THE OREGON PLAN *for Salmon and Watersheds*

Juvenile Salmonid Monitoring
In Coastal Oregon and Lower Columbia
Streams, 2014

Report Number: OPSW-ODFW-2015-1

Juvenile Salmonid Monitoring in Coastal Oregon and Lower Columbia Streams, 2014

Oregon Plan for Salmon and Watersheds

Annual Monitoring Report No. OPSW-ODFW-2015-1

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SUMMARY

This report analyzes data from juvenile salmonid surveys across coastal Oregon in 2014. Results from 2014 are compared with results from previous years and used to describe trends in juvenile salmonid distribution and abundance for the three coho Evolutionarily Significant Units (ESU) and the four steelhead Distinct Population Segments (DPS) in coastal Oregon. For prior reports visit https://nrimp.dfw.state.or.us/crl/default.aspx?pn=WORP.

The Oregon Coast Coho (OCC) ESU density estimate in 2014 was lower than the recorded high estimate in 2013. The 2014 density estimate was also lower than the 1998-2013 average for the ESU. Site occupancy in 2014 was similar to 2013. Occupancy rates appear to be increasing for the ESU since the start of monitoring in 1998. The pool population estimate in 2014 was lower than in 2013 and lower than the average of the cohorts from 2010-2012.

In the OCC ESU plots of parr abundance with female spawner abundance suggest limits in freshwater habitat to parr production when spawner abundance exceeds approximately 80,000 females. Parr production rates typically decrease when female spawner abundance increases.

The Southern Oregon Northern California Coho (SONCC) ESU density estimate in 2014 was similar to the 2013 estimate. The 2014 density estimate was lower than the average for the ESU from 1998-2013. Site occupancy in 2014 was similar to 2013. Occupancy estimates for the last 3 cohorts have been the lowest recorded since monitoring began. Pool population estimates were similar to 2013, but lower than in most years, with the exception of the estimates from 1998-2000.

Lower Columbia River Coho (LCR) density, site occupancy, and pool population estimates were similar to 2013 and to the average since 2006.

The Oregon Coast Steelhead DPS density estimate in 2014 was lower than 2013 but similar to the average from 2002-2013. Pool population estimates in 2014 were similar to 2013 and to the 2002-2013 average. The site occupancy estimate in 2014 was the highest recorded. The last four cohorts have had the four highest occupancy estimates.

In the Klamath Mountain Province (KMP) DPS, steelhead density in 2014 was higher than the record low estimate in 2013 and similar to the DPS average from 2002-2013. The pool population estimate in 2014 was lower than 2013, but similar to the average from 2002-2013. Site occupancy was similar to 2013 and to the 2002-2013 average for the DPS.

Steelhead density estimates in the LCR and the Southwest Washington (SWW) DPSs in 2014 were similar to each other, to averages for each DPS since 2006, and to the 2013 estimates. Site occupancy in 2014 for the LCR DPS was the highest recorded. In the SWW DPS site occupancy was similar to 2013 and to the 2006-2013 average estimates. Pool population estimates for LCR and SWW were similar to the 2006-2013 average of the estimates for the DPSs and to 2013 estimates.

The original pool depth criteria was ≥40cm in maximum depth. This was changed to ≥20cm in 2010. Analyses based on the ≥20cm maximum depth criteria produced larger pool population estimates with proportionately smaller confidence intervals than analyses based on the ≥40cm maximum depth criteria. Population estimate trends that included shallow pools tracked with those based on the former pool criteria.

INTRODUCTION AND METHODS

As part of the Oregon Plan for Salmon and Watersheds, the Oregon Department of Fish and Wildlife (ODFW) initiated this project in 1998 to monitor the abundance and distribution of juvenile coho salmon (*Oncorhynchus kisutch*) in coastal Oregon streams (Figure 1). Originally the project surveyed 1st-3rd order (wadeable) streams within the rearing distribution of coho in the Oregon Coast Coho (OCC) and Southern Oregon Northern California Coho (SONCC) Evolutionarily Significant Units (ESU). In 2002 surveys were added for juvenile steelhead (*Oncorhynchus mykiss*) in the Klamath Mountain Province (KMP) and Oregon Coast Distinct Population Segments (DPS). In 2002 surveys were also added in 4th-6th order (non-wadeable) streams. In 2006, the Oregon portions of the Lower Columbia River (LCR) coho ESU and steelhead DPSs were included. Surveys in 4th to 6th order streams were discontinued in 2009 for the Oregon Coast Coho ESU, in 2012 for the Lower Columbia Coho ESU, and in 2013 for the SONCC.

