THE OREGON PLAN for Salmon and Watersheds

Status of Oregon Coastal Stocks of Anadromous Salmonids, 2000-2001 and 2001-2002

Report Number: OPSW-ODFW-2002-3

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Steven Jacobs
Julie Firman
Gary Susac
David Stewart
Jared Weybright

Coastal Salmonid Inventory Project
Western Oregon Research and Monitoring Program
Oregon Department of Fish and Wildlife
28655 Highway 34
Corvallis, OR 97333

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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 2001 brood year for salmon and the 2002 brood year for steelhead. Status is generally assessed along two levels of geographic aggregation: Evolutionary Significant Units (ESUs) and Gene Conservation Areas (GCAs) or Monitoring Areas (MAs). ESUs were defined by the National Marine Fisheries Service in conducting reviews for protection under the federal Endangered Species Act. GCAs and MAs are usually subsets of 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 52 years. There are four GCAs within the Oregon Coastal ESU. Spawner abundance trends are available for each GCA over a 16-year period form 1986-2001. 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, North-Mid Coast and Mid-South Coast GCAs have remained stable, whereas fall chinook in the Umpqua GCA increased dramatically. The North-Mid Coast GCA is composed of fall chinook stocks originating from three Basin Complexes. Trends in these Basin Complexes differ. Over the past 16 years, no trends are apparent for the Siletz-Alsea Complex however counts obtained in 2001 represent a record high spawner abundance for this complex. Similar to the Siletz-Alsea Complex, spawner density in the Siuslaw Basin Complex does not show a trend over the last 16 years and counts observed in 2001 were slightly below the record high of 1988. In contrast, there is a declining trend in spawner abundance of fall chinook stocks in the Tillamook-Nestucca Complex.

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 42-year period that coastal populations of this ESU have been monitored, spawner abundance has shown relatively high variation. A general decline occurred during the period of 1970-90. Since 1990, Southern Oregon coastal stocks have shown in increasing trend in spawner abundance. Counts in 2001 represent the fourth highest spawner abundance on record and a record high since survey effort was enhanced in 1986. Spawner populations of interior stocks of the Rogue Basin have fluctuated between two general levels of abundance during the 25-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 abundance of South Coast fall chinook has 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 MAs within the Oregon Coastal ESU. The South Coast MA 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 52-year period of record. However, the level of both spawner escapement and pre-harvest abundance observed in 1999-2001 continue to show improvements from the record low levels observed in 1997 and 1998. Indexes of adult recruits per spawner are available for the 1950-98 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 the period of the mid-1970s to the mid-1990s. Since 1995 there has been an increasing trend in survival. The value of 4.5 recruits per spawner observed for the 1998 brood year is the highest observed in the last 12 years.

Estimates of the abundance of adult coho spawners within the four MAs 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 over 160,000 adults in 2001. Using a relationship between abundance in the Standard Index and random spawner surveys to calibrate historic abundance estimates shows the abundance of spawners in the Oregon coastal ESU in 2001 to be the largest occurring since 1971. Among the four MAs, spawner abundance has generally been lowest in the North Coast MA and highest in the Mid-South Coast MA. In the North Coast MA, spawner abundance has averaged about 8,000 adults, and has ranged from about 2,200 adults to about 34,000 adults. Conversely, in the Mid-South Coast MA, spawner abundance has averaged more than 26,000 adults and been as high as 74,000 adults in 2001. The most productive basins in this MA 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 estimate of naturally produced adult coho is available for a 21-year period beginning in 1980. During this period, run size has ranged from about 300 adults in 1993 to near 12,200 adults in 2001. Significant harvest occurred during 1980-90. Given this, total stock abundance peaked at about 14,000 adults in 1981 and in 2001. Spawning surveys in randomly selected stream reaches show the Lower Applegate, Upper Illinois, Evans Creek and Little Butte Creek Basins to be important areas for coho production in the Rogue Watershed.

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. With the exception of the Mid-Coast MA in 1998, wild fish were the dominant component of natural spawner populations in all Monitoring Areas over the last four years. Coded-wire tag recoveries that were recovered in 2000 and 2001 showed that most hatchery strays originated from Lower Columbia River hatchery facilities.

Chum

All Oregon coastal stocks of chum salmon are part of the Pacific Coast ESU. This ESU encompasses all 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 54-year period. Coastal chum abundance reached record low levels in 1996. Spawner abundance observed in 2001 showed a marked increase from that occurring during the prior eight years.

Monitoring of chum populations in the Nehalem Basin, Netarts Bay and Yaquina Bay chum populations was initiated in the late 1980s and early 1990s. Two of these populations (Nehalem and Yaquina) showed record high abundance in 2001.

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 have completed five years of research evaluating the feasibility of conducting spawning surveys for Oregon coastal steelhead. We found that surveys could be successfully conducted over the range of stream order and throughout the season (late January-mid May) that are used for spawning. We also found that redds are the best field metric for indexing spawner abundance and we developed criteria for distinguishing steelhead redds from lamprey redds.

We have completed three years of a study to evaluate of spawner surveys in Smith River (Umpqua Basin). We estimated that between 1,440 and 19,00 wild adult winter steelhead passed the trap site at Smith River Falls during these three years. 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, estimates of total redds ranged between 1,300 and 1,800 in this portion of the basin.

We found a highly significant relationship between steelhead spawner abundance and the number of redds counted upstream from four calibration sites over the last five years. This relationship suggests that redd counts may provide a reliable means of indexing the abundance of Oregon Coastal steelhead. We also found that in the Smith River basin, the ratio of female spawners to estimated redds was very consistent during the last three years (range of 1.59 to 1.63). We plan to initiate coast-wide spawning surveys in 2003 to monitor Oregon coastal steelhead.

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 Native Fish Conservation 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*). Jacobs et al. (2001) reports of survey based assessments for these species through the 1999 run year.

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 2001. Specifically, results of the 2000-2001 and 2001-2002 seasons are presented. Data from individual survey sites is not presented in this report. Survey data is 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 steelhead, 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 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 surveyed 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 fish and to counts redds. 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.

Carcasses of spawned-out salmon and steelhead encountered in all surveys were inspected for tags and fin-clips. Salmon 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.

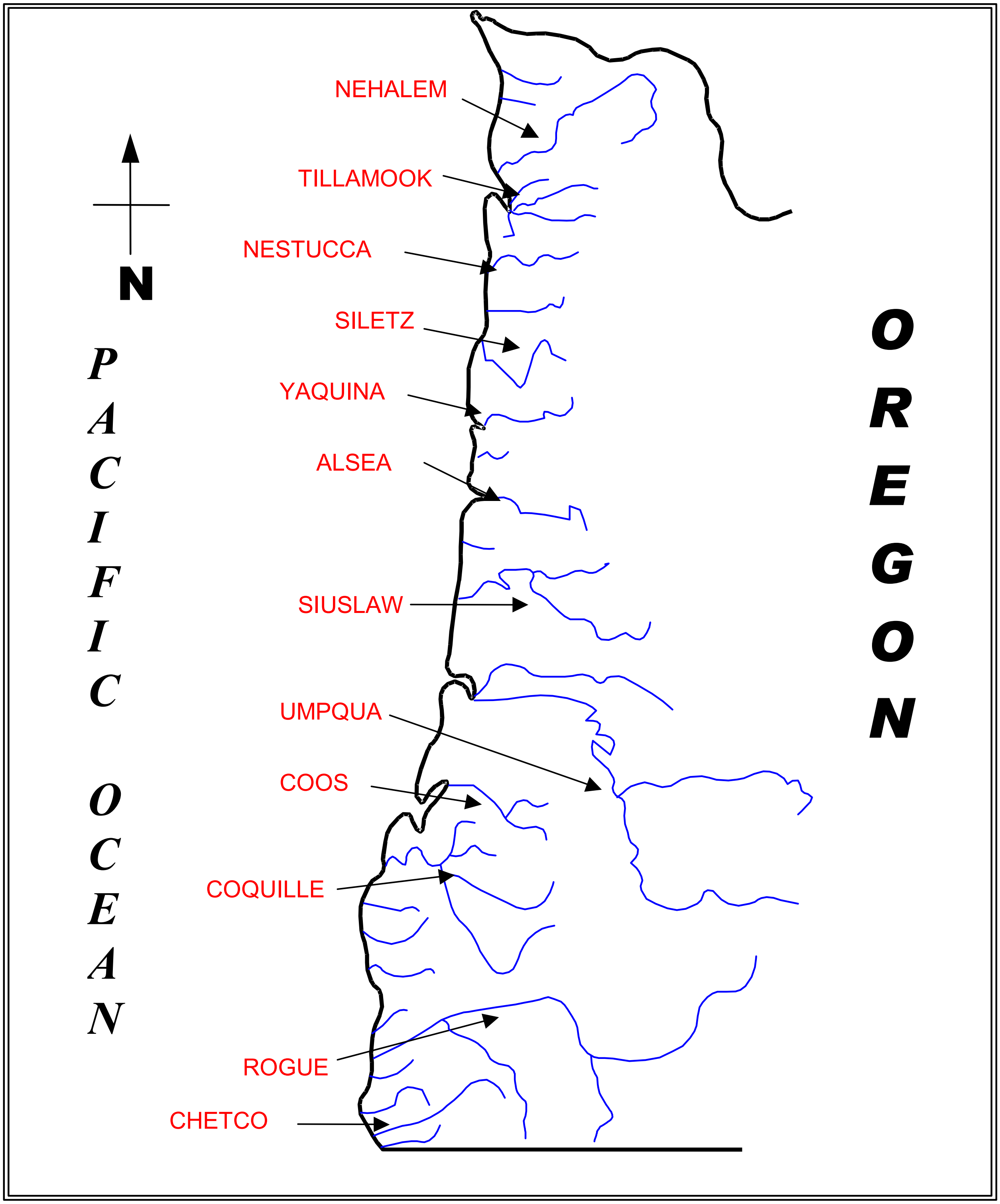


Figure i-1. Map of the Oregon coast showing major river basins.

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 2000 and 2001 survey seasons for representative Oregon coastal river basins. Also shown are limits of the of the 80^{th} and 20^{th} percentiles of mean daily flows for the 40-year period back through 1957. Relative to long-term average conditions, 2000 was an extremely dry spawning season. During most of the season, stream flow remained below average levels. There were no significant freshets. Fish gained access to some survey sites on the flow events that occurred in late November and late December but the magnitude of these events was insufficient to allow access to many of the smaller tributaries. These conditions can have mixed effects on spawning surveys. Little disruption of sampling schedules occurs under persistent low flow conditions, however these conditions can also alter spawner distribution and delay spawn timing.

Stream flow during the 2001 survey season was much closer to long-term average conditions. Spawners were able to gain access to mainstems and larger tributaries beginning with the small flow events that occurred in late October. By mid November, frequent freshet events provided ample opportunities for spawners to access all available spawning streams. The two large events in December and March disrupted surveys. 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.

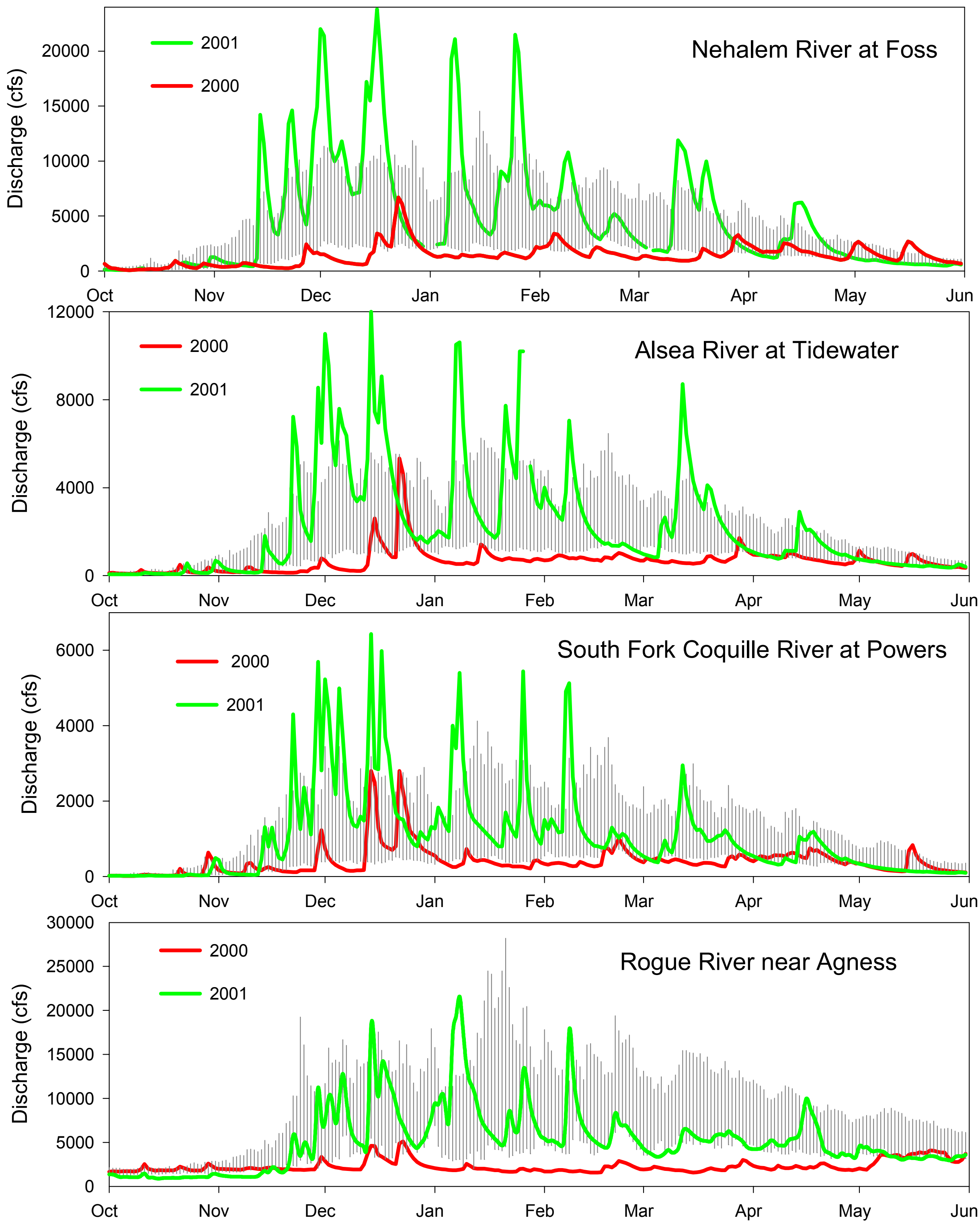


Figure i-2. Daily mean river discharge in cubic feet per second by Surface Water Station for the 2000 and 2001 spawning survey seasons (2001 and 2002 USGS water years) (Miller 1997). Vertical bars represent limits of the 80th and 20th percentiles of mean daily flows for the 40-year period back through 1957. Data obtained at: http://water.usgs.gov/.

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, Jacobs 2002a). 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 is 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.

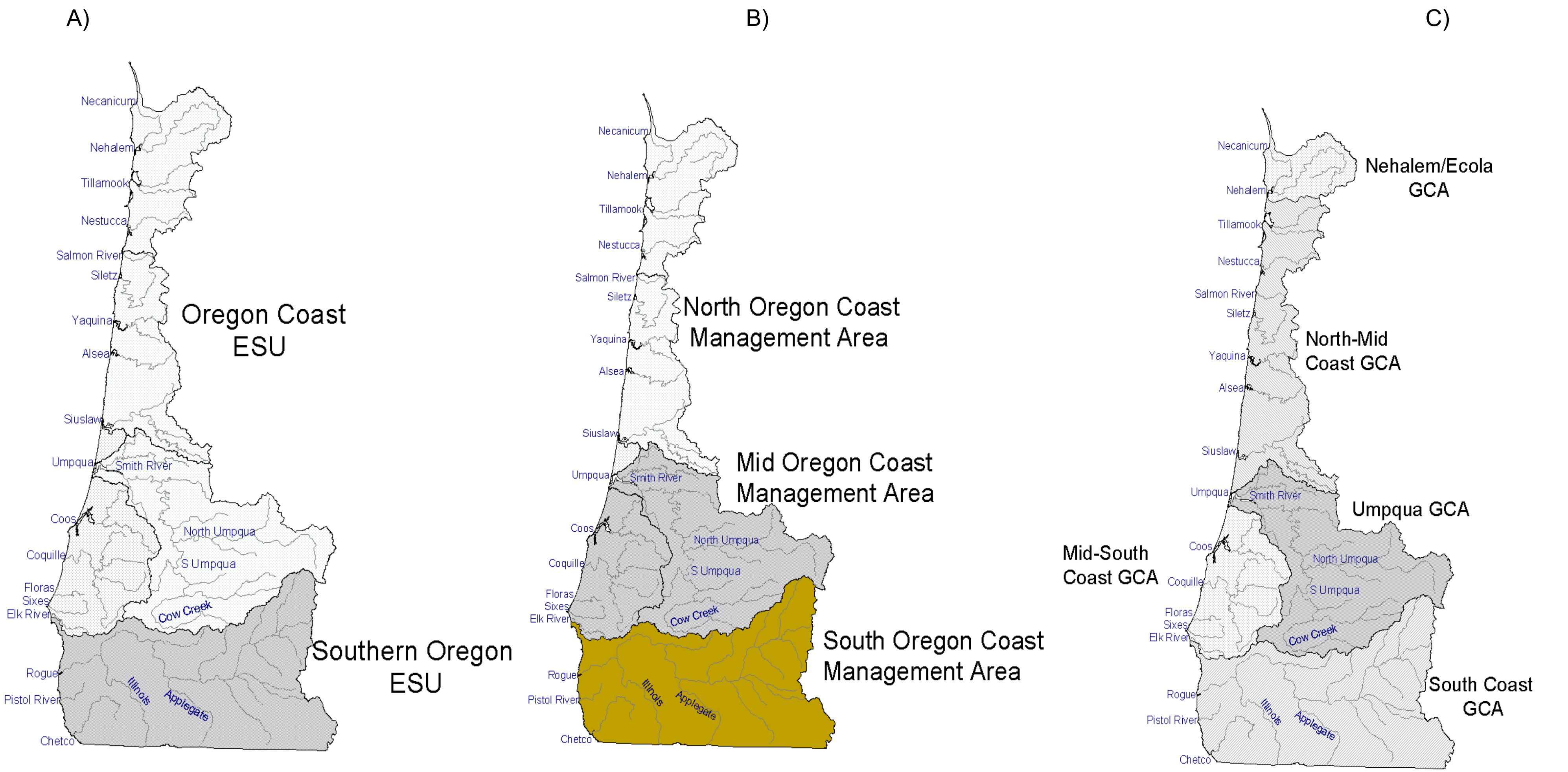


Figure 1-1. Geographic strata for Fall Chinook Salmon for coastal areas in the state of Oregon. A) Evolutionary Significant Units (ESUs) as defined by the National Marine Fisheries Service. B) Fishery Management Areas as defined by the Chinook Technical Committee of the Pacific Salmon Commission. C) 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 during the time when Standard Index sites were selected. 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 portions of the 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 years that would result in returns of age 2-5 spawners (1996-99 for 2000: 1997-2000 for 2001); 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 either of the spawning seasons. 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:

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

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:

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

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:

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

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, 2000 and 2001. 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 2000	Classification 2001
Nehalem/Ecola Gene Conservation Area				
Nehalem:				
Mainstem	Cook Creek	1.0	W	W
	Cronin Creek	1.0	W	W
	Humbug Creek	1.0	W	W
	East Humbug Creek	1.2	W	W
North Fork	Soapstone Creek	0.7	W	W
Salmonberry R.	Salmonberry River	0.5	W	W
North Mid Coast Gene Conservation Area				
Kilchis	Clear Creek	0.6	B	W
	Little South Fork, Kilchis River	1.0	W	W
Wilson	Little North Fork, Wilson River	0.5	W	W
	Cedar Creek	2.8	W	W
Tillamook	Tillamook River	1.8	W	W
	Simmons Creek	0.6	W	W
Nestucca	Clear Creek	0.8	W	W
	Niagara Creek	0.4	W	W
Siletz:				
Mainstem	Cedar Creek	1.6	W	W
	Euchre Creek	1.0	W	W
	Sunshine Creek	1.2	W	W
Rock Creek	Big Rock Creek	0.9	W	W
Yaquina	Upper Yaquina River	2.0	W	W
	Salmon Creek	0.6	W	W
Alsea:				
Drift Creek	Lower Drift Creek	1.5	W	W
Five Rivers	Lower Lobster Creek	2.2	W	W
	Buck Creek	1.0	W	W
North Fork	North Fork Alsea River	1.5	W	W
Siuslaw:				
Mainstem	Sweet Creek	0.5	W	W
	Lower Whittaker Creek	0.3	W	W
	Upper Whittaker Creek	0.4	W	W
	Esmond Creek	1.0	W	W
North Fork	North Fork Siuslaw River	0.8	W	W
Lake Creek	West Fork Indian Creek	1.2	W	W
	Rogers Creek	1.3	W	W
	Lake Creek	0.8	W	W

Table 1-1. Continued.

River basin or subbasin	Stream segment	Miles	Classification 2000	Classification 2001
Mid South Coast Gene Conservation Area				
Coos:				
Millicoma River	West Fork Millicoma River	0.5	F	F
	East Fork Millicoma River	0.5	W	W
South Fork	South Fork Coos River	1.0	W	W
	Williams River	1.0	W	W
Coquille:				
North Fork	North Fork Coquille River	1.0	W	W
	Middle Creek D	2.0	W	W
East Fork	Lower East Fork Coquille River	1.0	W	W
	Upper East Fork Coquille River	0.3	W	W
Middle Fork	Middle Fork Coquille River	0.5	W	W
	Rock Creek	0.5	W	W
South Fork	South Fork Coquille River	1.0	B	B
	Lower Salmon Creek	0.8	W	W
Floras Creek	Upper Floras Creek	0.5	W	W
Sixes River	Lower Dry Creek	1.7	W	W
	Upper Dry Creek	1.7	W	W
South Coast Gene Conservation Area				
Euchre Creek	Upper Euchre Creek	1.0	W	W
Rogue River				
Lower Mainstem	Jim Hunt Creek	0.8	F	F
	Upper Lobster Creek	1.0	B	W
Mid Mainstem	Rogue River (Middle A)	3.3	W	W
	Rogue River (Middle B)	10.9	W	W
Applegate River	Applegate River (Lower)	3.0	W	W
	Slate Creek	1.0	W	W
	Applegate River (Middle)	2.2	W	W
	Applegate River (Upper)	4.9	W	W
Hunter Creek	Upper Hunter Creek	1.0	F	W
Pistol River	Deep Creek	0.4	W	W
Chetco River	Big Emily Creek	1.0	W	W
Winchuck River	Bear Creek	0.8	W	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 generally occurs in mid-to-late November in the four northern GCAs and as late as mid December in the South Coast GCA. Flow-related survey conditions varied dramatically between the 2000 and 2001 seasons (Figure i-2). Extreme drought conditions persisted throughout the 2000 spawning season. These conditions resulted in extremely low stream flows in all coastal basins. One exception to this general pattern occurred in the mainstem Rogue and Applegate Rivers where reservoir augmentation moderated low flows to some degree. These low flow conditions had mixed effects on spawner surveys. Although surveys were not disrupted by high water, the lack of freshets limited spawner access to some survey sites.

In 2002, rainfall induced rises in stream flow began in late October and continued regularly throughout the chinook spawning season. This flow pattern allowed spawners free access to all available spawning habitat. The relatively large freshets in December hindered surveys in some sites. This affected counts of some of the later spawning populations, however except for populations in the coastal portion of the South Coast GCA most spawning is complete by mid December.

Spawning Timing

Observation of Oregon coastal fall chinook in natural spawning areas from mid October through January during the 2000 and 2001 spawning seasons are shown in Figure 1-2. Despite the drought conditions that persisted throughout the 2000 spawning season compared to the more normal stream flow conditions that occurred in 2001, spawning timing during the two seasons was similar. Among the five regions depicted in Figure 1-2, spawning occurs over a more contracted time frame in Nehalem/Ecola GCA and Interior Rogue portion of the South Coast GCA than in other GCAs.

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 1-3). 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 1-3, 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.

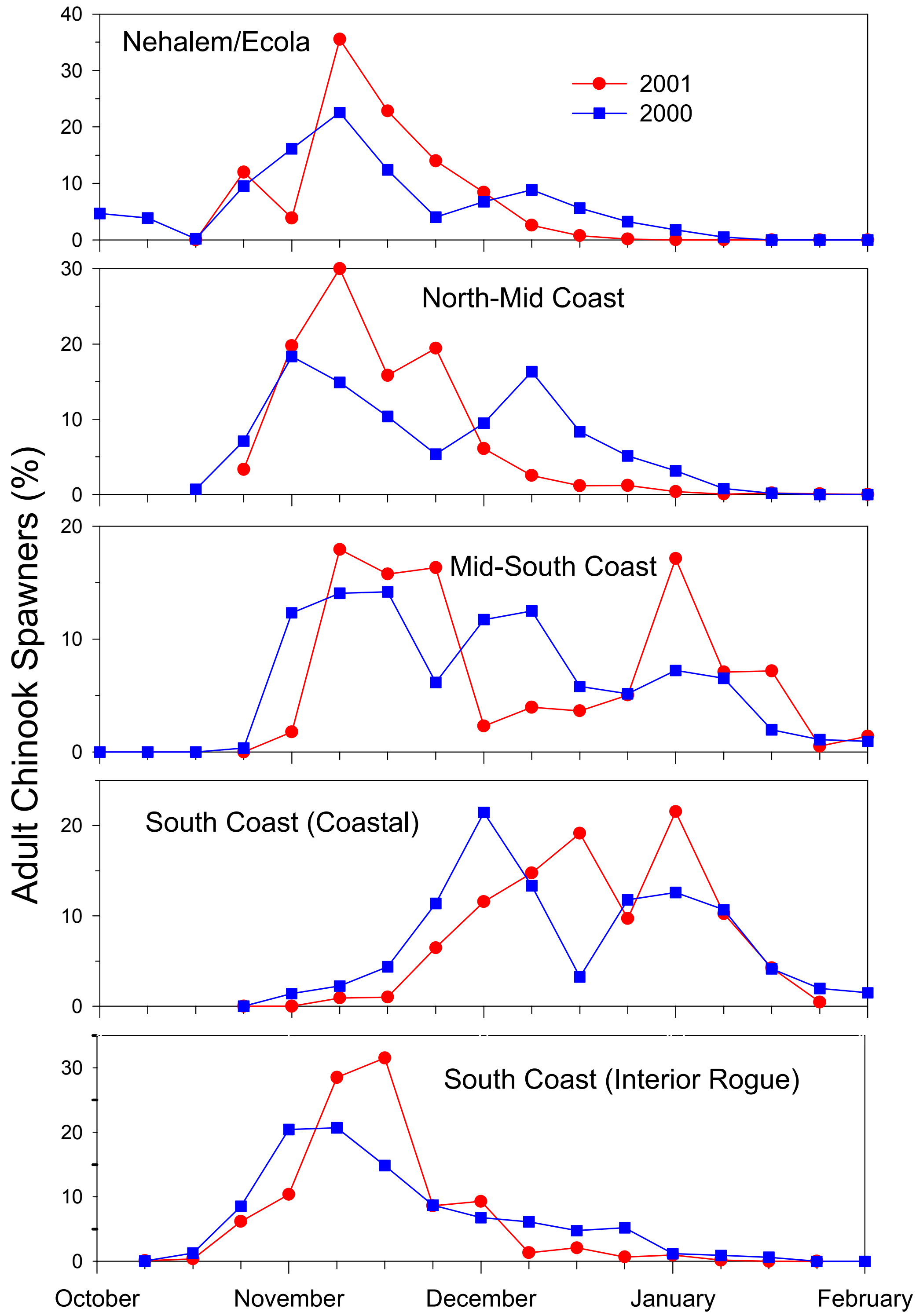


Figure 1-2. Temporal distribution of counts of adult chinook in standard and supplemental surveys during the 2000 and 2001 spawning seasons. Distributions in all areas except the South Coast (Interior Rogue) based on counts of live fish. The distributions in the South Coast (interior Rogue) are based on spawned carcasses.

