in Jacobs and Cooney 1997. Results for coho salmon have been reported through the 1997 return year in Jacobs and Nickelson (1998) and Jacobs (1999).

Coastal stocks of winter steelhead (*O. mykiss*) have not been monitored through spawner surveys. Traditionally, trend assessment for this species was based on salmon-steelhead tag recoveries from recreational fisheries. However, when most coastal fisheries were closed to the harvest of wild fish in the 1990s these data were no longer available. To fill this information void, we initiated a program in 1997 to experimentally conduct spawning surveys for coastal steelhead stocks (Susac and Jacobs 1999).

This report describes the results of ODFW's current monitoring through adult spawner surveys for the four species of coastal anadromous salmonids mentioned above. The report is organized into four separate chapters. Results cover monitoring conducted through 1999. Specifically, results of the 1999-2000 season are presented. Data from individual survey sites is not presented in this report. Survey data are available upon request. For availability, please refer to our web site:

http://osu.orst.edu/Dept/ODFW/other/spawn/index.html.

SURVEY PROGRAM DESIGN

Surveys were conducted throughout the spawning distribution of chinook, coho and chum salmon and steelhead in Oregon coastal watersheds (Figure i-1). The extent of the surveys varied among the four species. Survey effort is most extensive for coho and least extensive for chum and steelhead.

Surveys were classified into five separate types (*standard, random, supplemental, spot check* and *lake*) depending upon their use. *Standard* surveys are areas that have been surveyed consistently over a long period of time, and are used to index spawning abundance. These areas were selected as early as 1948 based on varied criteria including ease of access, and the assurance of finding some level of spawning. *Random* surveys are only conducted for coho salmon and are used to provide unbiased estimates of spawner abundance and distribution. These surveys are selected randomly from the estimated available spawning habitat within geographic strata of coastal stream basins. *Supplemental* surveys are typically selected to fill specific information needs and may vary from year to year. *Spot checks* are identical to supplemental areas except only selected gravel bars are surveyed to enumerate fish for the entire survey area. *Lake* surveys are located on tributaries of three major coastal lake systems: Siltcoos, Tahkenitch, and Tenmile, and are used to estimate the spawning escapement of coho salmon to these systems. Unique sets of survey sites are conducted for each of the four species.

Survey stream segments are also classified into four groups based on the potential influence of hatchery operations on the counts of spawning fish: 1) *fed* and 2) *unfed* consist of streams thought to have moderate to heavy hatchery influences on spawner abundance due to hatchery releases, either through public hatchery, private hatchery, or Salmon and Trout Enhancement Program (STEP) operations; 3) *broodstock* consist of streams where adults are collected to supplement egg and sperm supplies for propagation programs, and 4) *wild* consist of stream segments not matching one of the previous three conditions. In cases where streams were affected by more than one type of influence, classification was applied in the following priority order; *fed, broodstock, unfed,* then *wild*. The classification criteria vary slightly for each species and therefore are explained in detail in each respective chapter.

SURVEY PROCEDURE

Seasonal personnel were hired to conduct intensive stream surveys to count spawning fish and redds in pre-established stream segments. Specific stream segments were targeted for each species, however all species were counted in a given stream segment regardless of its specific target. Survey stream segments were repeatedly sampled, by either floating or walking, during the spawning season to obtain counts of live and dead salmon. Counts of jacks (chinook salmon $\leq$60 cm fork length and coho salmon $\leq$50 cm fork length) were kept separate from adults. Secondary information such as weather conditions, water clarity, and stream flow was also recorded each time a survey was conducted.

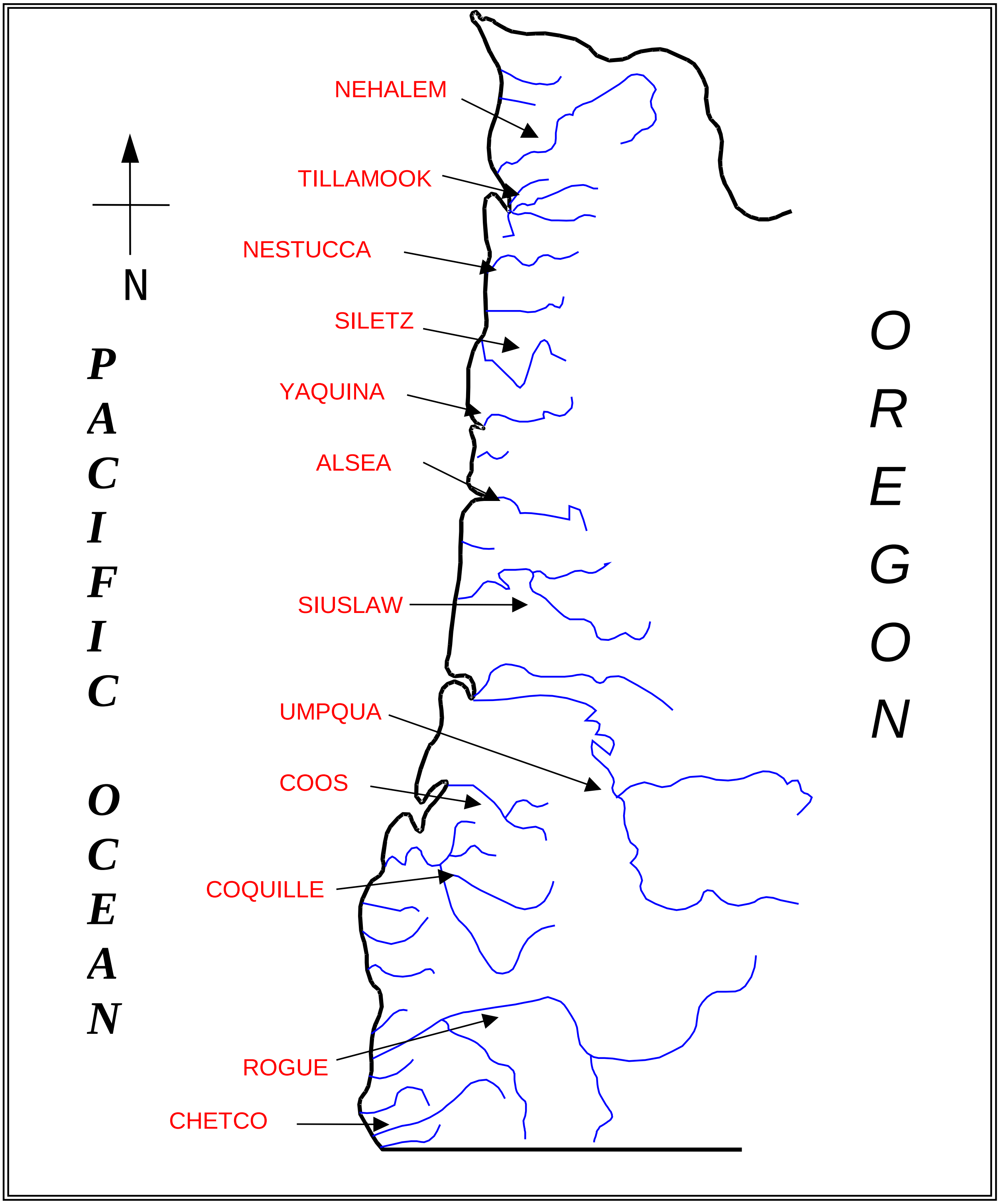

Figure i-1. Map of the Oregon coast showing major river basins.

Carcasses of spawned-out salmon encountered in all surveys were inspected for tags and fin-clips. Carcasses with missing adipose fins were sampled for coded-wire tags by removing their snout. Scale samples were taken from the key scale area (Nicholas and Van Dyke 1982) to estimate rearing origin (hatchery vs. wild). Scale samples from fall chinook and chum salmon were also examined to estimate age composition. Sex, MEPS (mid-eye to posterior scale) length, sampling location, and date were recorded for each fish sampled.

Assessment of Survey Conditions

The success of spawning surveys is largely dependent on stream flow conditions occurring during the spawning season. Flow regimes in Oregon coastal streams are typified by extreme inter-annual variation with maximum flows commonly exceeding minimum flows by two orders of magnitude. For most coastal systems, the spawning season of coastal salmonids begins during the period of minimum annual stream flow and continues throughout the highest flow period. Upstream migration and access to spawning streams is tied to rises in stream flow triggered by rain events. Spawning distribution and timing is partially dependent on the availability of suitable substrate, stream velocity and water depth (Smith 1973, Neilson and Banford 1983). The timing and distribution of survey counts will thus depend on how annual flow patterns affect upstream migration and the availability of spawning habitat. Flow patterns also affect our ability to conduct spawning surveys. High, turbid flows during freshets prevent surveys from being conducted. The duration of these freshet conditions can range from a few days to, in extreme cases, as long as two weeks. Information on the behavior of spawning salmonids during high freshet conditions is unavailable, however studies have shown that the life span of salmon in spawning streams is typically about 10-12 days (Willis 1954, Perrin and Irvine 1990). Given this, our protocol is to conduct surveys on an interval of 10 days to minimize error.

Figure i-2 illustrates flow conditions during the 1999 survey season for representative Oregon coastal river basins. Also shown are limits of the of the 80th and 20th percentiles of mean daily flows for the 40-year period back through 1957. Relative to long-term average conditions, 1999 was a relatively dry spawning season. During most of the season, stream flow remained within or below average levels. The first significant freshet did not occur until the last week of November. As shown in this figure, flows during the salmon spawning season show substantial temporal and geographic variation. For example, flows on the northern half of the coast peaked in November, whereas on the southern half of the coast flows peaked in January. The Thanksgiving Day freshet was most intense in the mid coast. During this event flows on the Siletz River peaked at 40,000 cfs and marked a new record for flows recorded at this site back through 1905. The degree to which river levels impact our ability to count spawners varies for each species and therefore is discussed in detail in each respective chapter.

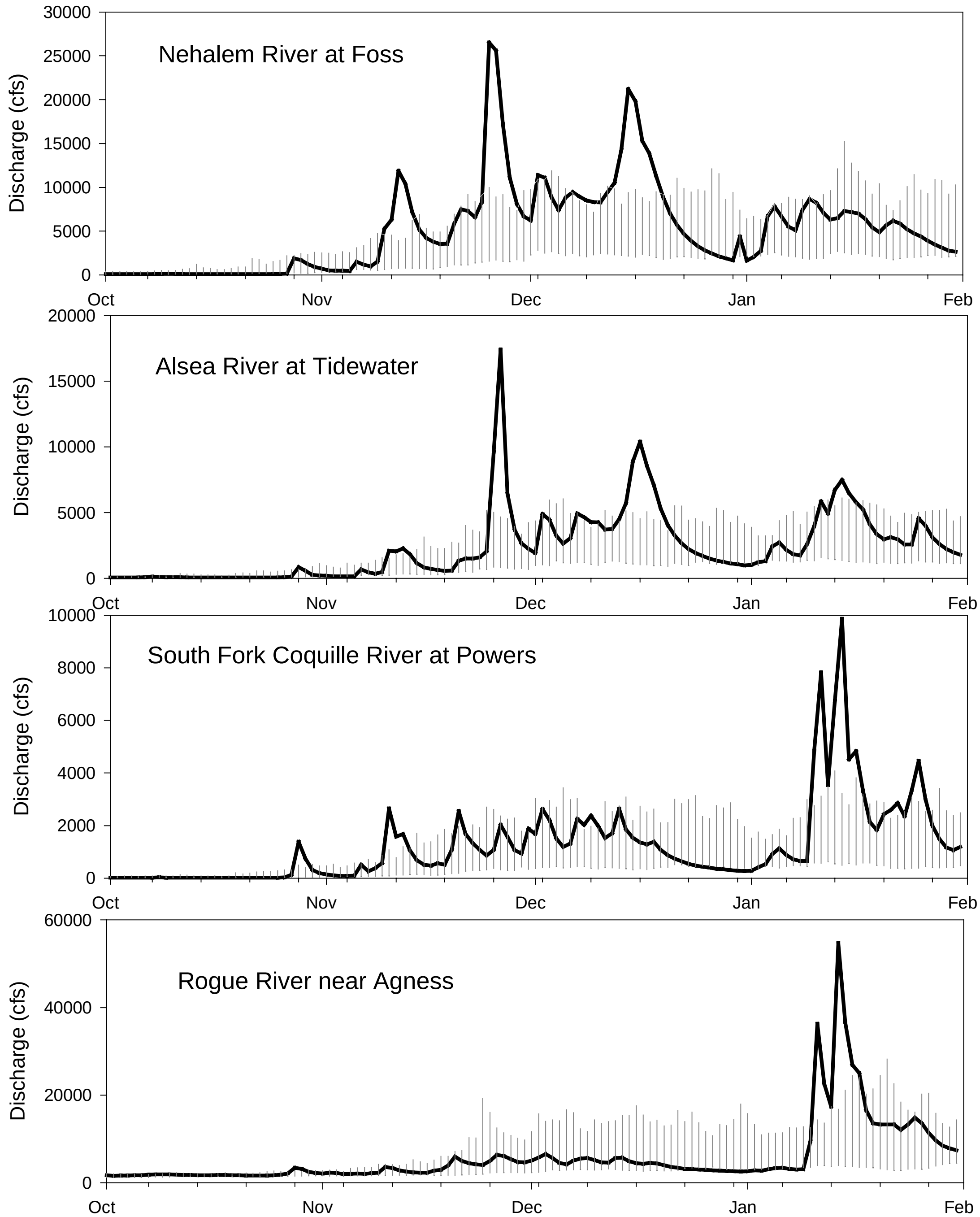

Figure i-2. Daily mean river discharge in cubic feet per second by Surface Water Station for the 1999 spawning survey season (2000 USGS water year) (Miller 1997). Vertical bars represent limits of the 80th and 20th percentiles of mean daily flows for the 40-year period back through 1957.

CHAPTER 1: FALL CHINOOK SALMON

CURRENT MONITORING PROGRAM

Native populations of chinook salmon in Oregon costal basins range from Ecola Creek, south through the Winchuck River (Kostow 1995). Throughout this range, chinook occur in mid to large watersheds that typically have relatively large estuaries. Oregon coastal chinook stocks almost exclusively display an ocean-type life history (Healey 1991), with juveniles entering the ocean during their first year of life (Nicholas and Hankin 1988). Within this life history, two major races of coastal chinook occur: fall-run and spring-run. Overall, fall-run stocks are the most abundant and widely distributed race. Spring-run stocks are primarily limited to larger basins in the northern half of the coast and the upper portions of the Umpqua and Rogue Basins. Systematic monitoring through spawning surveys has occurred only for fall-run stocks.

Since 1950, spawning fish surveys conducted in standard index areas have been used to assess status and trends of coastal stocks of fall-run chinook (Jacobs and Cooney 1997). In order to fulfill one of Oregon's participant obligations in the Pacific Salmon Treaty (PSC 1987), ODFW agreed to develop a program to monitor the spawning escapement of stocks of chinook salmon that contribute to ocean salmon fisheries addressed by the treaty. These chinook stocks originate from coastal basins from the Necanicum River through the Elk River. ODFW elected to use spawning surveys to accomplish this objective, thereby creating a need to expand the program. Beginning in 1986, ODFW increased the survey effort for monitoring the spawning escapement of coastal chinook salmon stocks. New survey sites were selected and pilot surveys were conducted during 1986 through 1988. Based on the evaluation of that survey effort, a portion of those surveys was incorporated into the standard index for coastal chinook salmon beginning in 1989. Stream segments were evaluated and chosen if they (1) were surveyed on a regular basis during the chinook salmon spawning season and (2) appeared to be a valid index of spawning escapement in the basins where they were located.

The Rogue River basin, which is not affected by the Pacific Salmon Treaty, is perhaps the single largest source of naturally produced fall chinook salmon among Oregon coastal river basins (Nicholas and Hankin 1988, ODFW 1991, Whisler and Jacobs 2000). Most fall chinook salmon in the Rogue Basin originate from the middle portions of the mainstem Rogue River, near Grants Pass, and the Applegate River Basin. Indexes of spawning escapement were not presented in versions of this report prior to 1991 because no historic spawning surveys were conducted in these areas. Surveys to count spawned carcass were established in the middle portions of the main stem Rogue River and the Applegate River Basin in 1977 as part of a research study to assess the effects of Lost Creek and Applegate Dams (ODFW 1992), and have continued each year thereafter. These surveys provide the best available means to assess the status of these stocks, and therefore are used as indexes of spawning escapement in this report.

ASSESSMENT UNITS

The National Marine Fisheries Service (NMFS) has designated two Evolutionary Significant Units (ESUs) for Oregon coastal chinook stocks (Myers et al. 1998). The *Oregon Coastal ESU* encompasses all coastal basins south to Cape Blanco (Ecola Creek through Elk River), including the entire Umpqua Basin. The *Southern Oregon and California Coastal ESU* begins south of Cape Blanco (Euchre Creek) and extents to the range of chinook in coastal watersheds of California. Within Oregon, this ESU covers the Euchre Creek through Winchuck River basins and includes the entire Rogue Basin (Figure 1-1A). Long-term trend data on spawner abundance are available for each of these ESUs.

The Chinook Technical Committee (CTC) of the Pacific Salmon Commission has grouped Oregon coastal stocks of fall chinook into three management areas for the purposes of fisheries management assessment (Figure 1-1B). These stock groupings were based on geographic similarities in ocean catch distribution and age of maturity (CTC 1994). Stocks contained within the *North Oregon Coast Management Area* originate from the Necanicum through Siuslaw Basins. These stocks primarily contribute to marine fisheries in Southeast Alaska and British Columbia, and primarily mature at age-5. Stocks comprising the *Mid Oregon Coast Management Area* originate from the Umpqua Basin and coastal basins south through Elk River. Stocks in this management area contribute to northern as well as Oregon marine fisheries and tend to exhibit a somewhat younger age of maturation. Stocks produced in coastal streams south of Elk River and in the entire Rogue Basin comprise the *South Oregon Coast Management Area*. These stocks primarily contribute to marine fisheries off Oregon and Northern California and tend to have the youngest age of maturity, as indicated by high incidences of females maturing at age-3.

The Oregon Department of Fish and Wildlife has divided the Oregon Coastal ESU into four Gene Conservation Areas (GCAs) for chinook salmon based on studies of genetic variation and life history traits (Kostow 1995; Figure 1-1C). This yields five GCAs for the Oregon Coast. The *Nehalem/Ecola GCA* encompasses these two watersheds and was designated based on the occurrence of a relatively large summer-run population in the Nehalem Basin. The *North-Mid Coast GCA* includes coastal drainage basins from Tillamook Bay, south to the Siuslaw River. The rivers in this GCA are relatively small, and lie in the wet, temperate region to the west of the Coast Range. The *Umpqua GCA* includes the entire Umpqua Basin, including the North and South Umpqua Rivers, Smith River and Elk and Cow Creeks. The Umpqua cuts through the coast range and has its headwaters in the Cascade Mountains. The lower basins draining the coast range are similar to those in the Mid-North Coast GCA, i.e. wet and temperate, but the upper basin in affected by snowmelt in the Cascades and by the relatively dry climate east of the Coast Range. The *Mid-South Coast GCA* covers Coos Bay, the Coquille Basin and smaller coastal basins to the southern tip of Cape Blanco (Elk River). The *South Coast GCA* includes the Rogue River drainage and small coastal streams south of Cape Blanco to the Oregon/California border. Like the Umpqua, the Rogue River cuts through the Siskiyou Mountains and has its headwaters in the Cascades. The upper basins are affected by the relatively dry climate east of the Siskiyous, and by snowmelt in the Cascades.

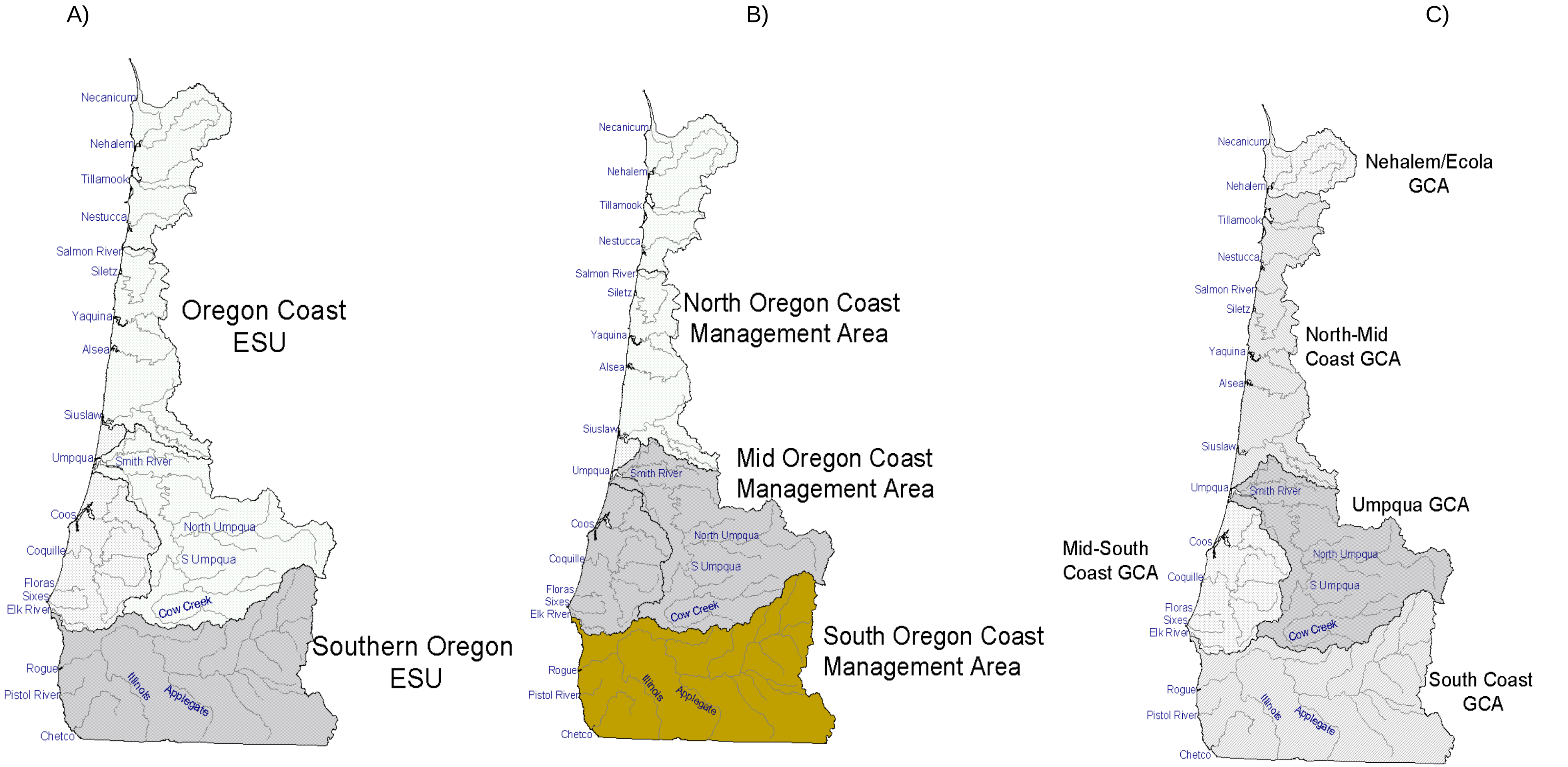

Figure 1-1. Geographic strata for Fall Chinook Salmon for coastal areas in the state of Oregon. A) Evolutionary Significant Units (ESUs) as defined by the National Marine Fisheries Service. B) Fishery Management Areas as defined by the Chinook Technical Committee of the Pacific Salmon Commission. C) Gene Conservation Areas (GCAs) as defined by the Oregon Department of Fish and Wildlife.

METHODS

Survey Design

The coastal portion of the standard spawning index for fall chinook salmon consists of 53 stream segments from 19 different river basins and totals 52.6 miles (Table 1-1). This index covers all GCAs within the Oregon Coast ESU except for the Umpqua GCA. Standard index sites were not established in the Umpqua Basin because available data and anecdotal information indicated that few fall chinook inhabited this basin. In an effort to provide some assessment of trends of Umpqua fall chinook we examined counts of chinook occurring in Buck Creek, a tributary to Smith River.

The standard index also covers coastal portions of the South Coast GCA. Seven index areas are located within six different basins within this GCA (Table 1-1). Included in this group are two index areas located in the lower portion of the Rogue Basin.

The standard index of carcass counts for fall chinook salmon spawning in the interior portion of the Rogue River totals 25.3 miles and consists of two surveys on the middle mainstem Rogue River, three on the Applegate River, and one on Slate Creek, a tributary of the Applegate River.

Surveys conducted for fall chinook salmon were classified to distinguish between streams indexing abundance of naturally produced fish from streams potentially influenced by fish culture activities. Hatchery-influence-classifications were based on the following criteria: streams were classified as being influenced by fed-fish if fed hatchery fall chinook (i.e. smolts or fingerlings) were released within 10 stream miles of the downstream end of the survey segment during 1994-98; streams were classified as being influenced by unfed-fish if unfed hatchery fall chinook (i.e. fry) were released within 10 stream miles of the downstream end of the survey segment during the same periods listed for fed-fish; streams were classified as being influenced by broodstock collection if live adult fall chinook were removed within 10 miles of the survey segment during the 1999 spawning season. All survey segments not matching any of these conditions were classified as wild index streams. Classifications of standard chinook stream segments are listed in Table 1-1.

Measures of Spawning Escapement

Spawning escapement was indexed as the peak count of live and dead fish observed in a given survey area. Peak counts were used to index spawning escapement in all survey areas except those conducted for interior populations of Rogue fall chinook.

Peak count per mile in a given stream segment (H_i) was calculated as follows:

$$H_i = P_i / m_i \tag{1}$$

where

P_i = peak count of live and dead fish in stream segment i, and

m_i = miles surveyed in stream segment i.

Average peak count per mile in a given set of stream segments (S) was calculated as follows:

$$S = \left[\sum_{i=1}^{n} P_i \Big/ \sum_{i=1}^{n} m_i \right] \tag{2}$$

where

n = number of stream segments surveyed,

Indexes of fall chinook spawning in the interior Rogue Basin were based on total counts of spawned-out carcasses. The average total count per mile for a given set of stream segments (R) was calculated as:

$$S = \left[\sum_{i=1}^{n} C_i \Big/ \sum_{i=1}^{n} m_i \right] \tag{3}$$

where

C_i = total count of carcasses in stream segment i.

Separate peak fish per mile and total carcass count per mile indexes were calculated for adults and jacks.