A Generalized Random Tessellation Stratified design (GRTS, Stevens 2002) was used to select sampling locations (GRTS points) in a spatially balanced, random fashion from within our sampling frame. The original sampling frame was based on a 100k stream layer for the Oregon Coast ESU. This was replaced by a frame based on a 24k stream layer in 2007. The 24k frame considered a greater expanse of streams to be within the rearing distribution of coho and steelhead and included distribution in the Oregon portions of the Lower Columbia River coho ESU and steelhead DPSs. Analyses for all years on the coast and Lower Columbia are currently based on the 24k frame. In 2012 a 24k sampling frame was developed for the SONCC/KMP. This frame also considered a larger expanse of streams to be within the rearing distribution than was formerly assessed. Until the 2012 frame is corroborated by field surveys, analyses in the SONCC/KMP will be based the assumed former distribution. Our sampling frame and survey design are described in detail by Jepsen and Rodgers (2004) and Jepsen and Leader (2007).

GRTS was used to select sample sites that were stratified by Monitoring Area (MA) and stream order (Table 1). Field crews surveyed a one kilometer stream reach encompassing the GRTS points during base low flow conditions. Within the reach, all pools that are ≥20cm deep and ≥6 m^2 in surface area were snorkeled with a single pass to identify and enumerate juvenile salmonids. Hard counts were made of all juvenile coho and chinook and of trout (steelhead and cutthroat) that are ≥90 mm in fork length. Presence was noted for dace, shiners, and trout <90 mm in fork length. Freshwater mussel presence and beaver activity were also described. Sites with poor water clarity or quality were electrofished using a single pass without block nets to determine pool occupancy for coho and site occupancy for steelhead and cutthroat. For quality control and to assess repeatability/precision approximately 15% of surveys in wadeable reaches are resurveyed by supervisory staff.

Our depth criterion was changed from ≥40cm to ≥20cm in 2010 when data from the Smith River Verification study (Constable and Suring, in prep.) was analyzed. The study suggested lowering the maximum depth threshold to ≥20 cm would allow surveyors to sample a larger and more consistent portion of the juvenile coho and steelhead summer populations. In order to compare current data to that from previous years, reports following the 2010 field season include an analysis of data from pools meeting the ≥40cm depth criterion and a second analysis of data from pools meeting the new depth criterion.

Data are summarized and presented by ESU, MA, and/or DPS and by stream order. Cumulative Distribution Function graphs, variances, and confidence intervals were created using tools developed by the EMAP Design and Analysis Team (EPA 2009). When making year-to-year, year-to-average, and brood group to brood group comparisons we considered a p-value ≤ 0.05 to indicate a significant difference. The following measures of fish distribution and abundance were calculated independently for coho and steelhead.

- Site occupancy
    - The percent of sites with at least one fish, calculated by dividing the number of sites with fish by the number of surveyed sites for each MA, ESU, or DPS. Site occupancy is also calculated for cutthroat.
- Pool frequency
    - The average percent of pools in a site that contain at least one fish. Pool frequency is first calculated at each site by dividing the number of pools with fish by the total number of surveyed pools. The resulting percent at each site is then averaged to obtain the estimated percent within the MA, ESU, or DPS.
- Fish density
    - The number of fish divided by the surface area of the pool which contained them. Density is first calculated for each pool in a site. The average density of all the pools in a site is the site density. The average of the site densities for all sites within a MA, ESU, or DPS produces the density estimate for the area.
- Pool population estimates
    - The estimate of the number of fish in pools for each MA, ESU, or DPS. Pool population estimates are calculated by multiplying the fish per kilometer at each site by the site weight. Fish per kilometer is the sum of the snorkel count at the site divided by the length of the site. Site weight is the total length (kilometers) of the rearing distribution in the MA, ESU, or DPS divided by the number of successfully surveyed sites in the area, adjusted for non-target sites (Stevens 2002). Pool population estimates provided in this report are based on un-calibrated snorkel counts in pools that meet size criteria. As such they do not represent total population estimates, but are appropriate for assessing trends.
- Percent Full Seeding
    - The percent of sites with average fish density $\geq$0.7 coho/m^2. This value is regarded as full seeding based on results from Nickelson et al. (1992) and Rodgers et al. (1992). Nickelson et al. estimate full seeding to be 1.0 coho/m^2 from electrofishing removal estimates and Rodgers et al. report that snorkelers observed 70% of the coho in electrofishing removal estimates.