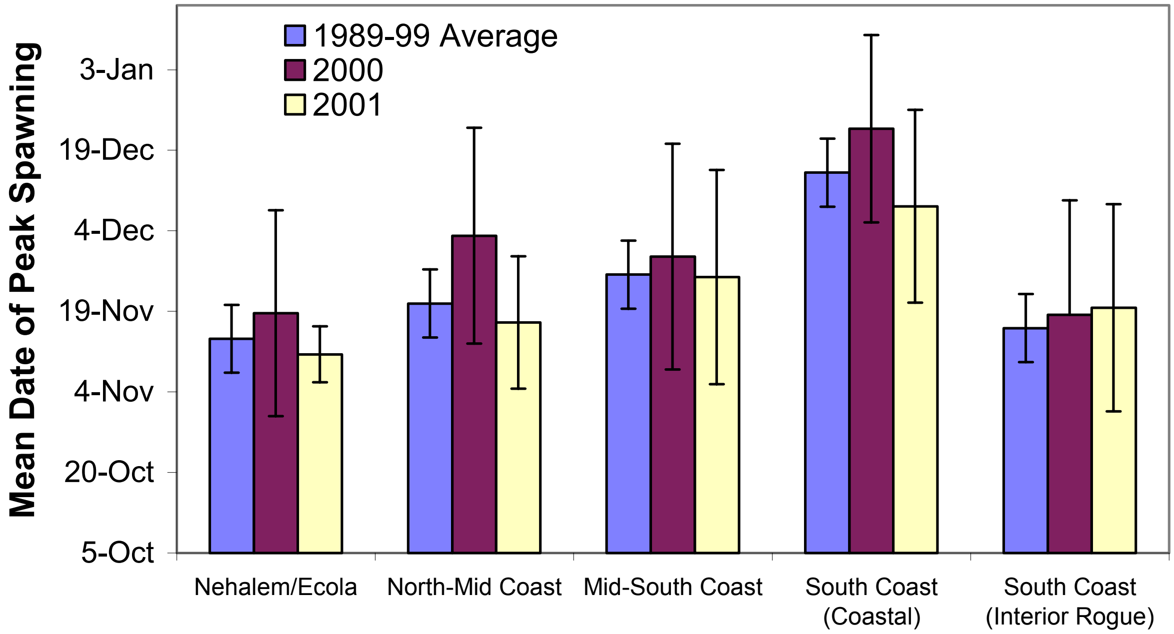


Figure 1-3. Mean date when peak counts of fall chinook were observed in standard survey areas within each Gene Conservation Area, 1988-1999, 2000 and 2001. Vertical lines represent one standard deviation about the mean.

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.

Index of Spawner Abundance

Results of standard surveys conducted for fall chinook in 2000 and 2001 summarized by GCA are listed in Table 1-2. All 60 index segments were surveyed in 2000. In total, over 850 miles of stream was visited over the course of the survey season to obtain abundance indices. In 2001, all sites except Middle Creek, Coquille River were surveyed. Landowner denial prevented the survey from being conducted until well into the spawning season. By this time peak spawning activity had already occurred.

Peak densities of adults in the Mid-South GCA and adults and jacks in the coastal portion of the South Coast GCA were the highest observed since the chinook survey program was expanded in 1986. 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 2000 and 2001.

Gene Conservation Area	Survey segments		Cumulative miles surveyed	Mean peak count per mile	
	Number	Total miles		Adults	Jacks
			2000		
Nehalem/Ecola	6	5.4	51.9	42.3	1.7
North-Mid Coast	26	29.0	259.5	47.6	3.4
Mid-South Coast			103.7	68.0	6.3
South Coast:	15	14.0			
Coastal	7	6.0	32.4	57.3	7.2
Interior Rogue[a]	6	25.3	253.7	134.3	7.6
Total	60	79.7	852.7	--	--
			2001		
Nehalem/Ecola	6	5.4	59.6	74.7	1.3
North-Mid Coast	26	29.0	258.4	99.2	6.5
Mid-South Coast	14	12.0	86.6	108.1	9.0
South Coast:					
Coastal	7	6.0	35.2	101.3	22.0
Interior Rogue[a]	6	25.3	211.5	252.2	30.3
Total	59	77.7	651.3	--	--

a *Cumulative count of spawned carcasses.*

Occurrence of Hatchery Fish in Natural Spawning Areas

Based on our criteria listed on page 12, few standard survey sites are influenced by fish culture activities (Table 1-1). In 2000, three of the 60 sites were in close proximity to fed fish releases and two were in close proximity to brood stock capture operations. In 2001, only two sites were near locations of fed fish releases and one site was close to the location of a brood stock capture program. Thus, if returning hatchery chinook home precisely to their point of release few hatchery fish should stray into standard index sites, and counts in these sites should be composed overwhelmingly of wild fish.

A portion of hatchery-reared fall chinook released from Oregon hatcheries are coded-wire tagged prior to release (Lewis 2002). These fish can be identified in spawning surveys as carcasses possessing an adipose fin-clip. Table 1-3 list the occurrence of coded-wire tagged hatchery fish recovered in natural spawning areas in 2000 and 2001 from all surveys conducted in each year. A total of 28 recoveries occurred in 2000 and 120 occurred in 2001. Basins having concentrations of recoveries included the Necanicum, Coquille, Sixes, Lower Rogue and Chetco. Among these basins, recoveries of hatchery spawners occurred in, or near to standard survey sites in the Sixes and Lower Rogue Rivers. These results are generally consistent with the results of the classification criteria of standard survey sites where most sites index primarily wild fish.

Table 1-3. Hatchery-reared fall chinook possessing coded-wire tags that were recovered on spawning surveys in Oregon Coastal Basins, 2000 and 2001.

Recovery				Release			
Basin	Subbasin	Number	Average Recovery Date	Hatchery	Average Brood Year	Stock	Release Site
2000							
Alsea R.	Drift Creek	1	1/5/01	Elk R.	97	Elk R.	Elk R.
Coos R.	Millicoma R.	1	11/25/00	Priorli Cr.	98	Coos R.	Morgan Cr
Coos R.	Millicoma R.	3	11/11/00	Priorli Cr.	96	Coos R.	Morgan Cr
Floras Creek	Main Stem	2	1/20/01	Elk R.	97	Elk R.	Elk R.
Sixes R.	Main Stem	2	12/26/00	Elk R.	96	Elk R.	Elk R.
Sixes R.	Main Stem	11	1/8/01	Elk R.	96	Elk R.	Elk R.
Rogue R.	Main Stem	2	12/8/00	Indian Cr.	97	Lwr. Rogue R.	Lwr. Rogue R.
Rogue R.	Lobster Creek	3	11/21/00	Indian Cr.	97	Lwr. Rogue R.	Lwr. Rogue R.
Chetco R.	North Fork	2	12/23/00	Elk R.	97	Chetco R.	Chetco R.
Winchuck R.	Main Stem	1	12/28/00	Elk R.	95	Chetco R.	Chetco R.
2001							
Necanicum R.	Main Stem	7	11/29/01	Nehalem	97	Trask	Necanicum R.
Kilchis R.	Main Stem	1	12/13/01	Trask	97	Trask	Trask R
Wilson R.	Little North Fork	1	12/9/01	Trask	97	Trask	Trask R
Yaquina R.	Main Stem And Bay	1	12/10/01	Salmon R.	98	Yaquina Bay	Yaquina R.
Yaquina R.	Main Stem And Bay	2	11/30/01	Yaquina Bay	97	Siletz R.	Yaquina R.
Alsea R.	Drift Creek	1	1/3/02	Elk R.	97	Elk R.	Elk R.
Alsea R.	Five R.	1	12/31/01	Elk R.	97	Elk R.	Elk R.
Coquille R.	Main Stem And Bay	2	11/16/01	Butte Falls	96	Coquille R.	Ringold Pond
Coquille R.	Main Stem And Bay	9	11/13/01	Butte Falls	97	Coquille R.	Sevenmile Cr.
Coquille R.	East Fork	1	--	Butte Falls	97	Coquille R.	Sevenmile Cr.
Floras Creek	Main Stem	1	12/27/01	Elk R.	98	Elk R.	Elk R.
Sixes R.	Main Stem	59	12/26/01	Elk R.	97	Elk R.	Elk R.
Sixes R.	Middle Fork	1	12/27/01	Elk R.	97	Elk R.	Elk R.
Elk R.	Main Stem	1	1/14/02	Elk R.	98	Elk R.	Elk R.
Rogue R.	Main Stem	23	11/30/01	Indian Cr.	97	Lwr. Rogue R.	Lwr. Rogue R.
Rogue R.	Lobster Creek	1	11/26/01	Indian Cr.	97	Lwr. Rogue R.	Lwr. Rogue R.
Rogue R.	Lobster Creek	1	11/12/01	Trinity R.	97	Trinity R.	Trinity R.
Chetco R.	Main Stem	2	12/10/01	Elk R.	97	Chetco R.	Chetco R.
Chetco R.	North Fork	5	12/19/01	Elk R.	97	Chetco R.	Chetco R.

Trends in Spawner Abundance

ESUs

The 52-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 2002). 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 has existed since the mid 1970s 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.

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 19 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 (Figure 1-4, middle panel). This index has shown a general downward trend during the period of 1972-1990. Since 1990, spawner abundance of these stocks has shown in increasing trend. The spawner density observed in 2001 represents the fourth highest abundance on record. Factors that are likely contributors to the increasing trend in the spawner abundance of these stocks include improved marine survival and lower exploitation in ocean fisheries.

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.

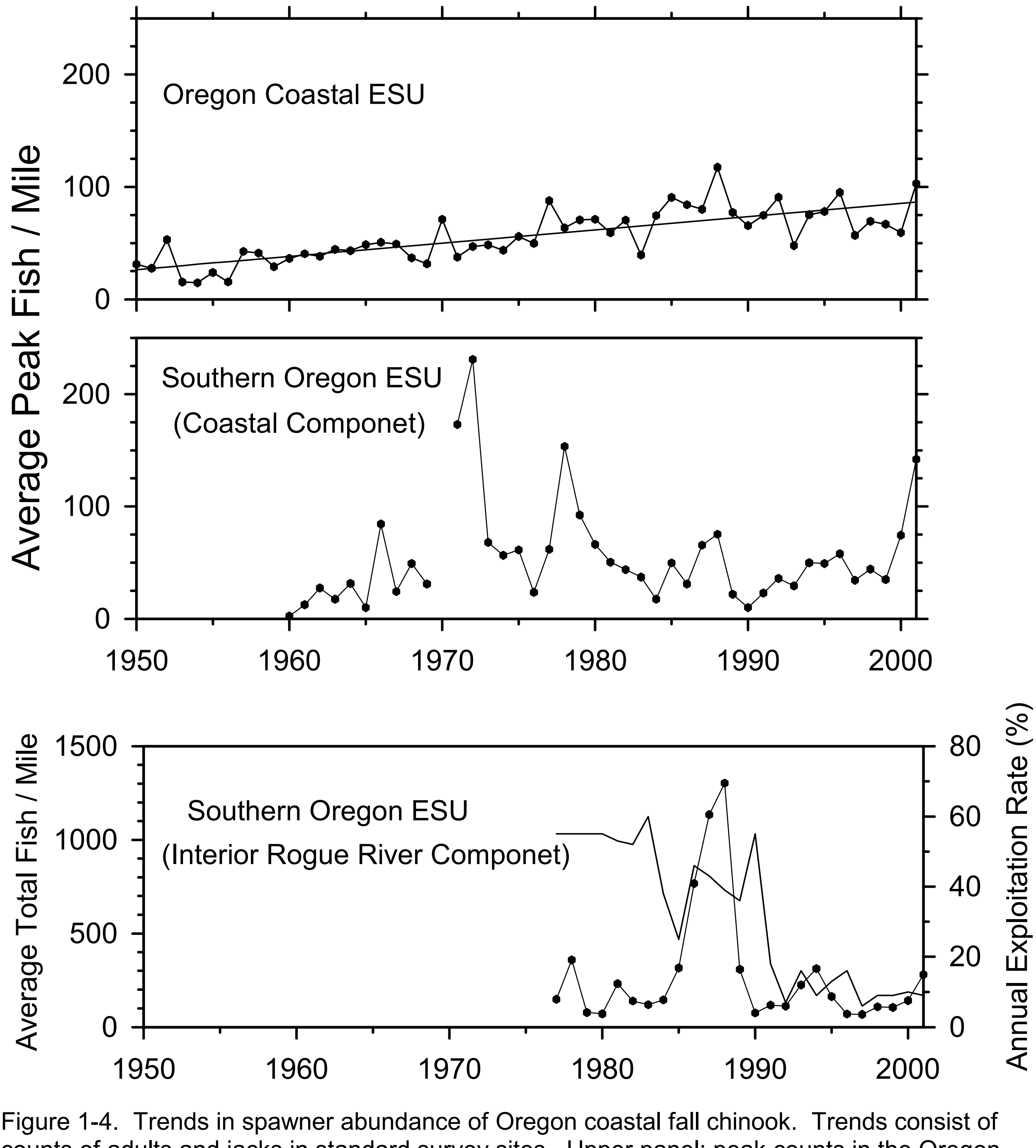


Figure 1-4. Trends in spawner abundance of Oregon coastal fall chinook. Trends consist of counts of adults and jacks in standard survey sites. Upper panel: peak counts in the Oregon Coastal ESU and coastal component of the South Coast ESU. The trend line fitted to the data in the upper graph is significant (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 (PFMCb 2002).

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 River fall chinook resulted in substantially reduced ocean fisheries off Southern Oregon and Northern California from the early 1990s to the present (PFMCb 2002). Interior Rogue stocks are primarily harvested in this area of the Pacific Ocean (Lewis 2002). 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 16 years. None of the GCAs exhibited statistically significant trends over this time period (Figure 1-5). The declining trend that was present for the North-Mid GCA through the 1999 return year (Jacobs et al. 2002) became non significant with the inclusion of 2000 and 2001 data. However, subdividing this GCA into its major basin complexes indicates that a declining trend persists in the Tillamook Bay -Nestucca Basin Complex (Figure 1-6). Reasons for this decline are unclear but may be partially attributed to angler harvest in recreational fisheries or the February 1996 flood (Jacobs et al. 2000). The other basin complexes in this GCA showed healthy levels of spawner abundance for the period of record. Spawner abundance in survey sites averaged greater than 50 spawners per mile in both the Siletz-Alsea and Siuslaw basin complexes. The spawner density observed for the Siuslaw basin complex in 2001 comprised a record high level. Despite the decline in the Tillamook-Nestucca component of the North-Mid GCA, the overall abundance of chinook in this GCA remains at healthy levels.

Despite the lack of significant trends for the four other GCAs, some informative patterns are apparent. For all GCAs where data are available (Nehalem/Ecola, Mid-South Coast and South Coast) a substantial upturn in spawner abundance occurred in 2001. Furthermore, spawner densities observed in these GCAs have remained relatively high and stable over the 16-year period of record. In the Nehalem/Ecola and the Mid-South Coast GCAs, spawner densities have averaged over 70 fish per mile and the coefficients of variation of these densities remained below 35%. In the South Coast GCA, spawner densities have averaged 40 fish per mile and the coefficient of variation of spawner density has been higher (60%), however this higher variability is due to the relatively large increases in spawner abundance that occurred in this GCA during 2000 and 2001. These results indicate that fall chinook in these three GCAs are at healthy levels of abundance.

Prior to the mid-1980s, fall chinook were relatively rare in the Umpqua GCA. Standard spawning surveys were never established in the 1950s in the Umpqua GCA because fall chinook were not an abundant species (Nicholas and Hankin 1988). However, surveys in Buck Creek, a standard 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 during 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). Unfortunately, data are not available for 2000 and 2001 because denial by private landowners prevented crews from accessing the survey site. 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 1987 to 1997 (ODFW 1999).

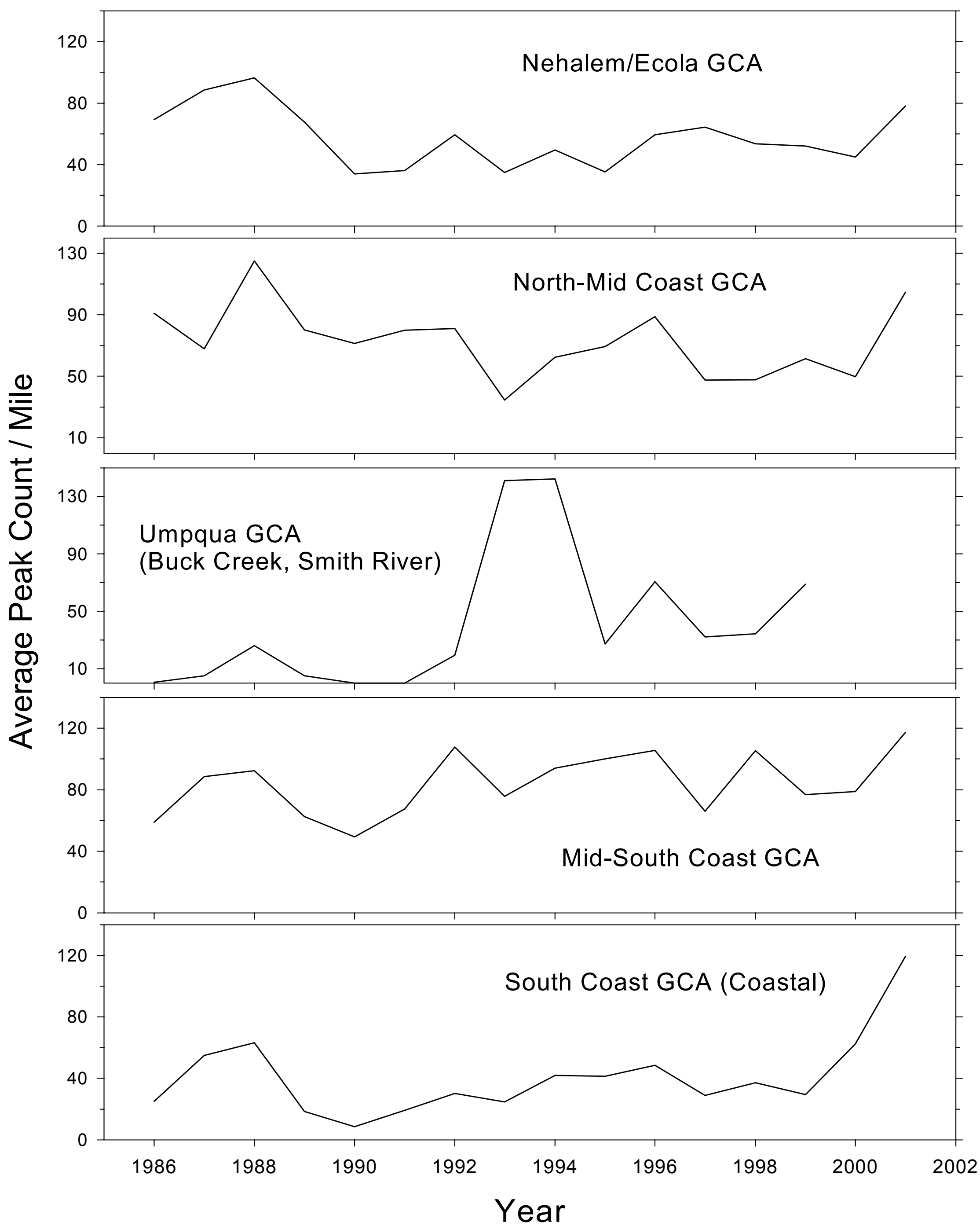


Figure 1-5. Trends in the spawning escapement of fall chinook salmon in Gene Conservation Areas of the Oregon Coast, 1986-2001. Counts include adults and jacks.

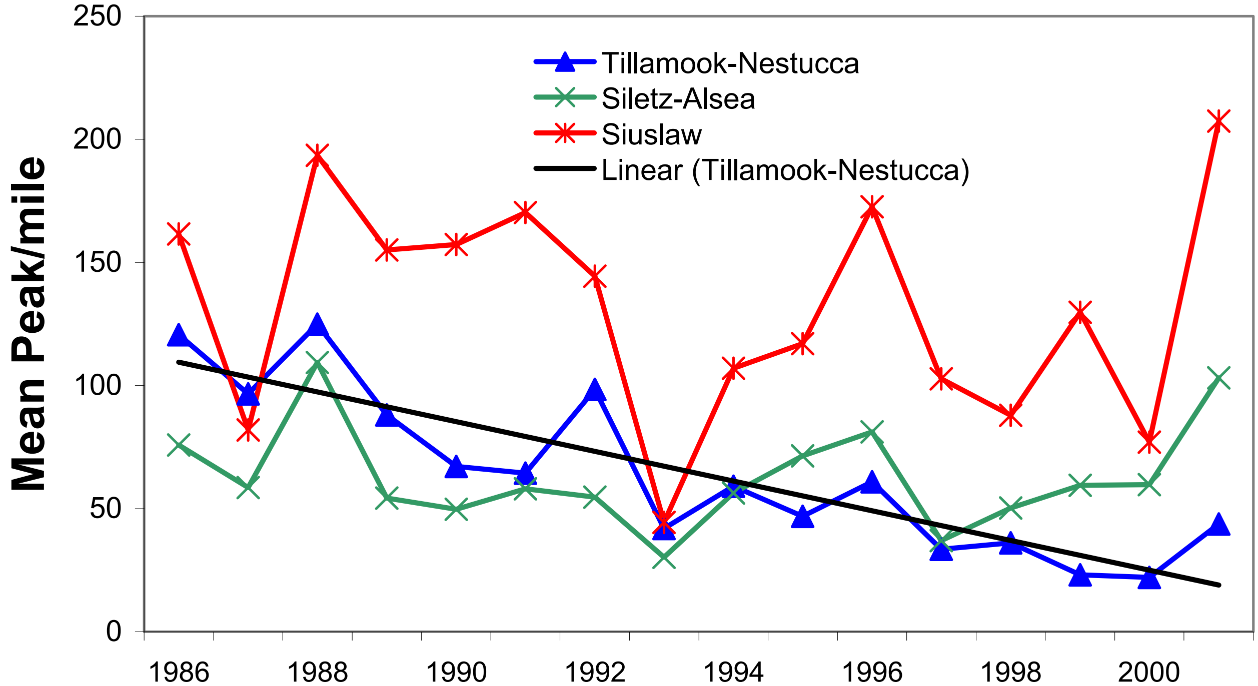


Figure 1-6. Trends in the spawning escapement of fall chinook salmon in major basin complexes within the North-Mid Coast Gene Conservation Area, 1986-2001. Counts include adults and jacks. The Tillamook-Nestucca Complex exhibits a significant ($p<0.001$) declining trend during this time period.

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 2002a). 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 Monitoring Areas (MAs) along the Oregon coast. To obtain target precision for these annual estimates, sample sizes were increased to 120 surveys per MA. 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, Stevens 2002). 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 Basin 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.

We adopted the coastal GCAs as MAs associated with Oregon Plan funded assessments beginning in 1998. To provide more resolution in our assessments we further divided the Mid-North Coast GCA into two subsets: the *North Coast MA* and the *Mid-Coast MA* (Figure 2-1C). The *North Coast MA* encompasses coastal basins from the Necanicum River south to the Neskowin and includes the Nehalem, Tillamook Bay and Nestucca Basins. The *Mid-Coast MA* covers the Salmon through Siuslaw Basins. Other major watersheds in this GCA include the Siletz, Yaquina and Alsea Basins.

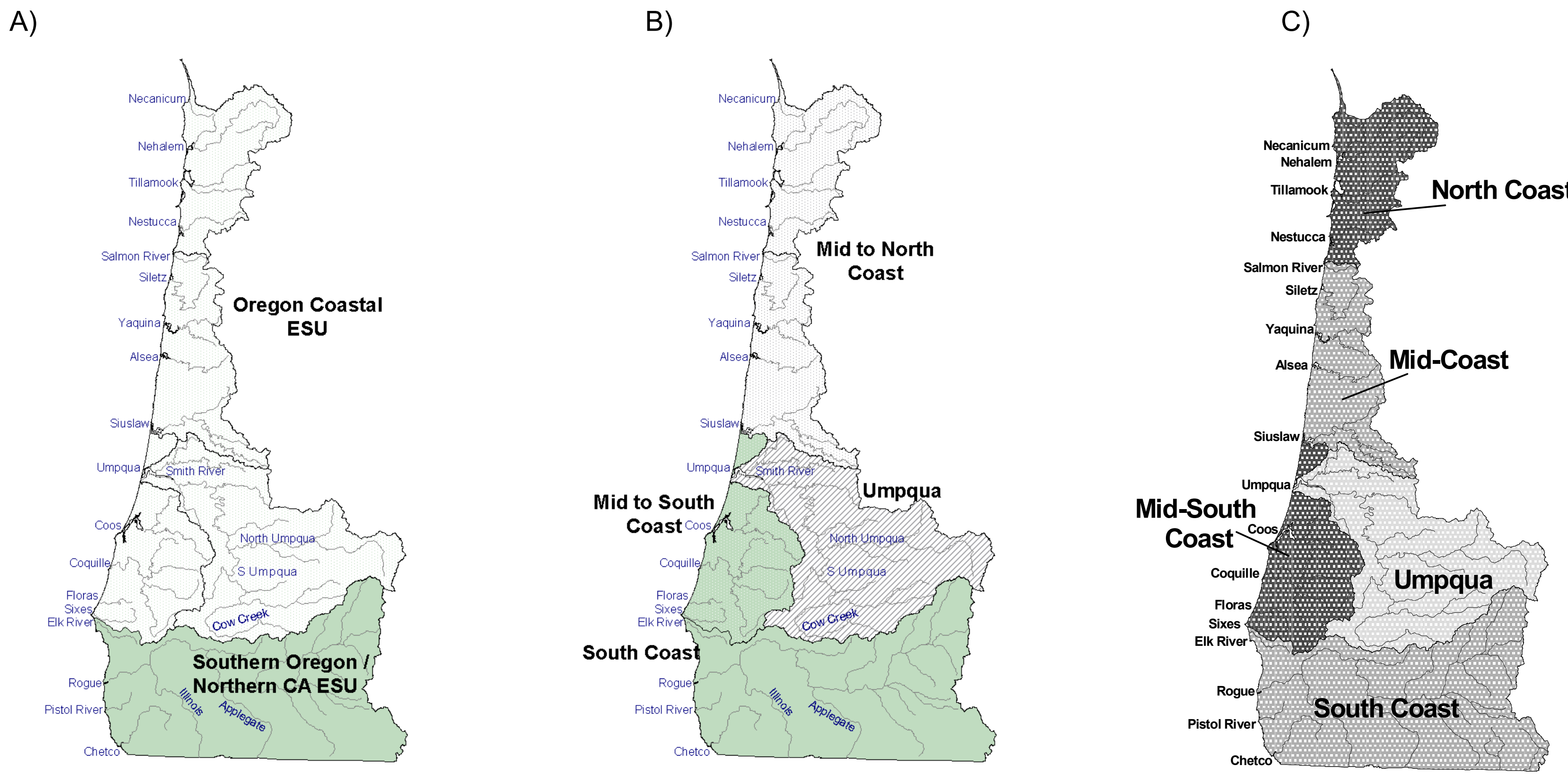


Figure 2-1. Geographic strata for coho salmon for coastal areas in the state of Oregon. A) Evolutionary Significant Units (ESUs) as defined by the National Marine Fisheries Service. B) Gene Conservation Areas (GCA) as defined by the Oregon Department of Fish and Wildlife. C) Monitoring Areas established for monitoring associated with the Oregon Plan.