Table 1-1. Standard spawning surveys conducted for fall chinook salmon in Oregon coastal river basins, 1999. Potential hatchery-influence is indicated for each survey year (F = fed fish; U = unfed fish; B = broodstock; W = wild index).

River basin or subbasin	Stream segment	Miles	Classification
	Nehalem/Ecola Gene Conservation Area		
Nehalem:			
Mainstem	Cook Creek	1.0	W
	Cronin Creek	1.0	W
	Humbug Creek	1.0	W
	East Humbug Creek	1.2	W
North Fork	Soapstone Creek	0.7	W
Salmonberry R.	Salmonberry River	0.5	W
	North Mid Coast Gene Conservation Area		
Kilchis	Clear Creek	0.6	U
	Little South Fork, Kilchis River	1.0	U
Wilson	Little North Fork, Wilson River	0.5	U
	Cedar Creek	2.8	U
Tillamook	Tillamook River	1.8	F
	Simmons Creek	0.6	F
Nestucca	Clear Creek	0.8	W
	Niagara Creek	0.4	W
Siletz:			
Mainstem	Cedar Creek	1.6	W
	Euchre Creek	1.0	W
	Sunshine Creek	1.2	W
Rock Creek	Big Rock Creek	0.9	W
Yaquina	Upper Yaquina River	2.0	W
	Salmon Creek	0.6	W
Alsea:			
Drift Creek	Lower Drift Creek	1.5	W
Five Rivers	Lower Lobster Creek	2.2	W
	Buck Creek	1.0	W
North Fork	North Fork Alsea River	1.5	W
Siuslaw:			
Mainstem	Sweet Creek	0.5	W
	Lower Whittaker Creek	0.3	W
	Upper Whittaker Creek	0.4	W
	Esmond Creek	1.0	W
North Fork	North Fork Siuslaw River	0.8	W
Lake Creek	West Fork Indian Creek	1.2	W
	Rogers Creek	1.3	W
	Lake Creek	0.8	W

Table 1-1. Continued.

River basin or subbasin	Stream segment	Miles	Classification
	Mid South Coast Gene Conservation Area		
Coos:			
Millicoma River	West Fork Millicoma River	0.5	W
	East Fork Millicoma River	0.5	W
South Fork	South Fork Coos River	1.0	B
	Williams River	1.0	W
Coquille:			
North Fork	North Fork Coquille River	1.0	W
	Middle Creek D	2.0	W
East Fork	Lower East Fork Coquille River	1.0	W
	Upper East Fork Coquille River	0.3	W
Middle Fork	Middle Fork Coquille River	0.5	W
	Rock Creek	0.5	W
South Fork	South Fork Coquille River	1.0	W
	Lower Salmon Creek	0.8	W
Floras Creek	Upper Floras Creek	0.5	W
Sixes River	Lower Dry Creek	1.7	W
	Upper Dry Creek	1.7	W
	South Coast Gene Conservation Area		
Euchre Creek	Upper Euchre Creek	1.0	U
Rogue River			
Lower Mainstem	Jim Hunt Creek	0.8	F
	Upper Lobster Creek	1.0	W
Mid Mainstem	Rogue River (Middle A)	3.3	W
	Rogue River (Middle B)	10.9	W
Applegate River	Applegate River (Lower)	3.0	W
	Slate Creek	1.0	W
	Applegate River (Middle)	2.2	W
	Applegate River (Upper)	4.9	W
Hunter Creek	Upper Hunter Creek	1.0	U
Pistol River	Deep Creek	0.4	U
Chetco River	Big Emily Creek	1.0	W
Winchuck River	Bear Creek	0.8	W

RESULTS AND DISCUSSION

Assessment of Survey Conditions

Oregon coastal fall chinook generally spawn during November and December, with some spawning into January, particularly in coastal portions of the South Coast GCA. Survey conditions can vary dramatically during this period depending on the onset of fall rainfall and subsequent flow conditions. Peak spawning activity in the four northern GCAs generally occurs in mid-to-late November. During this period in 1999, flow-related survey conditions varied both geographically and temporally (Figure i-2). One major high flow event disrupted fall chinook surveys in the Nehalem/Ecola and North-Mid Coast GCAs. This event occurred during the third week of November and was most intense in the Siletz and Nestucca Basins (panels 1 and 2 of Figure i-2). Although intense, this event was short in duration, with flow in most areas returning to surveyable levels within about one week and remaining there until the freshet of mid-December.

Stream flow conditions in the Umpqua and Mid-South GCAs generally were conducive for surveys throughout the 1999 season. As indicated by flows recorded on the South Fork of the Coquille River (panel 3 of Figure i-2), no major flow events occurred during the 1999 spawning season. However, the regularly spaced low intensity events did provide enough flow to allow fish to regularly access survey areas.

In the South Coast GCA, stream flow remained below average until mid-January (panel 4 of Figure i-2). This provided ideal survey conditions throughout survey sites in this GCA, especially for mainstem sites in the interior Rogue Basin. The mid-January freshet occurred after essentially all spawning was complete.

Spawning Timing

With the exception of the coastal portion of the South Coast GCA, peak spawning activity of fall chinook generally occurs during mid to late November (Figure 1-2). Within the coastal portion of the South Coast GCA, peak spawning activity occurs, on average, about one month later than in other areas. It appears that access to freshwater may influence patterns of spawning timing for coastal fall chinook stocks. As shown in Figure 1-2, with the exception of the interior Rogue portion of the South Coast GCA, spawn timing is progressively later for more southerly located GCAs. River basins inhabited by fall chinook in the three northern GCAs generally have relatively large estuaries with sharp tidal fluctuations. These tidal fluxes allow adults to enter and remain in river mouths prior to increases in stream flow. Conversely, basins in the South Coast GCA do not have large estuaries. Chinook in these basins are dependent on suitable river flow to access river mouths. Because river flow typically does not increase prior to the occurrence of fall rain, access to spawning streams is later for these stocks than it is for stocks in more northern GCAs. The exception to this pattern is the early spawn timing of interior Rogue fall chinook. This exception is likely the result of sustained high summer-fall flows in this basin. Because of the size of its drainage basin and flow augmentation from reservoirs, flows at the mouth of the Rogue River consistently exceed 1,500 cubic feet per second during all months of the year.

Differences in spawn timing among the three Northern GCAs may relate to fall flow patterns. Timing of peak spawning is related to October rainfall (Figure 1-3). This relationship suggests that geographic clines in spawn timing are related to the timing of intensity and rises in stream flow above summer low levels.

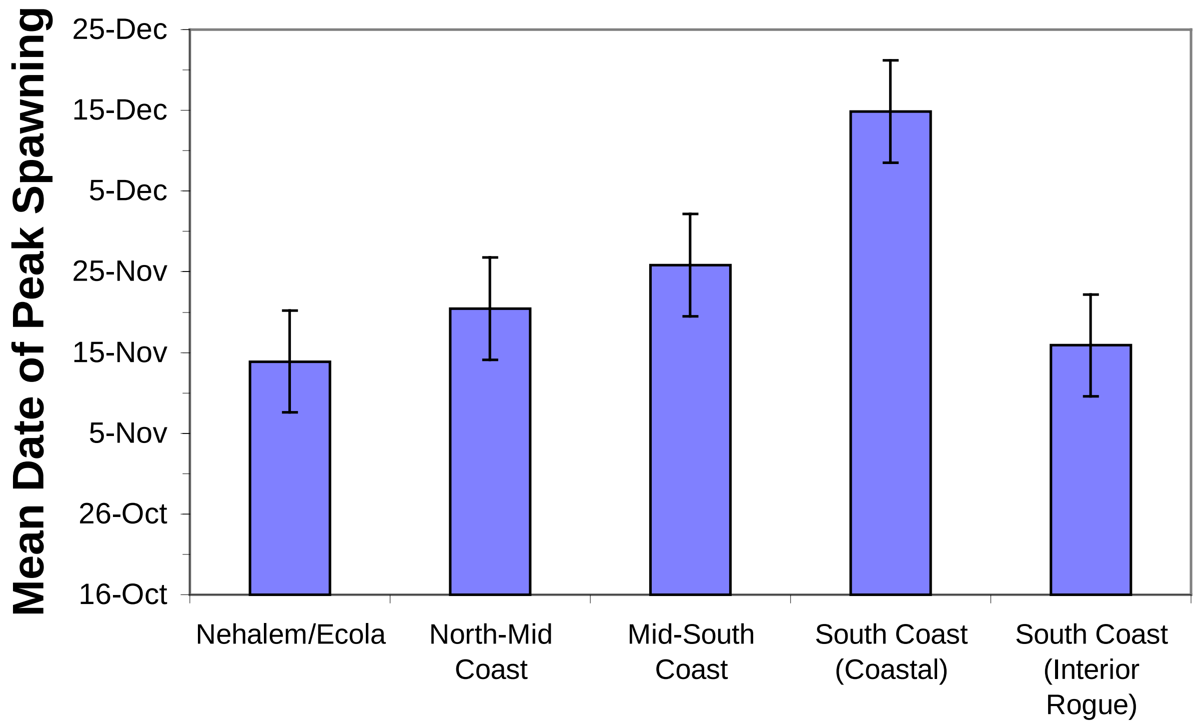

Figure 1-2. Mean date when peak counts of fall chinook were observed in standard survey areas within each Gene Conservation Area, 1999. Vertical lines represent one standard deviation about the mean.

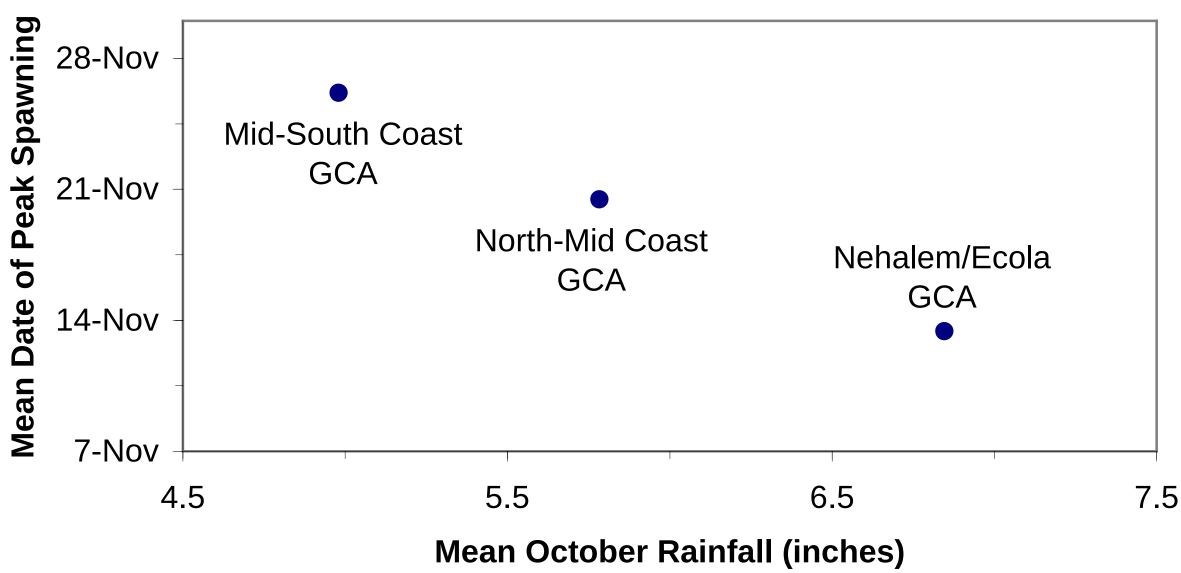

Figure 1-3. Relationship between mean October rainfall and mean date of peak spawning for Oregon coastal fall chinook in the three northern Gene Conservation Areas. October rainfall was averaged for the period of 1930-98. Rainfall measurements for each GCA are as follows: Nehalem/Ecola: Seaside, North-Mid Coast: Newport, Mid-South Coast: North Bend.

Index of Spawner Abundance

Results of standard surveys conducted for fall chinook in 1999 summarized by GCA are listed in Table 1-2. All 60 index segments were surveyed in 1999. In total, over 700 miles of stream was visited over the course of the survey season to obtain abundance indices. Because standard survey sites were not chosen from a randomized sampling design, spawner density estimates obtained from these sites should only be used to index spawner abundance. These data are not appropriate for extrapolating absolute abundance.

Table 1-2. Summary of survey effort and peak fish per mile counts of fall chinook salmon in standard stream segments by Gene Conservation Area in 1999.

Gene Conservation Area	Survey segments		Cumulative miles surveyed	Mean peak count per mile	
	Number	Total miles		Adults	Jacks
Nehalem/Ecola	6	5.4	51.9	51.3	1.5
North-Mid Coast	26	28.2	259.5	58.8	2.7
Mid-South Coast	15	14.0	103.7	73.0	3.9
South Coast:					
Coastal	7	6.0	32.4	25.8	4.5
Interior Rogue[a]	6	25.3	253.7	106.2	6.7
Total	60	78.9	701.2	--	--

a *Cumulative count of spawned carcasses*.

Trends in Spawner Abundance

ESUs

The 50-year trend of average peak count densities indicates that the overall spawning escapement of fall chinook salmon spawners in Oregon coastal river basins has increased throughout the Oregon Coastal ESU (Figure 1-4). Regression analysis indicates that this increase is significant ($R^2 = 0.60$, $p<0.0001$). Ocean fishery recovery of coded-wire tagged fish indicates that stocks in this ESU tend to be north-migrating (Nicholas and Hankin 1988, Lewis 1998). Factors contributing to the cause of this increasing trend may include improvements in marine survival and reductions in ocean fishery exploitation.

Atmospheric conditions relating to marine productivity have been shown to relate to trends of salmon abundance in the northeastern Pacific (Beamish et al. 1999). The climatic regime that existed from the mid 1970s until the mid to late 1990s has directly correlated to an increasing abundance trend. Because fall chinook stocks in the Oregon Coastal ESU rear extensively in the northeastern Pacific, it is possible that the marine survival of these stocks has improved under this climate regime.

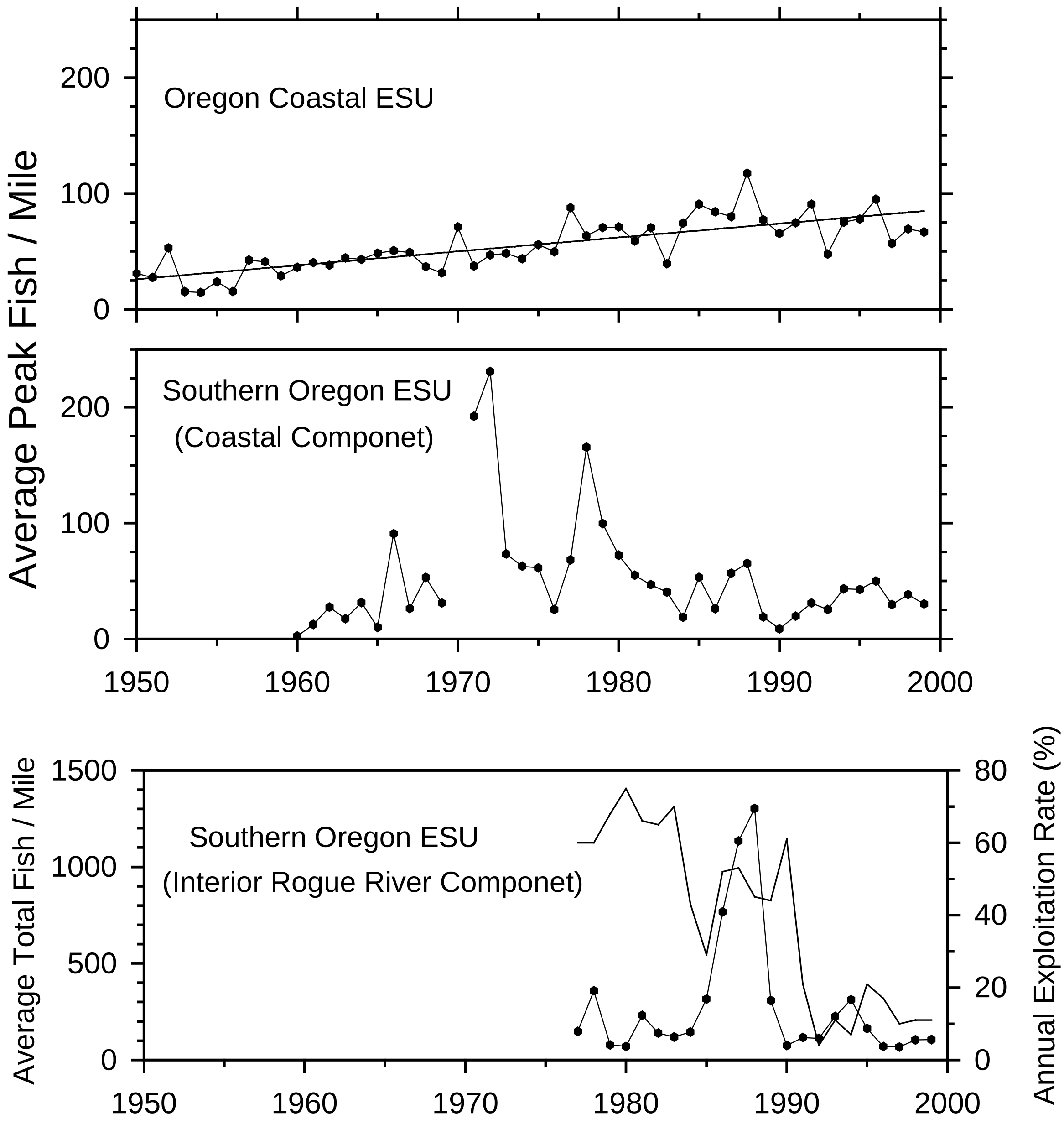

Figure 1-4. Trends in spawner abundance of Oregon coastal fall chinook. Trends consist of counts of adults and jacks in standard survey sites. Upper panel: peak counts in the Oregon Coastal ESU and coastal component of the South Coast ESU. The trend line fitted to the data in the upper graph is significant ($R^2 = 0.60$, $p<0.0001$). Lower panel: counts of spawned carcasses in the interior Rogue portion of the South Coast ESU. Also shown is the estimated annual ocean fishery exploitation rate of fully vulnerable Klamath River fall Chinook (PFMC 2000a).

Harvest reductions associated with the implementation of the Pacific Salmon Treaty were initiated for North Eastern Pacific ocean salmon fisheries in 1984. These regulations have resulted in a reduction in the ocean fishery exploitation of north-migrating fall chinook stocks (CTC 1999). Higher escapement rates associated with reductions in fisheries exploitation have probably contributed to higher spawner abundance occurring in this ESU during the last 15 years.

Peak count indices of fall chinook salmon from coastal basins in the Southern Oregon ESU have fluctuated wildly throughout the 40-year period counts have been made, and have generally shown a downward trend since the record high in 1972 (Figure 1-4, middle panel). Inconsistent survey effort in this index for years prior to 1986 contributes to the volatile nature of the historic record. Because of this inconsistency, we believe it is most appropriate to compare index counts since 1986 to the average annual count during the period from 1960-85. For the period of 1960-85, this index averaged 63 fish per mile. From 1986-99 the index averaged 35 fish per mile, a reduction of 44%. The difference of count densities was significant ($p<0.03$, t-test with unequal variances). This change and the declining trend in the index indicate that the spawning escapement of these stocks has declined from levels occurring prior to 1986. Because these stocks rear extensively within the continental shelf off Oregon and Northern California (Lewis 1998), this decline may have been influenced by the 1976-77 climate regime shift which resulted in poorer survival of west coast salmon stocks (Hare et al. 1999).

Trends of Interior Rogue spawner populations are available back through 1977 (Figure 1-4, lower panel). These populations spawn principally in middle portions of the mainstem Rogue River and in the Applegate River. The trend in the abundance of these populations differs substantially from the trend of coastal stocks within the same ESU. Spawner abundance of Interior Rogue fall chinook has varied between two general levels over three different time periods. During 1977-84 and during the 1990s the abundance index was fairly stable, averaging about 150 spawners per mile. In contrast, during the period of 1985-89 the index of spawner abundance averaged about five times higher, peaking in 1988 at over 1,300 fish per mile. Spawner abundance during the period of peak abundance in the latter half of the 1980s was the result of production of the 1983 and 1984 brood years. The exceptionally high production of these broods was hypothesized to be the result, at least in part, of increased marine survival associated with the cessation of the 1982-83 El Niño. However, a mechanism for this is yet to be identified. Another factor that may have contributed to the high production was the effect of the operation of Applegate Dam on the distribution of Applegate spawners. Because of flow augmentation during the period of upstream migration, Applegate fall chinook used more of the basin for spawning after the dam became operational in 1981 (Fustish et al. 1988). More dispersed spawning may have improved freshwater survival of juveniles.

Given the changes that have occurred in ocean fishery exploitation, recent trends in the abundance of Interior Rogue fall chinook spawners present a somewhat misleading measure of the status of this stock. Changes in harvest policies for Klamath fall chinook resulted in substantially reduced ocean fisheries off Southern Oregon and Northern California from the early 1990s to the present (PFMC 2000a). Interior Rogue stocks are primarily harvested in this area of the Pacific Ocean (Lewis 1998).

As shown in Figure 1-4, ocean fishery harvest impacts that affected Interior Rogue chinook dropped precipitously beginning in 1991. Because of this, spawner abundance comprises an appreciable larger fraction of stock abundance during the 1990s than in earlier periods. Thus, actual population abundance for these stocks is presently at record low levels.

GCAs

Increases in survey effort beginning in 1986 provide sufficient data for assessing trends in spawner abundance for individual GCAs over the last 14 years. Among the five coastal GCAs, only the North-Mid Coast exhibited a significant trend ($p<0.05$) during this period (Figure 1-5). Regression analysis indicated that spawner abundance in the North-Mid Coast GCA declined by an average of 5% per year between 1986-99. Subdividing this GCA into major basin complexes indicates that this decline is primarily attributed to a decline in spawner abundance in the Tillamook Bay and Nestucca Basins (Figure 1-6). Reasons for this decline are unclear. As discussed earlier, ocean harvest impacts on stocks within this GCA appear to be reduced through implementation of the Pacific Salmon Treaty. However, there are intensive sport fisheries in both the Tillamook Bay and Nestucca Basins. Angler harvest of fall Chinook in Tillamook Bay has increased significantly during the period of 1975-97 (Figure 1-7). The February 1996 flood may have reduced survival of spawners returning during the three most recent years. Without more intensive monitoring of harvest and escapement for stocks in this GCA, it is impossible to determine changes in total (ocean and freshwater) harvest impacts. This decline could also be related to declines in freshwater or marine survival. Regardless of the cause, the decline in spawner abundance in the North-Mid GCA is relatively minor and spawner densities in survey areas remain relatively high. Given this, we believe that overall, stocks in this GCA are at healthy levels of abundance.

Despite the lack of significant trends for the four other GCAs, some informative patterns are apparent. One such pattern is the increase in spawner abundance in the Umpqua GCA. Prior to the mid-1980s, fall chinook were relatively rare in this GCA. Standard spawning surveys were never established in the 1950s in the Umpqua GCA because fall chinook was not an abundant species (Nicholas and Hankin 1988). However, counts in Buck Creek, a standard survey site for coho salmon, have been conducted back through 1950. Review of these data revealed that very few fall chinook were counted in this survey site prior to the 1990s. As recently as the ten-year period between 1982 and 1991, the peak density of chinook in this survey site averaged less than four fish per mile and no chinook spawners were observed in half of these years. In contrast, since 1992, peak densities of fall chinook in Buck Creek have averaged near 70 spawners per mile, peaking near 140 per mile (Figure 1-5). Although limited in scope, results from Buck Creek indicate that the fall chinook population spawning in the Umpqua GCA is increasing. This trend is also mirrored in the pattern of salmon-steelhead tag derived estimates of fall chinook harvest from the Umpqua Basin, which reveal a substantial increase over the period from 1985 to 1997 (ODFW 1999).

There is a suggestion of a slight increasing trend in spawner abundance since 1990 for the two southernmost GCAs (Figure 1-5). This increase may be related to reductions in ocean fishery impacts associated with Klamath chinook management. Additionally, increased spawner abundance in the coastal portion of the South Coast GCA may also be related to hatchery releases in a number of south coast basins (Table 1-1).

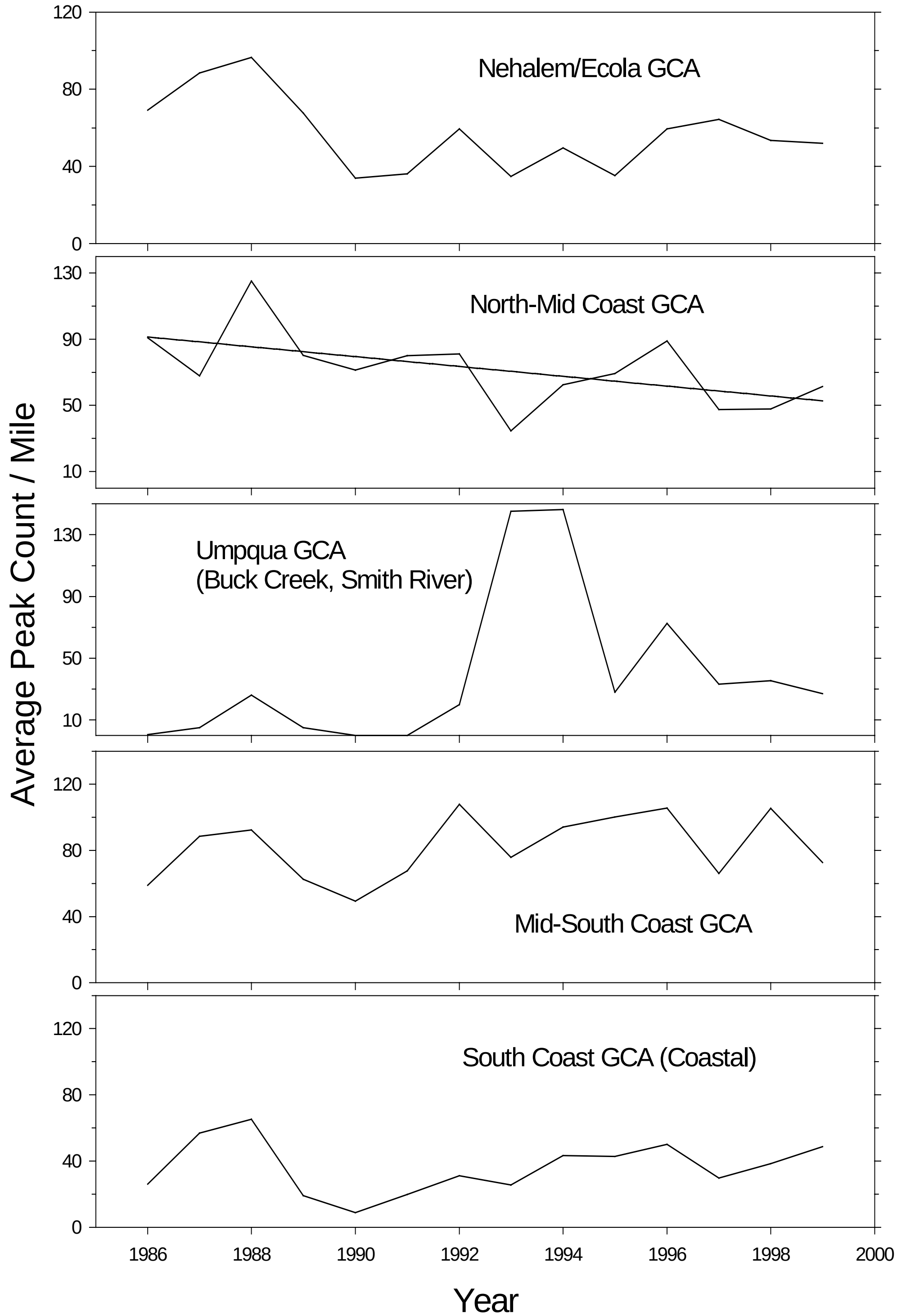

Figure 1-5. Trends in the spawning escapement of fall chinook salmon in Gene Conservation Areas of the Oregon Coast, 1986-99. Counts include adults and jacks.