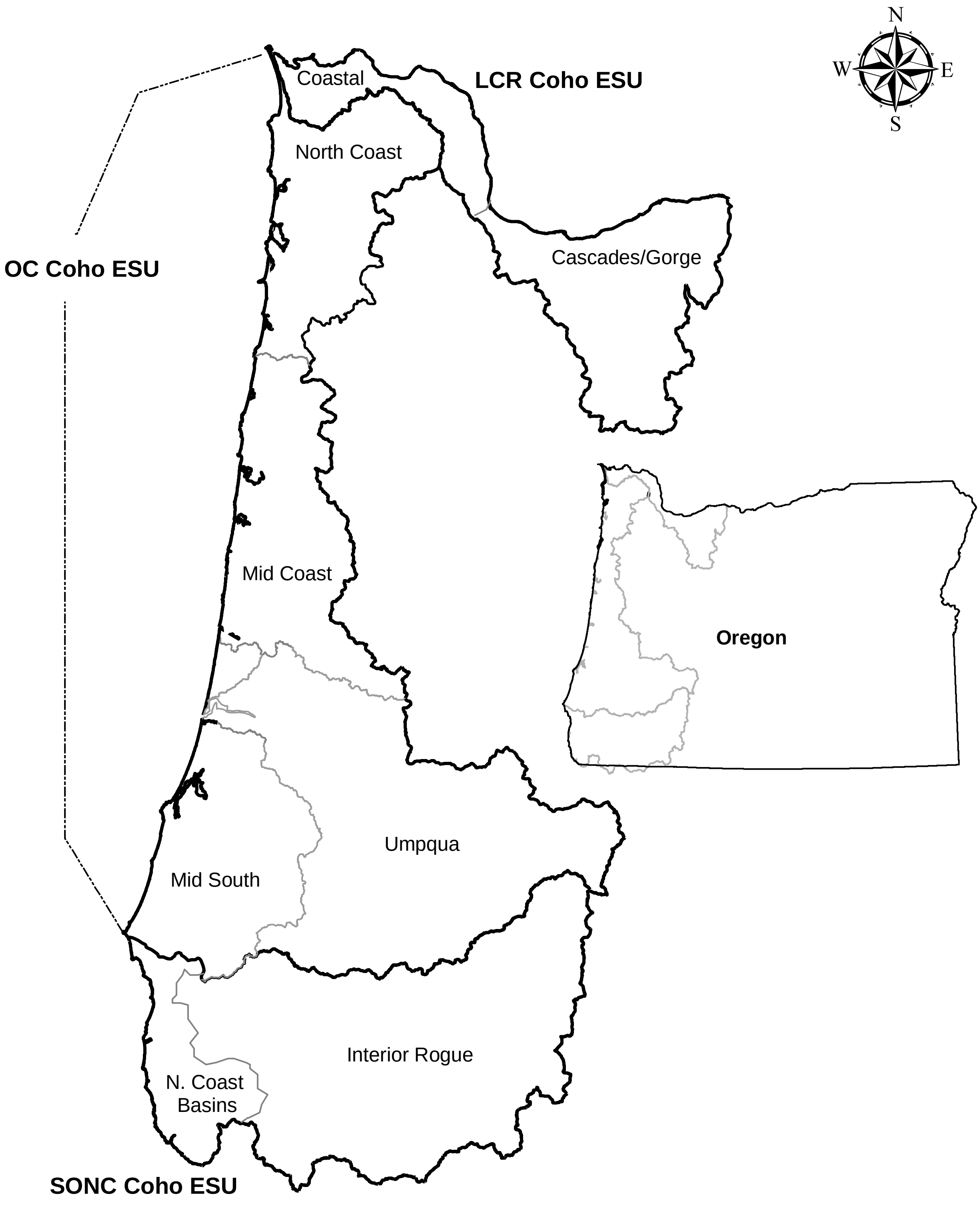

Figure 1. The spatial extent of the study area showing the Oregon portion of coho ESUs and the monitoring areas/strata within each ESU.

In 2014, the 17th season of juvenile coho monitoring in the OCC and SONCC ESUs was completed, yielding 17 years of distribution and abundance data. To facilitate analyses across this time site occupancy and population estimate data were pooled for each three-year interval into five successive brood groups, based on the conventional three-year coho life cycle (reviewed by Weitkamp et al., 1995). The last complete brood group is from 2010-2012. 2013 and 2014 are analyzed as individual years. Analyses based on these brood groups will supplement analyses based on a year-to-year or year-to-average condition. Comparisons among brood groups (as opposed to individual cohorts or years), can assist long term analysis by moderating variation in brood lines, i.e. comparing a weak brood line to a strong brood line, and allow the detection of trends among composites of the three cohorts across time, giving a more complete picture of the overall coho summer rearing population than an individual year. Comparisons of brood groups can also mitigate the effects of extreme years on an average condition (a combination of all years) when compared to a single year yet still be sensitive enough to illustrate trends in a population across time. Brood groups provide a much greater sample size that can result in smaller confidence intervals which provide added sensitivity for trend detection. Combining three successive brood years into a single brood group can present a composite perspective of the status of juvenile coho populations.

Juvenile steelhead data was pooled into brood groups following the 2013 field season. Steelhead brood groups were based on a typical four-year life cycle (reviewed by Busby et al., 1996).

In the lower Columbia coho data will be pooled following the 2015 field season and steelhead following the 2016 season.