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 throughout the course of the spawning season (O_i) was estimated using area-under-the-curve (AUC) techniques (Beidler and Nickelson 1980) using the following equation:

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

where

a = number of periods,
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:

$$N_i = (O_i)/(m_i) \quad (4)$$

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

$$N_i = (O_i)/(R_j) \quad (5)$$

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:

$$H_i' = (H_i)(PS_k) \quad (6)$$

and

$$N_i' = (N_i)(PS_k) \quad (7)$$

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 MA. Only recoveries on random surveys were used. Values were calculated as follows:

$$PS_K = Cu_K / (Cu_K + Cm_K) \quad (8)$$

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:

$$T = \sum_{i=1}^{n} N_i \Big/ n \quad (9)$$

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, 5 or 7).

Estimates of Coho Salmon Spawner Population Abundance

Oregon Coastal ESU

Coastal River and Lake Basins: Estimates of the population size of adult coho spawners were derived using a spatially-balanced stratified random probability design as described by Stevens (2002). This design uses AUCs obtained on randomly selected spawner surveys to estimate abundance. Stock size estimates were calculated using the equations in Stevens (2002). Estimates were calculated for each Monitoring Area, each ESU, and for the entire Oregon coast.

Success Rate of Survey Verifications: The initial sample draw includes an over-sample to compensate for sites that could not be surveyed. Surveys must be excluded for a variety of reasons: upon verification it may be found that the site is non-target (there is no spawning habitat within the survey, or it is upstream of a barrier), a landowner might deny access to survey the site, or the site might be too remote to feasibly sample it on a weekly basis. Some sites must be dropped because of workload, or because high flows and low visibility prevent us from surveying the site at adequate intervals to calculate the AUC. The proportions of the draw in each category for each Monitoring Area in 2000 and 2001 are illustrated in Figure 2-2. The ratio of surveyed sites remains fairly constant from year to year, but varies geographically. Even with the fairly high proportions of excluded sites in some Monitoring Areas, we have attained the target sample density in order to meet the confidence goals for population estimates (see Tables 2-2 and 2-3).

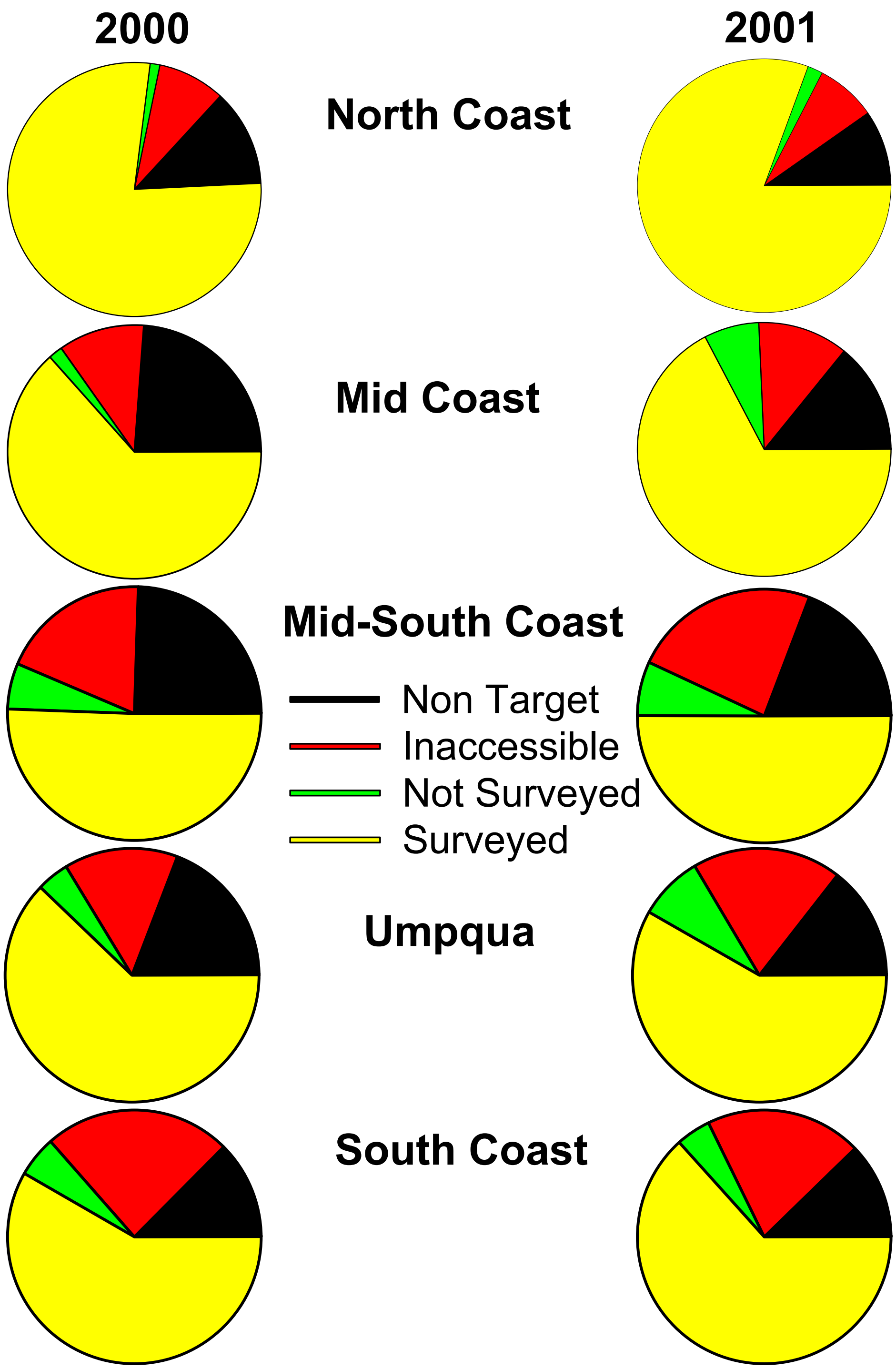


Figure 2-2. Survey verification success by Monitoring Area for 2000 and 2001. Non-target surveys are sites that are above impassable barriers or contain no spawning habitat. "Inaccessible" indicates surveys that were not verified due to denial of access by a landowner, or because the site was too remote to feasibly sample on a weekly basis. "Not surveyed" indicates that spawning habitat was verified, but the site was not surveyed successfully either because high flows and low visibility prevented surveys at adequate intervals to calculate the AUC, or because the site was dropped due to workload constraints. "Surveyed" indicates that the site was successfully surveyed and an AUC could be calculated.

Using a random sampling design and the 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 (Stevens 2002).

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. Solazzi (1984) demonstrated that surveyors tend to underestimate the number of spawners present by a factor of 1.75. We use the equations generated by Solazzi (1984) to adjust spawner estimates. Recent work comparing different estimation methods (Jacobs, 2002b) provides further evidence in support of the accuracy of AUC-based estimates.

5. *Spawning density estimates should be adjusted to exclude naturally spawning hatchery fish.*

Hatchery fish that stray from the point of release or that are released directly into natural spawning areas should not be included in estimates of OCN population abundance. The proportion of hatchery fish in spawner counts is estimated for each major basin or subbasin, and the counts from that area are adjusted accordingly.

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

$$TL = (U)(F) \qquad (10)$$

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:

$$L_m = \frac{B_m \left(G_{tm} \Big/ \sum_{i=1}^{n} G_{im} \right) \sum_{i=1}^{n} N_{im}}{Q} \qquad (11)$$

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 fin-mark rate of coho caught in the seine and returning to the hatchery. Estimates were calculated using the following equations:

$$\hat{N}_t = \frac{a(M+1)(C+1)}{(R+1)} \quad (12)$$

where

$\hat{N}_t$ = the estimated total population of adult coho (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.

$$\Phi_{\hat{N}_t} = 1.96\sqrt{\frac{\hat{N}_t^{\,2} CR}{(C+1)(R+1)}} \quad (13)$$

where

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

$$\hat{N}_w = \frac{\hat{N}_t[C-(RH/M)]}{C} \quad (14)$$

where

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

$$\Phi_{\hat{N}_w} = 1.96\sqrt{\frac{\hat{N}_w \hat{N}_t CR}{(C+1)(R+1)}} \quad (15)$$

where

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

RESULTS AND DISCUSSION

Assessment of Survey Conditions

Figure i-2 illustrates flow conditions during the 2000 and 2001 survey seasons for representative Oregon coastal river basins. Also shown are limits of the of the 80th and 20th percentiles of mean daily flows for the 44-year period back through 1957. As shown in this figure, flows during the 2000 salmon-spawning season were exceptionally low, and the first and only freshets appeared late in the season. These freshets were relatively low flow events, and no significant flow events occurred during the spawning season. Oregon coastal coho generally spawn during November through January. Flows remained near or below the 20th percentile of mean daily flow until late December, when a moderate flow event occurred. This was the first opportunity for spawning coho to enter most spawning areas, and was not great enough to allow fish to access many smaller tributaries. Flows remained extremely low in the south coast for the entire spawning season.

The flow regime encountered during the 2000 spawning-season was amenable to the methods employed here. Low flows provided good conditions to observe fish, and survey schedules were rarely interrupted. On the other hand, the extremely low flow regime that persisted throughout the 2000 season likely affected the distribution of coho salmon spawning. Coho generally spawn in small (first to third order) tributaries. Accordingly, our survey sites are restricted to these low order tributaries. The drought conditions that persisted throughout the 2000 season likely restricted or even prevented spawners from accessing some of our survey sites. This situation may have resulted in a negative bias in our estimates of spawner abundance.

Stream flows during the 2001 survey season were more similar to long-term average conditions with frequent major flow events. Spawners were able to gain access to mainstems and larger tributaries beginning with the small flow events that occurred in late October. By mid to late November, frequent freshet events provided ample opportunities for spawners to access all available spawning streams. A large and protracted cluster of flow events in December disrupted surveys. Freshets appeared every week or two on the Nehalem River until mid-December when there was a longer dry spell. Two additional flow events occurred in early and late January. The Alsea River mirrored this pattern, although the flow event around the first of December had two auxiliary peaks. Flow events were much more frequent on the Coquille River, coming every two or three days for a period that started in late November and ended in late December. These frequent high flows made it very difficult to maintain survey schedules in the Mid-South Coast Monitoring Area, and some surveys were delayed for more than 10 days. In the Rogue basin, flow rates did not come up until late November, and flows great enough to disrupt surveys were rarely encountered.

The impact of high water 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 by comparing them to estimates made using a mark-recapture protocol in the Smith River basin (Jacobs 2002). Results to date suggest that survey-based estimates are not strongly biased.

The survey-based estimate in Smith River for 2001 has a slight negative bias, which is consistent with the trend seen in 1999 and 2000. However there was no significant difference between estimates generated by the two methods in 1999 and 2000. Although it is difficult to draw conclusions with only three years of data, the years encompassed by this study do represent a wide variety of population densities and flow regimes. We will continue to explore ways to evaluate and improve the accuracy of our spawner estimates.

Spawning Timing

Figure 2-3 shows estimates of spawning timing of coastal coho based on when live adults were observed in survey areas. Timing is shown separately for each of the five Monitoring Areas, and is shown for 2000, 2001 and for the average of the previous five seasons (1995-99). Spawning primarily occurs during November and December in coastal Oregon streams, however in some cases, significant spawning activity can occur into January. Among the five Monitoring Areas, spawning generally occurs earliest in the North Coast, with peak spawning activity usually occurring in early-November. Spawning activity generally declines fairly quickly after the November peak. Coho stocks in the Mid Coast Monitoring Area 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 Monitoring Area, coho spawning in the Umpqua Monitoring Area show 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 Monitoring Area can be delayed. Coho spawners in the Mid-South Monitoring Area also exhibit a fairly protracted spawning timing, but don't tend to initiate spawning until about mid-November. Spawning in this Monitoring Area typically extends throughout January. Data on spawning timing of coho stocks in the South Coast Monitoring Area are available back through 1996. Most of the spawners in this Monitoring Area have been observed in the middle and upper portions of the Rogue Basin. Spawning activity for these stocks occurs primarily in December.

In 2000, spawning activity was delayed and contracted compared to 2001 and the five-year average, with peak spawning occurring in January in all five Monitoring Areas. In the four northern Monitoring Areas, spawning was compressed primarily to a four-week period in January. In the Mid-South Coast Monitoring Area, there was a smaller secondary peak that extended for approximately two weeks in mid-February. Spawning was somewhat more protracted on the South Coast, with most spawning occurring during an eight-week period that began in December and extended through early February.

The temporal pattern of spawning in 2001 was generally similar to the five-year average. The first peak of spawning activity occurred earlier than average in the Umpqua and Rogue River basins. The early arrival of spawners coincided with an early freshet (see Figure i-2) and was comprised primarily of strays from the Columbia River Basin (see Table 2-7)

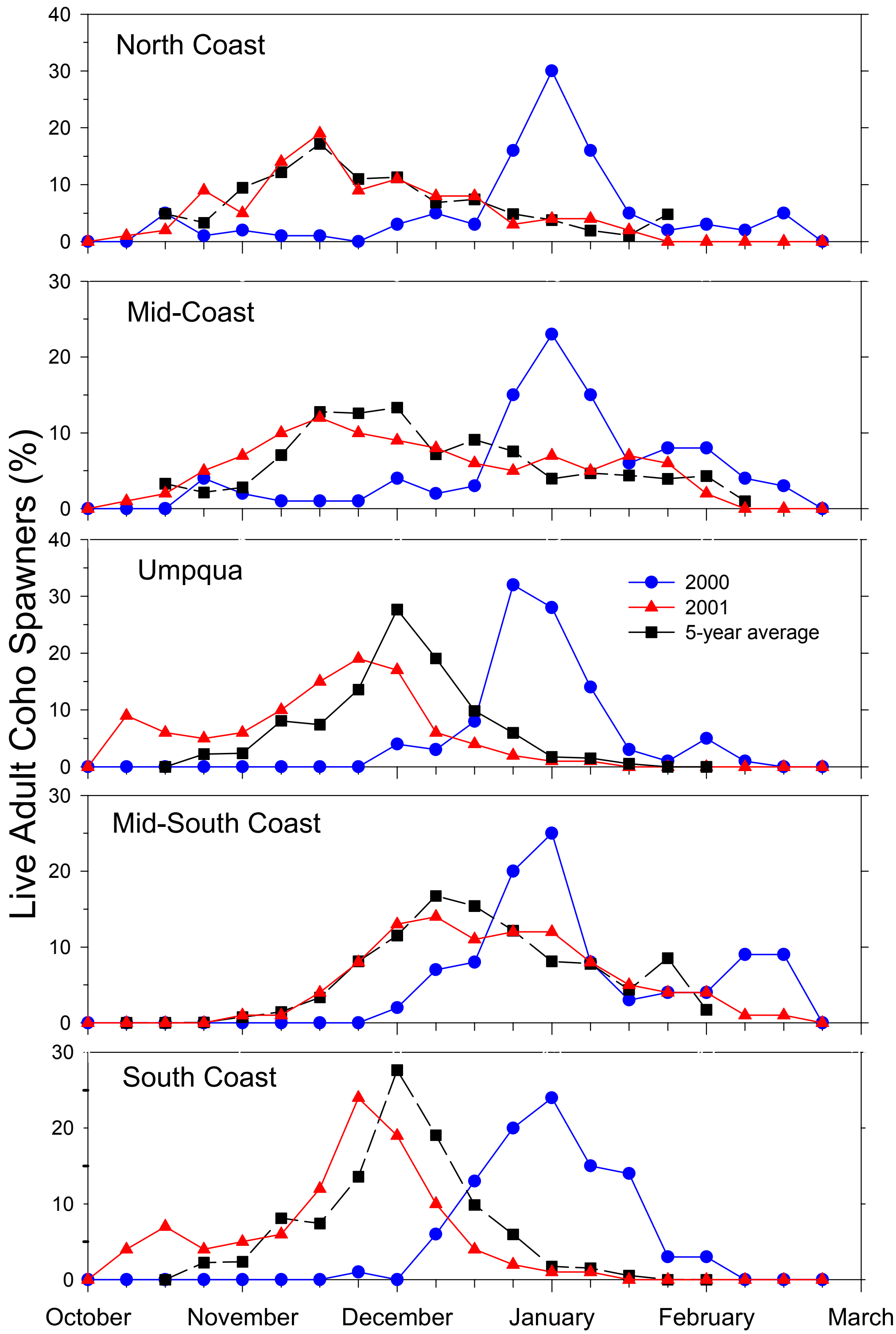


Figure 2-3. Temporal distribution of spawning coho salmon observed on spawning surveys for each Monitoring Area during the 2000 and 2001 spawning season and the five prior seasons (1995-99). For the South Coast Monitoring Area the prior season extends from 1996-99. Values plotted are the percent of total 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 43 standard stream segments in 2000 and 42 standard stream segments in 2001 (Table 2-1). We were denied access to three standard index sites in 2000 and an additional site in 2001. Hatchery origin spawners had negligible effects on the magnitude of these indices in 2000 and 2001. In 2000, AUC estimates of adult spawner density were lowest in the North Coast Monitoring Area and highest in the Mid-South Coast. Peak counts of jacks ranged from 1.5 fish per mile to 5.7 fish per mile, with the lowest densities in the North Coast and the highest densities in the Mid-South Coast. In 2001, the highest adult spawner densities were observed in the Umpqua Basin, with the lowest densities seen in the North Coast Monitoring Area. Densities in 2001 were higher than 2000 across the board, with a greater than two-fold increase seen in the Umpqua Basin. However, peak counts of jacks were lower in 2001 than in 2000, ranging from 0.3 jacks per mile in the North Coast Monitoring Area, to 2.7 jacks per mile in the Umpqua Basin.

Table 2-1. Summary of peak fish per mile counts and estimated total spawning escapement of coho salmon in standard stream segments by Monitoring Area for 2000 and 2001. Counts of adults in parenthesis are totals of all fish including fish that were estimated to originate from hatcheries.

Monitoring Area	Survey segments		Average peak count per mile		Estimated total escapement (fish/mile)[a]	
	Number	Total miles	Adults	Jacks	Stream segments	Adults
			2000 Spawning Season			
North Coast	14	15.1	13.3(13.6)	1.5	14	19.4
Mid Coast	16	16.0	15.3(15.9)	3.3	16	27.5
Umpqua	6	7.4	24.3(25.0)	3.7	6	39.3
Mid-South Coast	7	6.7	24.3(24.3)	5.7	7	48.2
Total Coastal ESU	43	45.2	17.4(17.9)	3.1	43	29.6
			2001 Spawning Season			
North Coast	14	15.1	13.6(13.9)	0.3	14	24.0
Mid Coast	16	16.0	14.6(16.0)	2.1	16	41.1
Umpqua	6	7.4	41.1(44.7)	2.7	6	110.0
Mid-South Coast	6	6.2	20.1(20.9)	1.1	6	61.1
Total Coastal ESU	42	44.7	19.4(20.7)	1.4	42	48.9

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

During the 21-year period when AUCs have been obtained from standard index areas there has been about a four-fold variation in adult spawner density (Figure 2-4). The density of 49 spawners per mile observed in 2001 is a record for this time series.

Over the last 21 years, peak counts have shown a general correlation to AUC escapement estimates (R^2 = 0.8422, p≤0.001; Figures 2-4 and 2-5), although the relationship between the two measures has not been completely consistent. From 1981-2001, peak counts have averaged 48% of the AUC estimate of total spawning escapement. This ratio has ranged from 37% in 1984 and 1985, to 62% in 1998. 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 (1982, 84-86, 88, 96 and 2001), peak counts accounted for 43% of AUC estimated spawning escapement, while in years of near-to-below average spawning escapement (1981, 83, 87, 90, and 97-99), the proportion was substantially higher (52%). An exception to this pattern occurred in 1993 and in 2000, average abundance years when this ratio was 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 in 1993 and for the early and middle portions of the spawning season in 2000.

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.

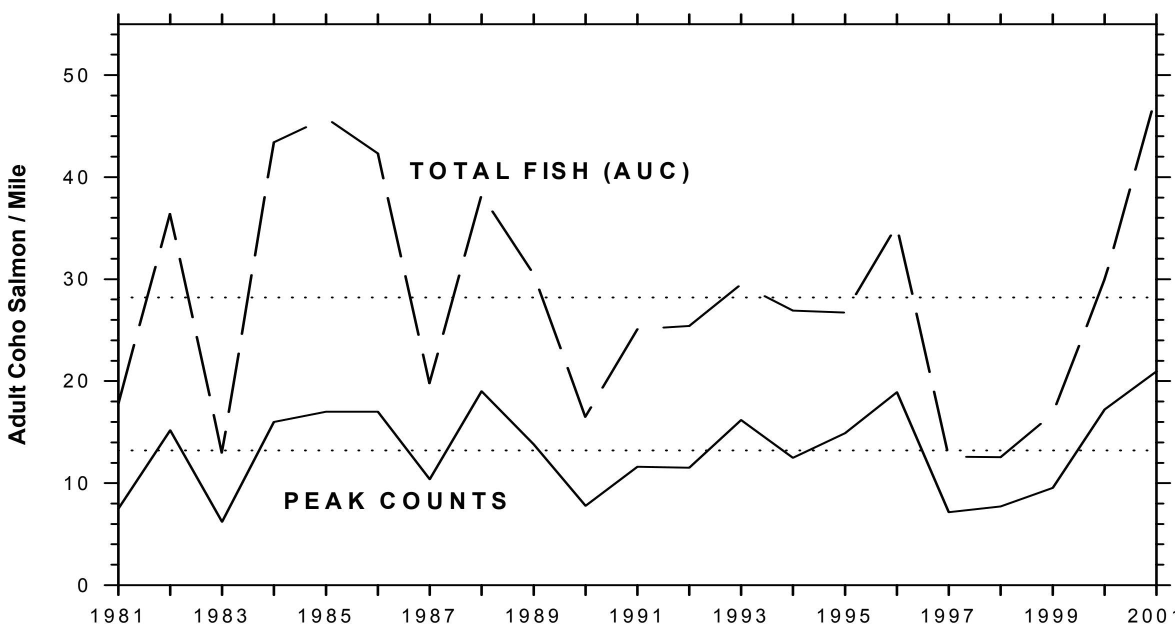


Figure 2-4. Indexes of the spawning escapement of adult coho salmon in standard stream segments in Oregon coastal river basins, 1981-2001. Twenty one-year averages of peak counts and total spawning escapement are shown with dotted lines.

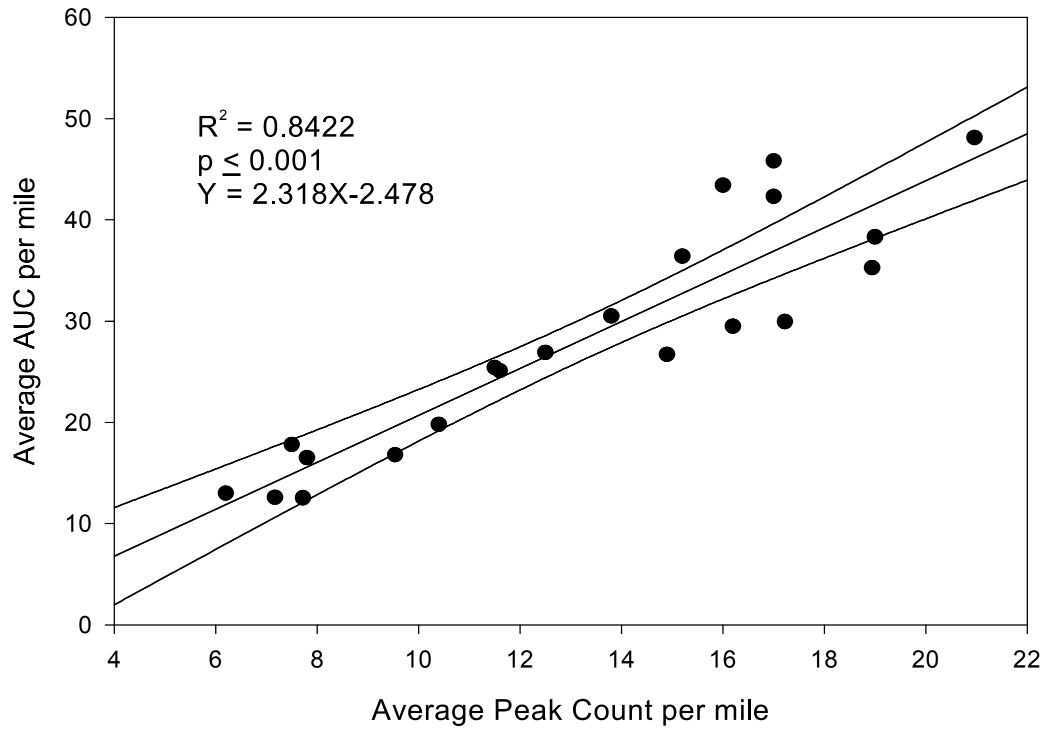


Figure 2-5. Relationship between average Peak Count per mile and average AUC per mile for adult coho salmon on standard survey sites in Oregon coastal river basins, 1981-2001. Parabolic lines indicate the 95% confidence interval for the regression equation.

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, 42 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 2002b) to this index provides an index of pre-harvest abundance. Both of these indices show significant ($p<0.001$) declining trends over the 52-year period of record (Figure 2-6). 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 abundances 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 levels of both spawner escapement and pre-harvest abundance observed in 1997 and 1998 were the lowest observed on record. Spawner escapement and pre-harvest abundance have increased each year since 1998, and the escapement observed in 2001 rivals the populations seen in the late 1960s and early 1970s. However, the pre-harvest abundance in recent years is still considerably lower than that seen in the 1960s and 70s, and both escapement and abundance were much greater in the 1950s.

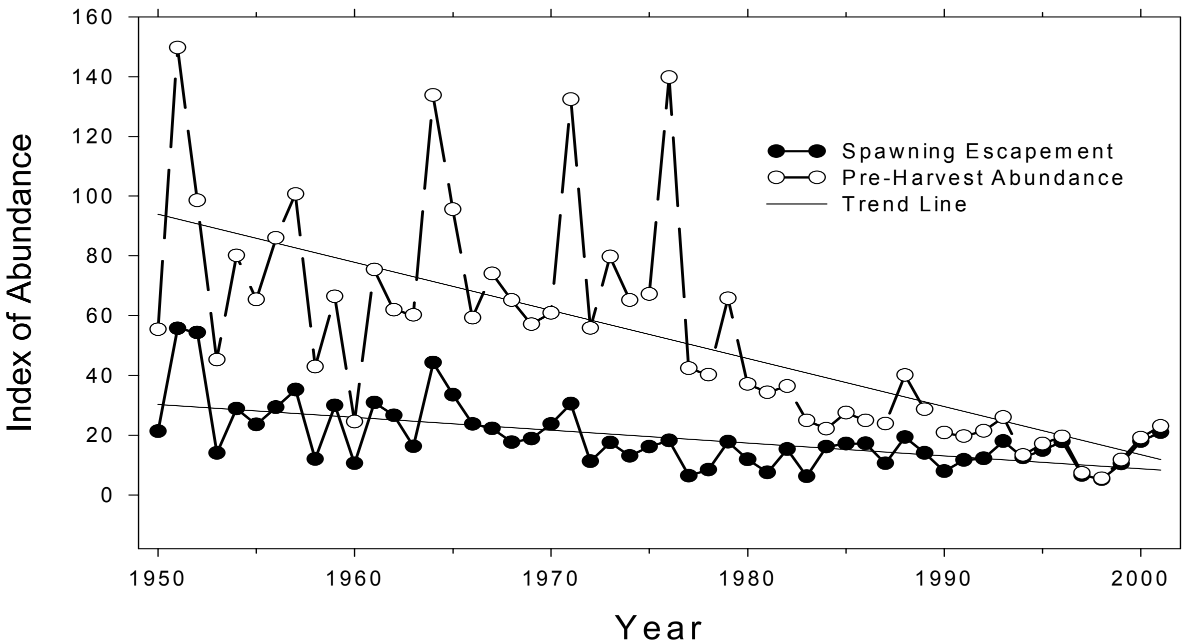


Figure 2-6. Trends in the pre-harvest abundance and spawning escapement of adult coho salmon as indexed by average peak counts in standard survey segments, 1950-2001. Both trend lines are statistically significant; spawner abundance: R^2 = 0.35, p<0.001; pre-harvest abundance: R^2 = 0.48, p<0.001.