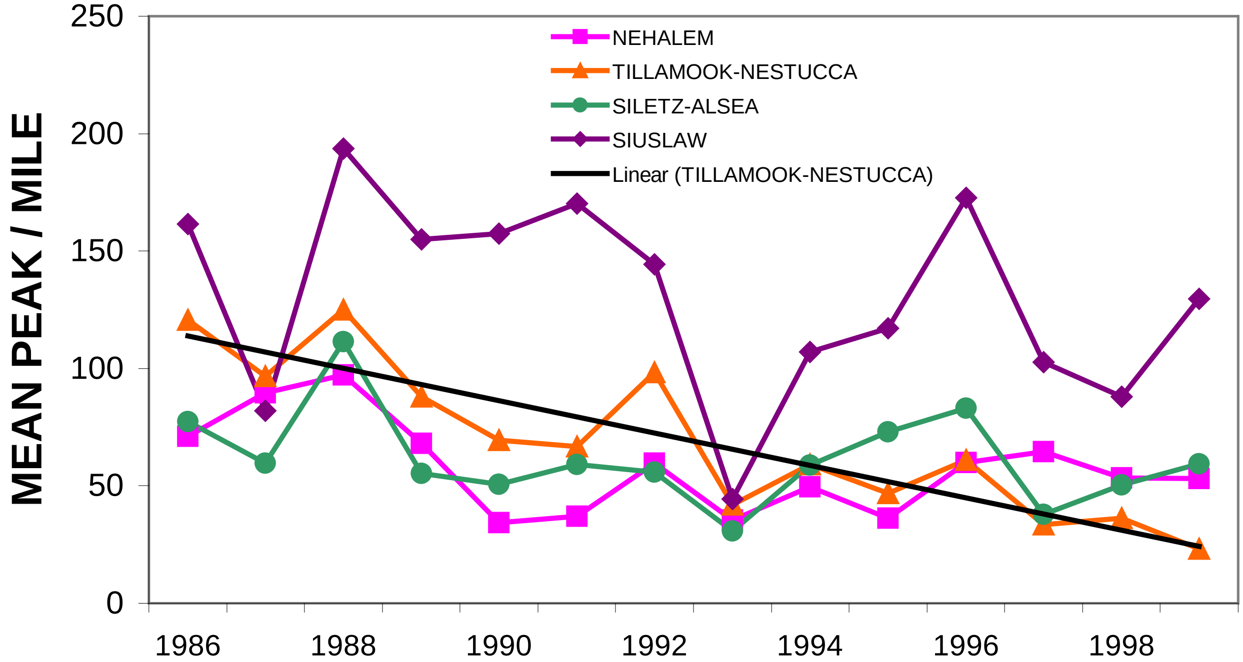

Figure 1-6. Trends in the spawning escapement of fall chinook salmon in major basin complexes within the North-Mid Coast Gene Conservation Area, 1986-99. Counts include adults and jacks. The Tillamook-Nestucca Complex exhibits a significant ($p<0.001$) declining trend during this time period.

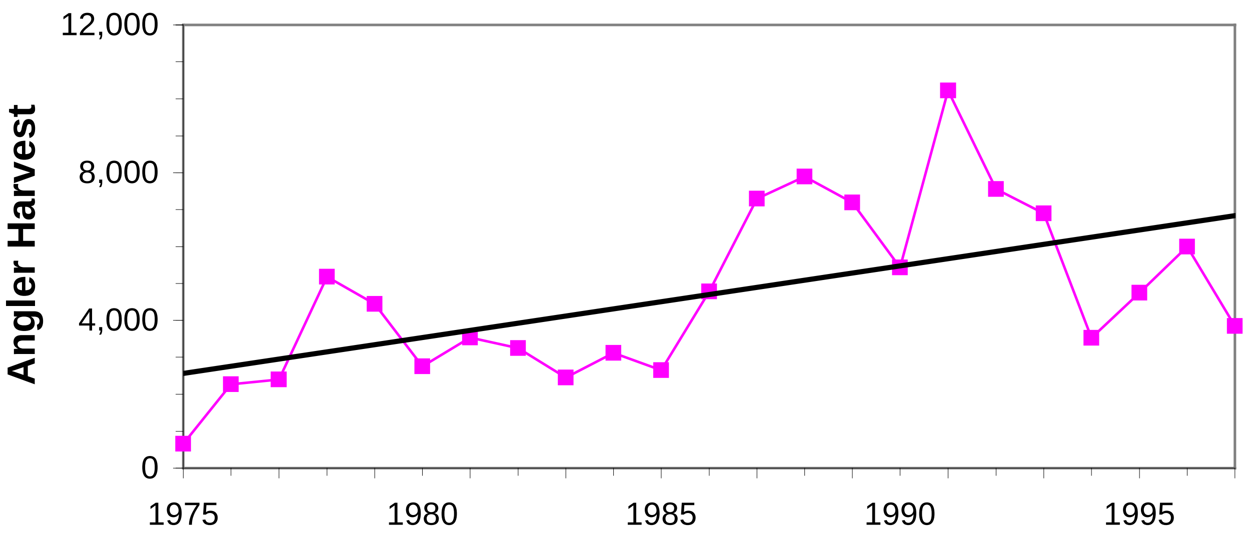

Figure 1-7. Trends in the angler harvest of fall chinook in Tillamook Bay, 1975-97. Harvest estimated through returns of salmon-steelhead tags. There is a significant increasing trend in angler harvest ($p<0.005$).

CHAPTER 2: COHO SALMON

CURRENT MONITORING PROGRAM

Since 1950, spawning fish surveys conducted in standard index areas have been used to assess status and trends of coastal coho salmon (Jacobs and Cooney 1997). Beidler and Nickelson (1980) evaluated the survey effort for coho salmon prior to 1981 and recommended three measures for improving the accuracy and precision of the coho salmon survey program. The first was to expand the standard index to at least 40 stream segments (areas). The second was to replace the peak count with estimates of the total number of spawners in survey stream segments as an index of spawning escapement using Area-Under-the-Curve (AUC) techniques. The third was to establish separate indexes for streams influenced by hatchery fish. These recommendations were adopted for coho salmon in 1981 and have been followed every year thereafter.

With the development of the ODFW Coho Salmon Plan (ODFW 1982) and the onset of more intensive regional management strategies for ocean salmon fisheries, the need for annual estimates of the total spawning escapement of naturally produced stocks of Oregon coastal coho salmon was established. These stocks are referred to as Oregon Coastal Natural (OCN) coho salmon. Extrapolations of spawning fish survey counts have been the best available means of estimating the spawning escapement of OCN stocks, and therefore have been used for this purpose since 1981 (PFMC 2000a). Changes made in stock size estimation methodology since 1981 were primarily made in order to increase accuracy and remove hatchery-produced coho salmon from the estimates.

A review of the OCN spawning survey program by the Oregon State University Department of Statistics (Ganio et al. 1986) led to the initiation of the OCN escapement methodology study in 1990. This study involved the development and experimental implementation of a stratified random sampling (SRS) approach to estimate OCN spawning escapement. The SRS approach consists of randomly selecting spawning survey sites from geographical strata in coastal stream basins and estimating spawner abundance from visual counts in these survey sites. Results of this study were summarized in Jacobs and Nickelson (1998).

In response to monitoring needs associated with assessing the progress of the Oregon Plan for Salmon and Watersheds (OPSW 1997) the SRS program was expanded in 1997. This expansion focused on obtaining reliable annual spawner abundance estimates for five individual Gene Conservation Areas (GCAs) along the Oregon coast. To obtain target precision for these annual estimates, sample sizes were increased to 120 surveys per GCA. Further implementation of Oregon Plan monitoring in 1998 resulted in the adoption of an integrated rotating panel sampling design that linked spawner surveys, habitat inventories and juvenile surveys (Stevens and Olsen 1999). In addition, this sampling design was based on the U.S. Environmental Protection Agency's (EPA) GIS-based Environmental Monitoring and Assessment Program (EMAP) site selection procedure (Stevens 1997).

ASSESSMENT UNITS

Long-term sampling associated with standard spawner surveys occurred in coastal basins south of the Columbia River to Cape Blanco. The National Marine Fisheries Service (NMFS) has designated two ESUs for Oregon coastal coho stocks (Weitkamp et al. 1995). The *Oregon Coastal ESU* encompasses all coastal basins north of Cape Blanco, including the entire Umpqua Basin. The *Southern Oregon ESU* begins at Cape Blanco and extents to Punta Gorda, California. Within Oregon, this ESU covers the Elk through Winchuck River basins and includes the entire Rogue Basin (Figure 2-1A). Long-term trend data on coho spawner abundance are available for each of these ESUs.

The Oregon Department of Fish and Wildlife has divided the Oregon Coastal ESU into three Gene Conservation Areas (GCAs) for coho salmon based on studies of genetic variation and life history traits (Kostow 1995; Figure 2-1B). This yields a total of four GCAs. The *Mid- to North Coast GCA* encompasses coastal drainage basins from the Necanicum River south to the Siuslaw River. The rivers in this GCA are relatively small and lie in the wet, temperate region to the west of the Coast Range. The *Umpqua GCA* includes the entire Umpqua Basin, including the North and South Umpqua Rivers, Smith River and Elk and Cow Creeks. The Umpqua cuts through the coast range and has its headwaters in the Cascade Mountains. The lower basins draining the coast range are similar to those in the Mid-North Coast GCA, i.e. wet and temperate, but the upper basin is affected by snowmelt in the Cascades and by the relatively dry climate east of the Coast Range. The *Mid- to South Coast GCA* is not geographically contiguous. It covers the Siltcoos and Tahkenitich Lake Basins north of the mouth of the Umpqua, and continues south of the Umpqua to the northern tip of Cape Blanco (Sixes River). Major basins in this GCA include Tenmile Lakes, the Coos and the Coquille. The coho populations in the lake systems have a lake-rearing juvenile life history. The *South Coast GCA* includes the Rogue River drainage and small coastal streams south of Cape Blanco to the Oregon/California border. Patterns of ocean upwelling transition at Cape Blanco, and apparently affect the ocean distribution of salmonids. Like the Umpqua, the Rogue River cuts through the Siskiyou Mountains and has its headwaters in the Cascades. The upper basins are affected by the relatively dry climate east of the Siskiyous, and by snowmelt in the Cascades.

The Oregon Plan for Salmon and Watersheds further divided the Mid-North Coast GCA into two subsets: the *North Coast GCA* and the *Mid-Coast GCA* (Figure 2-1C). The *North Coast GCA* encompasses coastal basins from the Necanicum River south to the Neskowin and includes the Nehalem, Tillamook Bay and Nestucca Basins. The *Mid-Coast GCA* covers the Salmon through Siuslaw Basins. Other major watersheds in this GCA include the Siletz, Yaquina and Alsea Basins.

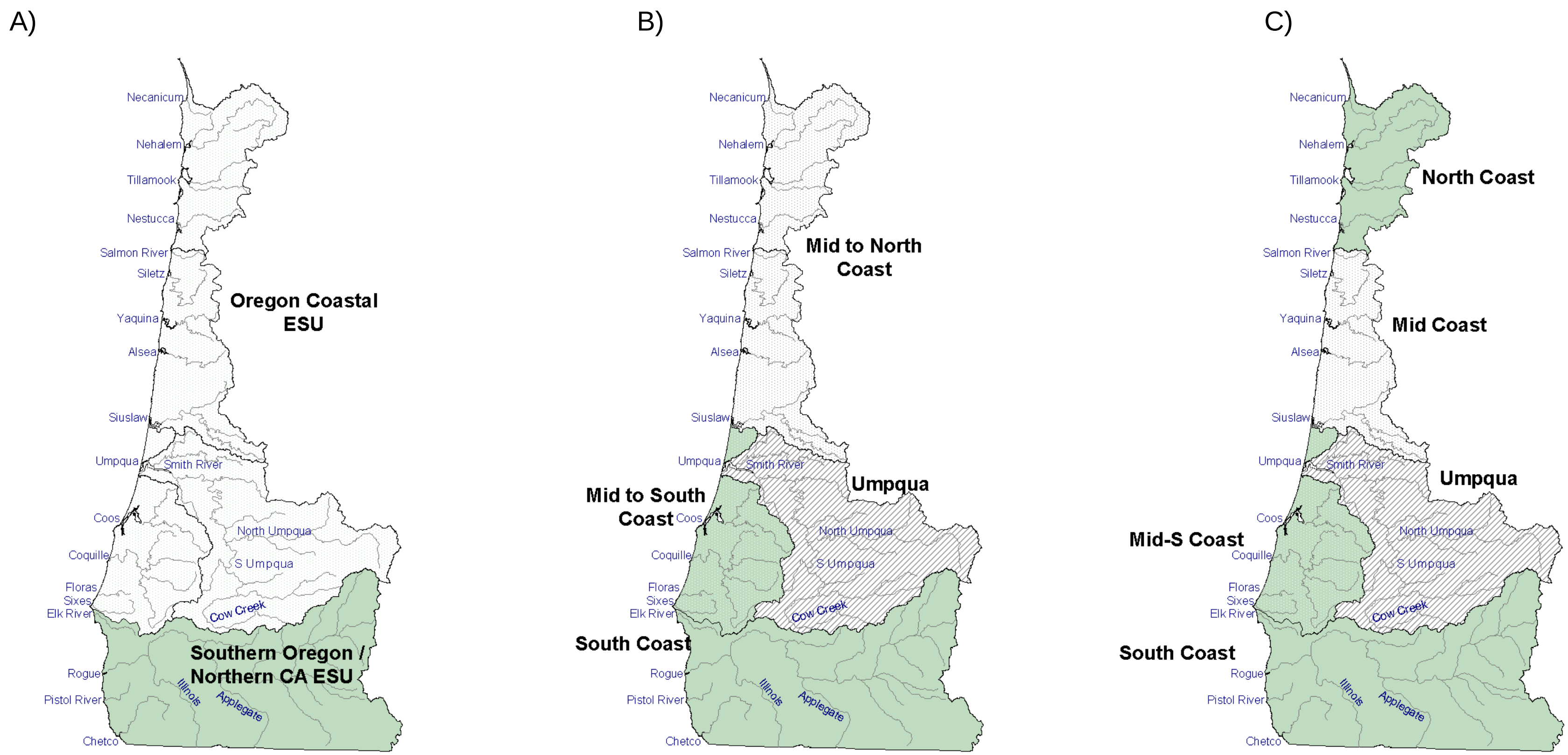

Figure 2-1. Geographic strata for coho salmon for coastal areas in the state of Oregon. A) Evolutionary Significant Units (ESUs) as defined by the National Marine Fisheries Service. B) Gene Conservation Areas (GCA) as defined by the Oregon Department of Fish and Wildlife. C) The Oregon Department of Fish and Wildlife further divided the Mid to North Coast GCA into the North Coast Gene Conservation Area (GCA) and the Mid Coast GCA.

METHODS

Measures of Spawning Escapement

Peak count per mile in a given stream segment (H_i) was calculated as follows:

$$H_i = P_i / m_i \qquad (1)$$

where

P_i = peak count of live and dead fish in stream segment i, and

m_i = miles surveyed in stream segment i.

Average peak count per mile in a given set of stream segments (S) was calculated as follows:

$$S = \left[\sum_{i=1}^{n} P_i \Big/ \sum_{i=1}^{n} m_i \right] \qquad (2)$$

where

n = number of stream segments surveyed.

The total number of coho salmon (adults or jacks) spawning in a given stream segment (O_i) throughout the course of the spawning season was estimated using area-under-the-curve (AUC) techniques (Beidler and Nickelson 1980) using the following equation:

$$O_i = \left[\left(\sum_{h=1}^{a} (C_{hi} t_{hi}) \right) \Big/ D \right] \qquad (3)$$

where

a = number of periods,

$\bar{C}_{hi}$ = mean count in period h,

t_{hi} = number of days in period h, and

D = average spawning life (days) of coho salmon in survey segments.

An average spawning life (D) of 11.3 days was used for coho salmon spawning in survey streams (Willis 1954, Beidler and Nickelson 1980, and Perrin and Irvine 1990). Survey data were screened to avoid making spawning density estimates for stream segments where few data points were available or significant portions of the run were missed. These qualification criteria pertained to: (1) the duration of the spawning season over which counts needed to be made, (2) the number of counts that needed to be conducted for each survey and (3) the number of times that the interval between successive counts could exceed ten days. Additionally, water visibility had to be acceptable (bottoms of riffles were visible) over the majority of the survey area. AUC estimates were not made for surveys that did not meet these criteria. If the first or last count in the index area was greater than zero, a count of zero was assumed to occur seven days before or after the actual count. These criteria were determined in part by stream flow conditions that existed during the spawning season (*see* **Assessment of Survey Conditions**) and by examining the spawning timing observed during the survey season for each GCA (*see* **Spawning Timing**). Most standard and SRS surveys were adequately conducted prior to and after coho salmon were observed in the spawning areas, providing confidence that we did not miss a notable portion of the spawning run.

The estimated spawning density (total fish per mile) for a given stream segment (N_i) was calculated as follows:

$$N_i = (O_i)/(m_i) \tag{4}$$

Unless, a previously unidentified migration barrier was identified in stream segment i, in which case:

$$N_i = (O_i)/(R_j) \tag{5}$$

where

R_j = miles of coho salmon spawning habitat in reach j.

The adult peak count per mile (H_i) and total number of adult coho salmon per mile (N_i) in a given stream segment were adjusted to eliminate the contribution of hatchery fish using the following equations:

$$H_i' = (H_i)(PS_k) \tag{6}$$

and

$$N_i' = (N_i)(PS_k) \tag{7}$$

where

PS_k = estimated proportion of total adult coho salmon spawners in coastal river basin or subbasin k that originated from natural production.

Values of PS_K were estimated from fin-mark recoveries. Adipose fin-marking occurred for all adult coho production at coastal hatchery facilities, thus the ratio of naturally produced coho could be calculated by dividing the number of unmarked coho carcasses by the total number of coho carcasses encountered. Fin-mark ratios were calculated for each major basin, and data were pooled within each GCA. Only recoveries on random surveys were used. Values were calculated as follows:

$$PS_K = Cu_K / (Cu_K + Cm_K) \tag{8}$$

where

Cu_K = number of unmarked (naturally produced) adult coho carcasses in area K, and
Cm_K = number of adipose fin-marked (hatchery produced) adult coho carcasses in area K.

The average total fish per mile (T) spawning in a given set of stream segments was calculated as follows:

$$T = \sum_{i=1}^{n} N_i \Big/ n \tag{9}$$

where

n = number of stream segments surveyed, and

N_i = estimated total number of spawning fish per mile in stream segment i (from equation 4 or 5).

Estimates of Coho Salmon Spawner Population Abundance

Oregon Coastal ESU

Coastal River and Lake Basins: Estimates of the stock size of adult coho spawners were derived from AUCs on random surveys using statistical protocols developed by the US EPA. Stock size estimates were calculated using the equations in Stevens (personal communication). Estimates were calculated for each GCA and then summed for the coast-wide total. The following calculations were performed to obtain estimates of OCN spawning escapement for each GCA:

Each survey site in a given GCA was given a sample weight based upon the number of spawning miles in the region, and the number of sites surveyed. The sample weight for a GCA equals the total spawning miles divided by the total number of sample sites, i.e. the number of spawning miles represented by each site:

$$w = \frac{L}{S} \tag{10}$$

where

w = the sample weight,
L = the total number of stream miles from which the sample was drawn, and
S = the total number of sites selected for sampling.

The inclusion probability is the inverse of the sample weight:

$$\pi = \frac{1}{w} \tag{11}$$

where

π = the inclusion probability.

Non-target sites (sites that had no coho spawning habitat) were simply dropped and not used in the analysis. Non-response (inaccessibility due to landowner denial or inability to physically reach the survey in a reasonable time) was dealt with using a simple weight modification model. This model assumes that the portion of the habitat represented by the non-responsive portion of the sample can be regarded as representative of the entire population. Sample inclusion probabilities (the inverse of the sample weight) were modified to compensate for inaccessible sites by multiplying the ratio of accessible sites to the total number of sites, times the inclusion probability. This correction increases the weight of each point that was successfully sampled:

$$\pi_r(s_i) = \frac{n_r}{n_0}\pi(s_i) \tag{12}$$

where

$\pi_r(s_i)$ = adjusted inclusion probability for sampled sites (response),
n_r = number of sites successfully sampled,
n_0 = number of sites originally selected, and
$\pi(s_i)$ = original sample inclusion probability.

Inclusion probabilities were also adjusted to reflect changes to the sampling universe that have occurred since the sample was drawn in 1998. Sample inclusion probabilities were modified by multiplying the inclusion probability by the ratio of the total spawning miles in 1998 divided by the total spawning miles in 1999 for each GCA.

$$\pi_m(s_i) = \frac{m_c}{m_0}\pi_r(s_i) \tag{13}$$

where

$\pi_m(s_i)$ = inclusion probability adjusted for change in spawning miles,
m_c = current spawning miles,
m_0 = original spawning miles, and

$\pi_r(s_i)$ = sample inclusion probability adjusted for non-response.

The population size of adult coho salmon within a GCA was estimated using the following equations:

$$\hat{Y}_i = N_i * \frac{1}{\pi_m(s_i)} \tag{14}$$

where

$\hat{Y}_i$ = expanded adult coho salmon population contribution from survey segment I, and
N_i = adult coho density in segment i.

The total population estimate for a GCA is estimated by simply totaling the expanded contribution from each survey segment:

$$\hat{Y}_G = \sum_{i=1}^{n} \hat{Y}_i \tag{15}$$

where

$\hat{Y}_G$ = estimated population size of adult coho salmon within a GCA.

Estimates of the precision of $\hat{Y}_G$ were calculated as follows:

$$\mathrm{V}\left(\hat{\mathrm{Y}}_{\mathrm{G}}\right) = \frac{n\sum_{i=1}^{n}\left(\hat{\mathrm{Y}}_{\mathrm{i}}\right)^2 - \left(\sum_{i=1}^{n}\hat{\mathrm{Y}}_{\mathrm{i}}\right)^2}{\mathrm{n}(\mathrm{n}-1)} * n \tag{16}$$

$$S(\hat{Y}_G) = [V(\hat{Y}_G)]^{0.5} \tag{17}$$

$$95\%\ \text{CI}\ \hat{Y}_G \approx [t_{0.05}v][S(\hat{Y}_G)] \tag{18}$$

where

v = degrees of freedom (n-1).

Coast-wide population estimates were calculated by summing $\hat{Y}_G$ as follows:

$$\hat{Y}_C = \sum_{G=1}^{5} \hat{Y}_G \tag{19}$$

where

$\hat{Y}_C$ = aggregate population estimate for entire Oregon coast.

Estimates of the precision of this aggregate estimate of population size were calculated as:

$$V(\hat{Y}_C) = \sum_{G=1}^{5} V(\hat{Y}_G) \tag{20}$$

$$s(\hat{Y}_C) = [V(\hat{Y}_C)]^{0.5} \tag{21}$$

$$95\% \text{ CI } (\hat{Y}_C) \approx [t_{0.05}v][S(\hat{Y}_C)]\,. \tag{22}$$

The population size of naturally produced adult coho salmon within a GCA was estimated using the following equations:

$$\hat{Y}_i' = N_i' * \frac{1}{\pi_m(s_i)} \tag{23}$$

where

$\hat{Y}_i'$ = expanded adult coho salmon population contribution from survey segment I, and
N_i' = adult coho density in segment i adjusted for hatchery influence (from equation 8).

The total naturally produced population estimate for a GCA is estimated by totaling the expanded contribution from each survey segment:

$$\hat{Y}_G' = \sum_{i=1}^{n} \hat{Y}_i' \tag{24}$$

where

$\hat{Y}_G'$ = estimated population size of naturally produced adult coho salmon within a GCA.

Estimates of the precision of $\hat{Y}_G$' were calculated as follows:

$$V(\hat{Y}_G') = \left[V(\hat{Y}_G) * V(\hat{P}_G)\right] + \left[V(\hat{Y}_G) * (P)^2\right] + \left[V(\hat{P}_G) * (Y)^2\right] \tag{25}$$

where

$$V(\hat{P}_G) = \frac{PS_k \;\, *Q}{\sqrt{n}}$$

PS_k = ratio of unmarked to marked carcasses (from equation 7),
Q = ratio of marked to unmarked carcasses, and
n = total number of carcasses

$$S(\hat{Y}_G') = [V(\hat{Y}_G')]^{0.5} \tag{26}$$

$$\text{95\% CI } \hat{Y}_G' \approx [t_{0.05}v][S(\hat{Y}_G')] \tag{27}$$

where

v = degrees of freedom (n-1).

Coast-wide population estimates of naturally produced coho salmon were calculated by summing $\hat{Y}_G$ as follows:

$$\hat{Y}_C' = \sum_{G=1}^{5} \hat{Y}_G' \tag{28}$$

where

$\hat{Y}_C'$ = aggregate of naturally produced population estimate for entire Oregon coast.