In 2014 budget restrictions caused reductions in the number of surveys we were able to complete in each monitoring area and ESU. Goals for survey effort were decreased by 40% and electrofishing, from which we gain distribution but not abundance data, was suspended for the season.

As in 2013, budget restrictions also limited resurvey efforts. Resurveys in 2014 were used early in the season as an extension of crew training to resolve difficulties with fish ID and inconsistencies with survey protocols. 2014 resurvey data was not used in assessments of the precision or repeatability of our surveys. These assessments are available in past reports.

RESULTS

Survey Effort

In 2014 we selected 338 sites within our sampling frame. Twenty nine of these sites were non-target (either above barriers to anadromy, in tidal areas, or otherwise beyond the distribution of potential rearing habitat). Of the remaining 309 sites, 38 were not surveyed because of landowner access restrictions, 31 were un-sampleable, 3 were inaccessible, and 16 were not visited due to time restrictions (Table 1). Sites that were not surveyed are assumed to be target, non-response.

A total of 3,446 pools in 222 sites were surveyed. Our goals for survey effort (reduced for the 2014 season) were met or exceeded in all MAs and strata, with the exception of the Interior Rogue and the coast stratum of the LCR ESU. Coho distribution and density estimates for are presented in Table 2.

Table 1. Survey effort goals and status for 2014 sites.

ESU	Monitoring Area/ Stratum	Survey Effort Goal	Status		
			Snorkeled	Target Non-response	Non-target
OCC	North Coast	24	24	13	2
	Mid Coast	24	31	6	3
	Mid South	24	27	14	3
	Umpqua	24	32	10	5
LCR	Coast	24	22	15	6
	Cascades/Gorge	24	28	13	6
SONC	Interior Rogue	36	30	9	1
	North Coast Basins	24	28	7	3

Table 2. Distribution and density estimates for juvenile coho from snorkel surveys in western Oregon streams, summer 2014.