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 1950-98 brood years (Figure 2-7). 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 2-7, survival rates of coastal coho stocks showed a steady decline for about 20 brood years. Survival rates were markedly improved for the 1997 and 1998 brood years compared to the previous six brood years, with the survival rate in 2001 approaching the average seen for stocks in the 1950s and 60s. The declining trend in survival as indexed by these values has been 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 declines in the quality of freshwater habitat.

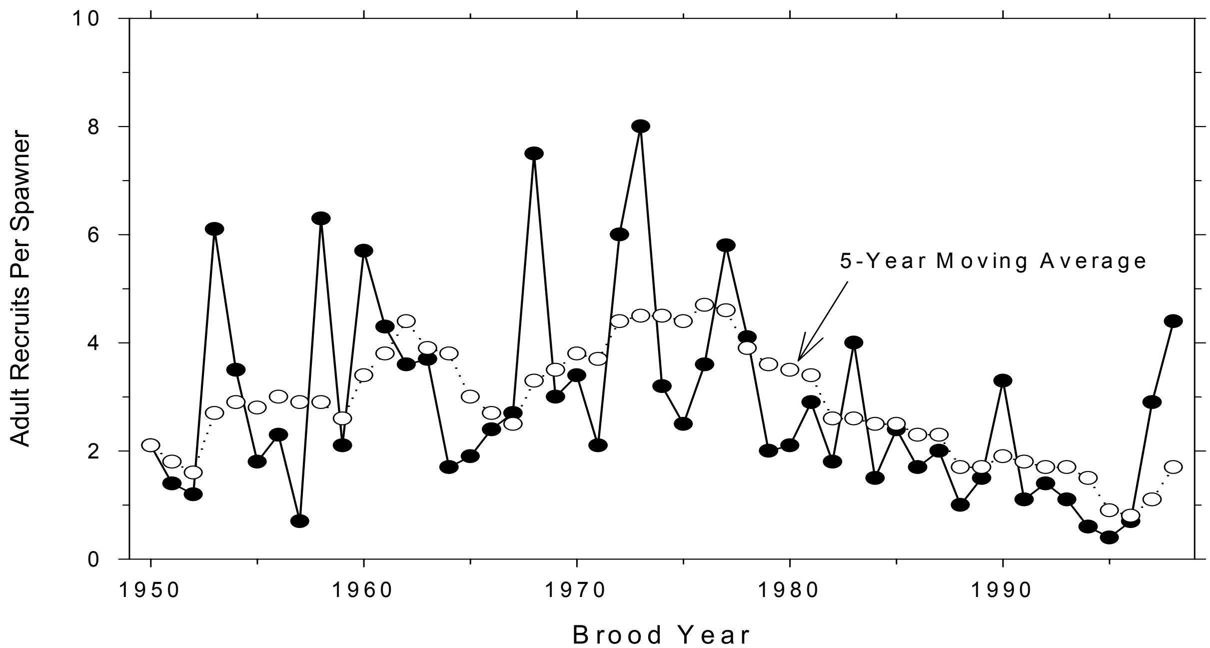


Figure 2-7. Indices of the ratio of adult recruits per spawner for Oregon coastal coho stocks during the 1950-98 brood years as indexed by average peak counts in standard survey segments.

Trends in Spawner Abundance Based On Random Surveys

We now have a sufficient history of data from random surveys for coho on the Oregon coast to detect trends based on this data set. Based on the last twelve years of data, statistically significant trends are present for two of the five coastal Monitoring Areas: the North Coast and the Umpqua River (Figure 2-8). Both trends are positive, with the slope indicating an increase of about 1,500 fish per year. In the North Coast, this trend is driven primarily by the Nehalem River, although a significant positive trend is also present in the Nestucca River. The strongest trend in the Umpqua basin is in Cow Creek.

Five years of data are available for the more intensive monitoring associated with the Oregon Plan. Significant trends were detected for a five-year interval of 1997-2001 in the North Coast and Mid Coast Monitoring Areas (Figure 2-9). The trend in the North Coast was again driven primarily by the Nehalem River. There were no statistically significant trends for any individual basins within the Mid Coast MA.

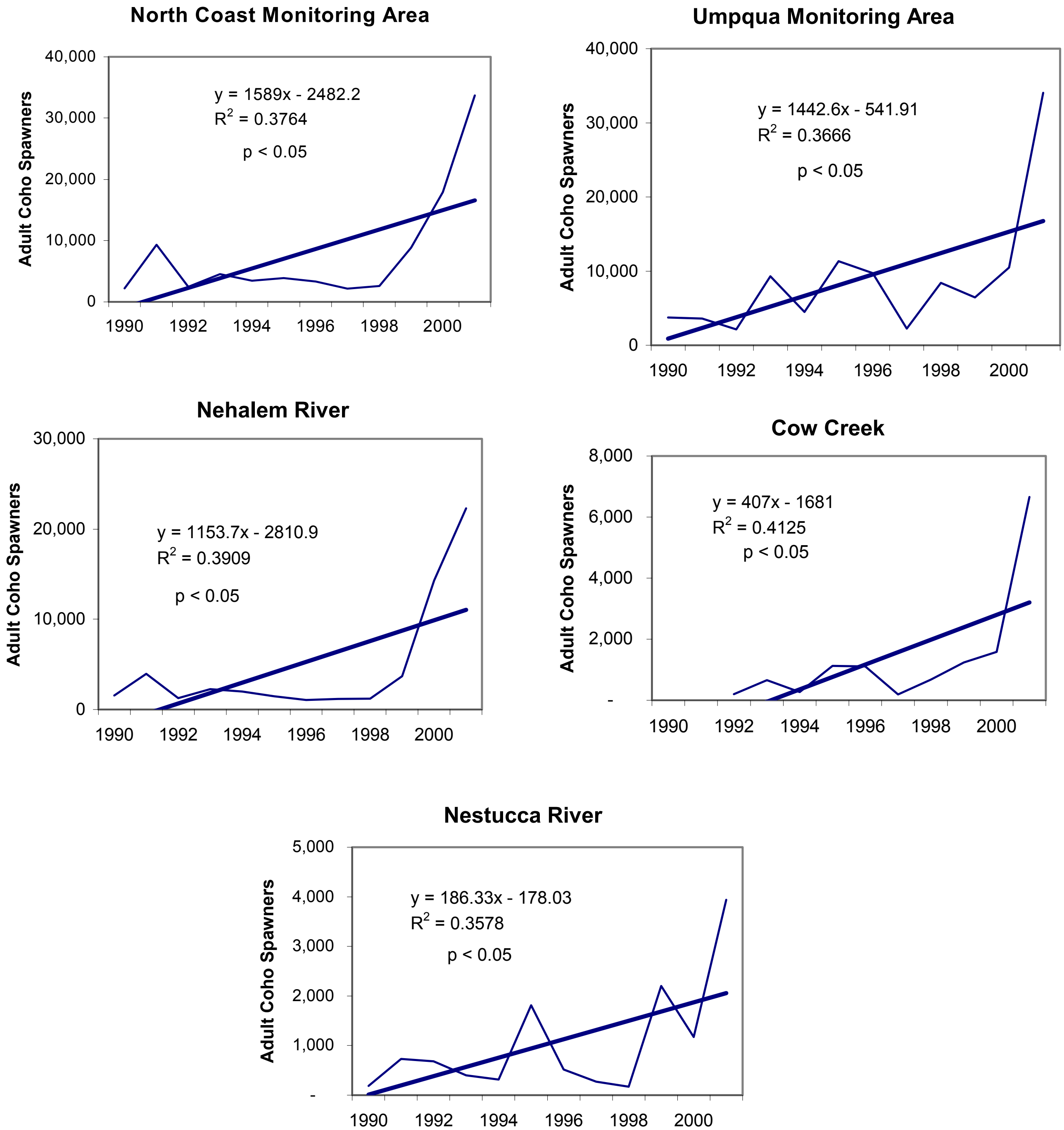
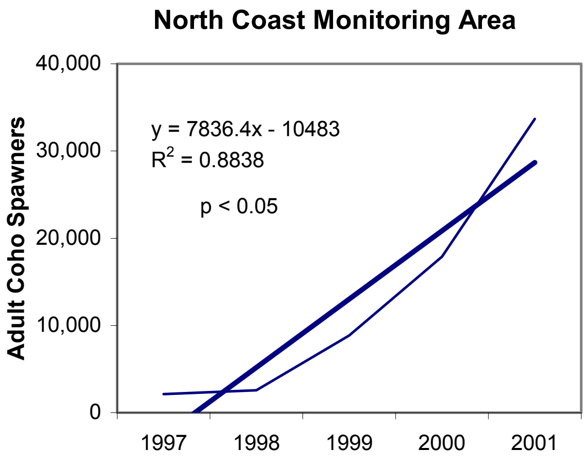
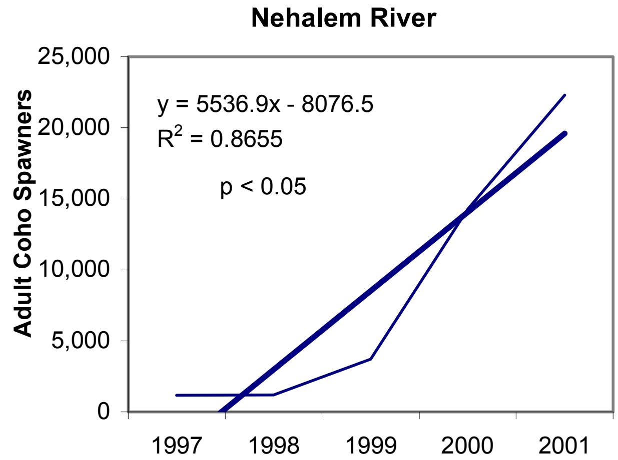


Figure 2-8. Twelve-year trends in coho spawner abundance based on random surveys. Statistically significant ($p < 0.05$) trends were observed in two Monitoring Areas (North Coast and Umpqua) and three smaller river basins (Nehalem, Nestucca, and Cow Creek).





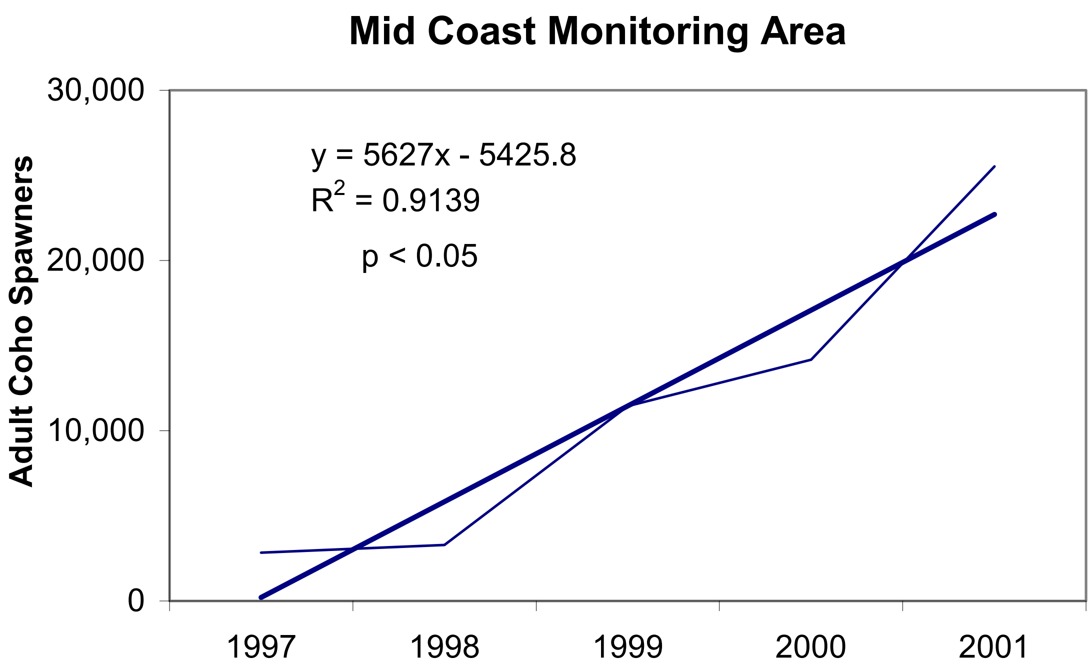


Figure 2-9. Five-year trends in coho spawner abundance based on random surveys. Statistically significant ($p < 0.05$) trends were observed in two Monitoring Areas (North Coast and Mid Coast) and one smaller river basin (the Nehalem River).

Spawner Distribution

Random 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 within stream reaches, they provide a means of investigating inter-annual changes in patterns of spawner distribution. The upper portion of Figure 2-10 illustrates the cumulative frequency of different levels of spawner density within available spawning habitat of river basins in the Oregon Coastal ESU for 2000, 2001, 1997 (the year having lowest abundance) and the prior ten-year average (1990-99). 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 2001, only about 20% of the stream reaches were devoid of spawners and about 80% of reaches had spawner densities of about 60 adults per mile or less. Generally, the more linear a curve is, the more uniformly spawners are distributed. These curves illustrate that spawner distribution is not uniform but highly skewed, with most of the available habitat being occupied by few or no spawners at all in most years. In years with relatively high spawner escapement, there is a somewhat more even distribution of fish throughout their geographic range.

Despite this general pattern, there are differences in patterns of spawner distribution among different years. 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. Annual values corresponding to fixed positions on the distribution curves are shown in the lower portion of Figure 2-10. These positions are marked on the upper portion of Figure 2-10 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 past twelve 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 30% in 2001 to near 90% in 1997. This means that during the period of 1990-2001 from 10% to 70% of the spawning habitat had spawner densities exceeding 10 adults per mile.

The two other trend lines shown in the lower portion of Figure 2-10 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 1990-2001, having lowest densities in 1990 and 1997, highest densities in 1996, 2000 and 2001, and a stable trend during 1991-96 and an increasing trend from 1997-2001.

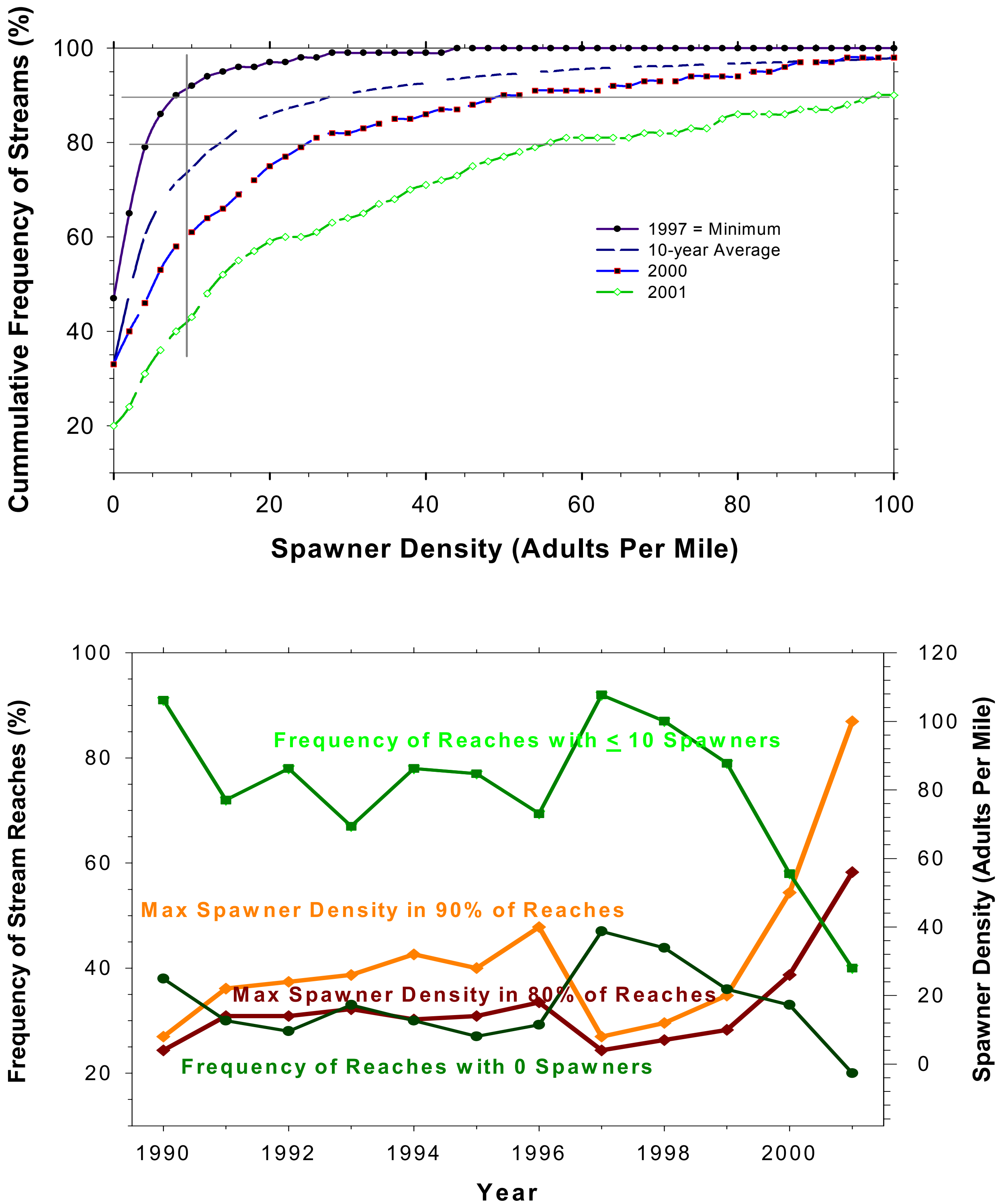


Figure 2-10. Distribution of coho salmon spawners within available spawning habitat within the Oregon Coastal ESU, 1990-2001. The upper portion of the figure shows cumulative frequencies of spawner density among available stream reaches during 2000, 2001, the lowest abundance year (1997) and the ten-year average. Also shown by the vertical and horizontal lines are positions of distribution benchmarks depicted in the lower portion of the figure.

A key aspect of the EMAP sampling framework used for monitoring coastal coho is the rotating panel design (Firman and Jacobs 2001). Based on this design, four independent panels of sample sites are used each year as the random selection of spawner surveys. One of these panels is composed of sites that are resampled in every year. We now have four years available of spawner abundance in these annual random sites. Besides having utility for trend detection, annual random sites can be used to assess spatial distribution patterns.

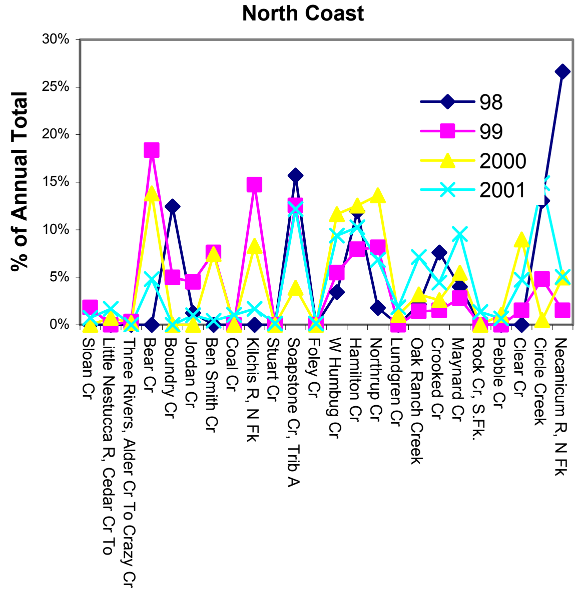
Figure 2-11 shows the distribution of adult coho spawners among annual random sites in each of the five MAs. Spawner densities are adjusted to compensate for differences in spawner abundance among the four return years. What this figure illustrates is the interannual consistency (or variability) of spawner distribution among these sites. Furthermore, because these sites are selected randomly, these patterns can be inferred as representations of interannual patterns that occur across all spawning habitat in each of these MAs.

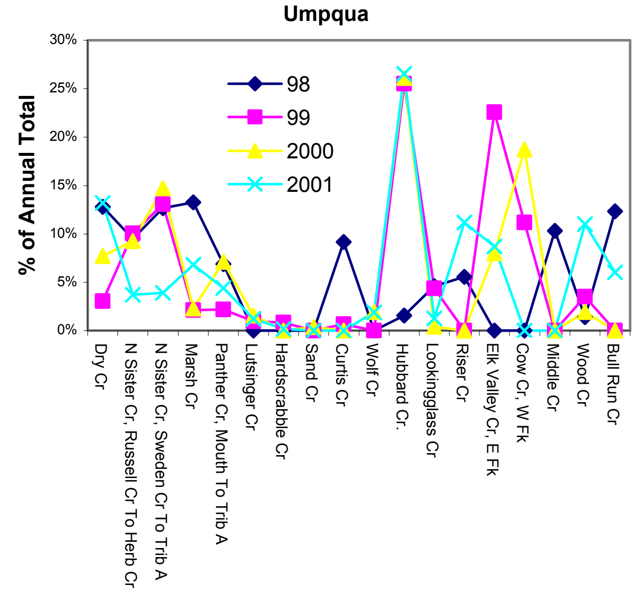
Although limited by only four years of data, several patterns are apparent from this analysis. These patterns are as follows: There is substantial interannual variability in the spatial distribution of spawning. Sites that comprise a substantial proportion of the relative abundance in one year can have low proportion or even void of fish in another year. Despite this interannual variability, there are some sites that consistently support relatively high spawner densities. Examples of such sites are middle Nehalem River tributaries in the North Coast MA; Five Rivers, Elkhorn and Spout Creeks in the Mid Coast MA; Steel, Middle and Fivemile Creeks in the Mid-South Coast MA; Smith River Tributaries in the Umpqua MA and Waters and North Fork Little Butte Creeks in the South Coast MA. The consistent utilization of these sites for spawning suggests that they are associated with perennially productive freshwater habitat.

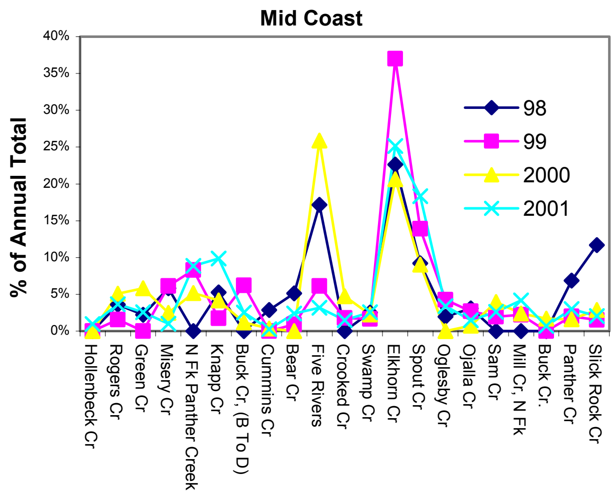
Another emergent pattern is, that aside from the South Coast MA, essentially no sites were void of spawners among all four return years. In the North Coast, Mid Coast and Umpqua MAs there were no sites that were void of spawners in all four years. In the Mid-South MA, only two of the 19 sites were consistently void of spawners, Crystal and Spruce Creeks. These sites may have passage barriers downstream from the survey area. The pattern of widespread habitat utilization by coho spawners suggests that coho are good at colonizing available habitat. If this trait is indeed present, it provides evidence that coastal coho are adapted to utilize habitat one it becomes available. This hypothesis has implications to habitat restoration programs as a tool to recover coastal coho. Coho may be able to quickly colonize restored habitat.

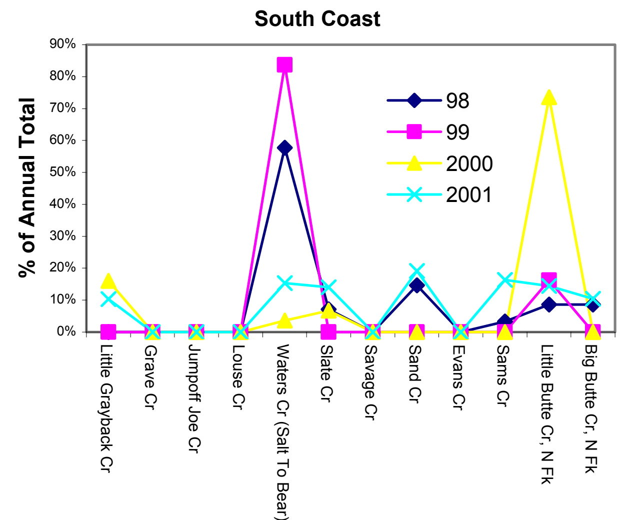
In contrast to the four northern MAs, over 40% of the annual sites in the South Coast MA were void of spawners in all four years. This suggests that productive habitat is more fragmented in this MA. This pattern may be expected given that coho rely of cool, low gradient tributaries for spawning and rearing and this type of habitat in limited in the South Coast MA.

A final pattern that is apparent from this analysis is, that during the highest abundance year (2001), spawner distribution was more uniform than in the three preceding years. This condition is apparent from the lower variability among relative site densities during 2001 compared to the three previous years (Figure 2-11). This pattern is consistent with the pattern present in Figure 2-10, and suggests that spawners utilize more habitat in years of higher abundance.









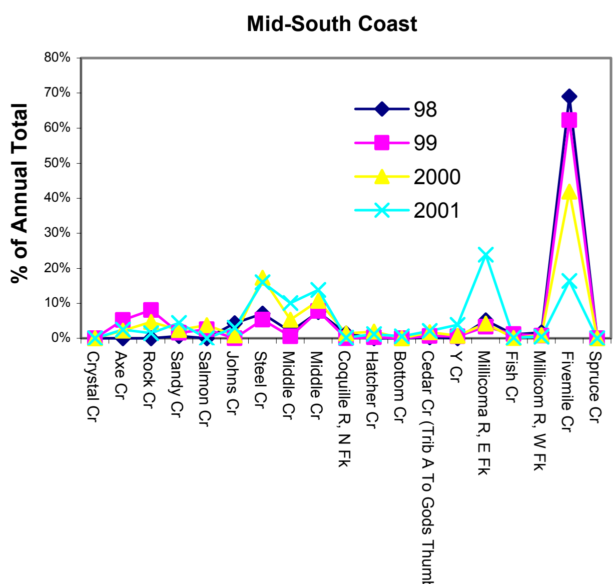


Figure 2-11. Distribution of adult coho spawner among annual random sites in each Monitoring Area, 1998-2001. Data are plotted as the proportion of annual total abundance among all sites that each individual site comprises. Only sites having valid AUC estimates in each of the four years are used. Sites are plotted in as south to north, downstream to upstream order within each Monitoring Area with southernmost downstream site located adjacent to the left-hand axis.