Estimates of the precision of this aggregate estimate of the population size of naturally produced salmon were calculated as:

$$V(\hat{Y}_C') = \sum_{G=1}^{5} V(\hat{Y}_G') \tag{29}$$

$$s(\hat{Y}_C') = [V(\hat{Y}_C')]^{0.5} \tag{30}$$

$$\text{95\% CI } (\hat{Y}_C') \approx [t_{0.05}v][S(\hat{Y}_C')]. \tag{31}$$

Using random sampling and AUC methodology to derive unbiased estimates of OCN spawning escapement relies on the validity of several assumptions:

1. *All sites have an equal probability of selection for sampling.*

The EMAP site selection technique forces an equiprobable selection that is uniformly distributed.

2. *Selected sites provide an unbiased sample of OCN spawning habitat.*

This assumption implies that our site selection methods provide a representative sample of spawning habitat and OCN spawners. A random selection will generate an unbiased sample if: (a) our database of spawning habitat is representative of the available OCN spawning habitat, and (b) no differences exist between the quality of spawning habitat between accessible and inaccessible sites.

3. *We are accurate in assuming zero escapement for sites judged to be devoid of spawning habitat*

Sites are assumed to be devoid of habitat if there is no spawning gravel present within the survey or if the survey is located upstream of an impassable barrier. Based on the results of surveys on verification sites (Jacobs and Cooney 1992), we are fairly confident of our ability to make correct assumptions of zero spawning density using the criteria listed in Jacobs and Cooney (1990).

4. *AUC methodology provides an unbiased estimate of the spawning density of coho salmon in spawning surveys.*

The assumptions implicit in the AUC methodology are discussed in detail in Ganio et al. (1986). We believe that this is the best method of determining spawning density estimates in Oregon coastal streams.

5. *Spawning density estimates should be adjusted to compensate for hatchery influence and surveyor observation bias.*

Hatchery strays should not be included in estimates of OCN populations. Hatchery influence is estimated for each major basin or subbasin, and the counts from that area are adjusted accordingly. Solazzi (1984) demonstrated that surveyors tend to underestimate the number of spawners present. We use the equations generated by Solazzi (1984) to adjust spawner estimates.

Coastal Lake Basins: Total spawning escapement of adult and jack coho salmon in the Tenmile Lakes Basin was calculated using the following equation:

$$TL = (U)(F) \tag{32}$$

where

TL = estimated spawning escapement of adults or jacks based on peak counts in 5.2 miles of spawning surveys,

U = mean of ratios of adult or jack populations from tagging studies to the peak counts/mile of each group in 5.2 miles in 1955 and 1970, (U_{adults} = 80.1; U_{jacks} = 149.0), and

F = average peak count per mile of adults or jacks in 5.2 miles of surveys.

The total spawning escapement of adult and jack coho salmon in the Siltcoos Lake and Tahkenitch Lake Basins was estimated using equation 10 as follows:

$$L_m = \frac{B_m \left(G_{tm} \Big/ \sum_{i=1}^{n} G_{im} \right) \sum_{i=1}^{n} N_{im}}{Q} \qquad (33)$$

where

L_m = total number of spawning fish in lake basin m,

G_{tm} = estimated total square yards of spawning gravel in lake basin m, ($G_{tSiltcoos}$ = 6,870; $G_{tTahkenitch}$ = 4,402),

G_{im} = estimated total square yards of spawning gravel in survey stream segment *i* in lake basin *m*,

B_m = correction factor to adjust for differences between spawning gravel quality within survey stream segments and spawning gravel quality within the entire lake basin, ($B_{Siltcoos}$ = 0.71; $B_{Tahkenitch}$ = 0.78),

N_{im} = estimate of the total number of spawning fish in stream segment *i* in lake basin *m* (from equation 2), and

Q = estimated proportion of total adult or jack coho salmon present in survey stream segments that are observed during spawning surveys, (Solazzi 1984).

Estimates of spawning gravel quantity and quality ("good" versus "marginal") in the Siltcoos Lake and Tahkenitch Lake Basins are from Saltzman (1966) and Saltzman (1963), respectively.

South Coast ESU

Rogue River Basin: Estimates of the spawner population of adult coho salmon in the Rogue River were derived using a Petersen mark-recapture technique. Seine catches at Huntley Park (river mile 8) were expanded by the inverse of the seine capture rate of fin-marked coho that returned to Cole Rivers Hatchery (river mile 155). Estimates of the wild and hatchery components were derived from the mark rate of coho caught in the seine and returning to the hatchery. Estimates were calculated using the following equations:

$$\hat{N}_t = \frac{a(M+1)(C+1)}{(R+1)} \qquad (34)$$

where

$\hat{N}_t$ = the estimated total population of adult coho (hatchery and wild) entering the Rogue River,.
a = constant to account for catch and straying of fin-marked hatchery fish (1.10),
M = the number of fin-marked adult coho returning to Cole Rivers Hatchery,
C = the total number of adult coho captured in the seine, and
R = the number of fin-marked adult coho captured in the seine.

$$\Phi_{\hat{N}_t} = 1.96\sqrt{\frac{\hat{N}_t^{\,2}CR}{(C+1)(R+1)}} \tag{35}$$

where

$\Phi_{\hat{N}_t}$ = 95% confidence interval of total population estimate.

$$\hat{N}_w = \frac{\hat{N}_t\left[C-\left(RH/M\right)\right]}{C} \tag{36}$$

where

$\hat{N}_w$ = the estimated wild population of adult coho entering the Rogue River, and
H = return of adult coho to Cole Rivers Hatchery.

$$\Phi_{\hat{N}_w} = 1.96\sqrt{\frac{\hat{N}_w\hat{N}_t CR}{(C+1)(R+1)}} \tag{37}$$

where

$\Phi_{\hat{N}_w}$ = 95% confidence interval of the wild population estimate.

RESULTS AND DISCUSSION

Assessment of Survey Conditions

Oregon coastal coho generally spawn during November through January. Survey conditions can vary dramatically during this period. During the 1999 season, stream flows in all coastal basins generally were below average throughout October and early November (Figure I-2). Flows sufficient to provide passage into spawning streams generally did not occur until mid-November. After this time flow patterns in coastal basins showed regional differences. Along the Northern half of the coast, there were two major flow events that disrupted spawning surveys. The first event occurred in late November. It consisted of an extremely intense but brief period of high flow. This event prevented surveys from being conducted at some sites for up to seven days. The second event occurred in mid December and was of lower intensity but longer duration. This event prevented some sites from being surveyed for up to 10 days. Along the southern half of the coast surveys were not disrupted by flow events until mid January. This event prevented valid surveys from being conducted for up to two weeks in some survey sites.

The impact of high flow events on the accuracy of spawner abundance statistics is not clear. Little information is available on the behavior of spawning salmon during high flow conditions. Abundance estimates will have a negative bias if spawning occurs during high flow events when surveys cannot be conducted. However, if spawning is restricted to moderate or low stream levels, high flow events should not affect survey-based abundance estimates. We are currently conducting studies aimed at assessing the accuracy of survey-based estimates. As the results of these studies become available, we will continue to assess the effects of flow conditions on the accuracy of survey data.

Spawning Timing

Figure 2-2 shows estimates of spawning timing of coastal coho based on when live adults are observed in survey areas. Timing is shown separately for each of the five GCAs, and is shown for 1999 and for the average of the previous five seasons (1994-98). As shown in this figure, within each GCA, the temporal pattern of spawning in 1999 was generally similar to the average pattern observed during the previous five years. Across the GCAs, spawning primarily occurs during November and December, however in some cases, significant spawning activity can occur into January.

Among the five GCAs, spawning generally occurs earliest in the North Coast GCA, with peak spawning activity usually occurring in early-November. Spawning activity in this GCA generally declines fairly quickly after the November peak. Coho stocks in the Mid Coast GCA generally exhibit the most protracted spawning timing on the coast. Significant portions of the spawning run occur throughout the period of November through mid-January. Next to the North Coast GCA, coho spawning in the Umpqua GCA shows the earliest and most compressed temporal spawning pattern. There is generally only one major component of the spawning run for Umpqua coho stocks that typically spawn as soon as flows are sufficient to allow access to spawning streams. However, because portions of the Umpqua Basin are more arid than other parts of the coast, spawning timing in this GCA can be delayed. Coho spawners in the Mid-South GCA also exhibit a fairly protracted spawning timing, but tend not to initiate spawning until about mid-November . Spawning in this GCA typically extends throughout January. In 1999, spawning activity in this GCA peaked in January. Data on spawning timing of coho stocks in the South Coast GCA are available back through 1996. Most of the spawners in this GCA have been observed in the middle and upper portions of the Rogue Basin. Spawning activity for these stocks occurs primarily in December.

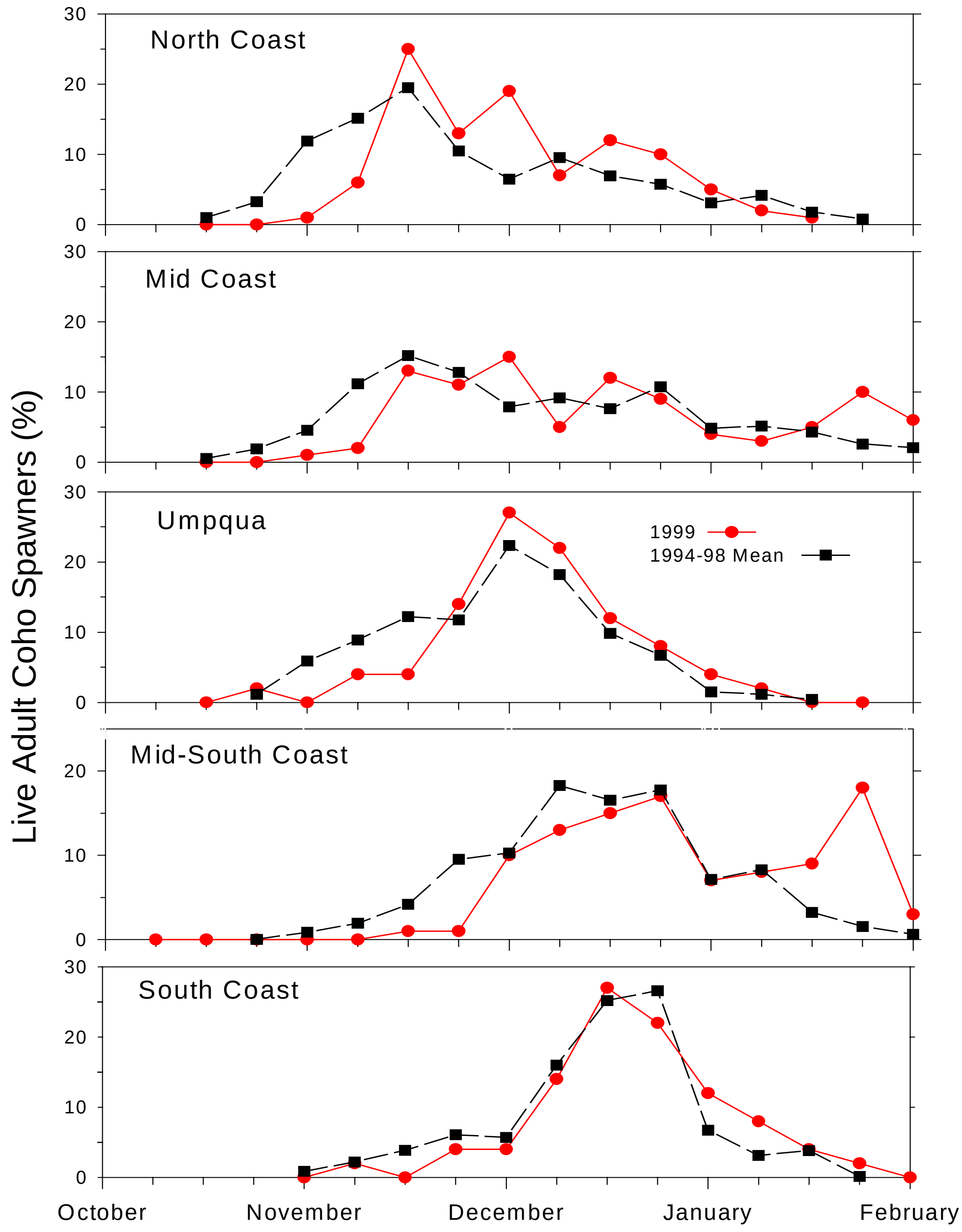

Figure 2-2. Temporal distribution of spawning coho salmon observed on spawning surveys for each Gene Conservation Area (GCA) during the 1999 spawning season and the five prior seasons (1994-98). For the South Coast GCA the prior season extends from 1996-98. Values plotted are the percent of total live adults counted in all survey segments targeting coho salmon by Julian week. Values are adjusted by weekly survey effort.

Measures of Spawner Abundance

Peak Counts and AUCs

Peak counts and AUCs were obtained from 46 standard stream segments in 1999 (Table 2-1). Hatchery origin spawners had negligible effects on the magnitude of these indices in 1999. AUC estimates of adult spawner density were lowest in the North Coast GCA and fairly consistent among the four other GCAs in the Oregon Coastal ESU. Peak counts of jacks averaged near one fish per mile each year. Jack counts have been consistently highest in the Mid-South Coast GCA each year.

Table 2-1. Summary of peak fish per mile counts and estimated total spawning escapement of coho salmon in standard stream segments by Gene Conservation Area, 1999. Counts of adults in parenthesis are totals of all fish including fish that were estimated to originate from hatcheries.

Gene Conservation Area	Survey segments		Average peak count per mile		Estimated total escapement (fish/mile)[a]	
	Number	Total miles	Adults	Jacks	Stream segments	Adults
North Coast	14	14.1	6.2(6.3)	0.4	14	7.9(8.0)
Mid Coast	17	17.1	9.7(9.9)	0.9	17	20.2(20.3)
Umpqua	7	9.2	19.4	0.9	7	25.3
Mid-South Coast	8	8.0	9.4	1.5	8	20.9
Total Coastal ESU	46	49.4	10.4(10.5)	1.3	46	17.5(17.6)

[a] *Derived from area-under-the-curve (AUC) estimates.*

Over the last 19 years, peak counts have shown a general correlation to AUC escapement estimates ($R^2 = 0.88$, $p<0.0001$; Figure 2-3), although the relationship between the two measures has not been completely consistent. From 1981-99, peak counts have averaged 47% of the AUC estimate of total spawning escapement. This ratio has ranged from 37% in 1984 and 1985 to 59% in 1999. This variability may in part be influenced by inter-annual variation in spawner abundance and run timing. Ratios of the magnitude of peak counts to AUCs generally are lower during years of high relative abundance. For the years with relatively high spawning escapement (1984-86), peak counts accounted for 38% of AUC estimated spawning escapement, while in years of below average spawning escapement, the proportion was substantially higher (48%). An exception to this pattern occurred in 1993, a relatively high abundance year when this ratio was also high. This likely was due in part to a delay in run timing that resulted from low stream flows through the middle portion of the spawning season.

These observations continue to support our contention that peak counts do not consistently represent the magnitude of OCN coho salmon spawning escapement over all abundance levels observed during the 50-year count history. Peak counts may under-represent high levels of spawning escapement. In addition, variation in run timing may have caused peak counts to only represent proportions of the spawning run in some years.

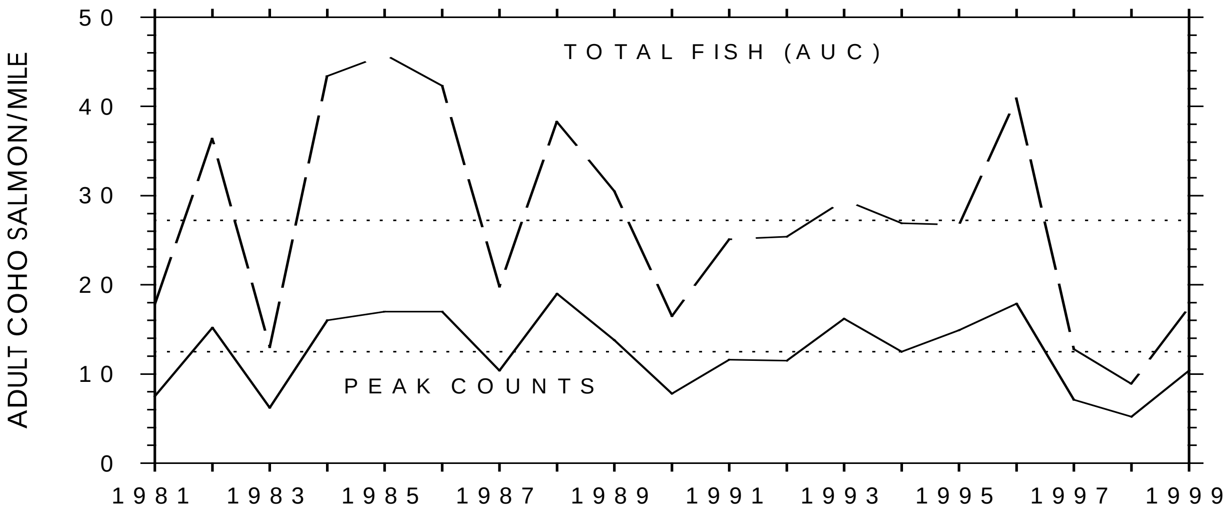

Figure 2-3. Indexes of the spawning escapement of adult coho salmon in standard stream segments in Oregon coastal river basins, 1981-99. Nineteen-year averages of peak counts and total spawning escapement are shown with dotted lines.

Trends in Spawner Abundance

Standard index areas have been surveyed in a fairly consistent manner since 1950 to monitor the spawning escapement of coastal coho stocks. Presently, 46 standard surveys located in 17 basins within the Oregon Coastal ESU are conducted annually to index historical escapement trends. Applying fishery impact rates (Lawson 1992, PFMC 2000b) to this index provides an index of pre-harvest abundance. Both of these indices show significant ($p<0.001$) declining trends over the 50-year period of record (Figure 2-4). Prior to the mid 1980s, spawner escapement of these stocks was heavily influenced by intense ocean fishery harvest. This is illustrated by the substantial difference between the two trend lines during this period. During this period, escapement showed a steady decline in the face some of the highest population abundance on record. However, since the mid 1980s, harvest restrictions have acted to maintain a relatively stable trend in escapement but, because overall stock abundance had declined so dramatically, recovery of spawner numbers was not possible. The level of both spawner escapement and pre-harvest abundance observed in 1997 and 1998 was the lowest observed on record.

A measure of the productivity of Oregon coastal coho stocks is the rate of replacement between parents and progeny. Indexes of adult recruits per spawner are available for the 1950-96 brood years (Figure 2-5). This index measures the overall survival of coastal coho from egg deposition to adulthood. These values range from eight to less than one. As clearly illustrated by the five-year moving average of these values plotted in Figure 2-5, survival rates of coastal coho stocks have shown a steady decline over about the last 20 brood years. Spawner replacement failed to occur for the three most recent brood years. Only in one other year (1957) has spawner replacement failed to occur. The declining trend in survival as indexed by these values is a major reason for the failure of coastal coho stock to recover despite reductions in harvest-related mortality. Reasons for declines in survival are probably associated with declines in marine productivity and perhaps declines in the quality of freshwater habitat.

Spawner Distribution

SRS surveys allow assessments of the distribution of spawning coho within available spawning habitat. Because these surveys consist of a representative sample of the occurrence of spawners among stream reaches, they provide a means of investigating inter-annual changes in patterns of spawner distribution. The upper portion of Figure 2-6 illustrates the cumulative frequency of different levels of spawner density within available spawning habitat of river basins in the Oregon Coastal ESU for 1999, 1997 (the year having lowest abundance) and 1996 (the year having highest abundance). Each curve shows the cumulative proportion of stream reaches where spawner density is at or below a specified level. For example, in 1997 about 47% of stream reaches had zero spawners and about 80% of stream reaches had spawner densities of four adults per mile or less. Conversely, in 1996, only about 28% of the stream reaches were devoid of spawners and about 80% of reaches had spawner densities of about 20 adults per mile or less. Metrics of spawner distribution in 1999 were intermediate to those observed in 1996 and 1997. Generally, the more linear a curve is, the more uniformly spawners are distributed. What these curves illustrate however is that spawner distribution is not uniform but highly skewed, with most of the available habitat being occupied by few or no spawners at all.

Despite this general pattern, there are differences in patterns of spawner distribution among different years. This is evident by differences in the shapes of the three curves. Given these differences, various positions on these curves can be used to track inter-annual variation in distribution patterns and provide benchmarks to gauge changes in spawner distribution as the Oregon Plan is implemented. Shown in the lower portion of Figure 2-6 are annual values corresponding to fixed positions on the distribution curves. These positions are marked on the upper portion of Figure 2-6 by the vertical and horizontal lines, and the Y-intercept.

One of these positions is the Y-intercept or frequency of stream reaches that are void of spawners. Over the ten seasons, an average of about 35% of the spawning habitat was void of spawners. In addition, there was a sharp increase in the frequency of unused spawning habitat in 1997 and 1998. The frequency of available stream reaches supporting a maximum of 10 spawners ranges from about 65% in 1993 to near 90% in 1997. This means that during the period of 1990-99, from 10% to 35% of the spawning habitat had spawner densities exceeding 10 adults per mile.

The two other trend lines shown in the lower portion of Figure 2-6 depict the maximum spawner density occurring in 80th and 90th percentiles of available stream reaches. Both of these data sets show similar trends over the period from 1990-99, having lowest densities in 1990 and 1997 and a stable or slightly increasing trend during 1991-96.

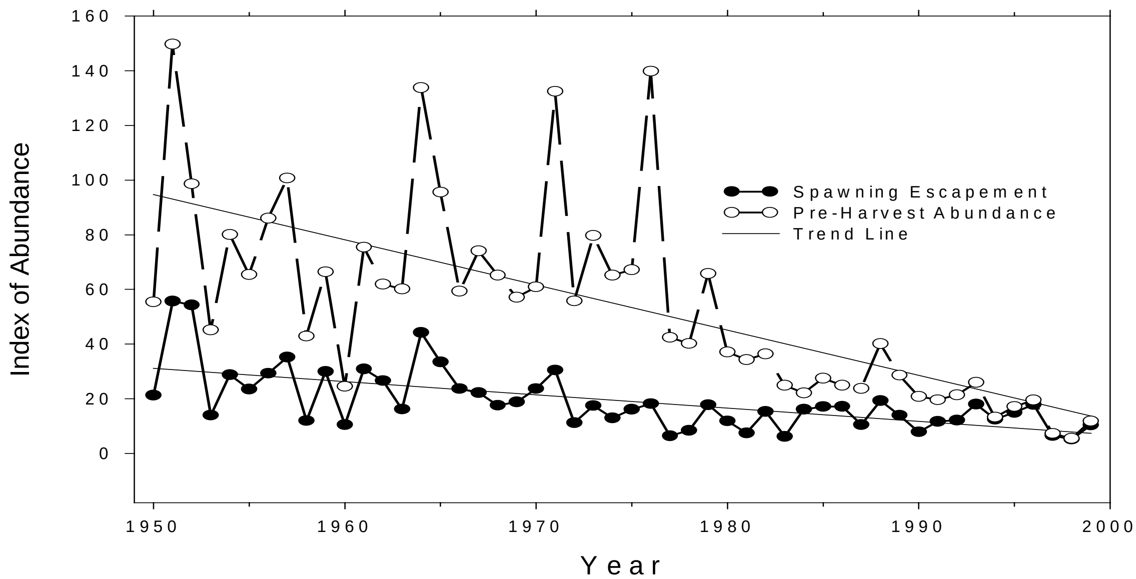

Figure 2-4. Trends in the pre-harvest abundance and spawning escapement of adult coho salmon as indexed by average peak counts in standard survey segments, 1950-99. Both trend lines are statistically significant; spawner abundance: $R^2 = 0.39$, $p<0.001$; pre-harvest abundance: $R^2 = 0.44$, $p<0.001$.

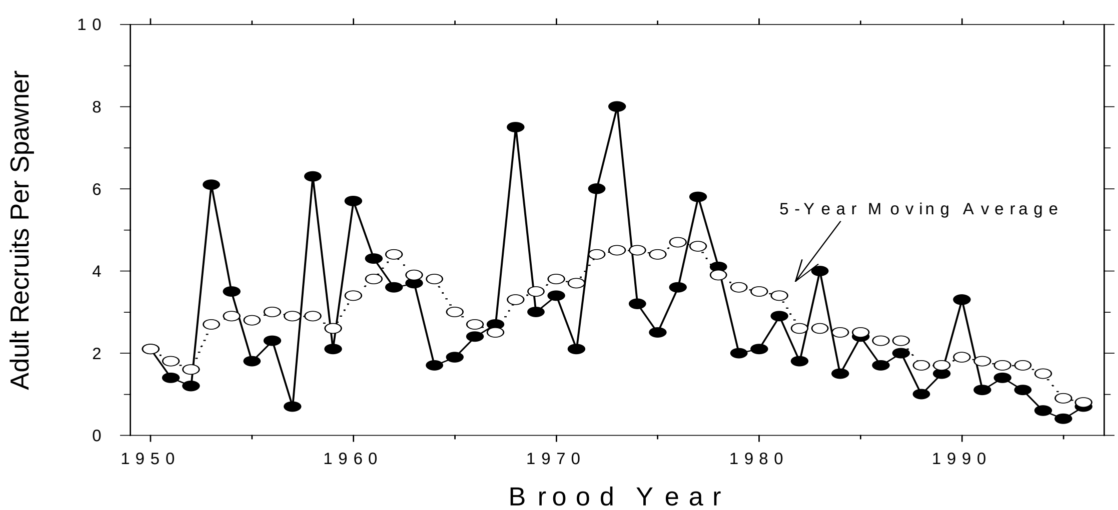

Figure 2-5. Indices of the ratio of adult recruits per spawner for Oregon coastal coho stocks during the 1950-96 brood years as indexed by average peak counts in standard survey segments.