Monitoring Area	Distribution			Density		
	Site Occupancy	Mean Pool Frequency	95% CI	Percent Sites > 0.7 coho/m^2	Mean Average Pool Density (coho/m^2)	95% CI
North Coast	79%	63%	± 21%	8%	0.223	± 47%
Mid Coast	90%	71%	± 13%	3%	0.202	± 32%
Mid South	93%	79%	± 14%	7%	0.272	± 36%
Umpqua	78%	60%	± 17%	13%	0.295	± 37%
South Coast Coho	42%	30%	± 10%	0%	0.071	± 49%
Lower Columbia	44%	30%	± 35%	0%	0.052	± 42%

Trends in Salmonid Distribution and Abundance

Oregon Coast Coho

Cumulative Distribution Function (CDF) graphs comparing density, percent occupancy, and percent of sites fully seeded in 2014 to the average of these metrics for all previous years are shown in Figure 2. In 2014 estimates of occupancy were higher than on average, but density and full seeding were lower. In the North Coast, Mid Coast, and Mid-South Coast, the CDF curve in 2014 was less than the average condition. In the Umpqua the curve was similar to average condition. For the Mid Coast and Mid-South Coast, this is the opposite of what was observed in 2013.

Density estimates and the percent full seeding since the start of monitoring are shown for each of the four Oregon Coast Coho MAs in Figure 3. Densities in 2014 were similar to 2013 for the North Coast and Umpqua (but the Umpqua had a low p-value of 0.09). Densities were lower in 2014 than in 2013 on the Mid Coast and Mid-South Coast, but it should be noted that the 2013 densities in these MAs were record highs. The percent of fully seeded sites in 2014 was similar to 2013 for the North Coast and the Umpqua. The percent of fully seeded sites in 2014 was lower than in 2013 for the Mid Coast and Mid-South Coast. Estimates of full seeding for these two MAs in 2013 were near or at record levels.

For the ESU as a whole, densities and percent full seeding are shown for each year in Figure 4. In 2014 average pool density for the ESU was 0.25 coho/m^2. Average density for the ESU in 2014 was lower than the record high in 2013 and lower than the average from 1998-2013. Percent full seeding in 2014 was lower than the record high in 2013 and lower than the average from 1998-2013.

Pool population estimates for the ESU (Figure 5) are combined by three-year periods to form five successive brood groups. The estimate for a brood group is the average of its three annual estimates. The last complete group is from 2010-2012. 2013 and 2014 are shown as individual years. The 2010-2012 brood group had a pool population estimate that was similar to the two preceding groups, and higher than estimates for the earliest two groups (1998-2000 and 2001-2003). The pool population estimate for 2014 was lower than the average from 2010-2012 and lower than the estimate from 2013.

Pool population estimates for the coastal MAs are shown in Figure 6. In all MAs, the estimate for the 2010-2012 group was similar to that of the preceding group (2007-2009) and higher than that of the earliest group (1998-2000). In all cases the earliest group had a lower estimate than any other group. The 2014 pool population estimate was similar to the 2013 estimate in the North Coast, Mid Coast, and Umpqua. The 2014 estimate in the Mid-South Coast was lower than the 2013 estimate. The 2014 estimate was similar to the average estimate from 2010-2012 in the Mid Coast and Umpqua but lower than the average estimate from 2010-2012 in the North Coast and Mid-South Coast.

Site occupancy estimates for the ESU are shown in Figure 7. Site occupancies are also pooled into brood groups, with the last complete group from 2010-2012 and 2013 and 2014 shown as individual years. The average site occupancy in the ESU was higher in the 2010-2012 group than in any other group. The estimate in 2014 was similar to 2013 and to the average of the 2010-2012 group. Occupancies in the ESU have increased in each successive brood group except between the third (2004-2006) and forth (2007-2009) group, where there was no significant difference.

Site occupancies for the Oregon coast MAs are shown in Figure 8. In all MAs except the Umpqua, occupancies in the 2010-2012 group were higher than in the earliest group. In all MAs except the Mid-South Coast, occupancies in the current brood group were higher than those in the preceding group. Occupancy estimates in 2014 for each MA were similar to those in 2013 and to the average of the current brood group.