Estimates of Spawner Abundance

EMAP Estimates for 2000 and 2001

Estimates of OCN spawning escapement and associated 95% confidence intervals derived from 2000 and 2001 random spawning surveys are presented in Table 2-2 and Table 2-3. Comparisons of 2000 and 2001 results to those of prior years are presented in Table 2-4. Five hundred one stream segments were successfully surveyed in 2000. In 2001 454 sites were successfully surveyed. The total sample size of survey sites was increased beginning in 1997 with the goal of increasing precision for coast-wide and Monitoring Area estimates to within ±20% and ±30%, respectively. The sample size 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 Monitoring Area for the four northern Monitoring Areas, and 60 sites in the South Coast Monitoring Area. The South Coast Monitoring Area 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 Monitoring Areas.

Target sample sizes were met in the North Coast and Umpqua Monitoring Areas in 2000 (126 and 120 sites respectively). Target Sample sizes were not met in the Mid Coast, Mid-South Coast, or South Coast Monitoring Areas (104/120, 95/120, and 56/60 sites, respectively). Principal reasons for not meeting target sample sizes included site accessibility, access denial from landowners and inappropriate site selections (see page 33). Despite failing to meet target sample sizes, target levels of precision were met in all but the Mid-South Coast (±38%) and South Coast Monitoring Areas (±58%). Precision for the remaining three Monitoring Areas averaged ±24%, and the coast-wide precision estimate was ±15%. Precision is lower in the Mid-South Coast monitoring Area because there were fewer sites in this Monitoring Area, and because there are a few highly localized areas with very high production (see section on Coastal Lakes). The patchiness of fish distribution results in the high variance for this monitoring area. Precision is lower in the South Coast because we sample at a lower density in the Monitoring Area (roughly one half the effort in the other four Monitoring Areas). In 2001, target sample sizes were only met in the North Coast Monitoring Area, however, target levels of precision were met in all monitoring areas. Precision averaged ±24% in the monitoring areas and the coast-wide precision estimate was ±14%.

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 501 and 454 estimates of spawning density, an estimated 61,670 ± 8,766 OCN coho salmon spawned in coastal basins in 2000 and 171,525 ± 23,817 OCN coho spawned in 2001. The spawner densities observed in 2001 were the highest densities seen in any coastal basin in the 12 years that randomized surveys have been conducted. These aggregates estimate include escapement in Siltcoos Lake, Tahkenitch Lake, Tenmile Lakes, and coastal basins south of the Coquille basin. These areas were randomly sampled for the first time in 1998. 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 in Table 2-4 to allow comparisons with prior years.

Table 2-2. Estimated spawning escapement of Oregon coastal natural coho salmon in 2000 based on randomly selected spawning surveys.

				Adult Coho Spawner Abundance[b]			
		Survey Effort		Total		Wild[c]	
Monitoring Area, Basin Group	**Spawning Miles[a]**	**Number Surveys**	**Miles**	**Estimate**	**Confidence Interval**	**Estimate**	**Confidence Interval**
Coast-wide	**4,223**	**501**	**473.0**	**63,082**	**8,905**	**61,670**	**8,766**
North Coast	**932**	**126**	**116.0**	**18,240**	**4,162**	**17,898**	**4,084**
Necanicum R, Ecola Cr	89	11	9.1	474	337	474	337
Nehalem R	449	59	58.4	14,335	3,778	14,285	3,765
Tillamook Bay	237	31	26.2	2,237	899	1,983	797
Nestucca R	145	22	20.4	1,194	654	1,171	641
Sand Lake and Neskowin Cr	11	3	2.0	0	0	0	0
Mid Coast	**1,151**	**104**	**96.7**	**14,791**	**3,637**	**14,181**	**3,487**
Salmon R	47	5	5.4	531	528	0	0
Siletz R	168	15	13.9	3,553	2,427	3,553	2,427
Yaquina R	106	10	9.7	647	578	647	578
Devils Lake, Beaver Cr	47	5	4.2	738	1,395	738	1,395
Alsea R	195	13	11.1	2,465	2,323	2,465	2,323
Small Ocean Tribs	13	1	0.6	0	NA	0	NA
Yachats R	35	4	3.4	79	131	79	131
Siuslaw R	488	46	43.6	6,767	2,233	6,767	2,233
Mid-Small Ocean Tribs	50	5	4.7	12	23	12	23
Mid-South Coast	**609**	**95**	**90.6**	**16,241**	**6,192**	**16,241**	**6,192**
Siltcoos and Tahkenitch Lks	45	7	5.2	2,972	3,879	2,972	3,879
Coos R	211	39	40.5	5,386	5,376	5,386	5,376
Coquille R	285	42	37.7	6,130	2,682	6,130	2,682
Tenmile Lks	28	1	1.0	313	NA	313	NA
Floras Cr, New R and Sixes R	39	6	6.2	1,440	2,539	1,440	2,539
Umpqua	**1,066**	**120**	**111.3**	**10,926**	**2,764**	**10,468**	**2,627**
Lower Umpqua and Smith R	262	37	32.6	3,792	1,330	3,696	1,284
Mainstem Umpqua R	171	23	22.4	3,005	2,018	2,774	1,862
Elk Cr and Calapooya Cr	161	15	16.1	1,913	1,828	1,864	1,781
Cow Cr	169	18	15.9	1,737	1,464	1,582	1,334
South Umpqua R	303	27	25.4	479	392	479	392
South Coast	**465**	**56**	**57.8**	**2,883**	**1,664**	**2,883**	**1,664**
Elk River	8	1	1.2	0	NA	0	NA
Lower Rogue R. Tributaries	37	0	0.0	NA	NA	NA	NA
Applegate River	78	12	12.9	147	138	147	138
Illinois River	110	12	11.4	1,467	1,324	1,467	1,324
Mainstream Tribs	146	18	19.1	372	368	372	368
Little Butte Cr	32	6	5.3	897	1,212	897	1,212
Evans Cr	37	5	5.1	0	0	0	0
Big Butte Cr	16	2	2.5	0	0	0	0

a *Average of 1998-2000* ratio *estimates. Ratio estimates derived from multiplying MA weight by number of target sites in each basin group and adjusting for revisions in spawning mileage.*
b *Estimates derived using EMAP protocol. Estimates are adjusted for visual observation bias.*
c *Estimates of wild spawners derived through application of fin-mark recoveries in random survey sites.*

Table 2-3. Estimated spawning escapement of Oregon coastal natural coho salmon in 2001 based on randomly selected spawning surveys.

Monitoring Area, Basin Group	Spawning Miles[a]	Survey Effort: Number Surveys	Survey Effort: Miles	Adult Coho Spawner Abundance[b] Total: Estimate	Total: Confidence Interval	Wild[c]: Estimate	Wild[c]: Confidence Interval
Coast-wide	**4,230**	**454**	**420.2**	**182,164**	**25,025**	**171,525**	**23,817**
North Coast	**939**	**121**	**114.4**	**34,506**	**6,231**	**33,667**	**6,080**
Necanicum R, Ecola Cr	84	9	9.2	5,431	2,049	5,247	1,979
Nehalem R	451	57	54.7	22,778	5,375	22,310	5,265
Tillamook Bay	235	29	26.4	2,156	1,023	1,883	893
Nestucca R	149	22	20.9	4,069	2,253	3,940	2,182
Sand Lake and Neskowin Cr	13	3	2.3	71	52	71	52
Small Ocean Tributaries	7	1	1.0	0	NA	0	NA
Mid Coast	**1,160**	**102**	**69.5**	**27,953**	**5,493**	**25,528**	**5,016**
Salmon R	49	6	5.4	1,285	964	310	233
Siletz R	166	11	10.2	2,052	1,105	1,437	773
Yaquina R	111	10	7.7	3,191	2,469	3,039	2,351
Devils Lake, Beaver Cr	47	5	4.7	5,651	3,189	5,274	2,976
Alsea R	206	22	20.8	3,935	1,859	3,339	1,577
Yachats R	33	1	1.2	52	NA	52	NA
Siuslaw R	483	41	39.9	11,024	4,376	11,024	4,376
Mid-Small Ocean Tribs	53	6	6.6	764	876	764	876
Mid-South Coast	**614**	**83**	**75.4**	**73,670**	**22,116**	**70,793**	**21,252**
Siltcoos and Tahkenitch Lks	43	4	2.1	3,877	4,127	3,877	4,127
Coos R	210	36	34.0	44,160	26,455	43,301	25,940
Coquille R	296	38	34.5	14,878	5,650	13,310	5,054
Tenmile Lks	30	3	2.5	8,779	7,204	8,741	7,172
Floras Cr, New R and Sixes R	35	2	2.3	1,976	3,036	1,945	2,989
Umpqua	**1,069**	**97**	**82.6**	**37,938**	**7,803**	**34,041**	**6,872**
Lower Umpqua and Smith R	256	36	22.8	8,975	2,913	8,850	2,806
Mainstem Umpqua R	178	5	19.1	12,014	6,186	8,177	4,211
Elk Cr and Calapooya Cr	155	4	5.0	2,628	2,670	2,581	2,621
Cow Cr	174	19	18.1	7,306	5,187	6,661	4,728
South Umpqua R	306	19	17.6	7,015	4,393	6,482	4,059
South Coast	**448**	**51**	**51.3**	**8,098**	**2,695**	**7,497**	**2,495**
Elk River	8	0	0.0	NA	NA	NA	NA
Lower Rogue R. Tributaries	37	1	0.9	586	NA	130	NA
Applegate River	76	8	9.3	1,030	697	991	670
Illinois River	104	10	8.2	3,553	2,548	3,553	2,548
Mainstream Tribs	144	16	17.6	813	778	662	633
Little Butte Cr	32	6	5.6	811	612	811	612
Evans Cr	40	9	8.6	1,080	766	1,080	766
Big Butte Cr	15	1	1	225	NA	225	NA

a *Average of 1998-2001 ratio estimates. Ratio estimates derived from multiplying MA weight by number of target sites in each basin group and adjusting for revisions in spawning mileage.*

b *Estimates derived using EMAP protocol. Estimates are adjusted for visual observation bias.*

c *Estimates of wild spawners derived through application of fin-mark recoveries in random survey sites.*

Table 2-4. Annual estimates of wild coho spawner abundance in coastal river basins within the Oregon Coastal ESU, 1990-2001.

Monitoring Area, Basin Group	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
North Coast:												
Necanicum R. & Elk Cr.	191	1,135	185	941	408	211	768	253	946	728	474	5,247
Nehalem R.	1,552	3,975	1,268	2,265	2,007	1,463	1,057	1,173	1,190	3,713	14,285	22,310
Tillamook Bay	265	3,000	261	860	652	289	661	388	271	2,175	1,983	1,883
Nestucca R.	189	728	684	401	313	1,811	519	271	169	2,201	1,171	3,940
Sand Lake & Neskowin Cr		240	24	41	77	108	275	61	0	47	0	71
Miscellaneous	-	204	-	-	-	-	-	-	-	-	-	0
Total	**2,197**	**9,282**	**2,422**	**4,508**	**3,457**	**3,882**	**3,280**	**2,146**	**2,576**	**8,842**	**17,898**	**33,667**
Mid Coast:												
Salmon R.	385	39	28	364	107	212	271	237	8	175	0	310
Siletz R.	441	984	2,447	400	1,200	607	763	336	394	706	3,553	1,437
Yaquina R.	381	380	633	549	2,448	5,668	5,127	384	365	2,588	647	3,039
Devil's Lk. and Beaver Cr.	23	-	756	500	1,259	-	1,340	425	1,041	3,366	738	5,274
Alsea R.	1,189	1,561	7,029	1,071	1,279	681	1,637	680	213	2,050	2,465	3,339
Yachats R.	280	28	337	287	67	117	176	99	102	150	79	52
Siuslaw R.	2,685	3,740	3,440	4,428	3,205	6,089	7,625	668	1,089	2,724	6,767	11,024
Miscellaneous	207	-	700	180	250	231	1,188	13	71	0	12	764
Total	**5,591**	**6,732**	**15,370**	**7,779**	**9,815**	**13,605**	**18,127**	**2,842**	**3,283**	**11,442**	**14,181**	**25,528**
Umpqua:												
Lower Umpqua R. & Smith R.	589	1,316	1,759	4,804	1,689	6,803	4,904	935	5,118	2,323	3,696	8,850
Mainstem Umpqua	455	-	192	1,431	1,240	352	339	397	444	1,289	2,774	8,177
Elk & Calapooya Cr.	185	-	-	-	708	2,315	1,709	196	379	434	1,864	2,581
South Umpqua	2,508	2,284	-	2,415	579	755	1,685	512	1,807	1,219	479	6,482
Cow Cr.			201	661	269	1,124	1,112	193	678	1,234	1,582	6,661
Total	**3,737**	**3,600**	**2,152**	**9,311**	**4,485**	**11,349**	**9,749**	**2,233**	**8,426**	**6,466**	**10,468**	**34,041**
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	5,386	43,301
Coquille	2,712	5,651	2,115	7,384	5,035	2,116	16,169	5,720	2,466	3,001	6,130	13,310
Total	**4,985**	**9,464**	**18,660**	**22,668**	**19,720**	**12,467**	**28,297**	**6,847**	**5,633**	**7,946**	**11,516**	**56,611**
Oregon Coastal ESU	**16,510**	**29,078**	**38,604**	**44,266**	**37,477**	**41,303**	**59,453**	**14,068**	**19,816**	**34,646**	**54,063**	**149,847**

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 2002b). We now have twelve years of data encompassing different flow regimes and population sizes with which to compare the Standard Index and the random surveys.

Figure 2-12 shows the relationship between standard and random survey densities for the Oregon Coastal ESU over the last twelve years. On average, random spawner densities comprise 30% $\pm$ 6.5% of those in standard sites. The surveys in the Standard Index were chosen because of the presence of exceptional spawning habitat. Consequently, we would expect higher spawner densities in Standard Index surveys than the average densities in random surveys, which encompass a wider diversity of habitat quality. In years of relative high abundance, however, we would expect more spawners to stray from high quality spawning habitat as high quality habitat becomes saturated. A second order polynomial provides the best fit the twelve years of data, supporting this hypothesis. Using this equation, standard spawner densities explain 90% of the variation in random spawner densities.

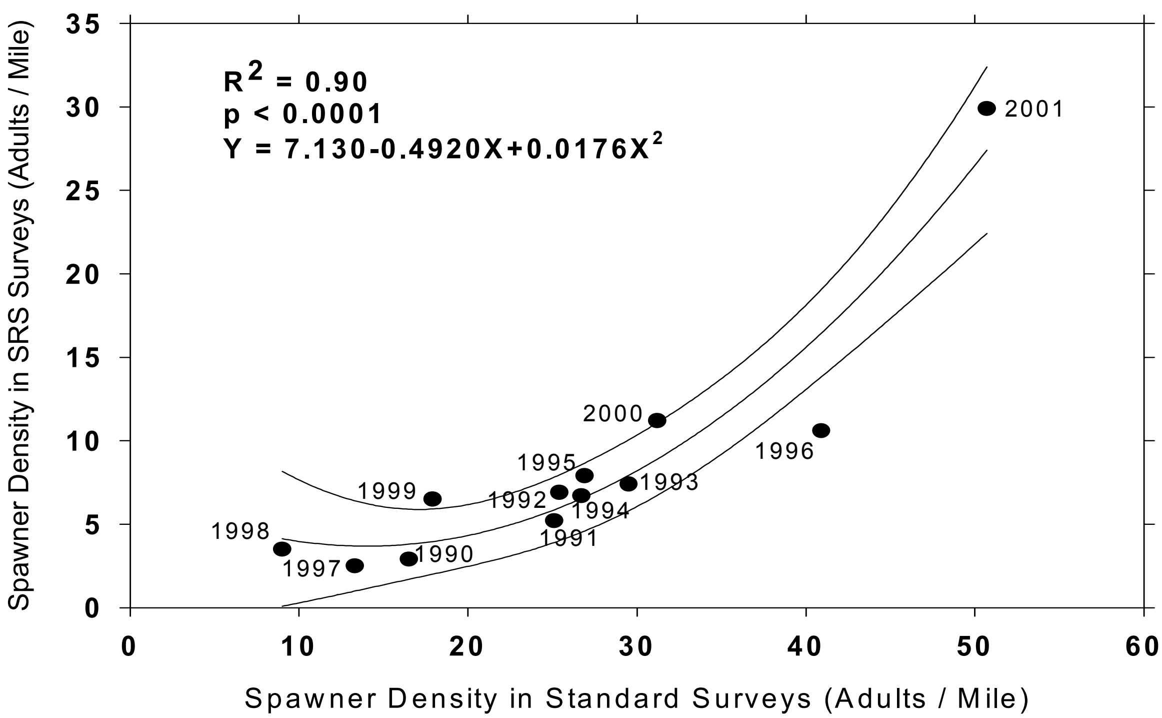


Figure 2-12. Relationship between spawner densities of adult coho salmon derived from standard and random survey sites, 1990-2001. Parabolic lines indicate the 95% confidence interval for the regression equation.

Relative to the calibration of historical OCN abundance, the model described above indicates that the standard index is not a consistent measure of spawner abundance. Higher densities in the standard index correspond to proportionally higher population abundances than do lower densities. Applying this model to the data series of the Standard Index (Figure 2-5) would result in a more severe decline in OCN population abundance over the last 52 years than are being depicted by the raw data. However, given the models reliance on the 2001 data point this conclusion should bee interpreted cautiously. More data points at high abundance levels are needed to validate the exact form of the model.

Coastal Lake Basins

Table 2-5 lists estimates of coho spawner abundance in Siltcoos, Tahkenitch and Tenmile Lakes in 2000 and 2001 as derived by the traditional methodology. Across these three systems, adult abundance ranged from 634 spawners in Tahkenitch Lake to 8,278 spawners in Tenmile Lakes in 2000. In 2001, 11,039 spawners were present in Tenmile Lakes, while Siltcoos and Tahkenitch had 5,104 and 3,526 spawners respectively. 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 45-year period for which estimates are available spawner abundance in these systems has ranged as high as 40,000 adults (Figure 2-13).

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 2-13).

Table 2-5. Estimated total spawning stock size of adult and jack coho salmon in Oregon coastal lake basins, 2000 and 2001.

Coastal lake basin	Estimated spawning stock size: Adults	Estimated spawning stock size: Jacks
2000		
Siltcoos Lake	3,835	1,757
Tahkenitch Lake	634	1,071
Tenmile Lakes	8,278	5,187
Total	12,747	8,015
2001		
Siltcoos Lake	5,104	436
Tahkenitch Lake	3,526	336
Tenmile Lakes	11,039	589
Total	19,669	1,361

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 50% 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.

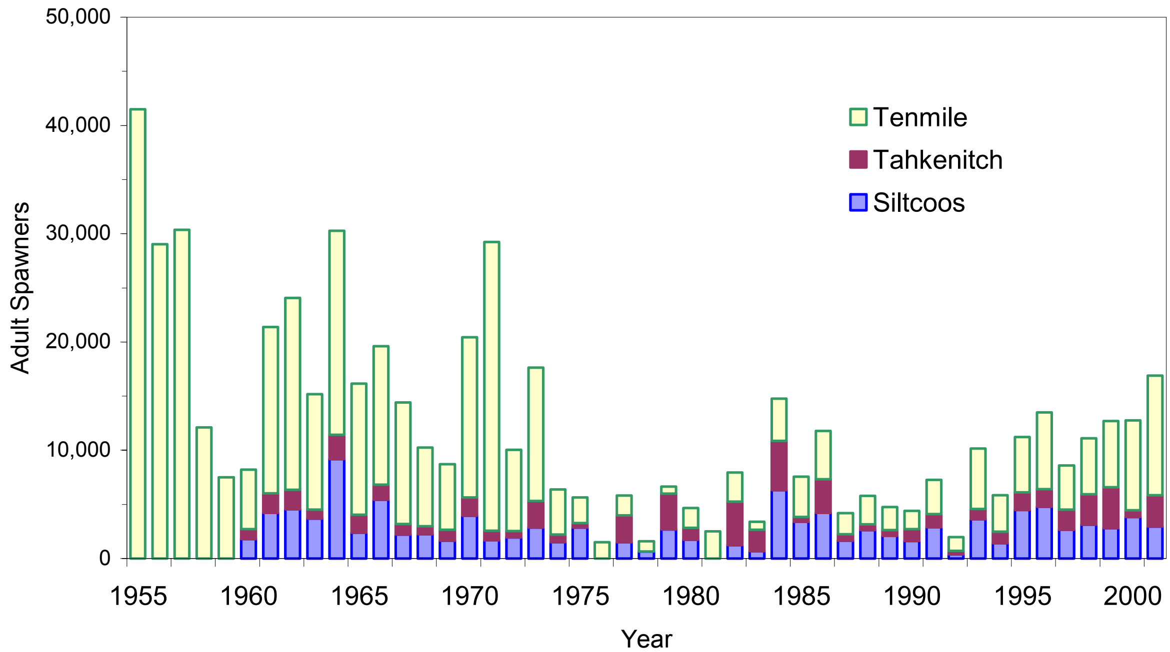


Figure 2-13. Estimated adult coho spawner abundance in Oregon coastal lake basins, 1955-2001. Estimates for Siltcoos and Tahkenitch Lakes and not available for 1955-59, 1976 and 1981. Estimates for Tahkenitch Lakes and not available for 1978.

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. Tables 2-2 and 2-3 list 2000 and 2001 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 EMAP estimate for Siltcoos and Tahkenitch Lakes was $\pm$105% in 2000 and $\pm$106% in 2001. Only one site in Tenmile Lakes was surveyed under the EMAP protocol in 2000, so it is not possible to calculate confidence intervals for this estimate. In 2001, the precision of the estimate for Tenmile Lakes was $\pm$82%. 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 Monitoring Area level. Annual abundance estimates for individual basins will generally not have high precision because of the low sample size of surveys in each basin.

Oregon Coastal ESU

Estimates of the abundance of adult coho spawners within the four Monitoring Areas that comprise the Oregon Coastal ESU are available back through 1990 (Figure 2-14). Spawner abundance in the Oregon Coastal ESU has ranged from about 20,000 adults in 1990 to over 160,000 adults in 2001. 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 Monitoring Areas, spawner abundance has generally been lowest in the North Coast Monitoring Area and highest in the Mid-South Coast Monitoring Area. However, in 2000 and 2001, the North Coast had sharp increases in spawner abundance. These increases resulted primarily from increases in spawner abundance in the mid and upper portions of the Nehalem Basin. In the North Coast Monitoring Area, spawner abundance has averaged about 8,000 adults, and has ranged from about 2,200 adults to over 33,000 adults. In the Mid-South Coast Monitoring Area, spawner abundance has averaged about 27,000 adults, and reached 70,587 adults in 2001. The most productive basins in this Monitoring Area have been the Coos, Tenmile Lakes and Siltcoos Lake Basins.

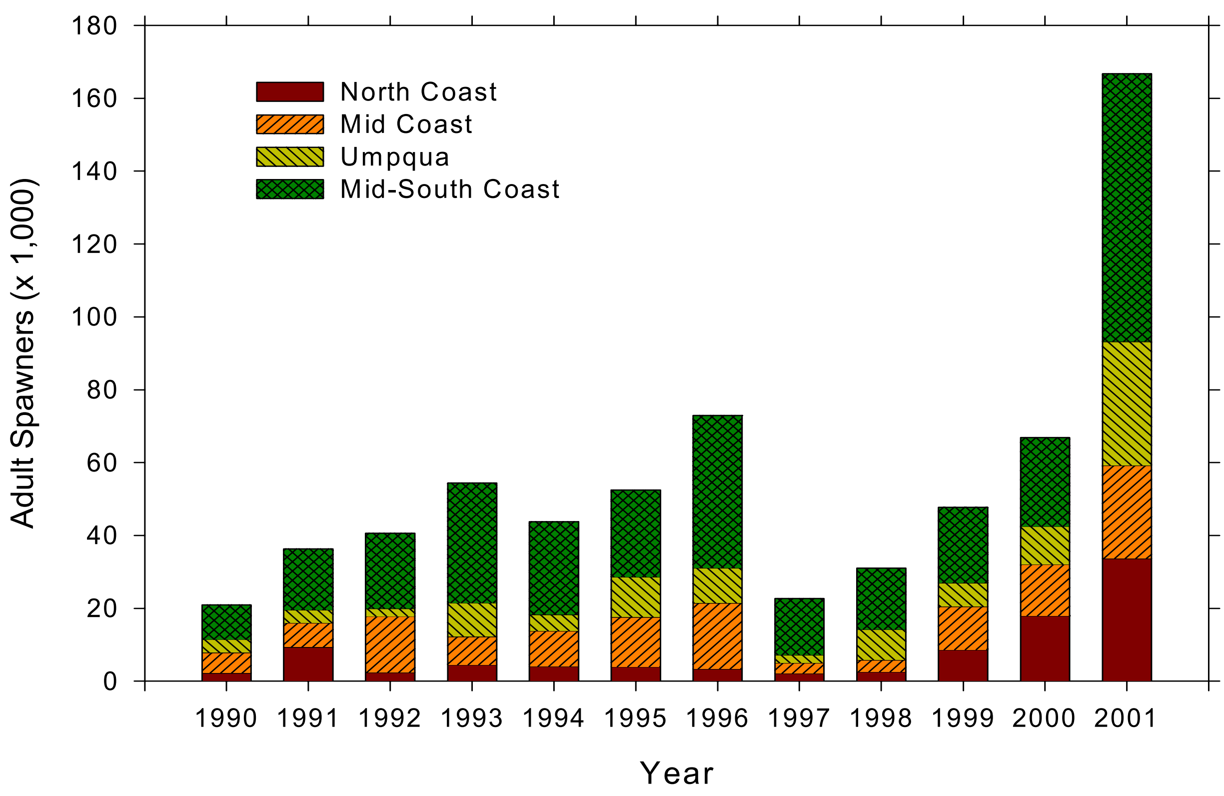


Figure 2-14. Estimated spawner abundance of coho salmon for individual Monitoring Areas within the Oregon Coastal ESU, 1990-2001. Bars show the contribution of each Monitoring Area to the total abundance of the ESU, including three coastal lake basins located within the Mid-South Coast Monitoring Area. Estimates of abundance in river systems are based on randomized methodology. Estimates of abundance in lake systems are based on traditional methodology.

Figure 2-15 depicts spawner replacement ratios of coho populations in each MA within the Oregon Coastal ESU for the 1990-98 brood years. Values less than one indicate that population abundance declined between successive generations. The pattern shown in this figure depicts substantial geographic and interannaul variation in survival. Prior to the 1996 brood year North Coast coho generally had poorer survival than coho in other MAs. Conversely, since 1996 survival has been highest for North Coast stocks. For the other three MAs spawners replaced themselves except during the 1994, 95 and 96 brood years, when survival was uniformly low.