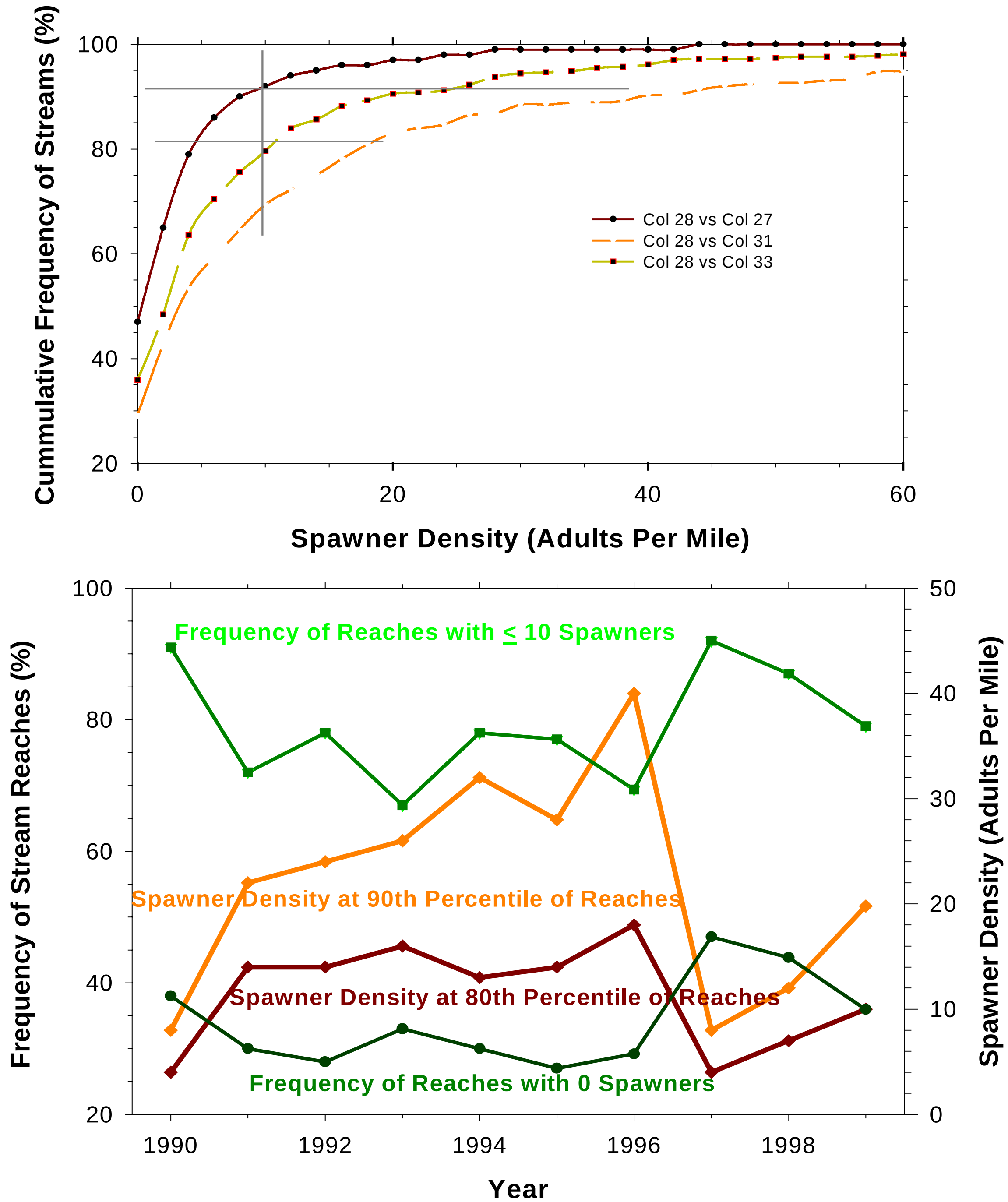

Figure 2-6. Distribution of coho salmon spawners within available spawning habitat within the Oregon Coastal ESU, 1990-99. The upper portion of the figure shows cumulative frequencies of spawner density among available stream reaches during 1999, the lowest abundance year (1997) and the highest abundance year (1996). Also shown by the vertical and horizontal lines are positions of distribution benchmarks depicted in the lower portion of the figure.

Estimates of Spawner Abundance

EMAP Estimates for 1999

Estimates of OCN spawning escapement and associated 95% confidence intervals derived from 1999 random spawning surveys are presented in Table 2-2. Comparisons of 1999 results to those of prior years are presented in Table 2-3. Four hundred sixty five stream segments were successfully surveyed in 1999. The total sample size was increased beginning in 1998 with the goal of increasing precision for coast-wide and GCA estimates to within ±18% and ±30%, respectively. The sample rates necessary to attain these levels of precision were estimated based on a power curve generated with sampling data from 1990 to 1996 (Jacobs and Nickelson, 1998). Target sampling rates were 120 sites per GCA for the four northern GCAs, and 60 sites in the South Coast GCA. The South Coast GCA was randomly sampled for the first time in 1998, so the target sampling rate was somewhat arbitrary compared to the statistical methods that were used to set goals for the other four GCAs.

Target sample sizes were not met in any GCA in 1999, For GCAs where our target was 120 sites, actual sample sizes ranged from 94 to 113 sites. Principal reasons for not meeting target sample sizes included site accessibility, access denial from landowners and inappropriate site selections. Because of failing to meet target sample sizes, target levels of precision were also not met. Precision for the four northern GCAs averaged ±37%, and the coast-wide precision estimate was ±20%. We are currently in collaboration with the U.S. Environmental Protection Agency to develop precision calculations that utilize pair-wise inclusion densities to take advantage of the uniform spatial distribution of the EMAP sample selection process. This approach should improve our confidence intervals considerably.

Spawning densities were modified to compensate for the presence of hatchery-reared fish, and to adjust for the estimated bias associated with visual counts by surveyors (Solazzi 1984). Based on 465 estimates of spawning density, an estimated 42,765 ± 8,738 OCN coho salmon spawned in coastal river basins in 1999. This aggregate estimate includes escapement in Siltcoos Lake, Tahkenitch Lake, Tenmile Lakes, and coastal basins south of the Coquille basin. These areas were randomly sampled in 1998 for the first time. Random sampling was initiated in Siltcoos Lake, Tahkenitch Lake, Tenmile Lakes, and coastal basins south of the Coquille in 1998 to coincide with random sites for habitat and juvenile coho monitoring. However, estimates from these areas were excluded to allow comparisons with prior years (Table 2-3).

Table 2-2. Estimated spawning escapement of Oregon coastal natural coho salmon in 1999 based on randomly selected spawning surveys.

Gene Conservation Area, Basin Group	Spawning Miles	Survey Effort: Number	Survey Effort: Miles	Adult Coho Spawner Abundance [a] Total: Estimate	Total: 95% Confidence Interval	Wild [b]: Estimate	Wild [b]: 95% Confidence Interval
NORTH COAST	**907**	**103**	**100.2**	**8,992**	**3,970**	**8,842**	**3,915**
Necanicum R, Ecola Cr and Midsize Ocean Tribs	114	13	11.0	728	354	728	354
Nehalem R	387	44	44.3	3,713	1,759	3,713	1,759
Tillamook Bay	264	30	30.0	2,303	1,469	2,175	1,411
Nestucca R	132	15	14.6	2,201	3,291	2,201	3,291
Sand Lake and Neskowin Cr	9	1	0.3	47	47		
MID COAST	**1,135**	**94**	**89.9**	**12,460**	**4,623**	**11,442**	**4,356**
Salmon R	48	4	3.4	210	160	175	149
Siletz R	133	11	11.6	1,177	836	1,177	836
Yaquina R	133	11	9.6	2,588	1,591	2,588	1,591
Devils Lake, Beaver Cr and Midsize Ocean Tribs	60	5	5.3	3,366	3,293	3,366	3,293
Alsea R	229	19	20.2	2,050	1,166	2,050	1,166
Yachats R	48	4	2.9	150	244	150	244
Siuslaw R	459	38	35.0	2,918	1,121	2,724	1,112
Mid-Small Ocean Tribs	24	2	2.0	0	0	0	0
MID-SOUTH COAST	**620**	**96**	**90.1**	**15,514**	**6,010**	**15,456**	**5,988**
Siltcoos and Tahkenitch Lks	52	8	5.7	4,899	3,372	4,837	3,333
Coos R	226	35	31.9	4,945	2,498	4,945	2,498
Coquille R	291	45	44.1	3,001	1,136	3,001	1,136
Tenmile Lks	19	3	2.8	2,506	2,748	2,506	2,748
Floras Cr, New and Sixes R	32	5	5.6	164	171	164	171
UMPQUA	**1,087**	**113**	**109.3**	**6,713**	**2,033**	**6,466**	**1,970**
Lower Umpqua and Smith R	250	26	25.2	2,323	1,302	2,323	1,302
Mainstem Umpqua R	212	22	21.7	1,369	837	1,289	804
Elk Cr and Calapooya Cr	154	16	16.8	513	358	434	321
Cow Cr	212	22	20.3	1,234	828	1,234	828
South Umpqua R	260	27	25.2	1,273	951	1,219	913
SOUTH COAST	**458**	**59**	**56.9**	**590**	**343**	**559**	**328**
Lower Rogue R	31	4	3.7	0	0	0	0
Applegate River	101	13	12.9	216	234	155	186
Illinois River	109	14	12.9	283	220	283	220
Mainstream Tribs	124	16	16.7	0	0	0	0
Little Butte Cr	31	4	3.5	64	49	64	49
Evans Cr	47	6	5.4	13	26	13	26
Big Butte Cr	16	2	1.8	13	25	13	25
COAST WIDE	**4,208**	**465**	**446.4**	**44,268**	**9,050**	**42,765**	**8,783**

[a] *Estimates derived using EMAP protocol. Estimates are adjusted for visual observation bias.*
[b] *Estimates of wild spawners derived through application of fin-mark recoveries in random survey sites.*

Table 2-3. Annual estimates of wild coho spawner abundance in coastal river basins within the Oregon Coastal ESU, 1990-99.

Gene Conservation Area, Basin/Group	Spawner Abundance by Return Year									
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
North Coast:										
Necanicum R. & Elk Creek	191	1,135	185	941	408	211	768	253	946	728
Nehalem R.	1,552	3,975	1,268	2,265	2,007	1,463	1,057	1,173	1,190	3,713
Tillamook Bay	265	3,000	261	860	652	289	661	388	271	2,175
Nestucca R.	189	728	684	401	313	1,811	519	271	169	2,201
Sand Lake & Neskowin Cr		240	24	41	77	108	275	61	0	47
Miscellaneous	-	204	-	-	-	-	-	-	-	
Total	**2,197**	**9,282**	**2,422**	**4,508**	**3,457**	**3,882**	**3,280**	**2,146**	**2,576**	**8,842**
Mid Coast:										
Salmon R.	385	39	28	364	107	212	271	237	8	175
Siletz R.	441	984	2,447	400	1,200	607	763	336	394	706
Yaquina R.	381	380	633	549	2,448	5,668	5,127	384	365	2,588
Devil's Lk. and Beaver Cr.	23	-	756	500	1,259	-	1,340	425	1,041	3,366
Alsea R.	1,189	1,561	7,029	1,071	1,279	681	1,637	680	213	2,050
Yachats R.	280	28	337	287	67	117	176	99	102	150
Siuslaw R.	2,685	3,740	3,440	4,428	3,205	6,089	7,625	668	1,089	2,724
Miscellaneous	207	-	700	180	250	231	1,188	13	71	0
Total	**5,591**	**6,732**	**15,370**	**7,779**	**9,815**	**13,605**	**18,127**	**2,842**	**3,283**	**11,442**
Umpqua:										
Lower Umpqua R. & Smith R.	589	1,316	1,759	4,804	1,689	6,803	4,904	935	5,118	2,323
Mainstem Umpqua	455	-	192	1,431	1,240	352	339	397	444	1,289
Elk & Calapooya Cr.	185	-	-	-	708	2,315	1,709	196	379	434
South Umpqua	2,508	2,284	-	2,415	579	755	1,685	512	1,807	1,219
Cow Creek			201	661	269	1,124	1,112	193	678	1,234
Total	**3,737**	**3,600**	**2,152**	**9,311**	**4,485**	**11,349**	**9,749**	**2,233**	**8,426**	**6,466**
Mid-South Coast:										
Coos Bay & Big Cr.	2,273	3,813	16,545	15,284	14,685	10,351	12,128	1,127	3,167	4,945
Coquille	2,712	5,651	2,115	7,384	5,035	2,116	16,169	5,720	2,466	3,001
Total	**4,985**	**9,464**	**18,660**	**22,668**	**19,720**	**12,467**	**28,297**	**6,847**	**5,633**	**7,946**
Oregon Coastal ESU	**16,510**	**29,078**	**38,604**	**44,266**	**37,477**	**41,303**	**59,453**	**14,068**	**19,816**	**34,646**

Relationship between Standard and Random Surveys

The relationship between spawner density in standard and random surveys is the basis calibrating historical estimates of OCN abundance and assessing the reliability of the Standard Index. The relationship developed by Jacobs and Nickelson (1998) was the basis of calibrating OCN abundance estimates used in the Pacific Fisheries Management Council Process to manage ocean salmon fisheries (PFMC 2000b). Because of the limited number of data points used in establishing this relationship it is important to update it as additional data become available.

Figure 2-7 shows the relationship between standard and random survey densities for the Oregon Coastal ESU over the last ten years. Standard spawner densities explain 83% of the variation in random spawner densities. On average, random spawner densities comprise 26% of those in standard sites.

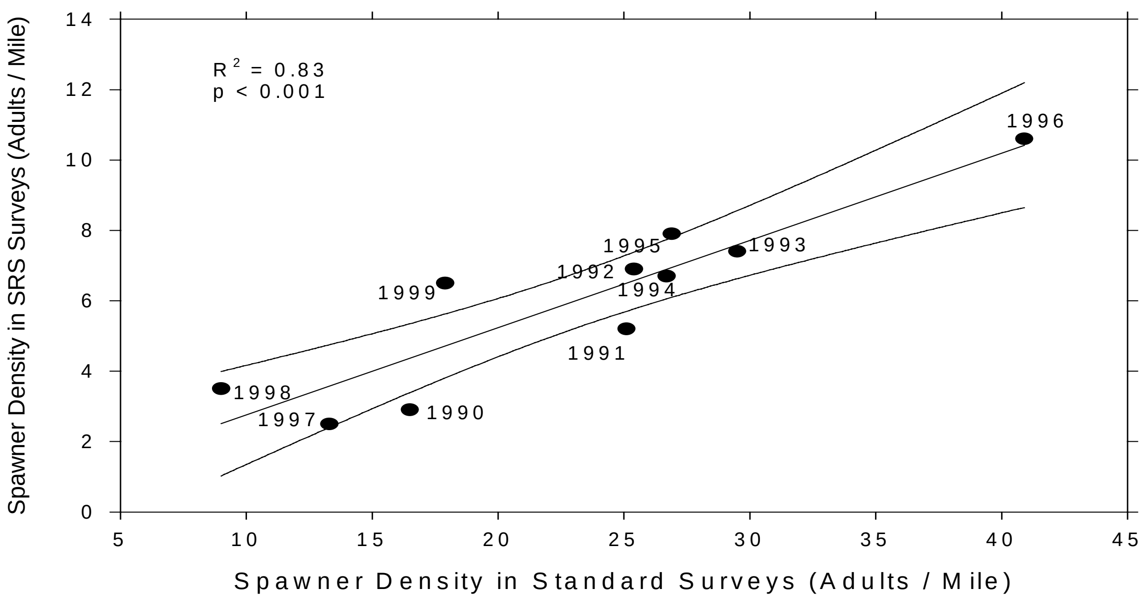

Figure 2-7. Relationship between spawner densities of adult coho salmon derived from standard and random survey sites, 1990-99. Parabolic lines indicate the 95% confidence interval for the regression equation.

Coastal Lake Basins

Table 2-4 lists estimates of coho spawner abundance in Siltcoos, Tahkenitch and Tenmile Lakes in 1999. Across these three systems, adult abundance ranged from 2,800 spawners in Siltcoos Lake to 6,100 spawners in Tenmile Lakes. These three lake basins continue to be the most productive systems for coho salmon along the Oregon coast.

Spawner abundance per unit of available spawning habitat is generally an order of magnitude higher in these lake systems than in neighboring river basins. Over the 40-year period for which estimates are available spawner abundance in these systems has ranged as high as 30,000 adults (Figure 2-7).

Reasons for this high productivity are probably related to additional rearing opportunities associated with the lake environment (Reimers 1989). Spawner abundance is generally related to the size of each of the watersheds, with the largest system (Tenmile Lakes) having the largest population followed by Siltcoos Lake and then Tahkenitch Lake (Figure 2-7).

Table 2-4. Estimated total spawning stock size of adult and jack coho salmon in Oregon coastal lake basins, 1999.

	Estimated spawning stock size	
Coastal lake basin	Adults	Jacks
Siltcoos Lake	2,819	898
Tahkenitch Lake	3,769	1,345
Tenmile Lakes	6,123	1,777
Total	12,710	4,021

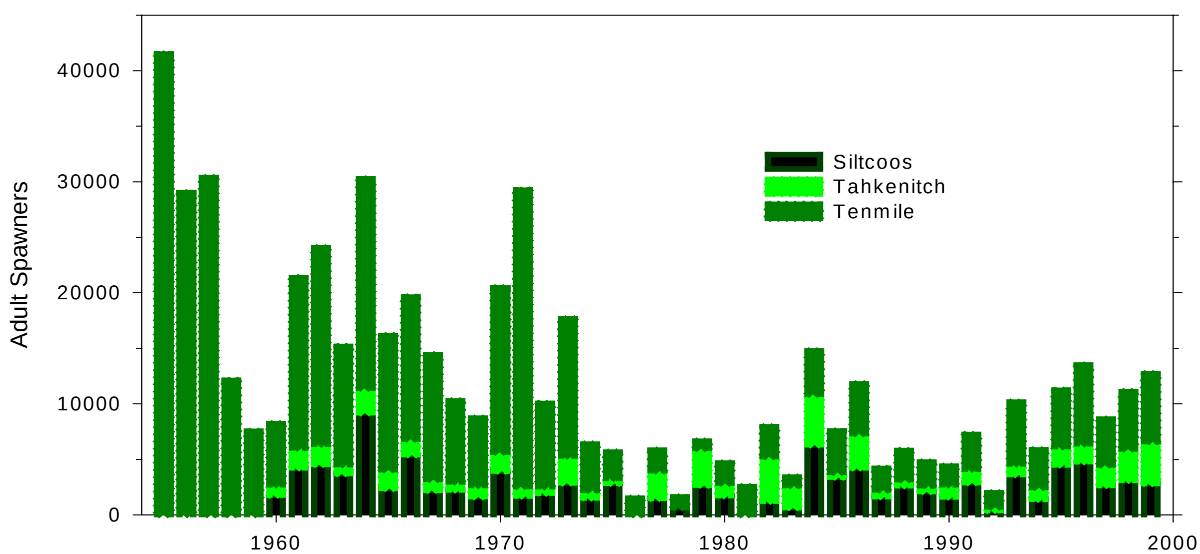

Figure 2-7. Estimated adult coho spawner abundance in Oregon coastal lake basins, 1955-99. Estimates for Siltcoos and Tahkenitch Lakes and not available for 1955-59, 1976 and 1981. Estimates for Tahkenitch Lakes and not available for 1978.

Interestingly, the rate of maturing as age-2 jacks is also higher in coastal lake systems. Jack:adult ratios are much higher in these three lake systems than in neighboring river systems. Among the three lake systems jacks comprise from 10% to 48% of the spawner escapement. Surprisingly however, none of the three lake systems show strong brood year relationships between jack escapement and either adult escapement or adult recruitment. Reasons for the lack of relationships between jack and adult abundance may be due to inter-annual variation in maturity rates or error in the accuracy of abundance estimates.

The change in survey protocol in 1998 provided the first opportunity to compare coastal lake spawner abundance estimates derived from the traditional methodology with abundance estimates based on the EMAP approach. Table 2-2 lists 1999 adult spawner estimates for Tenmile Lakes and the aggregate of Siltcoos and Tahkenitch Lakes derived from the EMAP methodology. The EMAP-derived estimates are substantially lower than the traditional estimates, however, the utility of these comparisons is compromised by the low precision associated with the EMAP estimates. Relative precision of the two EMAP estimates was ± 50% and ± 110%, respectively. The lack of precision of EMAP estimates at the individual basin level is related to the sampling design, which is structured to maximize precision at the GCA level. Annual abundance estimates for individual basins will generally not have high precision because of the low sample size of surveys in each basin. For example, the 1999 estimate for Tenmile Lakes was based on three surveys. Because of this, the accuracy of traditional spawner abundance estimates for coastal lakes will need to be assessed through a long-term comparison of the two sets of estimates.

Rogue River Basin

Estimates of the run size of coho salmon to the Rogue River Basin for 1980-99 are presented in Table 2-5. Also shown are components used to derive estimates. Estimates of wild fish are based on the observation of fin-marks at the seining site. Since 1994, mass marking of hatchery releases has produced estimates with good precision (95% confidence intervals of about ±10%). Prior to 1994, estimates are appreciably less precise with some years having confidence intervals that approached or exceeded the point estimate. Over the 19-year period of 1980-99, run size estimates for wild Rogue Basin coho have averaged about 2,800 adults, ranging from about 300 in 1993 to about 8,000 in 1997. The 1,400 adults estimated to return in 1999 is about half of the long-term average.

With the adoption of comprehensive coast-wide spawning surveys through the EMAP process, survey-based estimates of Rogue Basin spawner abundance are available starting in 1998. Because survey-based estimates are independent of mark-recapture estimates derived from hatchery returns and Huntley Park seining, we are able to compare the two to assess consistency in our assessment programs. Table 2-2 lists the survey-based estimate of adult spawner abundance for the Rogue Basin in 1999. Because the value in Table 2-2 pertains to spawner escapement and not run size, the value needs to be adjusted before it can be directly compared to the mark-recapture estimate. Major components not included are angler harvest and returns above the Elk Creek trap site. Including these components yields an estimate of 960 ± 343 adults. The estimate of the wild run size based on mark-recapture methods is 1,438 ± 324. Given the precision of these estimates, they are not significantly different from each other, however the survey-based estimate appears lower. We will continue to track the correspondence of these two estimates as additional data become available.

Table 2-5. Estimates of adult coho run size in the Rogue River derived through capture at the Huntley Park seine site and returns to Cole Rivers Hatchery, 1980-98.

	Huntley Park Seine		Cole Rivers Hatchery		Adult Coho Run Size			
	Fin-marks	Total	Adult	Adult Fin-	TOTAL		Wild	
Year	(R)	(C)	Returns	Marks (M)	N	95% C I	N	95% C I
1980	24	150	4,136	810	5,388	1,929	986	825
1981	33	210	6,904	1,787	12,207	3,758	4,796	2,356
1982	4	24	132	129	715	561	593	511
1983	4	19	790	268	1,184	899	449	554
1984	28	229	3,482	1,210	10,564	3,594	6,847	2,894
1985	41	127	613	515	1,731	429	1,066	337
1986	10	84	3,216	523	4,451	2,454	1,193	1,270
1987	8	96	4,073	503	5,971	3,716	1,942	2,119
1988	62	421	8,159	1,949	14,368	3,272	5,510	2,027
1989	12	82	1,329	305	2,152	1,074	780	647
1990	1	57	453	103	3,306	4,502	3,051	4,325
1991	9	105	2,209	277	3,244	1,913	1,027	1,076
1992	4	91	1,356	168	3,422	2,917	2,208	2,343
1993	3	34	756	104	1,006	928	361	556
1994	95	174	6,586	6,308	12,651	1,700	5,439	1,115
1995	149	212	8,698	8,521	13,311	1,159	3,761	616
1996	223	375	7,922	7,214	13,321	1,109	4,622	653
1997	245	501	7,934	7,569	16,992	1,516	8,282	1,059
1998	79	165	2,863	2,385	5,447	859	2,316	560
1999	108	163	4,335	3,741	6,193	673	1,438	324

Abundance by ESU and GCA

Oregon Coastal ESU

Estimates of the abundance of adult coho spawners within the four GCAs that comprise the Oregon Coastal ESU are available back through 1990 (Figure 2-8). Spawner abundance in the Oregon Coastal ESU has ranged from about 20,000 adults in 1990 to near 80,000 adults in 1996. From 1990-96, spawner abundance in this ESU showed a somewhat increasing trend; however, in 1997 and 1998 abundance fell to near the level observed in 1990. Since 1997, spawner abundance has increased in each successive year. Among the four GCAs, spawner abundance has generally been lowest in the North Coast GCA and highest in the Mid-South Coast GCA. In the North Coast GCA, spawner abundance has averaged about 3,700 adults, and has ranged from about 2,200 adults to about 9,300 adults. Conversely, in the Mid-South Coast GCA, spawner abundance has averaged more than 14,000 adults and been as high as 28,000 adults in 1996. The most productive basins in this GCA have been the Coos, Tenmile Lakes and Siltcoos Lake Basins.

Southern Oregon ESU

Production of coho salmon in the Southern Oregon ESU overwhelmingly occurs in the Rogue Basin. Recent adult and juvenile sampling conducted within this ESU, but outside of the Rogue Basin, failed to locate any significant coho populations. Run size estimate of naturally produced adult coho is available for a 20-year period beginning in 1980 (Figure 2-9). During this period, run size has ranged from about 300 adults in 1993 to near 8,000 adults in 1997. The estimated run of 1,400 adults in 1999 was the lowest observed since 1993. Ocean fishery harvest can be estimated through coded-wire tag recoveries of coho released from Cole Rivers Hatchery. Accounting for this harvest shows a somewhat different pattern of Rogue coho abundance. Significant harvest occurred during 1980-90. Given this, total stock abundance peaked at about 14,000 adults 1981.