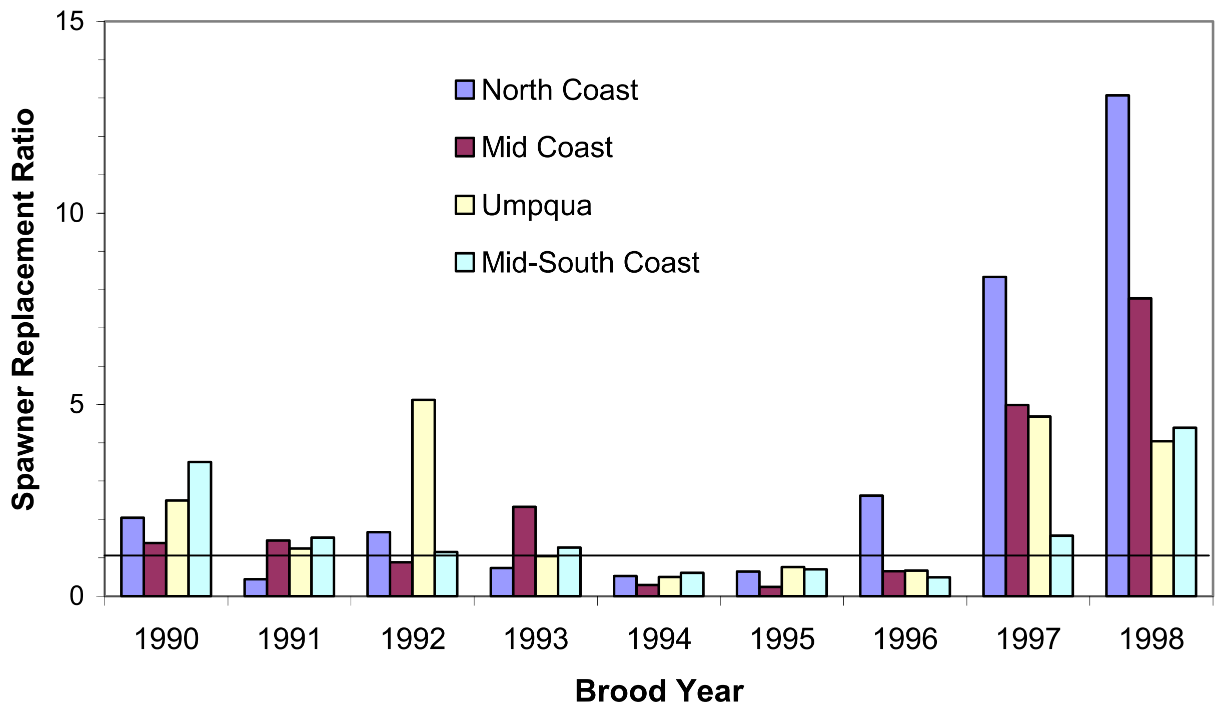


Figure 2-15. Spawner replacement ratios for coho populations within each of the four Monitoring Areas that compose the Oregon Coastal ESU. Values shown are the ratio of the abundance of adult spawners in each brood year to the abundance of adult spawners three years later. Horizontal line represents a value of one, or spawner replacement.

Southern Oregon ESU

Production of coho salmon in the Southern Oregon ESU overwhelmingly occurs in the Rogue Basin. Recent juvenile sampling conducted within this ESU, but outside of the Rogue Basin, failed to locate any significant coho populations (Telephone interview on 25 October 2002 with Thomas Satterthawite, Oregon Department of Fish and Wildlife, Southwest Region Monitoring Coordinator, Grants Pass). Estimates of the run size of coho salmon to the Rogue River Basin for 1980-2001 are presented in Table 2-6. 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 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. The run size estimates for 2000 and 2001 were the highest observed in the last twenty years.

Survey-based estimates of Rogue Basin spawner abundance have been available since the initiation of an integrated monitoring program in 1998 that included comprehensive coast-wide spawning surveys. Because survey-based estimates are independent of mark-recapture estimates derived from returns and Huntley Park seining, we are able to compare the two to assess consistency in our assessment programs. Tables 2-2 and 2-3 list the survey-based estimate of adult spawner abundance for the Rogue Basin in 2000 and 2001. Adjusting this estimate for angler harvest and returns above the Elk Cr. trap site yields estimates of 4,514 spawners in 2000 and 9,708 spawners in 2001. The estimates of the wild run size based on mark-recapture methods are 10,966 ±1,673, and 12,213 ±1,290 substantially higher than the survey-based estimates. This is not surprising considering the exceptional flow regime that occurred in 2000. Flows in the Rogue River basin remained well below the 40-year average for the entire spawning season, and were below the 20th percentile for this period for most of the season (Figure i-2). Consequently, spawning fish were never able to reach many spawning areas and likely spawned in larger order streams that are not part of the EMAP sampling approach. However, a similar (though lesser) discrepancy has been seen in each of the four years for which a randomized sample estimate is available. We will continue to track the correspondence of these two estimates, as additional data become available.

Run size estimates of naturally produced adult coho are available for a 20-year period beginning in 1980 (Figure 2-16). During this period, run size has ranged from about 300 adults in 1993 to 12,000 adults in 2001. 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 in 1981 and 2001.

Table 2-6. 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
2000	194	505	9,225	7,385	21,083	2,320	10,966	1,673
2001	423	1040	11,984	9,396	25,379	1,860	12,213	1,290

Estimates of the ratio of adult recruits per spawner for the 1980-98 brood years of Rogue River coho are shown in Figure 2-17. This measure of survival has shown no discernable pattern over the 17-year period. Survival has shown 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 recruits to spawner ratios is substantially better beginning with the 1993 brood year. The ratio of recruits per spawner was greater than one for both the 1997 and 1998 brood years. The 1998 brood year had high survival with a ratio of 6.2 recruits per spawner.

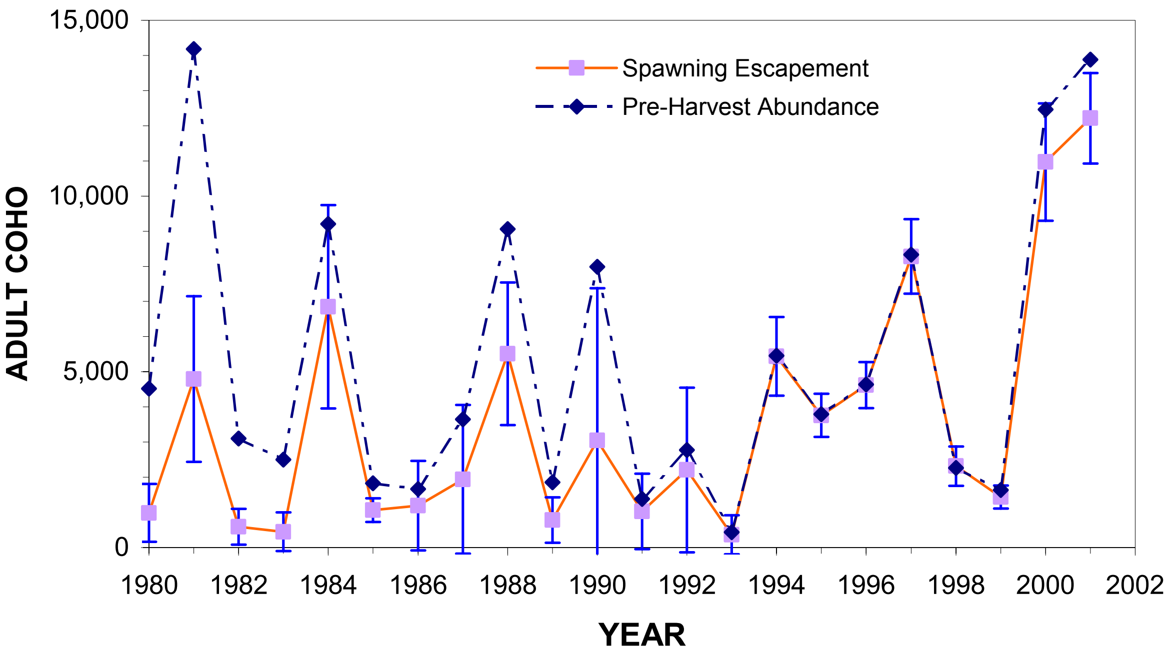


Figure 2-16. Trends in spawning escapement and pre-harvest abundance of Rogue River coho salmon, 1980-2001. Vertical bars represent 95% confidence intervals for estimates of spawner abundance.

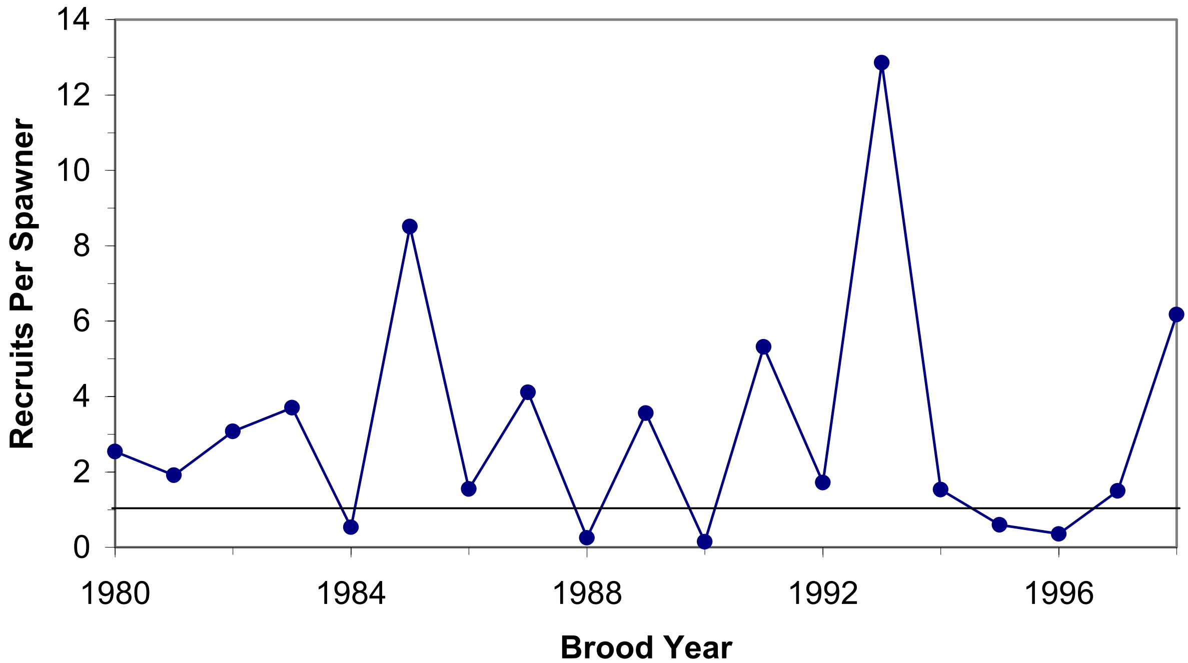


Figure 2-17. Estimated recruit per spawner ratio for adult Rogue River coho salmon during the 1980-98 brood years. Horizontal line depicts level of spawner replacement.

Occurrence of Hatchery Fish in Natural Spawning Areas

Random surveys provide the most representative sample of fin marks and scales from naturally spawning fish because they are taken from an unbiased sample of the available habitat. 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 fish to be estimated from recovery of fin-marked carcasses. Figure 2-18 shows the proportion of natural spawning coho in each Monitoring Area estimated by this methodology during 1998 through 2001. With the exception of the Mid-Coast MA in 1998, wild fish were the dominant component of natural spawner populations in all Monitoring Areas over the last four years. During the last two years, the proportion of hatchery-reared coho among naturally spawning populations ranged from zero in the Mid-South Coast in 2000, to 7.9% in the Umpqua Monitoring Area in 2001.

The number of coded-wire tag recoveries in 2000 was insufficient to draw any conclusions about the origin of strays. In 2001, the largest contingent of hatchery-reared fish that strayed into the spawning grounds originated in Columbia River hatcheries (40%). North Coast hatcheries and Umpqua River hatcheries each accounted for 21% of strays, and 12% came from the South Coast. A handful of strays originated in Mid Coast (Salmon River, 5%) and Mid-South Coast (Bandon, 2%) hatcheries (Table 2-7). The largest numbers of strays were seen in the South Coast Monitoring Area and on the Umpqua River. Fifty percent of the strays in the South Coast originated in Columbia River hatcheries, and 57% of strays in the Umpqua came from outside the region (75% of those from Columbia River hatcheries).

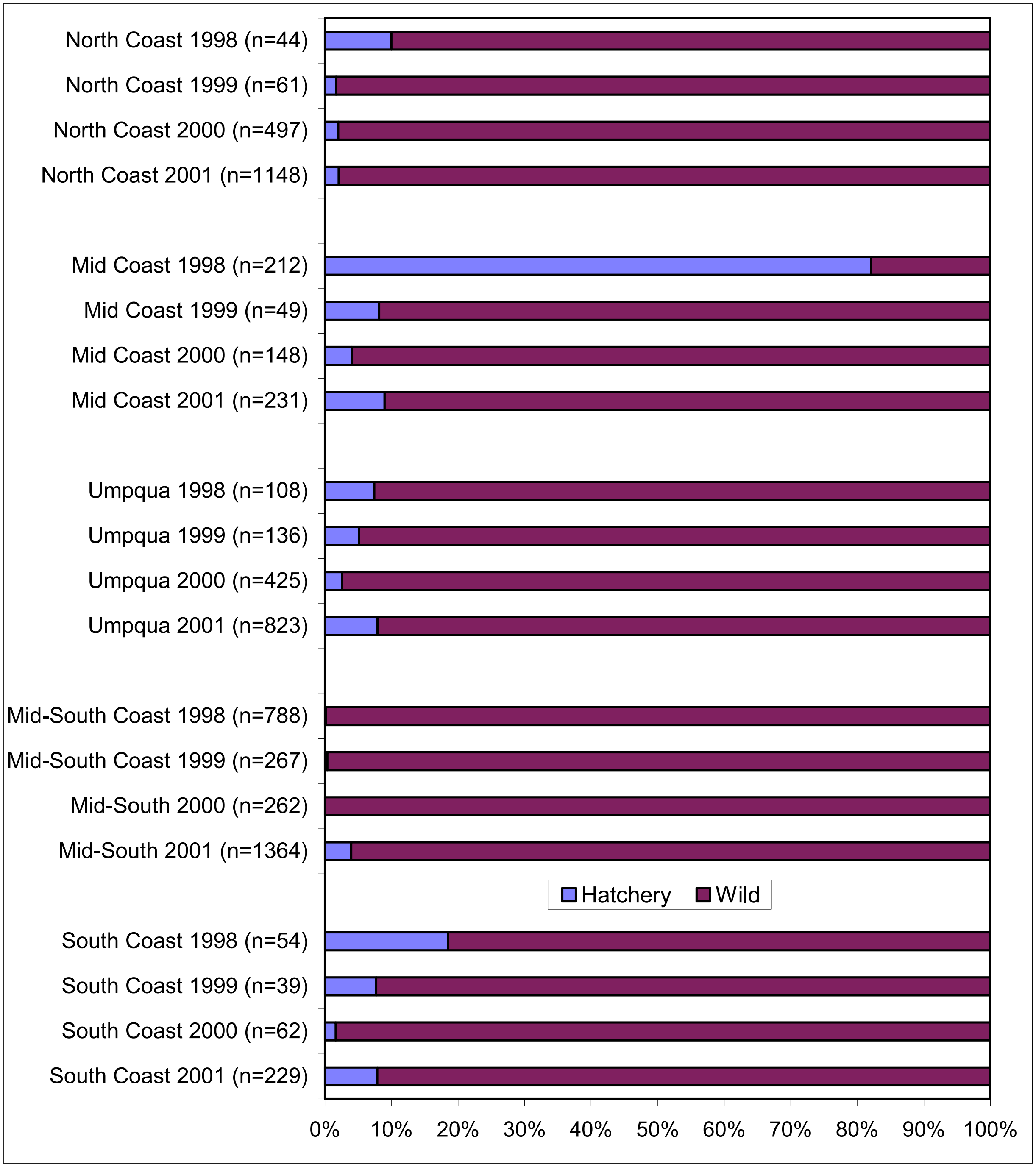


Figure 2-18. Rearing origin of naturally spawning adult coho in Oregon coastal Monitoring Areas, 1998-2001. Estimates are derived from recovery of adipose fin-marked carcasses on random spawning surveys.

Table 2-7. Hatchery-reared fall chinook possessing coded-wire tags that were recovered on spawning surveys in Oregon Coastal Basins, 2000 and 2001.

Recovery				Release		
Basin	Subbasin	Number	Average Recovery Date	Area	Hatchery	Release Site
			2000			
Trask R.	South Fork	1	11/3/00	North Coast	TRASK	TRASK R.
Salmon R.	Main Stem	1	12/12/00	Olympic Peninsula	QUINAULT NFH	COOK CR.
Salmon R.	Main Stem	319	11/19/00	Mid-Coast	SALMON R.	SALMON R.
		17	11/15/00	Mid-Coast	SALMON R.	SILETZ R.
		1	11/6/00	North Coast	TRASK	TRASK R.
Alsea R.	Drift Creek	1	12/29/00	Lower Columbia	LEWIS R.	LEWIS R.-NFk
Umpqua R.	Main Stem	1	11/6/00	Lower Columbia	LEWIS R.	LEWIS R. -NFk
	South Umpqua	7	1/2/01	South Umpqua	GALESVILLE TRP	COW CR.
			2001			
Necanicum R.	Main Stem	1	11/8/01	Lower Columbia	EAGLE CR. NFH	YOUNGS BAY
		1	11/8/01	Lower Columbia	NORTH TOUTLE	GREEN R.
Nehalem R.	Main Stem	2	11/16/01	North Coast	TRASK R. PONDS	TRASK R
	North Fork	3	11/26/01	North Coast	NEHALEM	N FK NEHALEM
Trask R.	South Fork	1	11/12/01	Mid-Coast	SALMON R.	SALMON R.
	South Fork	2	11/8/01	North Coast	TRASK R. PONDS	TRASK R.
Siletz R.	Main Stem	1	11/6/01	Mid-Coast	SALMON R.	SALMON R.
Alsea R.	Main Stem	1	12/6/01	North Coast	NEHALEM	N FK NEHALEM
	Five Rivers	1	11/19/01	Lower Columbia	ELOCHOMAN	TONGUE PT.
Cape Cr.	Main Stem	1	12/4/01	Lower Columbia	SANDY	CEDAR CR.
Umpqua R.	Main Stem	1	11/15/01	Lower Columbia	BIG CR.	BIG CR.
		1	11/18/01	Mid-South Coast	BUTTE FALLS	SEVENMILE CR.
		1	11/6/01	Lower Columbia	CEDC	YOUNGS BAY
		1	11/27/01	Lower Columbia	ELOCHOMAN	LEWIS R. -NFk
		2	11/27/01	Lower Umpqua	GARDINER CR	UMPQUA R.
		1	11/12/01	Lower Columbia	LEWIS R.	LEWIS R -NFk
		2	11/15/01	Lower Columbia	NORTH TOUTLE	GREEN R.
	South Umpqua	3	12/14/01	South Umpqua	GALESVILLE TRP	COW CR.
		1	11/5/01	Lower Columbia	LEWIS R.	LEWIS R. -NFk
	Calapooya Cr.	1	12/29/01	North Umpqua	ROCK CR.	ROCK CR.
Coos R.	Main Stem	1	11/10/01	Mid-Columbia	LTL W. SALMON	LTL W SALMON R
	Millicoma R.	1	12/10/01	North Umpqua	ROCK CR.	ROCK CR.
		1	11/12/01	Lower Columbia	SANDY	CEDAR CR.
Coquille R.	Main Stem	1	1/4/02	Mid-South Coast	BANDON	FERRY CR.
	North Fork	1	12/3/01	Mid-Columbia	CHIWAWA	CHIWAWA R.
Sixes R.	Main Stem	1	12/27/01	Mid-Columbia	KLICKITAT	KLICKITAT R.
Rogue R.	Main Stem	1	1/18/02	Upper Rogue	COLE R.	ROGUE R. R-4
		1	11/19/01	Lower Columbia	ELOCHOMAN	LEWIS R. -NFk
		1	12/8/01	North Umpqua	ROCK CR.	ROCK CR.
	Lobster Cr.	1	11/8/01	Lower Columbia	GRAYS R.	GRAYS R.
	Applegate R.	1	1/16/02	Lower Columbia	FALLERT CR.	FALLERT CR.
		1	11/21/01	North Umpqua	ROCK CR.	ROCK CR.

There was a temporal component associated with the origin of strays in 2001. Carcasses of Columbia River strays were collected on the spawning grounds earlier than strays from other locations, appearing from 5 November to 27 November on the Umpqua Basin. In the South Coast MA, one coded-wire tagged carcass from Fallert Cr. (Lower Columbia) was recovered in January, but all other Columbia River strays were recovered in early November. Assuming that coho live about 11 days on the spawning grounds, these fish would have appeared on survey segments during late October and early November, coinciding with an the unusually early appearance of coho spawners in both the Rogue River and the Umpqua River (Figure 2-3). When we graph the spawn timing of marked and unmarked live adult coho in the South Coast MA, there is a clear separation between marked and unmarked fish (Figure 2-19). This indicates that very limited interbreeding occurred between hatchery and wild fish.

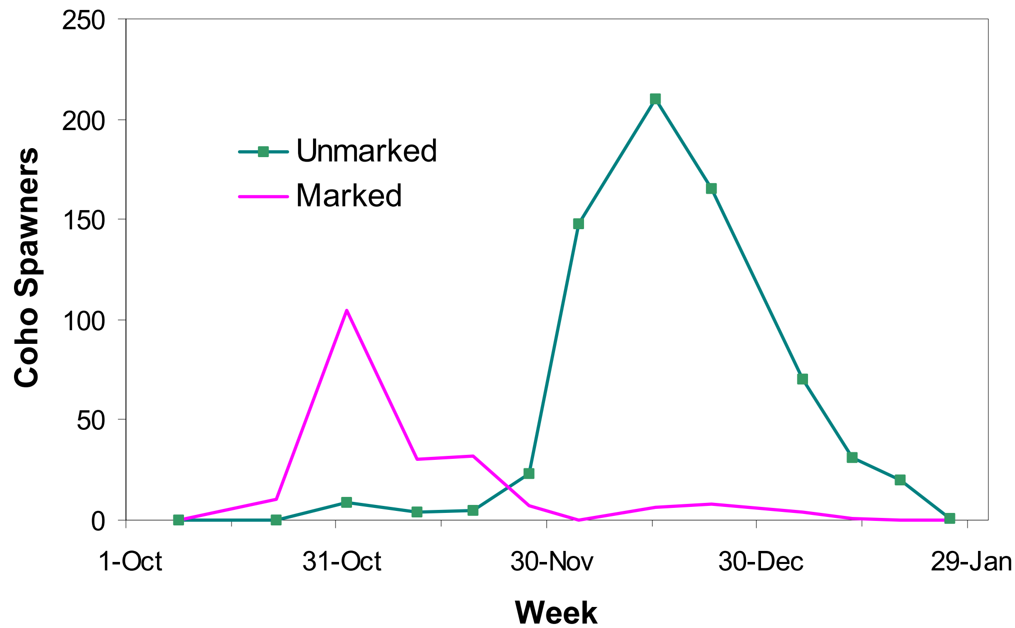


Figure 2-19. Temporal distribution of marked and unmarked spawning coho salmon observed on spawning surveys in the South Coast Monitoring Area during the 2001 spawning season.

Observations of Fin Marks on Live and Dead Fish

Beginning in 2000, two different methods were employed to determine the proportion of hatchery strays on the spawning grounds. In addition to estimates based on recovery of fin-marked carcasses, marks on live fish were also recorded. If surveyors could not determine whether a live fish was marked or not, the mark was recorded as unknown, and the data were not used in this analysis. The results of these two methods in 2000 and 2001 are presented in Table 2-8. Only basins with a minimum sample size of 10 carcass recoveries or live observations were used for this comparison. The marked:unmarked ratios calculated by each method were consistent.

A paired t-test showed no statistical differences between the two methods. The relationship between the two methods was close to 1:1, and the variation in estimates made using observations of live fish explained 83% of the variation seen in estimates made using carcasses observations (Figure 2-20). The largest discrepancy observed amongst the five Monitoring Areas was the estimate for the Mid Coast in 2001 (live estimate = 2.5% marked, carcasses estimate = 9.0% marked). Because surveyors were able to distinguish fin marks on many more live fish than dead fish, estimates based on marks on live fish are a more sensitive indicator of the presence of hatchery strays on the spawning grounds.

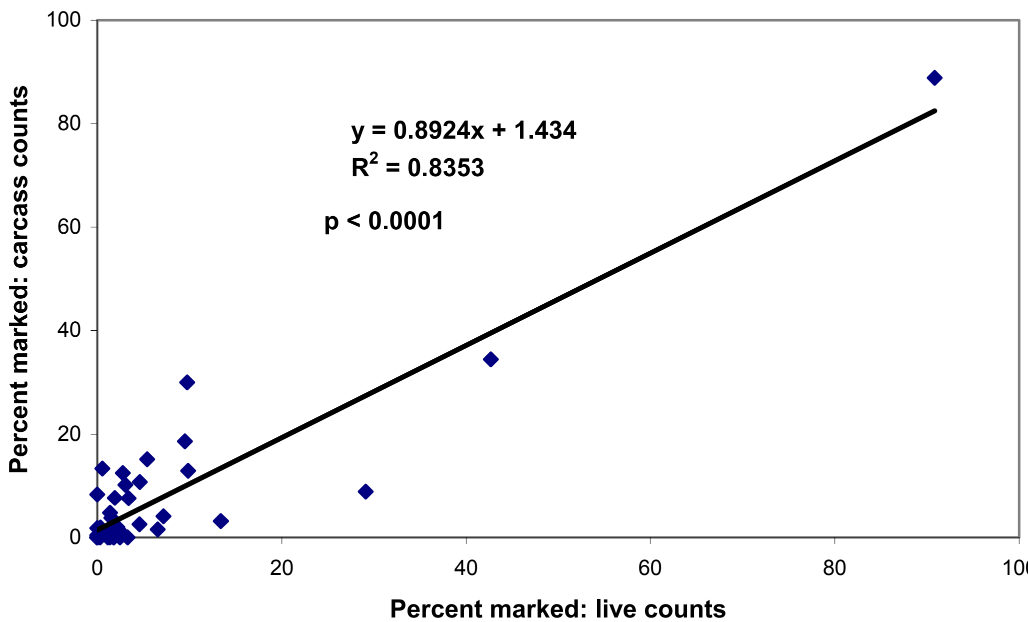


Figure 2-20. Relationship between estimates of stray rates based on observations of fin marks on live coho and carcasses in random coho surveys in 2001.

Table 2-8. Mark ratios based on observations of adipose fin marks on live and dead coho spawners in random coho surveys in 2000 and 2001. Values have been adjusted to account for the marked: unmarked ratio at the nearest hatchery facility. Only Basin Groups with a minimum sample size of 10 carcasses or live mark observations were included for this comparison.