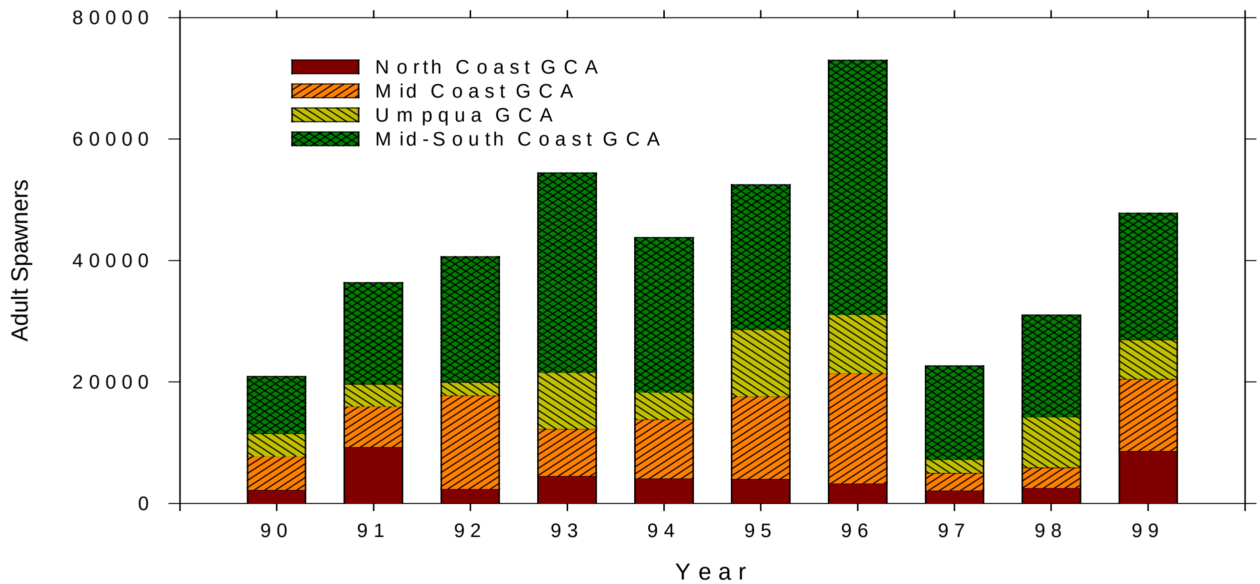

Figure 2-8. Estimated spawner abundance of coho salmon for individual Gene Conservation Areas (GCAs) within the Oregon Coastal ESU, 1990-99. Bars show contribution of each GCA to the total abundance of the ESU, including three coastal lake basins located within the mid-south GCA. Estimates of abundance in river systems are based on SRS methodology. Estimates of abundance in lake systems are based on traditional methodology.

Estimates of the ratio of adult recruits per spawner for the 1980-96 brood years of Rogue River coho are shown in Figure 2-10. This measure of survival has shown no discernable pattern over the 17-year period. Survival has shown fairly dramatic inter-annual variation, ranging from less than one to greater than twelve recruits per spawner. Spawners failed to replace themselves five times during this period. Survival was highest for the 1985 and 1993 brood years when levels of about 8 and 13 recruits per spawner occurred. There are no strong cyclic patterns exhibited by any of the three brood cycles, however survival of the cycle beginning with the 1980 brood year averaged less than did survival for the two subsequent cycles. Because the precision associated with wild run size estimates was poor for many estimates prior to 1993, the reliability of recruitper spawner ratios is substantially better beginning with the 1993 brood year.

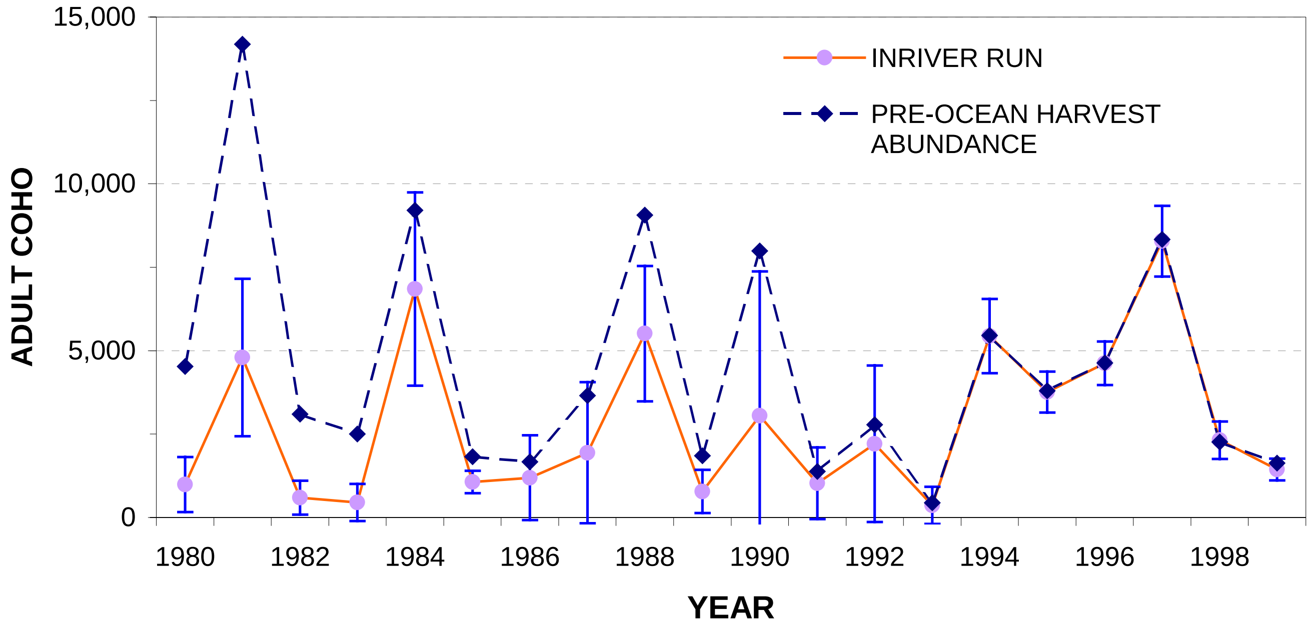

Figure 2-9. Trends in spawning escapement and pre-harvest abundance of Rogue River coho salmon, 1980-99. Vertical bars represent 95% confidence intervals for estimates of spawner abundance.

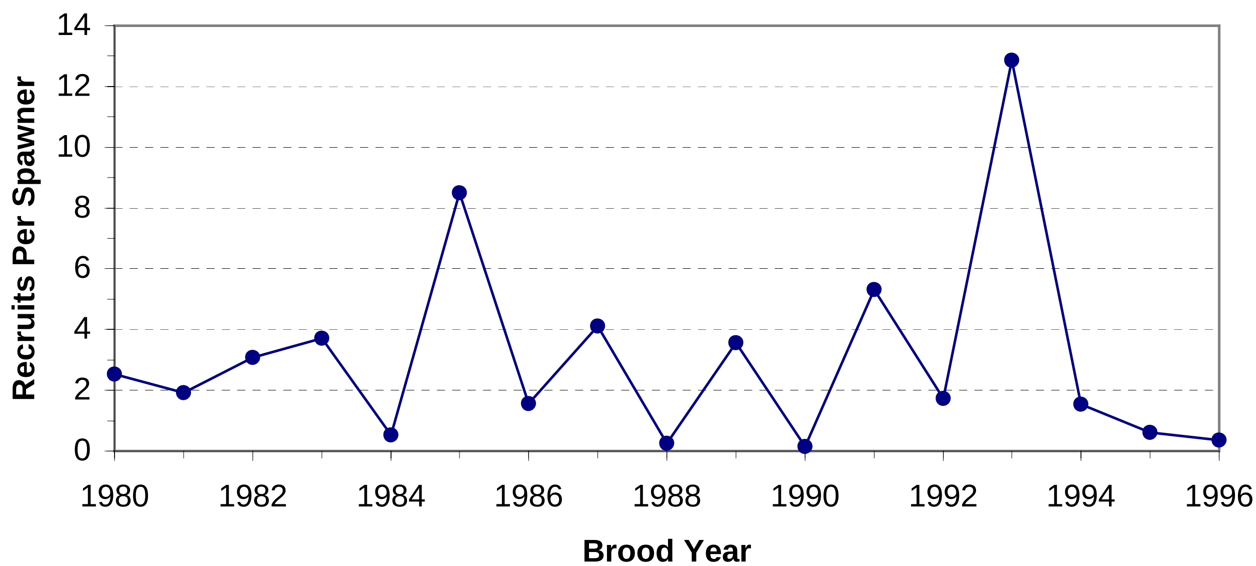

Figure 2-10. Estimated recruit per spawner ratio for adult Rogue River coho salmon during the 1980-96 brood years.

Occurrence of Hatchery Coho in Natural Spawning Grounds

Random surveys provide the most representative sample of scales from naturally spawning fish because they are taken from an unbiased sample of the available habitat. However, given the relatively poor spawner escapements that have occurred in recent years and the difficulty in recovering coho carcasses on spawning surveys, we generally have insufficient sample sizes to draw inference from in any one given year. To compensate for this, we pooled samples to provide estimates of rearing origin for the most recent 8-year period. Figure 2-11 shows the rearing origin of spawners in major coastal basins estimated from scales collected on random surveys during 1992-99. Also shown are the sample sizes available for each basin. In some of the smaller basins, even after pooling, sample sizes are insufficient to reliably estimate the proportion of wild and hatchery spawners.

Three major conclusions can be drawn from this analysis: (1) hatchery strays occur in essentially every major coastal basin, (2) in some basins natural spawning is dominated by hatchery strays, and (3) although hatchery strays are widespread, they compose a minor portion of the natural spawners in the most productive GCAs. As shown in Figure 2-11, hatchery-origin spawners were found in essentially every coastal basin, including basins where no hatchery releases occur such as the Necanicum, Wilson, Nestucca Rivers and Beaver Creek. In the Nehalem, Trask and Salmon River Basins, stray hatchery fish have been the dominant source of natural spawners. Each of these basins supports large hatchery programs. The patterns of straying into these three basins are different, however. In Salmon River, hatchery-origin spawners are recovered throughout the watershed, whereas in the Trask and Nehalem they are restricted primarily to spawning streams in close proximity to hatchery facilities. Although straying appears to be widespread, hatchery-origin coho make up a relatively insignificant portion of the natural spawners south of the Mid Coast GCA. During the period corresponding to that shown in this figure, spawner abundance in the Umpqua and Mid-South Coast GCAs accounted for more than 60% of the total abundance of natural spawners (*see* Figure 2-8). Straying was apparently insignificant in the area where most natural spawning occurred.

Beginning in 1998, returns of adult coho originating from Oregon coastal hatcheries were essentially 100% marked with adipose fin clips. This mass marking enables the proportion of natural spawning hatchery fish to be estimated from recovery of fin-marked carcasses. Figure 2-12 shows the proportion of natural spawning hatchery coho in each GCA estimated by this methodology during 1998 and 1999. In 1998, wild fish were the dominant component of natural spawner populations in all GCAs except the Mid Coast. The proportion of hatchery coho among naturally spawning populations ranged from zero in the Mid-South Coast GCA to near 80% in the Mid Coast GCA. Within this GCA, fin-marked carcasses were recovered in the Salmon, Siletz, Yaquina, Alsea and Beaver Creek Basins. In 1999, among all the GCAs, hatchery fish comprised less than 10% of the natural spawners.

Figure 2-11. Rearing origin of naturally spawning adult coho salmon in major coastal river basins over the 6-year period of 1992-99. Estimates derived from analysis of scales collected on random spawning surveys. Samples from the Rogue Basin are only from the most recent 4-year period (1996-99). Solid bars represent hatchery fish and open bars represent naturally produced fish.

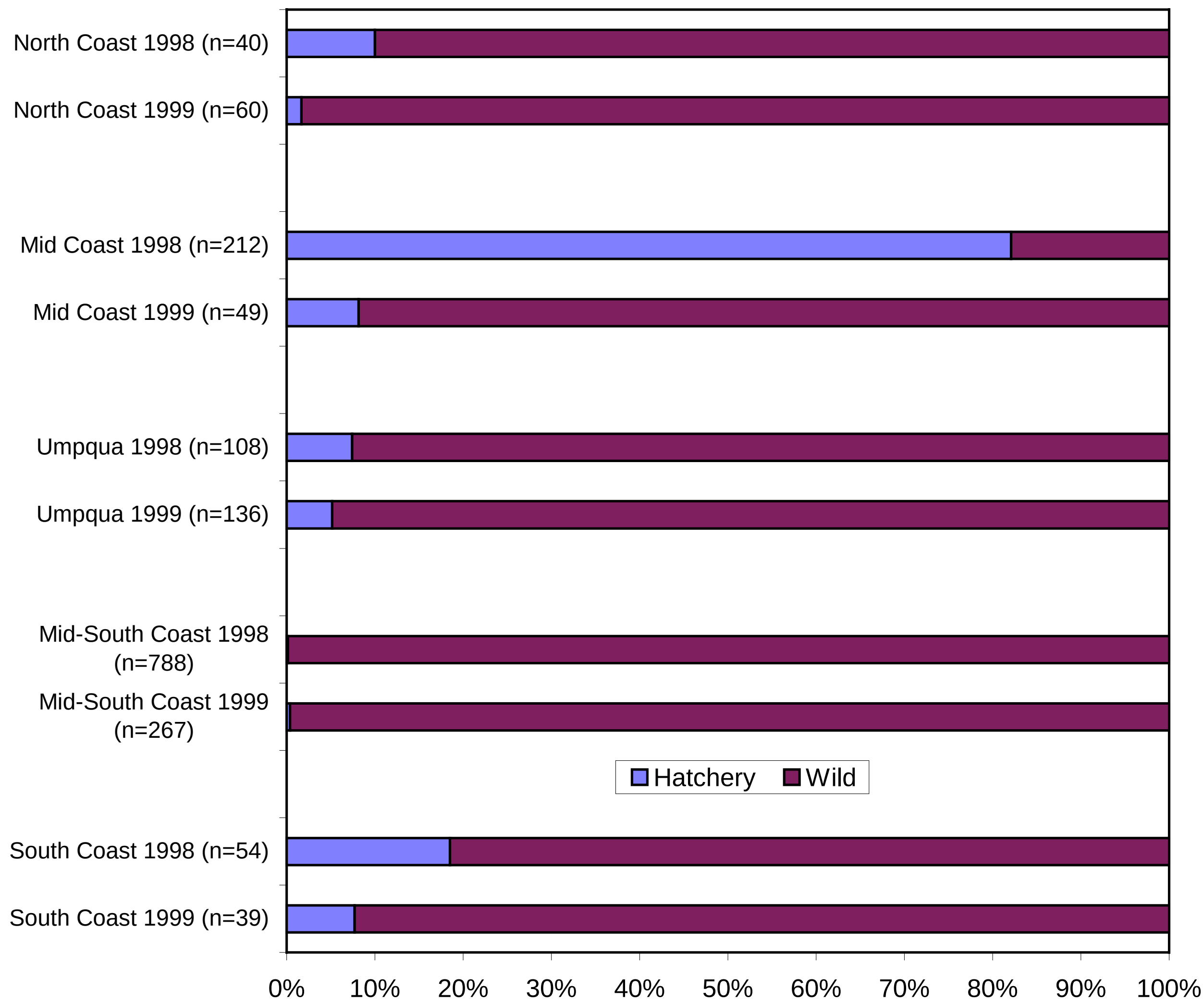

Figure 2-12. Rearing origin of naturally spawning adult coho in Oregon coastal Gene Conservation Areas, 1998 and 1999. Estimates are derived from recovery of adipose fin-marked carcasses on random spawning surveys.

In 1998, because no coded-wire tags were recovered outside of Salmon River, it is not possible to determine the origin of the majority of hatchery strays. All strays identified by coded-wire tags in Salmon River originated from Salmon River Hatchery. Hatchery coho also returned to Fall Creek Hatchery in the Alsea River, the release facility in Yaquina Bay and portions of the Siletz Basin. It is likely that other strays in the Mid Coast GCA were composed of a combination of these fish. In 1999, coded-wire tags were recovered in Salmon River and the Umpqua Basin. All tags originated from smolt releases in each respective basin.

Table 2-6 compares estimates of hatchery:wild ratios derived from mark recoveries and scale analysis. Any conclusions drawn from these results must be qualified by the generally poor sample sizes that were obtained within sampling locations. Given this caveat, two major conclusions can be drawn: (1) estimates based on scales were generally consistent with estimates derived from mark-recoveries in terms of distinguishing areas having high levels of hatchery influence from areas where little or no straying occurred, however, (2) the two methods did not always agree relative to the magnitude of hatchery straying.

Scale analysis generally estimated higher proportions of stray hatchery fish than did mark recovery. Within 7 of the 23 sampling locations listed in Table 2-6, scale analysis showed higher proportions of hatchery spawners. Estimates of the proportion of stray hatchery fish based on scale analysis were substantially higher than those derived from mark-recovery in the Siletz, Siuslaw, Smith, Mainstem Umpqua, and Floras/New River Basins. There were three basins where estimates based on marks were higher than estimates based on scale analysis.

The discrepancy between estimates of the proportion of hatchery-origin spawners derived from scale analysis versus mark-recovery raises questions about the accuracy of our estimates of straying rates of hatchery-origin into natural spawning areas. One of the major weaknesses of the scale analysis methodology is the absence of a comprehensive reference collection of scale samples from known natural-origin fish. Without this resource, it is not possible to adequately represent the occurrence of all natural rearing patterns in the distinction process.

The accuracy of estimates of the occurrence of hatchery spawners based on mark-recovery is also dependent on a number of conditions. Paramount among these is the accurate recording of the presence of fin-marks and the ability of samplers to recognize the presence of marks on carcasses. Because of the rigors of spawning and decomposition, adipose fin-marks cannot always be distinguished in carcasses recoveries. To accommodate this, data collection and recording procedures were modified starting in 1998 to distinguish among marked, unmarked and carcasses that were unrecognizable regarding fin marks. Mark proportions were based only from carcasses where fin-clips could be identified. These procedures should have minimized errors associated with mark-recovery.

The results in Table 2-6 and the similar results in 1998 (Jacobs et al. 2000) suggest that scale analysis may have over-estimated proportions of hatchery spawners in natural spawning areas in past years. If this occurred, wild spawner abundance would have been underestimated to the degree that biased hatchery:wild ratios were used to adjust population estimates.

Table 2-6. Number of marked and unmarked adult coho salmon sampled on 1999 coastal spawning ground surveys and percent hatchery origin estimated by scale analysis.

	Carcasses examined for fin-marks on random surveys			Scale samples obtained in all survey sites		
Major basin or Basin Group	**Carcasses recovered**	**Fin-Marks**	**Percent hatchery[a]**	**Scale Samples**	**Percent hatchery from scales**	**Percent hatchery from fin-marks[a]**
Necanicum R and Ecola Cr	8	0	0.0%	8	0.0%	0.0%
Nehalem R	14	0	0.0%	12	8.3%	11.5%
Tillamook Bay	18	1	5.6%	20	10.0%	10.1%
Nestucca R	20	0	0.0%	16	0.0%	0.0%
Salmon R	6	1	17.5%	30	43.3%	48.9%
Siletz R	5	2	41.9%	8	62.5%	39.3%
Yaquina R	6	0	0.0%	8	0.0%	0.0%
Devils Lake and Beaver Cr	13	0	0.0%	24	0.0%	0.0%
Alsea R	4	0	0.0%	7	0.0%	0.0%
Siuslaw R	15	1	6.7%	24	12.5%	4.2%
Coastal Lakes	80	1	1.3%	428	0.2%	0.2%
Smith R	25	0	0.0%	36	5.6%	0.0%
Mainstem Umpqua R	17	1	5.9%	10	20.0%	10.0%
Elk Cr and Calapooya Cr	13	2	15.4%	9	22.2%	22.3%
Cow Cr	34	1	3.0%	45	4.4%	4.5%
South Umpqua R	47	3	6.4%	38	7.9%	7.9%
Coos R	85	0	0.0%	97	3.1%	0.0%
Coquille R	40	0	0.0%	84	0.0%	0.0%
Tenmile Lakes	80	0	0.0%	164	0.0%	0.0%
Floras Cr and New R	4	0	0.0%	15	13.3%	0.0%
Applegate River	7	2	33.1%	7	28.6%	33.1%
Illinois River	31	1	3.2%	33	3.0%	0.0%
Evans Cr	1	0	0.0%	1	0.0%	0.0%

a *Adjusted to account for marked:unmarked ratio at release at nearest hatchery facility*.

CHAPTER 3: CHUM SALMON

CURRENT MONITORING PROGRAM

Spawning fish surveys have been conducted since 1948 to assess trends in spawning escapement of chum salmon. The most substantial commercial harvest of Oregon coastal chum salmon occurred in the Tillamook Bay net fisheries. To measure escapement past the commercial net fisheries, three survey areas were established in Tillamook Basin tributaries. In addition, dead fish were measured and sorted by sex during spawning ground surveys to furnish a means of comparing the size and sex distribution of the commercial catch with the spawning escapement component of the run (Oakley 1966). When commercial fishing was closed in Tillamook Bay in 1962, spawning surveys were retained to monitor the status of the chum salmon population.

In the late 1950s and early 1960s, passage problems in two of the standard surveys and habitat degradation in the third magnified the problems associated with relying on such a small sample size (Isaac 1966, Oakley 1966). As a result, 11 additional surveys were added in 1960 from the best-known spawning areas in the Miami, Kilchis, and Tillamook Rivers to provide more meaningful and reliable data on chum salmon spawning populations (Oakley 1966). Most of these surveys were routinely conducted for the next two decades and some were ultimately reclassified as standard index survey areas. Currently, the standard index is composed of the three original standard surveys, four additional areas (selected from the 11 surveys done in the 1960s and 1970s), and one survey in the Nestucca Basin.

A growing emphasis on management of populations within individual river basins has generated a need to better understand the status of individual populations of chum salmon on the Oregon coast. For this reason, additional chum salmon spawning surveys were selected in 1991 in the Nehalem, Netarts Bay, and Yaquina Basins, and most have been continued since that time. The results of these surveys are presented in this report and are referred to as supplemental chum salmon surveys.

ASSESSMENT UNITS

The National Marine Fisheries Service includes all Oregon coastal stocks of chum salmon as part of the *Pacific Coast ESU*. This ESU encompasses all coastal chum stocks in the U. S., from Washington through California (Johnson et al. 1997). There is some debate if occurrences in Southern Oregon and California actually constitute viable breeding populations. GCAs have not yet been described for Oregon chum populations (Kostow 1995). To our knowledge, based on our sampling, Coos Bay is the southern extent of viable chum populations on the Oregon Coast.

METHODS

Survey Design

The chum salmon standard index area was composed of seven stream segments in tributaries of Tillamook Bay that totaled 4.8 miles and one stream segment in Clear Creek (Nestucca River) that totaled 0.8 miles. For 1999, nine supplemental stream segments were surveyed totaling 7.5 miles.

Hatchery releases of chum salmon have never occurred in Tillamook Bay or the Nestucca River Basin. As a result, all standard index stream segments are classified as wild index sites. Additionally, supplemental surveys in Netarts Bay and the Yaquina are classified as wild index areas. A private hatchery released chum salmon into the Nehalem River from 1981-93. Given these releases, returning hatchery adults could have influenced counts in Nehalem chum surveys through 1997. Beginning in 1998, counts were no longer affected by hatchery returns.

Measures of Spawning Escapement

Chum salmon spawning escapement was indexed as the peak count of live and dead fish observed in a given survey area. Average peak count per mile in a given set of stream segments (S) was calculated as follows:

$$S = \left[\sum_{i=1}^{n} P_i \Big/ \sum_{i=1}^{n} m_i \right] \tag{1}$$

where

n = number of stream segments surveyed,

P_i = peak count of live and dead fish in stream segment i, and

m_i = miles surveyed in stream segment i.

RESULTS AND DISCUSSION

Assessment of Survey Conditions

Figure i-2 illustrates flow conditions during the 1999 survey season for the Nehalem River near Foss. Also shown are limits of the 80th and 20th percentiles of mean daily flows for the 40-year period extending back to 1957. Flow levels in this basin provide an indicator of survey conditions for chum salmon during the 1999 spawning season. Oregon chum salmon generally spawn during November and December. Flow conditions generally remained low during the 1999 spawning season except for two high water events that occurred during November. These events disrupted spawning surveys only in the largest streams surveyed for chum salmon. Surveys located on the mainstem Miami and Kilchis Rivers each had a 13 day gap between successive visits. Except for this disruption, survey counts were completed on schedule.

Spawning Timing

Chum spawning occurs primarily during the latter portion of November to mid-December, with peaks typically occurring near 1 December. Figure 3-1 shows spawning timing of chum salmon in coastal basins based on when live adults are observed in all survey areas. Timing is shown separately for the Nehalem Basin, Tillamook Bay, Netarts Bay and the Yaquina Basin. Among all these locations, the temporal pattern of spawning observed in 1999 was generally similar to that observed during the five previous years. This suggests that the spawn timing of Oregon chum stocks is relatively consistent, with little inter-annual variability. The consistency of chum spawn timing is also exhibited by the trend of dates of peak spawning in standard survey sites over the last 11 years (Figure 3-2). During this period average date of peak spawning as varied by only 10 days or less.

With the exception of Tillamook Bay, spawn timing of Oregon chum stocks is similar among coastal basins. Spawning peaks in mid-November and is fairly contracted, lasting about one month. In contrast, chum spawning in Tillamook Bay is later and more protracted. Spawning of Tillamook Bay chum peaks in late-November to early-December and lasts about six weeks. Reasons for the later spawn timing of Tillamook Bay chum compared to other coastal stocks are not clear. One note worthy difference is the absence of any hatchery releases of chum in this basin, whereas all other basins shown in Figure 3-1 have received hatchery plants.

Index of Spawning Abundance

A total of 17 surveys (12.3 miles) were conducted 1999 to assess the condition of chum salmon stocks. Survey sites were not chosen using a randomized sampling design, so spawner density estimates obtained from these surveys should only be used as an index of spawner abundance. These data are not suitable for extrapolations of total abundance.

Eight standard stream segments were surveyed in the Tillamook and Nestucca Basins during the 1999 spawning season. The average peak counts (fish per mile) in the standard streams are reported in Table 3-1. No chum salmon were observed in the Nestucca River survey site (Clear Creek). Nine supplemental surveys were conducted in 1999 to monitor chum populations outside of the index stream areas.