Monitoring Area, Basin Group	2000				2001			
	Live		Carcasses		Live		Carcasses	
	Total	% Marked	Total	% Marked	Total	% Marked	Total	% Marked
North Coast[a]	**1,974**	**1.3**	**497**	**2.0**	**2,532**	**3.3**	**1,148**	**2.1**
Necanicum R, Ecola Cr and Midsize Ocean Tribs	--	--	--	--	458	7.2	147	4.1
Nehalem R	1,618	0.5	377	0.4	1,815	2.0	920	2.1
Tillamook Bay	162	9.9	62	13.0	108	2.8	16	12.7
Nestucca R	137	2.2	51	2.0	149	13.4	63	3.2
Mid Coast[a]	**610**	**2.6**	**148**	**4.1**	**1,320**	**2.5**	**231**	**9.0**
Siletz R	162	3.1	23	0.0	133	9.8	20	30.0
Yaquina R	--	--	--	--	218	1.4	21	4.8
Devils Lake, Beaver Cr and Midsize Ocean Tribs	--	--	--	--	178	0.6	15	13.3
Alsea R	91	3.3	16	0.0	129	5.4	33	15.2
Siuslaw R	260	1.2	91	0.0	654	1.4	128	0.0
Umpqua Basin[a]	**873**	**4.0**	**425**	**2.6**	**2,229**	**9.8**	**823**	**7.9**
Lower Umpqua and Smith R	451	0.4	242	0.4	1,225	2.9	378	0.5
Mainstem Umpqua R	157	1.9	52	7.7	389	42.7	119	34.5
Elk Cr and Calapooya Cr	153	4.6	78	2.6	48	0.0	110	1.8
Cow Cr	79	29.2	45	8.9	361	3.1	137	10.3
South Umpqua R	--	--	--	--	206	3.4	79	7.6
Mid-South Coast[a]	**677**	**0.1**	**262**	**0.0**	**4,105**	**1.9**	**1,364**	**4.0**
Siltcoos and Tahkenitch Lks	12	0.0	42	0.0	102	0.0	81	0.0
Coos R	305	0.0	71	0.0	1,950	0.4	619	1.9
Coquille R	309	0.3	122	0.0	1,361	4.7	372	10.8
Tenmile Lks	39	0.0	26	0.0	540	0.0	227	0.4
Floras Cr, New R and Sixes R	--	--	--	--	152	6.6	65	1.5
South Coast[a]	**286**	**0.0**	**62**	**1.6**	**754**	**14.5**	**229**	**7.9**
Applegate River	16	0.0	12	8.3	132	1.5	53	3.8
Illinois River	123	0.0	43	0.0	255	0.0	27	0.0
Mainstream Tribs	--	--	--	--	84	9.5	43	18.6
Evans Cr	--	--	--	--	88	0.0	82	0.0
Total	**4,134**	**1.9**	**1,332**	**2.0**	**10,186**	**4.1**	**3,566**	**4.6**

a *Total for Monitoring Area including Basin Groups with sample sizes less than 10 samples.*

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 the assessment of the health of Oregon chum stocks 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 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 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. In 2000 and 2001, 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:

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

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

Stream flow conditions in Oregon coastal streams are typified by extreme inter-annual variation. This variation in stream flow can be seen by comparing the flow conditions during the 2000 and 2001 survey seasons for the Nehalem River near Foss (Figure i-2). Flow levels in this basin provide an indicator of survey conditions for chum salmon during these seasons. The

2001 season had two days with flows over 20,000 cfs between November and December. The 2000 survey season had one peak flow of just over 6,000 cfs. Stream flows can limit access to spawning areas in some streams. Chum salmon are not affected as much as other species since they generally spawn in the lower mainstem areas or the river.

Oregon chum salmon generally spawn during November and December. The 2000 season brought extremely low flows. This allowed all surveys to be conducted on a weekly basis. During the 2001 survey season, flows remained low until mid-November. This first event brought water levels up high enough to disrupt surveying in most of the mainstem and higher stream order survey sites. The Little North Fork Wilson River survey site had a 20-day gap between 18 November and 9 December, and Whiskey Cr. in Netarts Bay had a 15-day gap during this period. The second highest flows during the season occurred on 1 December and resulted in gaps between survey visits similar to those occurring two weeks prior. During this time period, Foley Cr. on the Nehalem experienced a 20-day gap between visits. All remaining survey sites are located in smaller tributaries and were surveyed on a regular basis, without disruption.

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. Within each of these basins, the 2000 and 2001 spawning years are compared to the six-year average between 1994-99. Among all these locations, the temporal pattern of spawning observed in 2000 and 2001 was generally similar to the long-term average. Peak spawning activity in 2000 and 2001 was within one week of the timing of the peaks of the long-term average. The severe drought induced low stream flow conditions that persisted throughout 2000 did not cause any substantial delays in spawning timing. 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 13 years (Figure 3-2). During this period average date of peak spawning as varied by only 10 days or less.

Index of Spawning Abundance

A total of 17 surveys (12.3 miles) were conducted in 1999 through 2001 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.

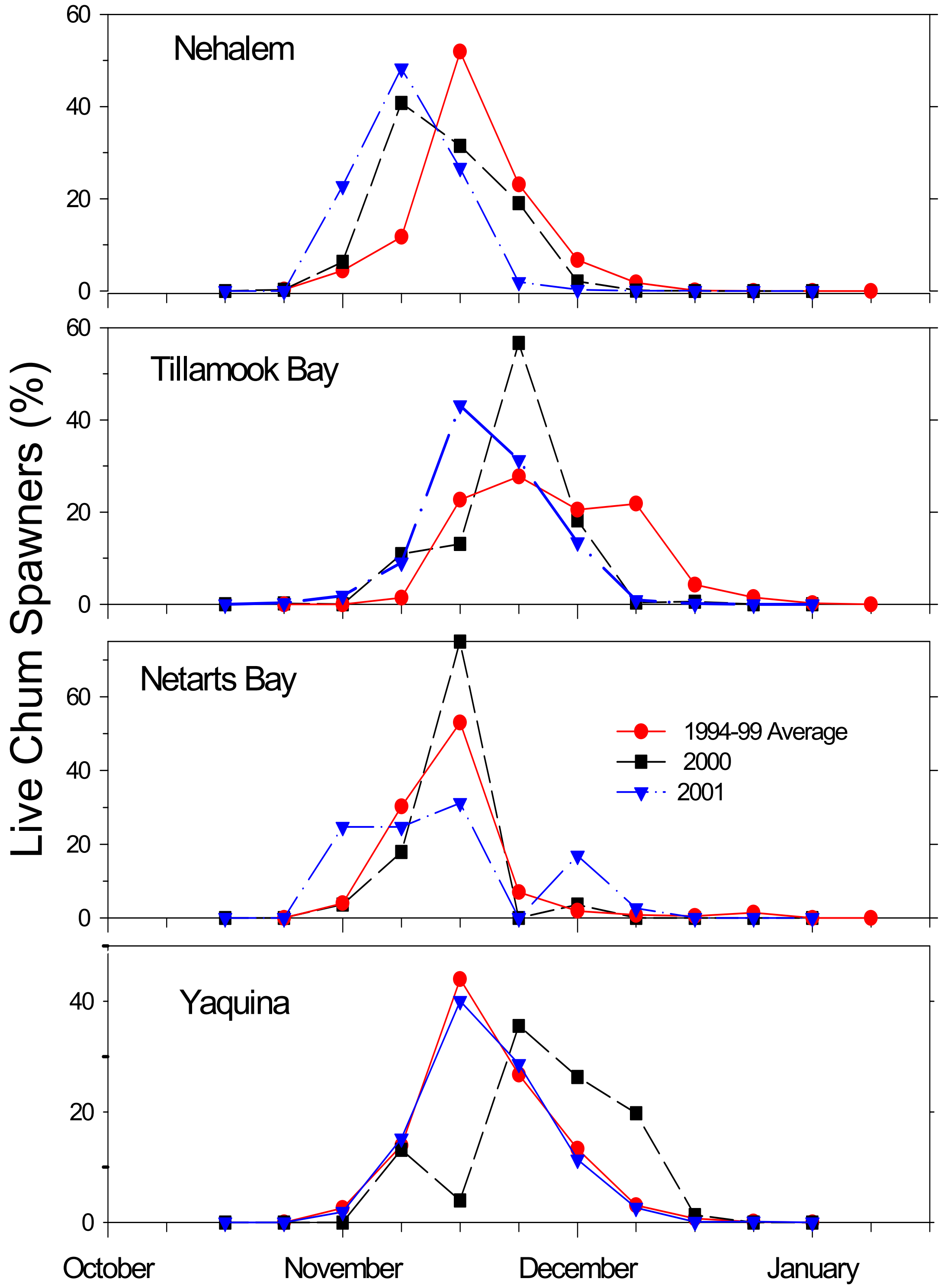


Figure 3-1. Spawning timing of chum salmon in 2000, 2001 and the average during the previous six seasons in selected coastal basins. Values plotted are the percent of total live adult chum counted that year in all survey segments targeting chum salmon.

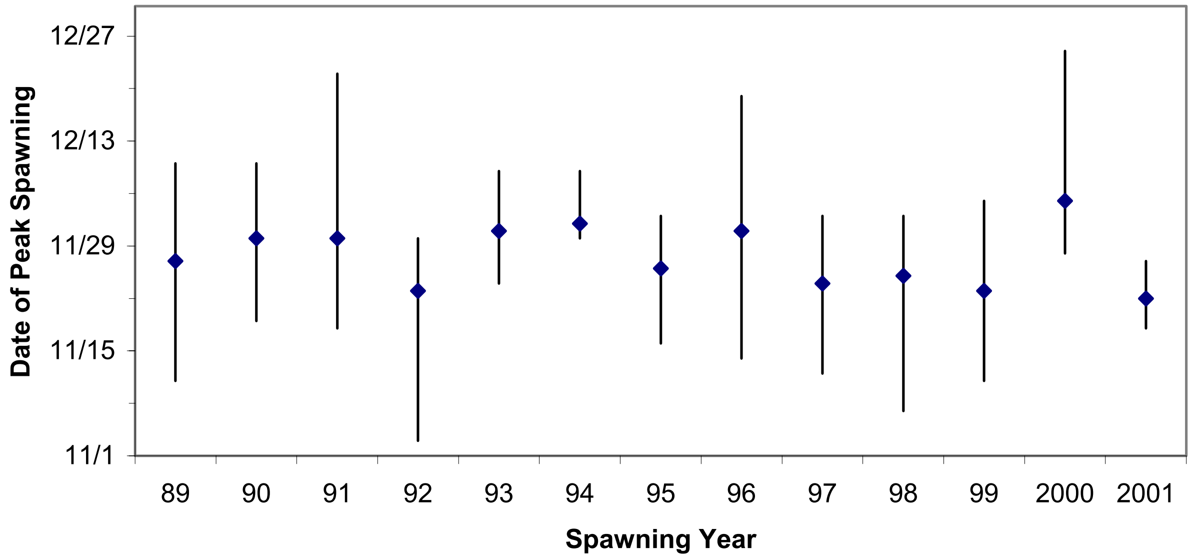


Figure 3-2. Mean time of peak spawning, and earliest and latest peak counts for standard chum surveys in 1989-2001.

Eight standard stream segments were surveyed in the Tillamook and Nestucca Basins during the 2000 and 2001 spawning seasons. The average peak counts (fish per mile) in the standard streams are reported in Table 3-1. Nine supplemental surveys were conducted in 2000 and 2001 to monitor chum populations outside of the index stream areas (Table 3-1). Chum peak counts were highest in both standard and supplemental surveys during the 2001 survey season.

Table 3-1. Summary of peak fish per mile counts of chum salmon in standard and supplemental stream segments, 2000 and 2001.

	Survey Segments		Average peak / mile	
Basin	Number	Total Miles	2000	2001
Standard Surveys				
Miami	3	1.4	56	603
Kilchis	3	2.1	145	531
Wilson	1	0.5	4	74
Nestucca	1	0.8	0	4
Total:	8	4.8	51	303
Supplemental Surveys				
Necanicum	2	2.1	21	9
Nehalem	4	3.7	150	319
Kilchis	1	0.5	94	326
Netarts	1	0.5	44	48
Yaquina	3	2.8	18	183
Total:	11	9.6	70	227

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 54-year period ($R^2 = 0.12$, $p<0.01$). A trend of gradual decline occurred from 1948 to the early 1960s, with peak densities going below 100 for the first time in 1960-61. Peak counts rose following the closure of the commercial fishery 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 peak density of 31 fish per mile occurred. Peak counts of chum salmon in standard index streams in the Tillamook and Nestucca Basins reached low levels in 1996 and remained at relatively low levels through 2000. This pattern changed in 2001 when spawner density was the highest observed in the last 15-year period back through 1988.

Consumptive fisheries for Tillamook Bay chum salmon were terminated in 1991. In the 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 fishery exploitation of Tillamook chum stocks during the period of spawner abundance monitoring, the low counts observed during recent 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 over the last 50 years.

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 except in 2002 when spawner density increased markedly in the Miami and Kilchis Rivers but not in the Wilson River. Peak counts in the Miami and Kilchis Rivers in 2001 were the highest recorded since 1992. Chum populations in the Nestucca River Basin have been uniformly low over the last thirteen years, and it may be that the Clear Creek index site no longer provides a suitable index for chum in this basin.

Supplemental Surveys

Peak counts from supplemental surveys show 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. Over the time series that is available, no discernable trend is apparent in spawner abundance in the Nehalem, Netarts or Yaquina Basins.

Peak counts in the Nehalem Basin were highest in 2002, with a secondary peak in 1992. 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). Beginning in 1998, all supplemental surveys are classified as wild. Thus, the record high spawner escapement observed for the Nehalem Basin in 2002 was composed of exclusively wild fish.

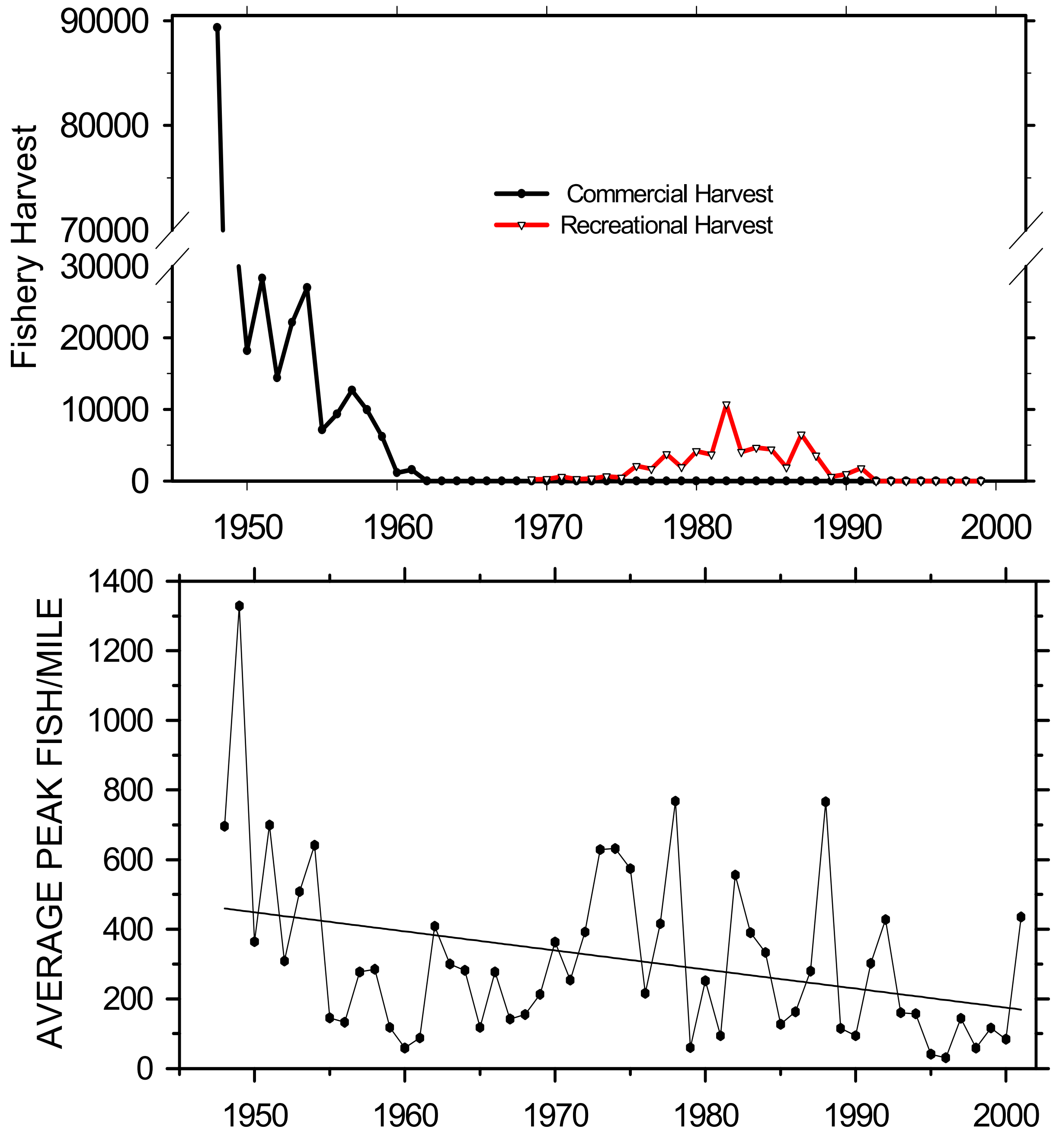


Figure 3-3. Trends in spawner abundance and fishery harvest of Oregon coastal chum salmon, 1948-2001. Upper panel: commercial and recreational harvest of chum salmon in Tillamook Bay. Lower panel: peak counts in standard survey sites. The trend line fitted to the data is significant (R^2 = 0.12, p<0.01).

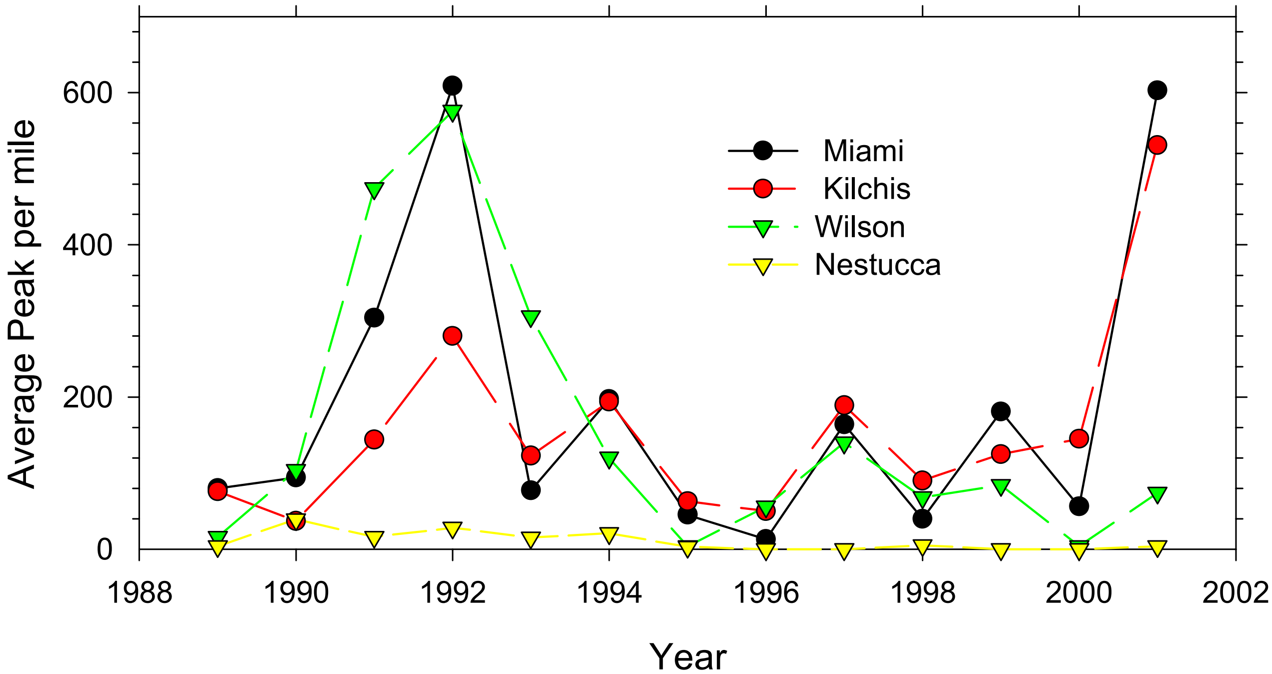


Figure 3-4. Average peak chum counts from standard surveys standardized to survey length in miles (1989-2001). Miami River Basin (n=3); Kilchis River Basin (n=3); Wilson River Basin (n=1); Nestucca River Basin (n=1).

The Whiskey Creek survey in Netarts Bay was initiated in 1993. Peak counts on this survey were relatively high (>300 fish per mile) in 1994. Since then counts reached a record low in 1996, rebounded to about 70 fish per mile in 1997 and have been fairly stable since then.

An 11-year time series is available for Yaquina Bay chum salmon. Over this time period average peak spawner densities have ranged from about 20 to 180 fish per mile. Counts in 1998 and 2001 represent record high spawner density for the period of record.

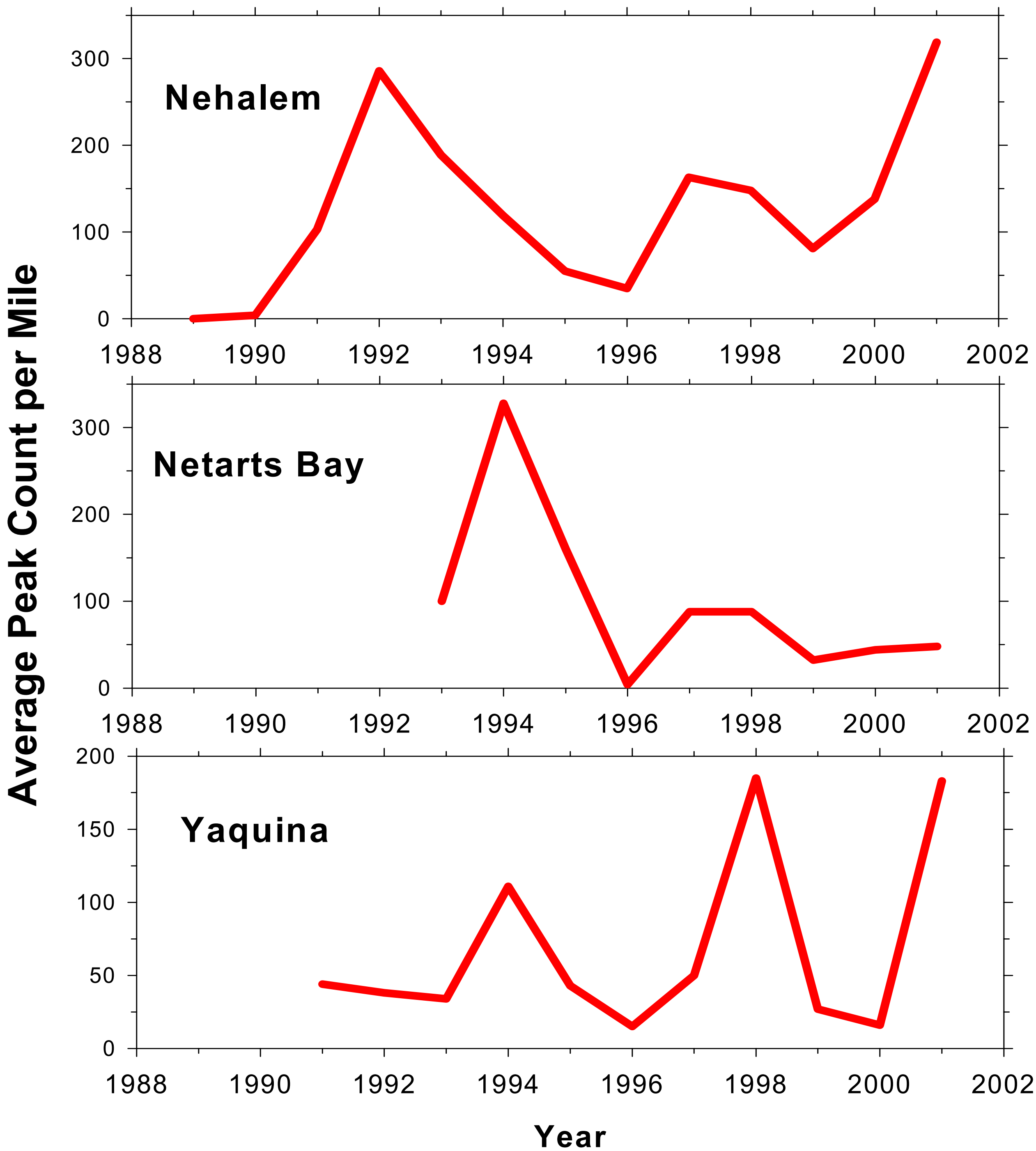


Figure 3-5. Average peak chum counts in supplemental surveys standardized to survey length in miles. Nehalem River (n=4); Netarts Bay (n=1); Yaquina Bay (n=3).

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 harvest tag 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 harvest tag data for indexing trends in coastal Oregon natural steelhead populations. Starting in 1997, the Western Oregon Research and Monitoring Program of ODFW began developing strategies for monitoring coastal salmonid populations. Historic data and published literature were reviewed in order to determine the best methods to monitor adult steelhead abundance in coastal watersheds. In 1998, pilot steelhead spawning surveys were implemented in selected coastal basins with the primary focus of developing survey methodologies and evaluating the reliability of spawning surveys to track abundance (Susac and Jacobs 1998). Field studies were continued in 1999 and expanded to include exploratory surveys to develop a list of potential annual survey sites over a broad geographic distribution for indexing steelhead abundance coast-wide (Jacobs et al. 2000).

A funding reduction forced dropping exploratory surveys in 2000. Remaining funds were reprioritized to initiate survey calibration studies in the Smith River Basin (Jacobs et al. 2001). We also conducted studies to assess the status of adult steelhead populations in the Nestucca and Alsea basins. The results of these studies are reported in Susac and Jacobs (2001), Susac and Jacobs 2002a and Susac and Jacobs 2002b). We have received funding to continue coast-wide monitoring beginning in 2003. This effort will use redd surveys selected using the Environmental Monitoring and Assessment Program (EMAP) sampling design (Firman and Jacobs 2001, Stevens 2002).

This chapter reports on 2001 and 2002 calibration studies in the Smith River Basin upstream from Smith River Falls and at the life cycle monitoring sites on the West Fork Smith River. These results along with the results from the monitoring studies in the Nestucca and Alsea Basins are discussed as they apply to coast-wide monitoring plans for 2003.

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 dominant 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. The sampling described in this chapter was confined to the mid and North Coast GCA. In some cases, for purposes of comparing results of surveys among geographic subunits of this GCA, we aggregated data by the Monitoring Areas listed for coho salmon (see page 27).

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 2001 and 2002 seasons. 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.

Objective 1 Results (Survey Feasibility)

Task 1.1 (Selection of Spawning Surveys)

For the 2002 sampling season we adopted the Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) sampling design methodology for all sample site selection. EMAP methodology forces a spatial balance of sampling points throughout spawning distribution of steelhead (Stevens 2002). In 2001 and previous years, EMAP sites were only used in the tributary stratum.

Task 1.2 (Survey Feasibility)

Surveys were successfully conducted at randomly selected sites located throughout the spawning distribution of winter steelhead in the Smith River Basin. These sites ranged in size from small first-order headwaters tributaries to large fourth-order mainstem sites. Small hard floored inflatable rafts, that enable the surveyors to stand up while floating the surveys, have been used for the larger order non-wadable streams. Standing gives the surveyors a better field of vision when spotting live adults and redds. We continued to use inflatable kayaks for streams that are too small for the rafts and slightly too big for wading.

Task 1.3 (Distinction of Redds)

Surveyors are generally 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 successfully tracked the number of days a subset of individual redd were distinguishable (redd longevity) throughout the 2001 and 2002 survey seasons in the Smith River Basin. As with the 2000 spawning season, the absence of significant freshets during the 2001 spawning season (Figure i-2) allowed surveyors to identify redds for an extended time period. Redd longevity ranged 21 to 133 days and averaged 49.2 days. The standard deviation of redd life was 27.2 days. During the 2002 spawning season stream flow conditions were more normal (Figure i-2) and redd longevity averaged 31.5 days with a standard deviation of 17.1 days.

The number of days redds remained visible during the 2001 and 2002 spawning seasons is shown in figure 4-1. During the 2001 season, none 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 still have observed 75 percent of the possible redds. Redd longevity in the 2002 season was significantly shorter from that in the 2001 season. ($p<0.001$, Mann-Whitney Rank Sum Test). During the 2002 spawning year, if surveys were conducted on a 14 day recurrence interval, 13 percent of the redds would have been missed. On a 3-week interval surveyors would have not been able to detect 32 percent of the deposited redds.

Based on the five seasons that we have assessed redd longevity, an overall average of about 95% of the redds are visible seven days after initial observation. After 14 days, the proportion of visible redds drops to about 86%. Based on these data a survey recurrence interval of 2 weeks would appear to be sufficient for observing the vast majority of redds that are present. However, because the manner in which redds were marked may have aided surveyors in detecting redds, these estimates may have a slight negative bias. Furthermore, the ability to distinguish steelhead redds from lamprey redds is aided by frequent visits to spawning areas. Given these factors we recommend conducting steelhead redd surveys in Oregon coastal streams on a 7-10 day recurrence interval.

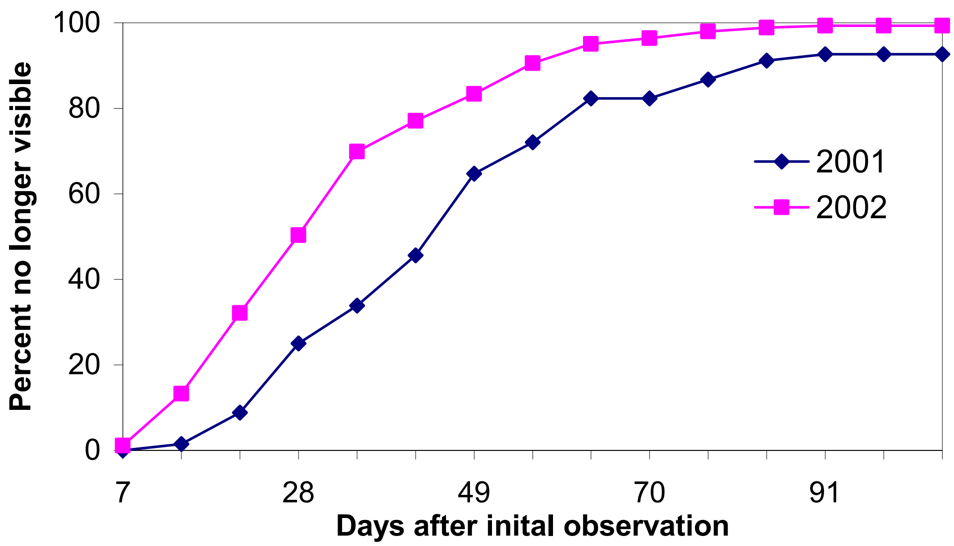


Figure 4-1. Longevity of steelhead redd visibility in the Smith River Basin, 2001. The figure shows the proportion of redds no longer visible at one-week intervals after the date of initial observation.

Task 1.4 (Spawning Timing)

The timing of steelhead spawning in the upper Smith River Basin was very similar for the 2001 and 2002 spawning years (Figure 4-2). Steelhead actively spawned from end of

January to the first part of May. Peak spawning occurred during the week ending March 25 during both spawning years. There was a smaller peak of spawning activity that also occurred during both years during the week ending February 25. Figure 4-2 also shows the cumulative percent of steelhead redds observed at weekly intervals for the Smith River Basin. This shows little spawning activity occurred prior to the third week of January spawning was complete by the end of the first week in May.

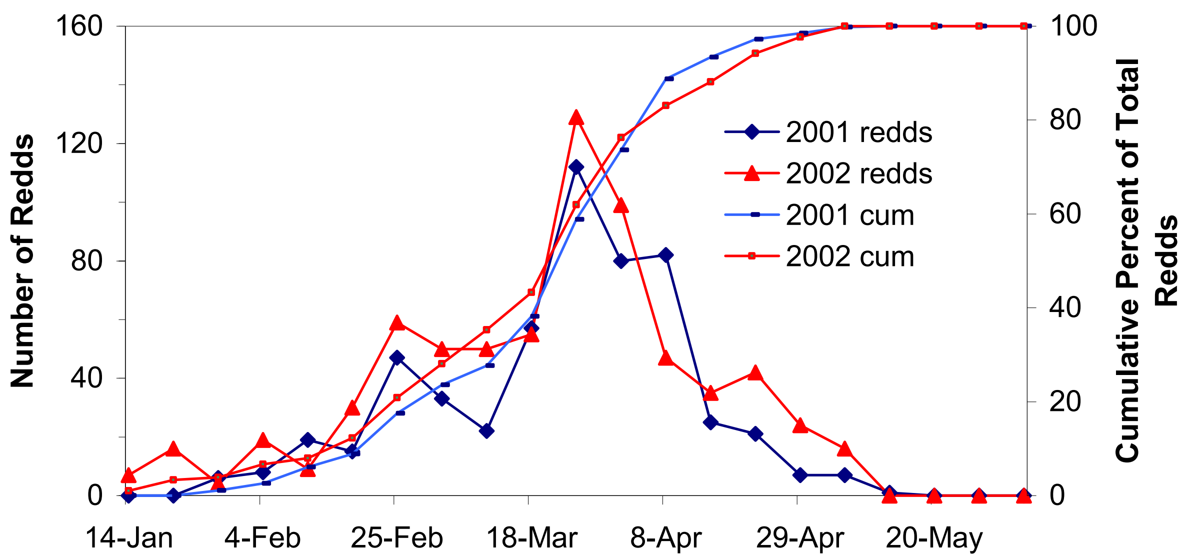


Figure 4-2. Number of new winter steelhead redds observed each week on random spawning surveys in the Smith River Basin, 2001 and 2002.

The timing of spawning activity was very consistent in the Smith River Basin during all three years of our study. This consistency occurred despite marked differences in flow regimes. The extreme drought conditions that persisted throughout the 2001 season were a sharp contrast to the more normal flow regime of the 2002 season (Figure i-2). These observations suggest that spawning timing of coastal winter steelhead is not heavily influenced by stream flow. In contrast to the apparent consistency in interannual spawning timing, there appears to be substantial variation in spawning timing among different populations of coastal winter steelhead. Similar to the Smith River, Alsea River steelhead spawning peaks in March (Susac and Jacobs 2002b). Alternatively, during the last two seasons Nestucca River steelhead have had peak spawning activity during the third week of April, with substantial spawning into mid-May (Susac and Jacobs 2001, Susac and Jacobs 2002a). Given this diversity in spawning timing among coastal steelhead, coast-wide surveys should span from mid-January through mid-May to encapsulate the run.

Task 1.5 (Visual Detection of Hatchery Strays)

Currently, all of the steelhead smolts released from Oregon coastal hatcheries are adipose fin-clipped. During the 2000-2001 return year, surveyors in Smith River were able to detect adipose fin-mark status for 57 of the 178 steelhead observed on spawning surveys. Of these, no fin-clipped adults were observed. An increased emphasis was placed on detection of fin-marks on surveys conducted in the Smith Basin in 2002.

This resulted in a substantial increase in proportion of observations that had valid determinations of fin-mark status. During the 2001-2002 return year surveyors were able to determine fin-mark status for 361 adults (70.9%)of a total of 509 adults observed.

During both years, the proportion of adults seen with fin-marks during surveys was not significantly different from the corresponding proportion of fin-mark adults seen during tagging at the falls. Through the 2000-2001 return year, a total of 532 adults were handled and observed for marks at the trap site at Smith River Falls of which sixteen were adipose fin-clipped for an estimated stray rate of 3.0 percent. On the spawning surveys no fin-marks were detected. Because of the low stray rate and the relatively small number of adults that fin-mark status was determined the difference proved to be statistically insignificant (p=0.370). During the 2001-2002 season a total of 830 adults were handled during tagging of which 16 were fin-marked for a stray rate of 1.9 percent. On the spawning surveys a total of 4 fin-marks were observed for an estimated stray rate of 1.1 percent. Again the difference between the two estimates was not significant (p=0.443). These results indicate that visual fin-mark observation is a reliable means of detecting the occurrence of hatchery fish in natural spawning populations when hatchery fish comprise a small fraction of the spawning population. Based on the results obtained for coho salmon (see Chapter Two), it also appears that visual mark observation may be useful for detecting occurrences when high proportions of hatchery spawners exist. We will have an opportunity of verifying this next season at the life cycle monitoring site on the North Nehalem River. Large numbers of hatchery steelhead return to this area. Starting next year, hatchery fish will be passed along with wild fish upstream of the adult trap. This change in protocol will enable us to compare fin mark ratios at the trap to those observed on spawning surveys.

Task 1.6 (Lamprey)

Lamprey spawning activity was observed on 26 (49%) of the 53 surveys conducted in Smith River in 2001. A total of 151 live spawners and 1,333 lamprey redds were observed. Spawning density was greater in the mainstem and larger stream order surveys than in the tributary surveys. The average number of redds-per-mile was 68.9 and 0.78 for mainstem and tributary reaches, respectively. The EMAP methodology yielded an estimate of 3,310$\pm$1,137 (95% CI) lamprey redds in spawning areas above Smith River Falls.

During the 2002 spawning year, pacific lamprey spawning activity was observed on 24 (41%) of the 59 surveys. A total of 66 live spawners and 982 redds were observed. As observed in 2001 spawning density was greater in the larger order surveys. The average redd density was 39.7 and 0.91 redds per mile for mainstem and tributary reaches, respectively. The EMAP methodology yielded an estimate of 2,344$\pm$945 (95% CI) lamprey redds in spawning areas above Smith River Falls.

Figure 4-3 shows the spawning timing of lamprey in Smith River in 2001 and 2002. For 2001, the majority of spawning took place over a 4-week period starting the third week of April, peaking during the week ending April 29. For the 2002 season, although there was a small peak of spawning activity during mid-April, spawning timing was similar to 2001, with peak spawning occurring during the week ending April 29. This is nearly a month latter that what was observed in Smith River in 2000 (Jacobs et al. 2001) and in other coastal basins in 1998 (Susac and Jacobs 1998) or in 1999 (Jacobs et al. 2000).

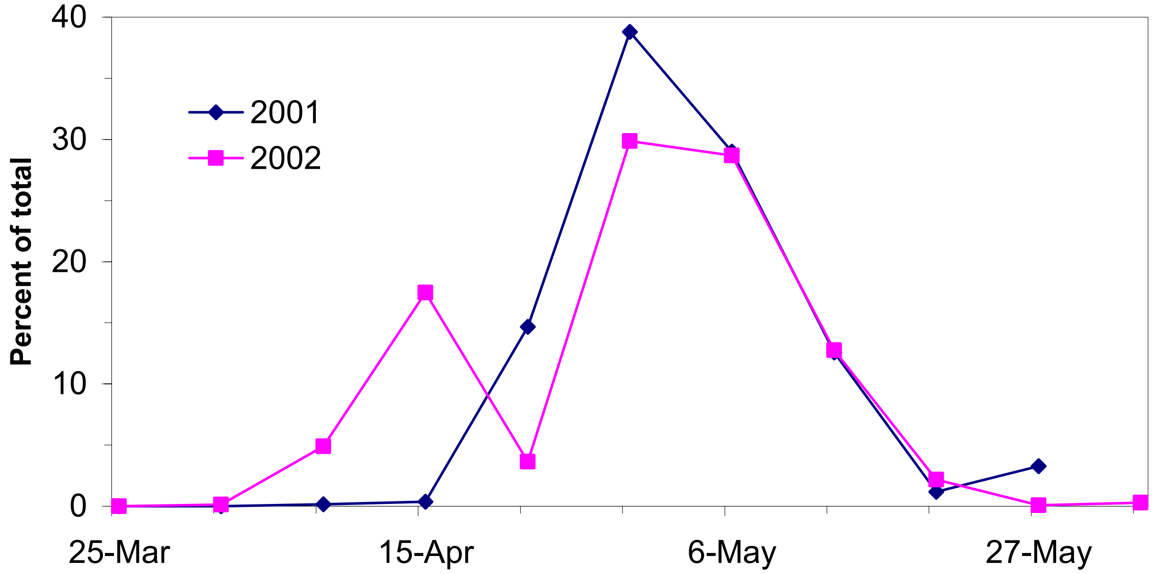


Figure 4-3. Timing of Pacific lamprey spawning (observation of redds) in the Smith River Basin, 2001 and 2002.

Objective 2 (Survey Reliability)

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

Smith River above Smith River Falls was selected as an area to tests survey reliability at the subbasin 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 225 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 and geology is typical many other Oregon coastal basins and, 5) the presence of a Life Cycle Monitoring Site on the West Fork Smith River. Unlike previous years, we did not conduct calibration surveys above any life cycle monitoring sites except upstream of the West Fork Smith site.

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

Mark recapture experiments were conducted in order to develop an estimate of adult winter steelhead abundance passing Smith River Falls during both 2000-2001 and 2001-2002 return years. Methods used to obtain mark-recapture estimates are described in Jacobs et al. (2001).

During the 2000-2001 return year adult trapping was conducted from 23 October through 16 April. Capture of adult steelhead occurred from the first of December through the first week in April. Peak capture took place during the week ending 11 February (Figure 4-4). A total of 218 males and 314 females were captured, tagged and released. Adults that retained tags from previous year's tagging were not re-tagged. Only one adult steelhead died as a result of the trapping and tagging operation during the 2000-2001 return-year. 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 100 double and 4 single tagged adults tagged were recovered at the West Fork Smith Trap. Using the method of Caughely (1977), the probability of losing a single tag was 2.0% and 0.04% for losing both tags. Each adult that was captured was measured to the nearest 5 mm fork length. A total of 217 males and 310 females were measured and averaged 70.7 cm and 71.6 cm respectively. Table 4-1 shows the minimum, maximum and average length of adult steelhead captured at Smith River Falls.

In the 2001-2002 return year, adult trapping was conducted from 17 October through 8 April (Figure 4-4). Capture of adult steelhead occurred from the first of December to the third week of April. Peak capture occurred during the week ending 14 January. There were three mortalities associated with trapping and handling during the 2001-2002 return-year. Fish were tagged with Floy supper-heavy-duty monofilament T-bar anchor tags. There was no tag loss on the 80 tagged adults recovered at the West Fork Smith River Trap. A total of 369 males and 412 females were measured during tagging at the falls (Table 4-1). Fish were somewhat larger in 2001 than in 2002.

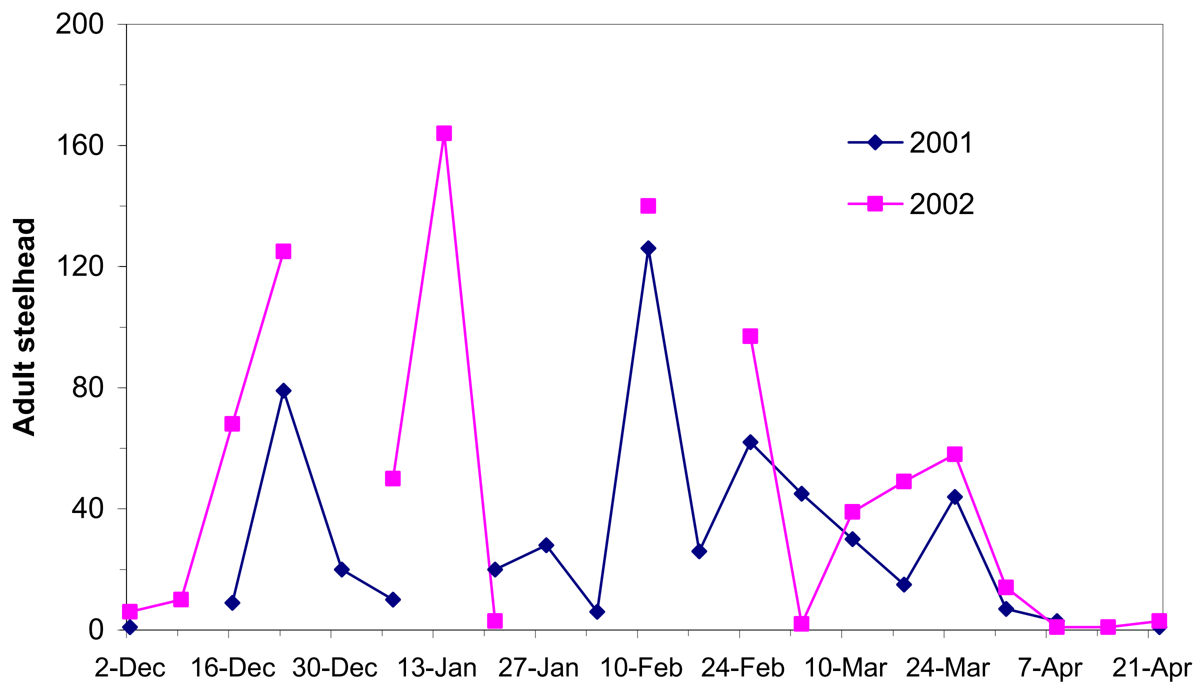


Figure 4-4. Weekly total of adult winter steelhead captured, tagged and released at Smith River Falls, 2000-2001 and 2001-2002 return years. Gaps in data series indicate periods when the trap did not function.

Table 4-1. Length in cm of adult steelhead captured at Smith River Falls during the 2000-2001 and 2001-2002 return years.

Sex	N	Min length	Max Length	Average	Standard Deviation
			2000-2001		
Males	217	37.0	95.0	70.7	12.4
Females	310	31.0	98.5	71.6	6.2
			2001-2002		
Males	369	44.0	89.0	68.6	6.4
Females	412	55.5	83.0	67.9	4.4

A total of 67 adults tagged during the 1999-2000 return year were again captured at the Smith River Falls trap in 2000-2001. Ten of these repeat spawners were males and 57 were females. Respective rates of repeat spawning for males and females were 12.8% and 30.7%. Estimates of repeat spawning rates were calculated by expanding the number previously tagged adults captured at the falls by the trapping efficiency at the falls. Trapping efficiency was determined by dividing the number of fish captured at the falls by the corresponding mark-recapture population estimate (see below). The amount of growth realized by the repeat spawners was unanticipated. Males grew more than females between years. Males grew an average of 9.6 cm between years. Females grew an average of 8.6 cm. Twenty-three adults tagged during the 2000-2001 return year were again captured at the Smith River Falls trap in 2001-2002. Six repeating males and 17 females were captured. Respective repeat rates were 11.2% and 18.6%. Males again grew more than females between years. Males grew an average of 9.7 cm between years while females grew an average of 4.8 cm.

Recapture of adults tagged at Smith River Falls for the mark-recapture experiment 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 2001 and 2002.

Table 4-2. Recovery of tagged and non-tagged adults at the West Fork Smith River Trap and on spawning ground surveys in the Smith River Basin, 2001 and 2002.

Location	Tagged	Untagged	Percent Tagged	Chi-Square[a]
		2001		
Tributary Surveys	36	14	72.0	A
Mainstem Surveys	37	55	40.2	B
West Fork Smith Trap	104	162	39.1	B
		2002		
Tributary Surveys	26	32	44.8	B
Mainstem Surveys	12	15	44.4	B
West Fork Smith Trap	80	125	39.0	B

a *Categories having different letters are significantly different form each other ($p<0.001$) based on Chi-Square contingency analysis.*

In 2001 the ratio of tagged to untagged fish was not consistent among all recovery areas. The proportion of tagged fish in the recoveries was significantly higher in tributary survey sites than it was in mainstem survey sites or at the west fork trap site ($p<0.001$). There was no significant difference between the proportion of tagged fish in mainstem survey sites and the West Fork trap site. This is the opposite of the pattern we observed in 2000, when the proportion of tagged fish was lower in tributary surveys than either in mainstem surveys or at the West Fork trap site. This difference may be related to the extremely low flow conditions that persisted throughout the 2002 season (Figure i-2). Regardless of the cause for the difference in ratio of tagged to untagged among the recovery sites in 2001, using a inaccurate ratio will lead to a biased population estimate. Although we do not have a direct means of assessing the accuracy of the ratios we are most confident about the accuracy of the ratio obtained at the west fork trap site because each fish is handled and inspected for tags. Observations on spawning surveys could be biased if tagged fish have a different vulnerability to being observed than untagged fish. Given the similarity in the ratio of tagged to untagged fish captured at the West Fork trap site and observed on mainstem survey sites, we believe the best mark-recapture estimate is obtained from the pool of recoveries at these two sites. The resulting population estimate and associated bootstrap analysis is presented in Table 4-3.

For the 2001-2002 spawning season there was little differenced between the ratio observed in the mainstem and tributary stratum. The tag rates were 44.4% and 44.8% respectively. The proportion of tagged adults at the West Fork trap was slightly lower at 39%. Analysis of the tagged rates at each of the recovery locations proved to be insignificant ($p= 0.444$). For the 2001-2002 population estimate, we felt that the combined recoveries from surveys and the West Fork provide the best estimate.

Table 4-3 shows the winter steelhead population estimates for return years 2000-2001 and 2001-2002. Run-size estimates were 1,366 and 1,995, respectively. Bootstrap analysis showed high precision and low bias for each estimate.

Table 4-3. Population estimates, upper and lower 95% confidence limits, bias and precision of adult winter steelhead migrating above Smith River Falls during return years 2000-2001 and 2001-2002.

Spawning Year	Peterson Estimate	Bootstrap Analysis				
		Average	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Bias [a]	Precision [b]
2001	1,366	1,370	1,226	1,534	4.17	12%
2002	1,995	1,998	1,760	2,280	3.63	14%

a *Difference of average bootstrap estimate and the 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 Smith River Basin upstream from Smith River Falls. Our intent is to estimate the number of redds within a target precision of ±30%. The sampling design and estimation methods followed those described in Stevens (2002), except that samples were separated into mainstem, upper mainstem and tributary strata. The tributary stratum consisted of our coverage of coho spawning distribution upstream from Smith River Falls. The mainstem stratum is comprised of the portion of the basin downstream from coho spawning distribution and upstream from 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. Target sample rates 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 1998 and surveys in Smith River in 2000. For 2001 analysis, we included the finite population correction in calculating estimates of variance because our sampling rate exceeded 10%. For 2002, variance estimates were calculated using neighborhood variance procedure described in Stevens (2002).

Throughout the 2000-2001 season, we conducted 53 surveys to estimate redd abundance (Table 4-4). This sample size equated to an overall sampling rate of 39% of the sampling frame. We estimated a total of 1,313 winter steelhead redds for the Smith River Basin upstream from Smith River Falls. Our target level for precision was met for the mainstem stratum, but not overall. The extreme low-flow conditions experienced throughout the spawning season severely limited spawning distribution into the smaller tributaries. Redds were seen in only three of the 17 first order tributaries surveyed. This disparity resulted in a larger variance than would be expected during normal flow conditions. During the 2001-2002 season, we conducted a total of 60 surveys. We estimated a total of 1,829 redds in the Smith River Basin above the falls with a 95% confidence interval of ±29.6 %.

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

During the 2001 and 2002 spawning years, 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. Unlike previous years our work was limited to Smith River above the falls and the West Fork Smith River above the Life Cycle Monitoring trap-site. 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=0.98, p< 0.0001).

Table 4-4. Estimates of winter steelhead redd abundance in the Smith River Basin upstream from Smith River Falls, 2001and 2002. Estimates are derived from redd counts on randomly selected spawning surveys.

Stratum	Survey Effort			Redds	
	Spawning miles	N	Miles	Estimate	95% Confidence Interval
2001					
Lower Mainstem	45.2	22	22.7	490	105
Upper Mainstem	11.1	3	2.5	80	34
Tributaries	169.2	28	24.8	743	628
Total	225.5	53	49.9	1,313	637
2002					
Lower Mainstem	49.9	19	19.5	261	506
Upper Mainstem	11.1	4	3.3	160	174
Tributaries	161.3	37	32.7	1,408	80
Total	222.3	60	55.5	1,829	541

Another measure of the reliability of redd surveys to index steelhead spawner abundance can be assessed through the three years of data collected in the Smith River. During this period female spawner abundance has ranged from 774 to 1,146 fish. Over this range the ratio of redds per female spawner has remained consistent, ranging from 1.58 to 1.63 (Table 4-5). Although the interannual range in spawner abundance has not been great, flow related survey conditions have varied appreciably during this period. The drought conditions of 2001 were a sharp contrast to the above average flow event that occurred in March of 2002 (Figure i-2). This condition suggests that the accuracy redd counts is not dramatically influenced by flow-related survey conditions. We plan to continue the calibration studies in Smith River in 2003. Clearly, additional data points are needed to validate the reliability of this methodology. However, given the results of our evaluation to date redd counts are proving to be a cost effective means of monitoring coastal steelhead abundance.

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	Spawning Habitat (miles)	Females Passed	Males Passed	Redds Observed	Redds per Female	Redds per Adult
1998	Nehalem R., Fishhawk Cr.	14.6	17	18	18	1.06	0.51
	Siletz R., Mill Cr.[a]	10.2	86	89	75	0.87	0.43
	Yaquina R., Mill Cr.	2.5	20	27	15	0.75	0.32
1999	Nehalem R., Fishhawk Cr.	11.6	22	33	22	1.00	0.40
	Siletz R, Mill Cr.[a]	10.2	48	40	48	1.00	0.55
	Yaquina R., Mill Cr.	2.2	28	28	27	0.96	0.48
2000	Nehalem R., Fishhawk Cr.	11.6	29	30	41	1.41	0.69
	Yaquina R, Mill Cr.	2.2	32	21	51	1.59	0.96
	Smith River[a,b]	225.0	881	517	1,438	1.63	1.03
	West Fork Smith R.[a]	22.4	274	179	326	1.19	0.72
2001	Smith River[a,b]	225.0	774	566	1,224	1.58	0.91
	West Fork Smith R.[a]	16.7	162	145	241	1.49	0.78
2002	Smith River[a,b]	225.0	1,146	985	1,829	1.59	0.86
	West Fork Smith R.[a]	18.5	409	328	327	0.86	0.48

a *Monitoring site is not a complete barrier. Adult passage estimated using mark-recapture techniques*.
b *Redd abundance are estimated based on statistical sampling design.*

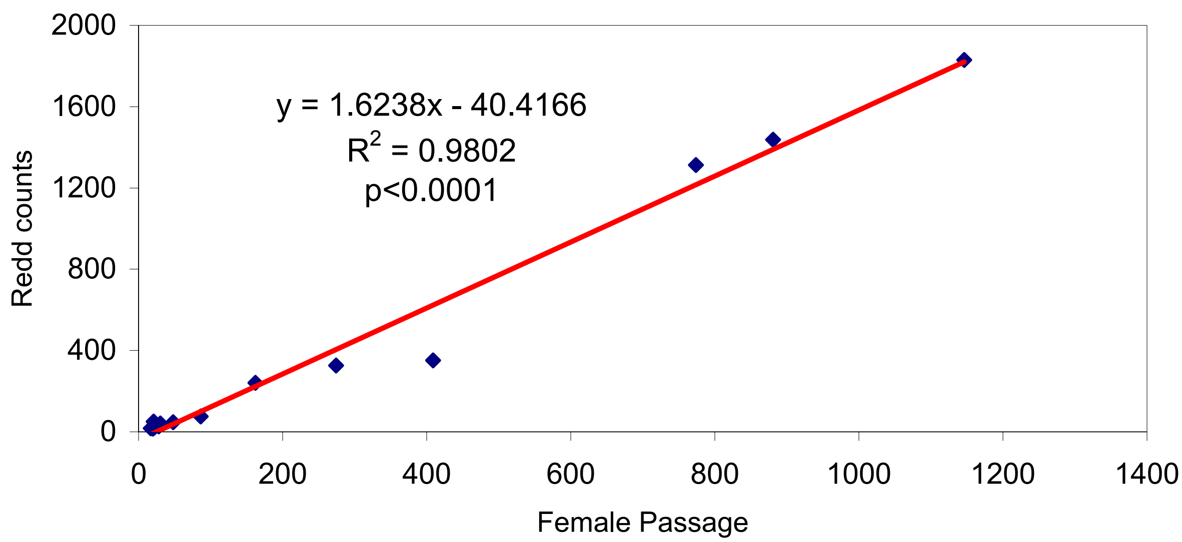


Figure 4-5. Relationships between adult winter steelhead passage and redd counts above calibration sites in 1998, 1999, 2000, 2001 and 2002.

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