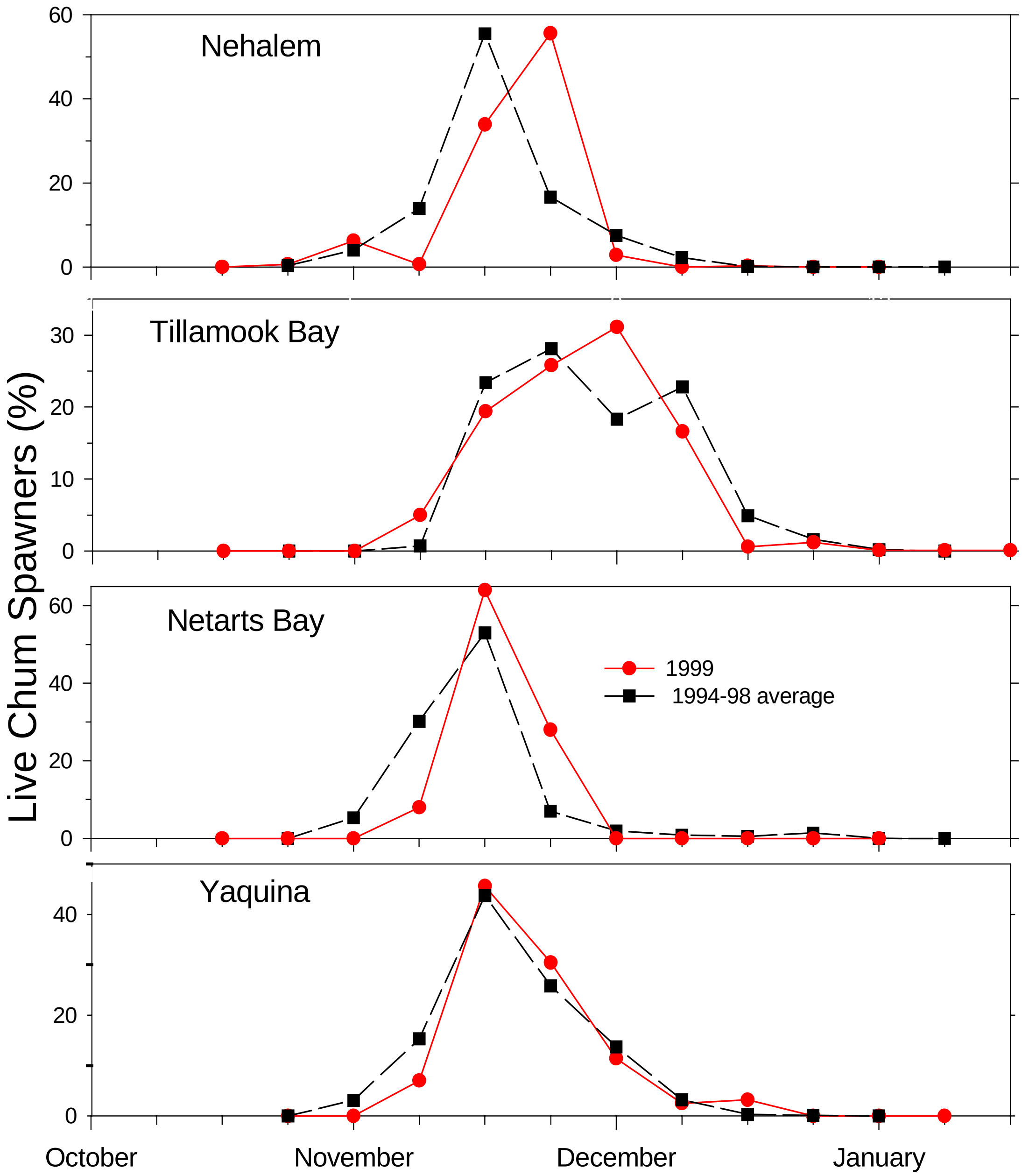

Figure 3-1. Spawning timing of chum salmon in 1999 and during the previous five seasons in selected coastal basins. Values plotted are the percent of total live adult chum counted that year in all survey segments targeting chum salmon.

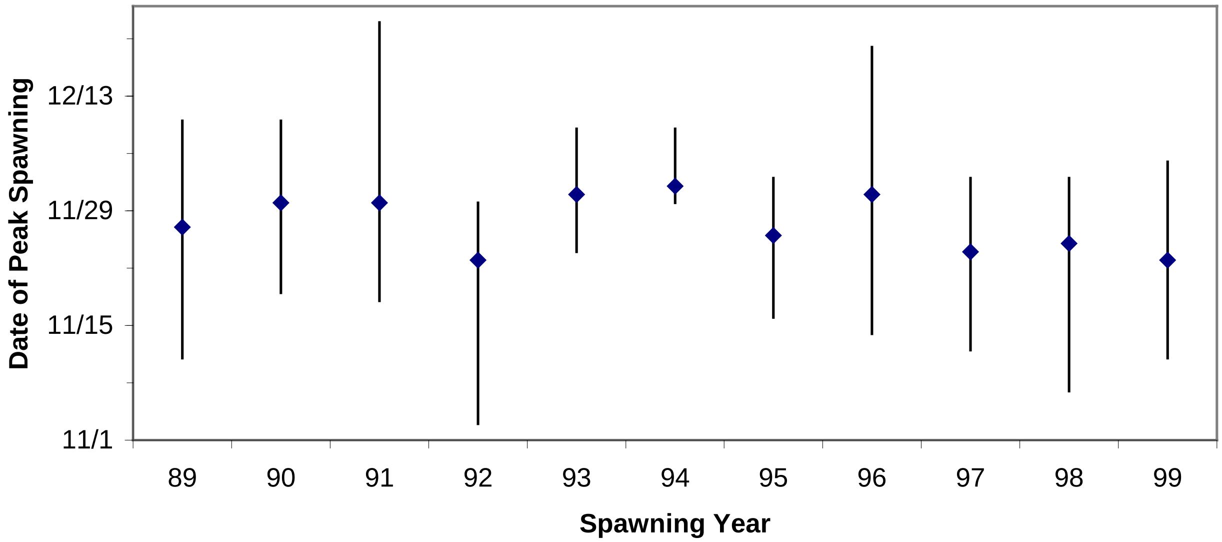

Figure 3-2. Mean time of peak spawning, and earliest and latest peak counts for standard chum surveys in 1989-99.

Table 3-1. Summary of peak fish per mile counts of chum salmon in standard stream segments, 1999.

Basin, Year	Survey segments		Average adult peak count per mile
	Number	Total Miles	
Miami	3	1.36	181
Kilchis	3	2.10	125
Wilson	1	0.50	84
Nestucca	1	0.80	0
Total:	8	4.76	116

Trends of Spawner Abundance

Standard Surveys

Average peak counts in standard chum surveys have varied widely since their beginning in 1948 (Figure 3-3). Despite this high variability, there is a statistically significant declining trend in this index over the 52-year period ($R^2 = 0.11$, $p<0.01$). A trend of gradual peak decline occurred from 1948 to the early 1960s, with peak per mile counts going below 100 for the first time in 1960-61. Peak counts rose following the closure of the commercial fishery for chum salmon in 1962, and from 1962-94 peaks ranged from 60 fish per mile in 1979 to 768 fish per mile in 1978. In 1996 a record low of 31 fish per mile occurred.

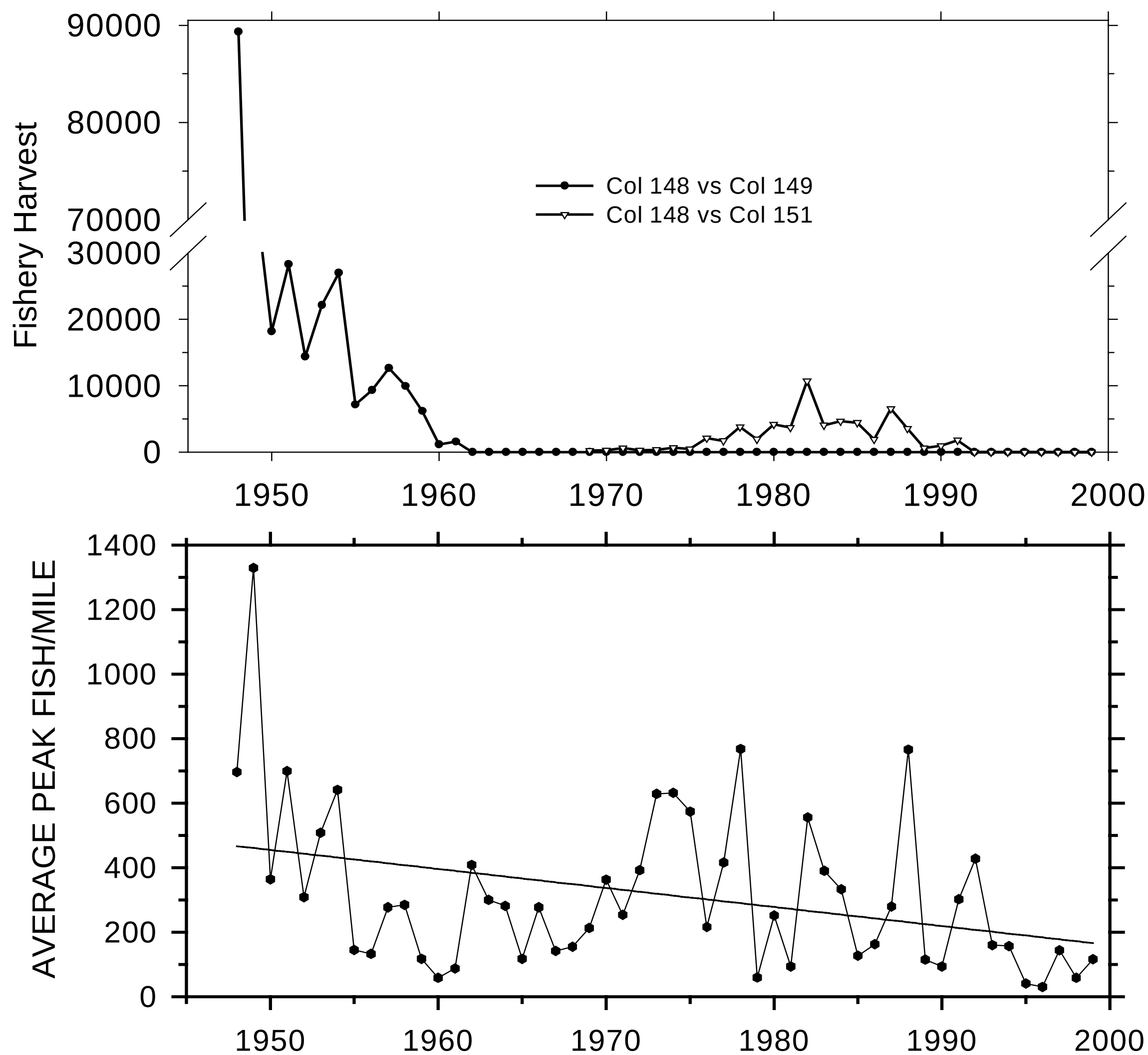

Figure 3-3. Trends in spawner abundance and fishery harvest of Oregon coastal chum salmon, 1948-99. Upper panel: commercial and recreational harvest of chum salmon in Tillamook Bay. Lower panel: peak counts in standard survey sites. The trend line fitted to the data is significant (R^2 = 0.11, $p<0.01$).

Peak counts of chum salmon in standard index streams in the Tillamook and Nestucca Basins were at record low levels in 1996 and have remained at relatively low levels since then. The most recent year having relatively abundant spawner escapement was 1998.

Consumptive fisheries for Tillamook Bay chum salmon were terminated in 1991. In the approximate 15-year period prior to 1991, substantial recreational chum harvest occurred in Tillamook Bay. Additionally, prior to 1961, Tillamook Bay supported a considerable commercial fishery for chum salmon (Figure 3-3). Given the changes that have occurred in the exploitation of Tillamook chum stocks during the period of spawner abundance monitoring, the low counts observed during the last five years represent the lowest run size for the period of record. This trend indicates that Oregon's largest population of chum salmon has experienced a major decline in their abundance.

Figure 3-4 shows standard chum peak counts for individual basins during the 10-year period between 1989 and 1998. The three tributaries of the Tillamook Bay co-vary closely. The greatest peak counts were seen in 1992, with secondary peaks in 1994 and 1997. Chum populations in the Nestucca River Basin have been uniformly low over the last ten years, and it may be that the Clear Creek index site no longer provides a suitable index for chum in this basin.

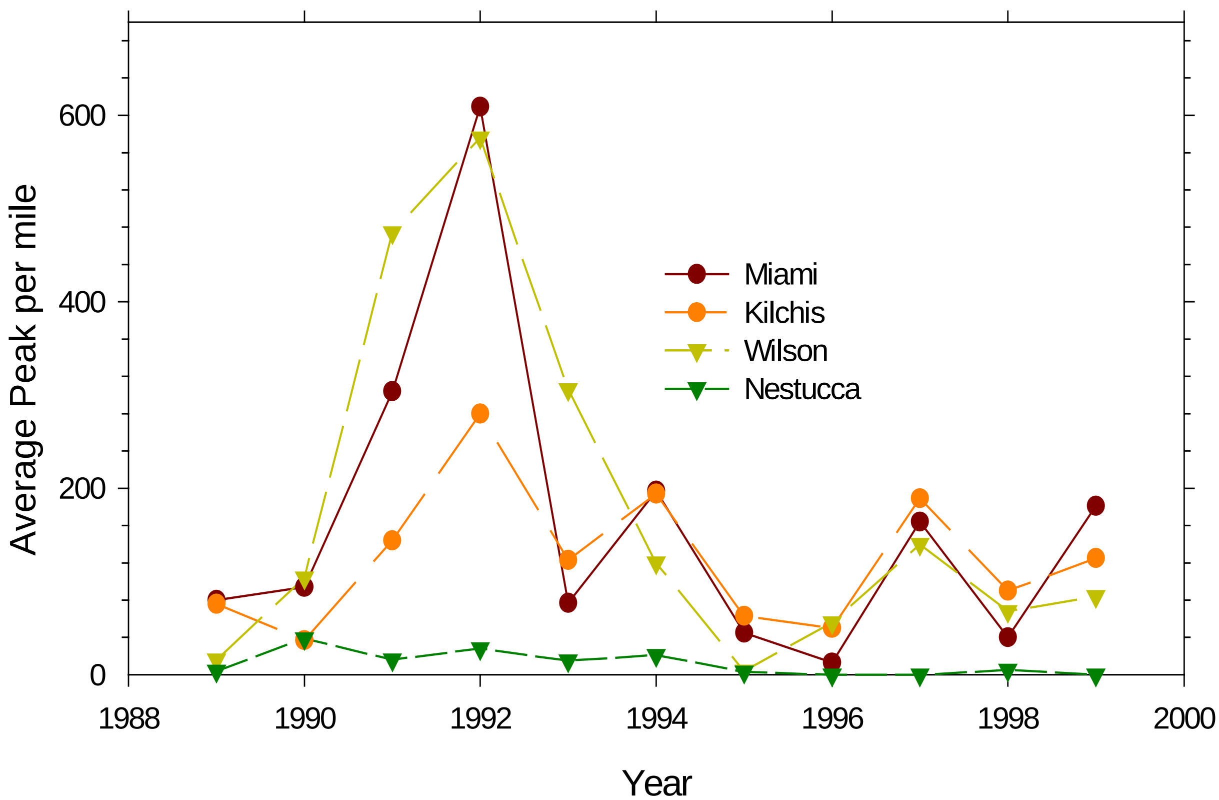

Figure 3-4. Average peak chum counts from standard surveys standardized to survey length in miles (1989-99). Miami River Basin (n=3); Kilchis River Basin (n=3); Wilson River Basin (n=1); Nestucca River Basin (n=1).

Supplemental Surveys

Peak counts from supplemental surveys show a greater variability between basins compared to the standard surveys in tributaries of Tillamook Bay (Figure 3-5). This is to be expected since the supplemental surveys are more geographically dispersed than the standard surveys. Peak counts in the Nehalem River Basin were highest in 1992, with a secondary peak in 1997. This pattern is similar to that seen in standard surveys in tributaries of Tillamook Bay, particularly tributaries in the Miami River Basin. It should be kept in mind that hatchery-reared chum were released in the Nehalem from 1981 until 1993, and that spawner counts prior to 1998 possibly include hatchery strays. The Nehalem Land and Salmon Hatchery released an average of 500,000 fed fry annually, with a peak release of 1.5 million in 1989 (Nickelson et al. 1992). In 1998, all supplemental surveys are classified as wild. The five supplemental surveys outside the Nehalem Basin were classified as wild in 1996-98.

A survey on Whiskey Creek a tributary of Netarts Bay was initiated in 1993. Peak counts on this survey were relatively high (>300 fish per mile) in 1994. This peak was not reflected in the Nehalem returns, however a peak was observed in some standard surveys in 1994. Trends in run size in 1996 to 1998 were similar in the Nehalem River, Netarts Bay, and the standard surveys.

The peak seen in 1992 was not reflected in peak counts from the Yaquina River Basin. The 1994 peak seen in Netarts Bay was also observed in the Yaquina River Basin. Chum populations in 1996 and 1997 were similar in all three basins, and in the standard surveys, but the Yaquina diverged from all other basins in 1998 when peak counts were the highest on record for these surveys (>150 fish per mile).

Counts of chum spawners declined in all three basins declined in 1999.

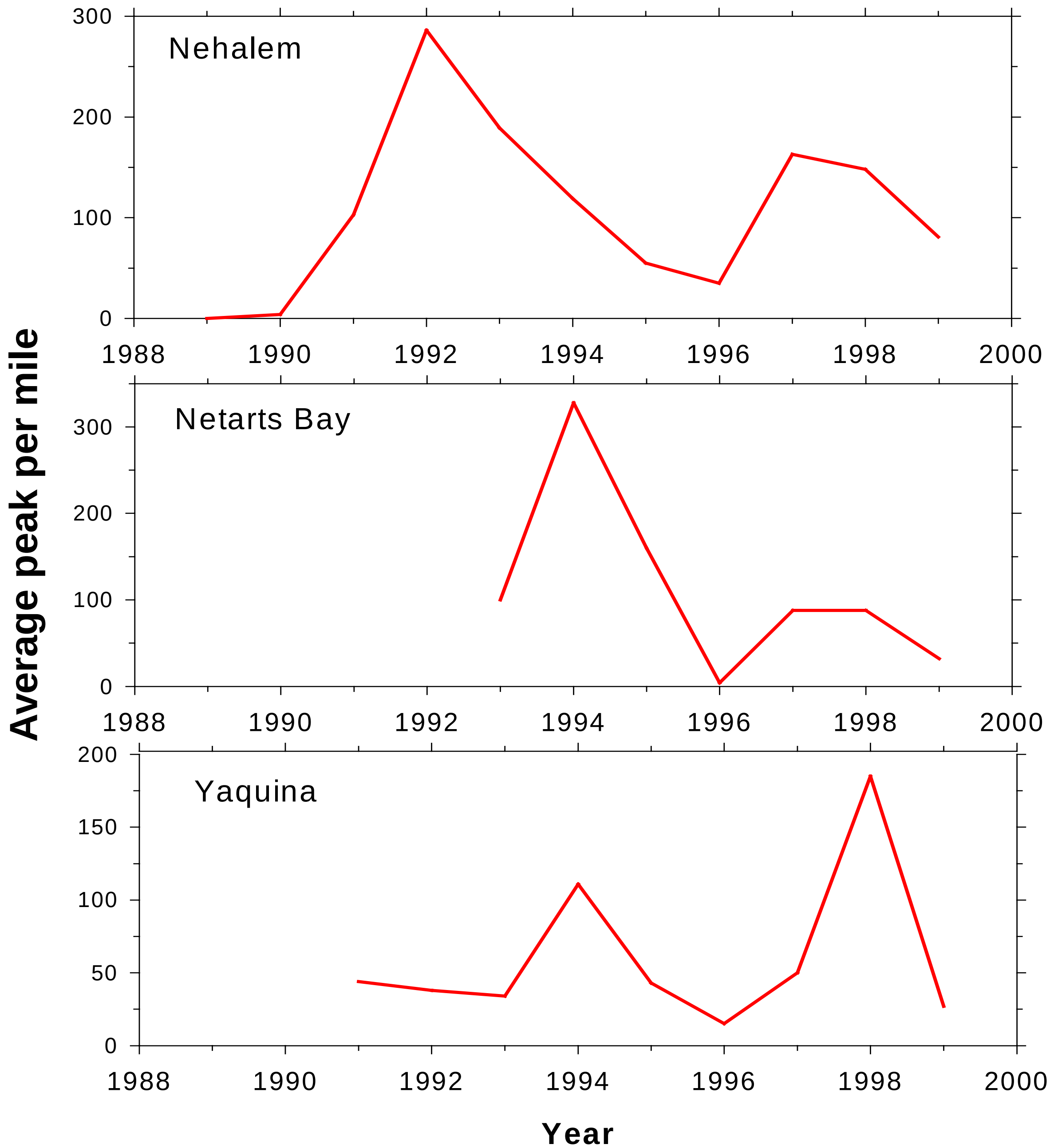

Figure 3-6. Average peak chum counts in supplemental surveys standardized to survey length in miles. Nehalem River (n=4); Netarts Bay (n=1); Yaquina Bay (n=3).

CHAPTER 4: STEELHEAD

CURRENT MONITORING PROGRAM

Winter steelhead have historically occurred in varying abundance in all of Oregon's coastal streams and in the Columbia River upstream to Fifteen-mile Creek near The Dalles (Wagner 1967). ODFW has used a combination of dam passage counts and angler catch card records for tracking trends in adult steelhead abundance (Kenaston 1989). Beginning in 1992, in an effort to conserve declining wild steelhead populations, ODFW began restricting the harvest of natural origin steelhead. Further restrictions were implemented in 1997, effectively eliminating the take of natural origin steelhead outside of the Rogue and Umpqua Basins where harvest is limited to one wild steelhead per week and five per year. The elimination or significant reduction in angler retention of natural origin steelhead has essentially eliminated the utility of using catch-card data for indexing trends in coastal Oregon natural steelhead populations. Starting in 1997, the Western Oregon Research and Monitoring Program of ODFW began developing integrated strategies for monitoring coastal salmonid populations. Part of these strategies was to develop monitoring methodologies for steelhead stocks. Historic data and published literature were reviewed in order to determine the best methods to monitor adult steelhead abundance. In 1998, pilot steelhead spawning surveys were implemented in selected coastal basins with the primary focus of developing survey methodologies and comparing survey counts above adult counting stations with known steelhead abundance (Susac and Jacobs 1998). Field studies in 1999 were intended to continue the evaluation of the relationship between survey count indices and adult passage (Jacobs et al. 2000). Further, exploratory surveys were conducted to develop a set of potential annual survey sites with a broad geographic distribution.

This chapter reports on year 2000 research activities. A budget shortfall that resulted in a funding reduction in 2000, and the addition of new work in the Smith River Basin forced dropping exploratory surveys. Project funded research activity was confined to the Smith River Basin and calibration surveys in Mill and Fishhawk Creeks. Smith River was added to the set of calibration sites for testing the reliability of survey methodology. This site provided the opportunity for testing survey methods in a large coastal basin. Population abundance was estimated by marking fish at Smith River Falls.

ASSESSMENT UNITS

The National Marine Fisheries Service has classified Oregon coastal steelhead into two ESUs (Busby et al. 1996). The *Oregon Coast ESU* includes populations occupying coastal basins south of the Columbia Basin south through Cape Blanco (Necanicum River through Sixes River). This ESU includes all coastal streams in this region as well as the entire Umpqua Basin. Winter steelhead dominate this ESU, except for native summer steelhead runs in the Upper Siletz Basin and the North Umpqua Basin. *The Klamath Mountains Province ESU* occupies river basins from the Elk River in Oregon to the Klamath and Trinity Rivers in California. In Oregon, this ESU includes all coastal basins from Elk River through the Winchuck River and the entire Rogue Basin. The Oregon portion of this ESU is also dominated by winter steelhead except for the summer steelhead run in the middle and upper Rogue Basin.

Kostow (1995) divides Oregon Coastal steelhead into three GCAs. The *Mid and North Coast GCA* occupies the exact same geographical area as the Oregon Coast ESU. The remaining two GCAs are partitions of the Klamath Mountains Province ESU. The *Cape Blanco to Border GCA* includes all coastal basins from Elk River south and the portion of the Rogue Basin upstream through the Illinois River Basin. The *Upper Rogue GCA* includes the portion of the Rogue Basin upstream from the mouth of the Illinois River that is accessible to anadromous forms of this species.

STUDY OBJECTIVES

Sampling was initiated in 1998 to work towards the goal of implementing a monitoring program for coastal winter steelhead stocks. Work priorities were identified to accomplish two major objectives. These objectives, along with associated work tasks are as follows:

OBJECTIVE 1. ASSESS THE FEASIBILITY OF CONDUCTING SPAWNER SURVEYS FOR WINTER STEELEHAD IN OREGON COASTAL STREAMS.

Task 1.1. Identify stream reaches where spawning occurs and that have potential as survey sites.

Task 1.2. Determine if spawner surveys can be conducted over the range of stream order and flow conditions present in winter steelhead spawning habitat during the spawning season.

Task 1.3. Develop methods for counting redds constructed by winter steelhead.

Activity 1.3.1. Determine the surveyors ability to distinguish steelhead redds form lamprey redds.

Activity 1.3.2. Determine the minimum longevity of steelhead redds in spawning streams.

Task 1.4. Determine the spawning season of winter steelhead in coastal streams.

Task 1.5. Determine if the ratio of wild to hatchery fish can be detected for spawning winter steelhead.

Task 1.6. Determine what information can be obtained for cutthroat and lamprey from winter steelhead spawning surveys.

OBJECTIVE 2. ASSESS THE RELIABILITY OF SPAWNER SURVEYS TO INDEX INTER-ANNUAL VARIATION IN THE ABUNDANCE OF COASTAL STOCKS OF WINTER STEELHEAD.

Task 2.1. Select watersheds where rigorous annual estimates of adult steelhead can be obtained**.**

Task 2.2. Estimate spawner abundance using trap catches or mark- recapture.

Task 2.3 Conduct spawner surveys in selected stream reaches upstream from trap sites to index population abundance.

Task 2.4. Compare population estimates to indices of spawner abundance derived from spawning surveys to assess reliability.

METHODS

No significant changes in spawner survey methodology occurred for studies conducted during the 2000 season. A detailed description of survey protocols and methodologies is provided in Susac and Jacobs (1998). Specific methodologies pertaining to the accomplishment of individual tasks are described in the corresponding task.

RESULTS

Objective 1 Results (Survey Feasibility)

Task 1.1, 1.2 (Spawning Surveys)

No exploratory surveys were conducted in 2000. Surveys were successfully conducted at randomly selected sites located throughout the Smith River Basin in 2000. These sites ranged in size from the mainstem Smith River to first order tributaries.

Task 1.3 (Distinction of Redds)

In 2000, our surveyors were comfortable with the criteria developed by Susac and Jacobs (1998) for distinguishing the difference between lamprey and steelhead redds.

Task 1.3 (Redd Longevity and Survey Recurrence Interval)

We were able to determine redd life on 148 redds in the Smith River basin in 2000. The absence of significant freshets after mid-January in the Smith River Basin allowed surveyors to identify redds for an extended period during the 2000 spawning season. Redd longevity ranged 7 to 92 days and averaged 40.7 days. The standard deviation of redd life was 16.9 days.

Longevity for steelhead redds observed in the Smith River Basin in 2000 is shown in Figure 4-1. Only 8.1% of the redds would have been missed had we surveyed on a two week reoccurrence interval. Further, had the surveys been conducted at monthly intervals surveyors would have still observed 74% of the possible redds.

Task 1.4 (Spawning Timing)

Steelhead spawning activity in the Smith River Basin was observed from the first week of January to the end of April, and peaked in mid March (Figure 4-2). This is less protracted than we have observed in other locations on the Oregon Coast (Jacobs et al. 2000.) Peaks in spawning activity were observed during mid February, mid-March and the end of March. Figure 4-2 also shows the cumulative percent of steelhead redds observed at weekly intervals for the Smith River Basin. Little spawning activity occurred prior to 1 February and spawning was complete by the end of April.

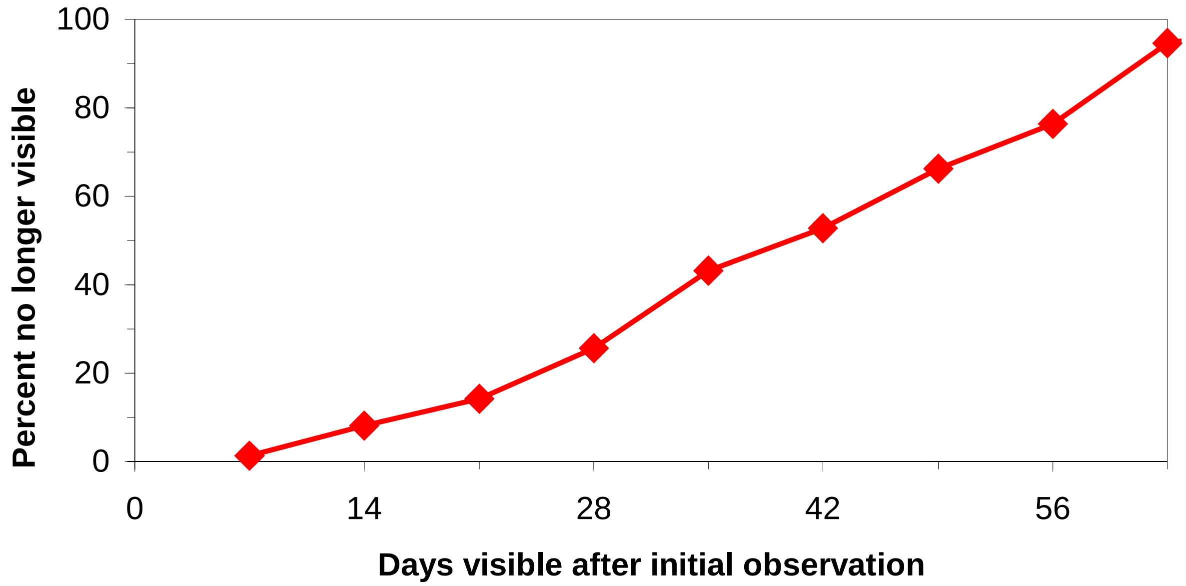

Figure 4-1. Longevity of steelhead redd visibility in the Smith River Basin, 2000. The figure shows the proportion of redds no longer visible at one-week intervals after initial observation.

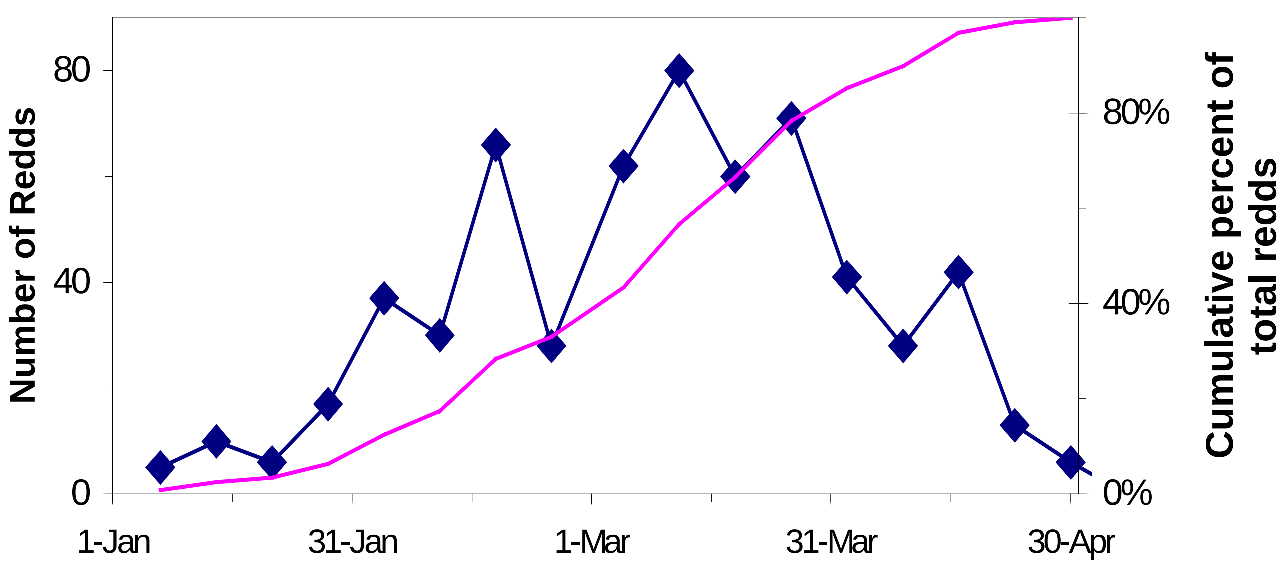

Figure 4-2. Number of new winter steelhead redds observed each week on random spawning surveys in the Smith River Basin, 2000.

Task 1.5 (Visual Detection of Hatchery Strays)

Currently, all of the steelhead smolts released from Oregon coastal hatcheries are adipose fin-clipped. We maintained statistics on surveyors' ability to visually detect fin-clips. Surveyors in Smith River were able to detect adipose fin-mark status for 45 of the 211 adult steelhead observed on spawning surveys. Of these 45 fish, one was fin-clipped for an overall hatchery rate of 2.2%. A total of 1,105 adults were observed for marks at the trap site at Smith River Falls. Twenty-nine were adipose fin-clipped. Hatchery origin adults comprised 2.6 % of the total run.

Task 1.6 (Lamprey)

Lamprey spawning activity was observed on 27 of the 47 (57%) of the surveys conducted in Smith River in 2000. A total of 113 live spawners and 933 lamprey redds were observed. Spawning density was greater in the mainstem and larger tributaries than in the smaller tributaries. The average number of redds per mile was 34.3 and 1.0 for mainstem and tributary reaches, respectively. The EMAP methodolgy yielded an estimate of 1,870 $\pm$ 501 (95%CI) lamprey redds in spawning areas above Smith River Falls. Figure 4-3 shows the spawning timing of lamprey in Smith River in 2000. The majority of spawning took place over a 4-week period starting the first week of April. This is very similar to what was observed in 1998 and 1999 in other coastal basins.

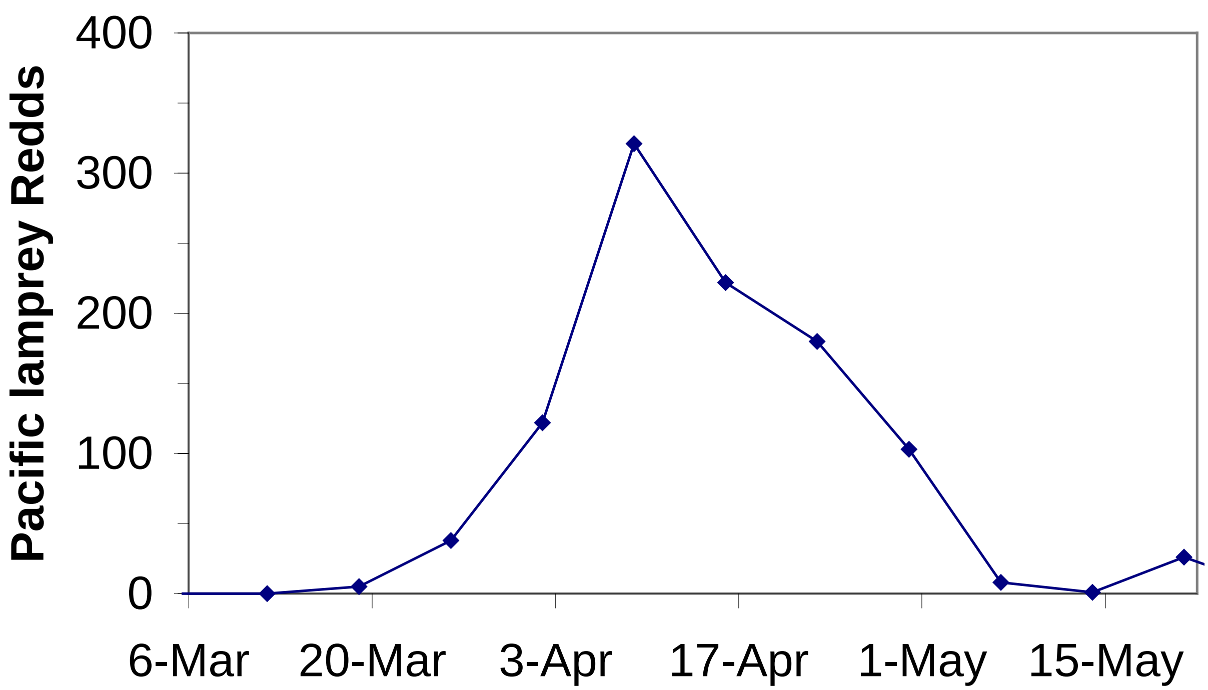

Figure 4-3. Timing of lamprey spawning in Smith River Basin, 2000.

Objective 2 (Survey Reliability)

Task 2.1. (Select watersheds where rigorous annual estimates of adult steelhead can be obtained)

The Smith River Basin upstream Smith River Falls was selected as an area to test survey reliability at the basin level. Smith River is a lower Umpqua River tributary and is located in northwestern Douglas County. Smith River Falls is located at river mile 29 and is an impediment for fish passage. There are 224 miles of steelhead spawning habitat above the falls.

Smith River was chosen for the following reasons: 1) the existence of adult trapping facilities in the fish ladder at the falls, 2) Smith River is relatively large in size, 3) there is little or no hatchery influence, 4) the stream flow regime is typical of Oregon coastal basins, and 5) the presence of a Life Cycle Monitoring Site on the West Fork Smith River that could be used to recapture tagged fish.

As in 1998 and 1999, spawning habitat was comprehensively surveyed for redds above fish counting stations on Fishhawk Lake Creek and Mill Creek (Yaquina Bay). Spawning habitat was also comprehensively surveyed for redds above the Life Cycle Monitoring Site on the West Fork of the Smith River.

Task 2.2. (Estimate spawner abundance using trap catches or mark- recapture).

A mark recapture experiment was conducted to determine the number of adult winter steelhead passing Smith River Falls. Adults were trapped in the fish ladder at Smith River Falls. Trapped fish had their sex determined, were measured for fork length to the nearest 0.5 cm, and were tagged with uniquely numbered brightly colored anchor tags (one on each side of the insertion of the dorsal fin). Scales were collected from a subsample of adults to document life history characteristics. After sampling, the adults were placed in a recovery area in the top end of the fish ladder. When fully recovered, adults volitionally exited the trap. Recovery of tagged adults occurred at the trap on the West Fork of the Smith River and by observation on spawning ground surveys. A Petersen mark recapture formula (Ricker 1975) was used to calculate the number of adults passing above Smith River Falls. Bootstrap techniques as described by Buckland and Garthwaite (1991) and Mooney and Duval (1993) were used to estimate variance, bias and confidence intervals of the population estimate. A detailed description of the procedure used is provided in Riggers et al. (1999).

Adult trapping was conducted from October 31, 1999 to May 15, 2000. Capture of adult steelhead occurred from mid December to the end of April. Peak capture took place during the week ending February 4 (Figure 4-4). A total of 428 male and 678 female steelhead were captured, tagged and released. One adult steelhead died as a result of the trapping and tagging operation during the 1999-2000 capture season.

Adults were tagged with sequentially numbered Floy dart tags. Two tags were placed on each adult to determine tag loss (one on each side at the base of the dorsal fin). A total of 270 double and 36 single tagged adults tagged were recovered at the West Fork Smith Trap. Using the method of Caughely (1977), the probability was 6.3% of losing a single tag and 4.0% of losing both tags.

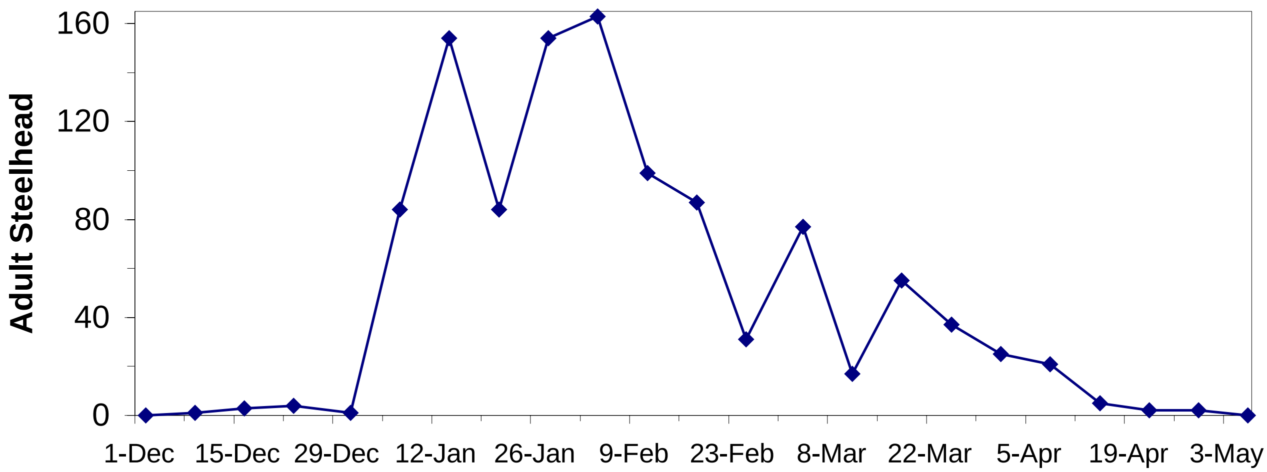

Figure 4-4**.** Weekly total of adult winter steelhead captured, tagged and released at Smith River Falls, 1999-2000 return year.

Each adult that was captured was measured to the nearest 5 mm fork length. Males averaged 672.5 mm and females averaged 668.2 mm. Table 4-1 shows the minimum, maximum and average length of adult steelhead captured at Smith River Falls.

Table 4-1 Length statistics of adult steelhead captured at Smith River Falls 1999-2000 return year.

Sex	N	Min length	Max Length	Average	Standard Deviation
Male	428	430	890	672.5	54.37
Female	678	450	870	668.2	52.86

Recapture of tagged adults occurred at the Life Cycle Monitoring Trap Site on the West fork of the Smith River located 7.5 miles upstream from the release site. Observations of positively identified tagged and untagged adults were also recorded on randomly selected stream reaches throughout the basin. Table 4-2 tabulates the recovery of adults by location during the 1999-2000 return year. The high-tagged rate observed on the mainstem surveys was probably due to sampling bias associated with the tags and survey methodology. Surveyors floated the mainstem surveys and often scared the fish before they saw them. The bright orange tags used to mark adults probably aided in the surveyor's ability to spot tagged adults. Because of this, it is likely that tagged fish observed on mainstem surveys do not accurately represent their true occurrence in the population. In contrast, the protocol used in tributary surveys minimizes spooking fish because surveyors approach fish from downstream locations. Also, the smaller channel size of tributaries enables surveyors to spot steelhead more easily than in mainstem areas. We did not observe a difference in tag rate between fish observed in upper and lower river tributaries.

Table 4-2. Recovery of tagged and non-tagged adults at the West Fork Smith River Trap and on randomly selected spawning ground surveys in the Smith River Basin 1999-2000 return year.

Location	Tagged	Not Tagged	Percent Tagged	Total
Tributary Surveys	34	19	64%	53
Mainstem Surveys	20	1	95%	21
West Fork Smith Trap	320	89	78%	409

Three separate estimates of adult steelhead run size were calculated (Table 4-3). The first estimate was calculated based on recoveries only from the West Fork Trap. The second estimate was based on recoveries from spawning surveys located in tributaries. We excluded recoveries in mainstem surveys because of the potential bias mentioned above. The third estimate was based on the pool of recoveries from tributary surveys and recoveries from the West Fork Trap. We believe that the third estimate is the most accurate and therefore it was used for assessing the reliability of survey-based estimates.

Table 4-3. Population estimate statistics using different recovery sites and combinations of recovery.

Recovery Location	Peterson Estimate	Bootstrap Analysis				
		Average	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Bias[a]	Precision[b]
West Fork Trap	1,411	1,409	1,351	1,472	-2.18	4%
Tributary Surveys	1,755	1,718	1,428	2,139	-37.10	24%
West Fk. and Tributary Surveys	1,441	1,440	1,380	1,508	-0.76	5%

a *Difference of average bootstrap estimate and Peterson estimate.*
b *Upper 95% confidence limit / average bootstrap estimate.*

Task 2.3 Conduct spawner surveys in selected stream reaches upstream from trap sites to index population abundance.

We implemented a random sampling design to estimate the abundance of steelhead redds in the Smith River basin upstream from Smith River Falls. Our intent was to estimate the number of redds within a target precision of $\pm$ 30%. The sampling design and estimation methods followed those described for coho in Chapter 2, except that samples were separated into mainstem and tributary strata. The tributary stratum consisted of our coverage of coho spawning distribution upstream from Smith River Falls. The mainstem stratum was comprised of the portion of the basin downstream from coho spawning distribution and upstream fro Smith River Falls. We added a third stratum to include upper mainstem reaches upstream from the South Fork because this portion of the basin was initially omitted from our sampling. Sample sizes for each stratum were derived using procedures described in Cochran (1977). Estimates of expected variance were based on redd surveys conducted in the North Nehalem Basin in 1988. We included the finite population correction because our sampling rate exceeded 10%.

Overall, we conducted 47 surveys to estimate redd abundance (Table 4-4). This sample size equated to an overall sampling rate of 23% of the sampling frame. We estimated that there were 1,438 winter steelhead redds in the Smith River Basin upstream from Smith River Falls. Our target level for the precision was essentially met for the overall redd estimate. Redd density was generally uniform among the three sampling strata at about seven redds per mile.

Table 4-4. Estimates of winter steelhead spawner abundance in the Smith River Basin upstream from Smith River Falls, 2000. Estimates are derived from redd counts on randomly selected spawning surveys.

		Survey Effort		Redds		Female Spawners[a]		Total Adult Spawners[b]	
Stratum	Spawning miles	N	miles	estimate	95% Conifi-dence Interval	estimate	95% Conifi-dence Interval	estimate	95% Conifi-dence Interval
Lower Mainstem	50	24	24.4	354	127	253	119	411	194
Upper Mainstem	12	3	2.5	87	38	62	33	102	54
Tributaries	136	20	18.5	997	427	712	377	1,159	614
Total	198	47	45.4	1,438	447	1,027	397	1,672	646

a *Derived by multiplying redd estimates by average of redd to female ratios from calibration sites that were comprehensively surveyed in 2000 (Fishhawk Lake Creek, Mill Creek Yaquina Basin and West Fork Smith River).*

b *Derived by dividing female spawner estimates by the proportion of females in the trap catch at Smith River Falls in 2000.*

Even though our random redd surveys were designed to estimate the number of redds above Smith River Falls it is possible to extrapolate back to the number of adults responsible for the estimated redd deposition. The redd-based estimate can then be compared with the mark recapture population estimate as an additional measure of survey reliability. Table 4-4 shows estimates of adult steelhead spawning abundance extrapolated from redd counts above Smith River Falls. To obtain spawner abundance estimates we applied estimates of redd:female and male:female ratios to redd estimates. The resulting overall population estimate was 1,672 adults, 232 fish or 16% higher than our mark-recapture estimate.

Task 2.4. (Compare population estimates to indices of spawner abundance derived from spawning surveys to assess reliability)

In 2000, we continued testing the reliability of spawner survey counts for indexing winter steelhead abundance by comparing survey counts with known adult abundance at calibration sites. As in 1998 and 1999, we obtained reliable steelhead passage counts at Mill Creek Yaquina and at Fishhawk Lake Creek. We added the West Fork Smith River above the Life Cycle Monitoring Trap-site and dropped surveys on Mill Creek Siletz. We comprehensively surveyed the spawning habitat above the weirs at each of these sites for redds and live adults. Statistics of fish passage and survey counts for each calibration site are listed in Table 4-5. The relationship between female adult passage and redd counts (Figure 4-5) continues to be strong (R^2=.0.99, P< 0.001), suggesting that redd counts are a consistent indicator of run size over female runs sizes from 17 to 900 fish. This relationship includes the female population and total redd estimate from the study area of Smith River above the falls. The magnitude of the two data points from the Smith River basin drives the relationship displayed in Figure 4-5. Omitting these points reduces the quality of the relationship (R^2=0.72, P< 0.008).

Table 4-5. Number of adult male and female winter steelhead passed at fish counting stations and redd counts for 1998-2000 return years.

Year	Monitoring Site	Females Passed	Males Passed	Survey Miles	Redds Observed	Redds/ Female	Redds/ Adult
1998	Fishhawk Cr.	17	18	11.6	18	1.06	0.51
1998	Siletz R, Mill Cr.[a]	86	89	10.2	75	0.87	0.43
1998	Yaquina R, Mill Cr.	20	27	2.2	15	0.75	0.32
1999	Fishhawk Cr.	22	33	11.6	22	1.00	0.40
1999	Siletz R, Mill Cr. [a]	48	40	10.2	48	1.00	0.55
1999	Yaquina R, Mill Cr.	28	28	2.2	27	0.96	0.48
2000	Fishhawk Cr.	29	30	11.6	41	1.41	0.69
2000	West Fk Smith R. [a]	274	179	16.7	326	1.19	0.72
2000	Yaquina R, Mill Cr.	32	21	2.2	51	1.59	0.96

a *Monitoring site is not a complete barrier. Adult passage estimated using mark-recapture techniques (Solazzi et al. 2000).*

Two calibration sites that have been consistently monitored over the last three years: Fishhawk Creek in the Nehalem Basin and Mill Creek in the Yaquina Basin. Neither of these sites has shown a consistent relationship between the number of redds counted and the number of adults trapped and passed. Although it is difficult to make conclusions with only three data points, results from these sites would suggest that redd counts may not be a reliable metric of adult run size. Redd to adult ratios are variable between sites and between the different sample years (Table 4-5). However, the limited size of the watersheds and the small spawner populations of these two sites, coupled with the high propensity of adult steelhead to move extensively prior to spawning, may contribute to the variation of these ratios. Clearly, more data are needed to assess the reliability of redd counts for indexing steelhead abundance. Additional data points from Smith River will be most useful because of its large size and productive steelhead run.

Despite our inability to verify that redd counts are a reliable monitoring tool for coastal steelhead stocks, we need to move forward with implementing a monitoring program. Currently, there is no systematic monitoring program in place for these stocks. Findings to date show that spawning surveys can be conducted over the range of habitats and throughout the season that coastal steelhead use for spawning. Redd counts appear to be the best measure of spawner abundance. Further, the relatively extended visibility of redds provides flexibility and efficiency that could be incorporated into sampling designs to reduce costs. An example of this efficiency would be conducting surveys on a two-week rotation to maximize the coverage by a given survey crew. The additional advantage that redds counts have is their demonstrated ability to also monitor trends in lamprey abundance.

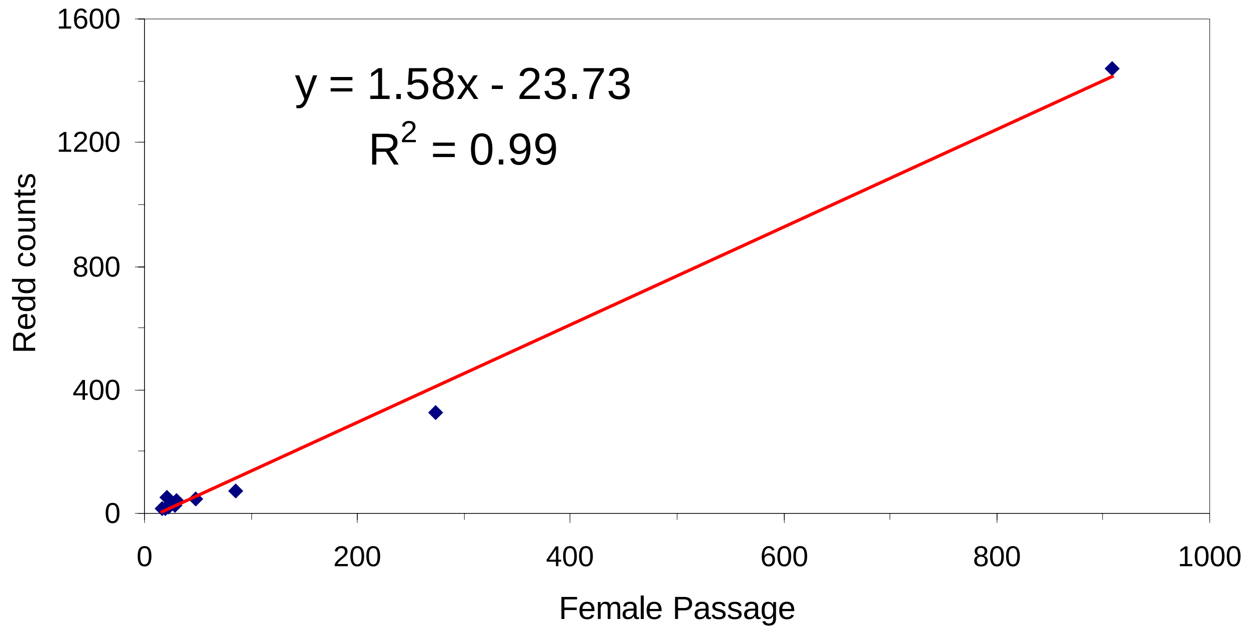

Figure 4-5. Relationships between adult winter steelhead passage and redd counts above calibration sites in 1998, 1999 and 2000.

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