When regressed with survey year, site occupancy rates ($R^2 = 0.504$, p value<0.003) for the ESU exhibited a moderate increasing trend. The significance of the trend is linked to lower spawner abundance during the first four years of monitoring. When these years are removed, the increasing trend is not significant. Pool population estimates did not exhibit an increasing trend when regressed with survey year.

Plots of parr abundance in pools with the abundance of female spawners which produced them suggest parr production was limited in the ESU (Figure 9). In years where female spawners number approximately 80,000 or less (1997-2001, 2005-2007, and 2012-2013) there is a positive relationship between increased female abundance and higher estimates of parr ($R^2 = 0.644$), but in years when female spawner abundance exceeds approximately 80,000 (2002-2004, 2008-2011) there does not appear to be a corresponding increase in parr (R^2 = 0.015).

Egg-to-parr survival rates were greatest when female spawner abundance is low and the rate typically decreased as the number of spawners increased (Figure 10). Percent egg-to-parr survival ranged from 0.8% in brood year 2011 (which had the highest number of females) to 4.5% in brood year 1999 (which had the 3rd lowest female abundance). It is important to note that the parr numbers given (and the survival rates that are based on these numbers) are from un-calibrated visual estimates only in pools meeting protocol criteria. Actual parr numbers are likely to be higher, although production would still seem to be limited above 80,000 female spawners and the relationship of decreased parr production to increases in spawner abundance would remain the same.

The lack of a corresponding increase in parr as female spawner abundances increase above 80,000 did not seem to be an effect of parr “spilling over” into less optimal habitats, such as riffles, where they would not be observed by snorkelers using our protocols. The number of fully seeded sites in years of high spawner abundance averaged 24%, which is similar to years of low spawner abundance.

Southern Oregon Northern California Coho

In 2014 the average density in pools was 0.071 fish/m^2 and 0% of the sites were fully seeded (Table 2). Coho occurred in 42% of the sites in the ESU and pool frequency was 30%. Density and the percent of sites fully seeded are shown in Figure 4. Although the 2014 point estimate for density is 3 times lower than the point estimate from 2013, the large standard error in 2013 did not allow for a significant difference between the two. The 2014 density estimate was lower than the average density for the ESU from 1998-2013. The percent of sites fully seeded in 2014 was lower than in 2013 and lower than the 1998-2013 average. Pool population estimates for the ESU are shown in Figure 5. Average pool population estimates from the 2010-2012 brood group are lower than those of the 2007-2009 and 2004-2006 groups, similar to those in 2001-2003 (but with a low p value of 0.06), and higher than those in the earliest group. The pool population estimate for 2014 was similar to the estimate for 2013 and to the average for the 2010-2012 brood group (although this is at least partially driven by the high standard error for the 2014 estimate). Site occupancies for the ESU are shown in Figure 7. The estimate for the 2010-2012 group was lower than any of the preceding groups. The estimate for 2014 was similar to 2013 and to the average for the 2010-2012 brood group. Occupancy estimates from 2012 to 2014 were the 1st, 2nd, and 3rd lowest recorded, respectively.

Regressions of both site occupancy and pool population estimates to survey year do not show detectable trend since monitoring began in 1998.

Lower Columbia Coho

The 2014 mean average density in pools was 0.052 fish/m^2 and coho occurred in 44% of 1st-3rd order stream reaches with a mean pool frequency of 30% (Table 2). No sites were fully seeded in the ESU for the second year in a row. Density estimates and estimates of full seeding are shown in Figure 4. The 2014 density estimate was similar to 2013, and was not significantly different from the average for 2006-2012. Although no sites were fully seeded in 2014, the average for the ESU since 2006 is 2% with a high standard error, consequently 2014 was similar to the average. Pool population estimates and site occupancies are shown in Figure 11. These metrics will be pooled into brood groups at the end of the 2015 field season. The percent of occupied sites in 2014 was similar to 2013 and to the average for the ESU. Pool population estimates in 2014 were similar to 2013 and to the average for the ESU.

Regressions of both site occupancy and pool population estimates to survey year do not show detectable trends since monitoring began in 2006.

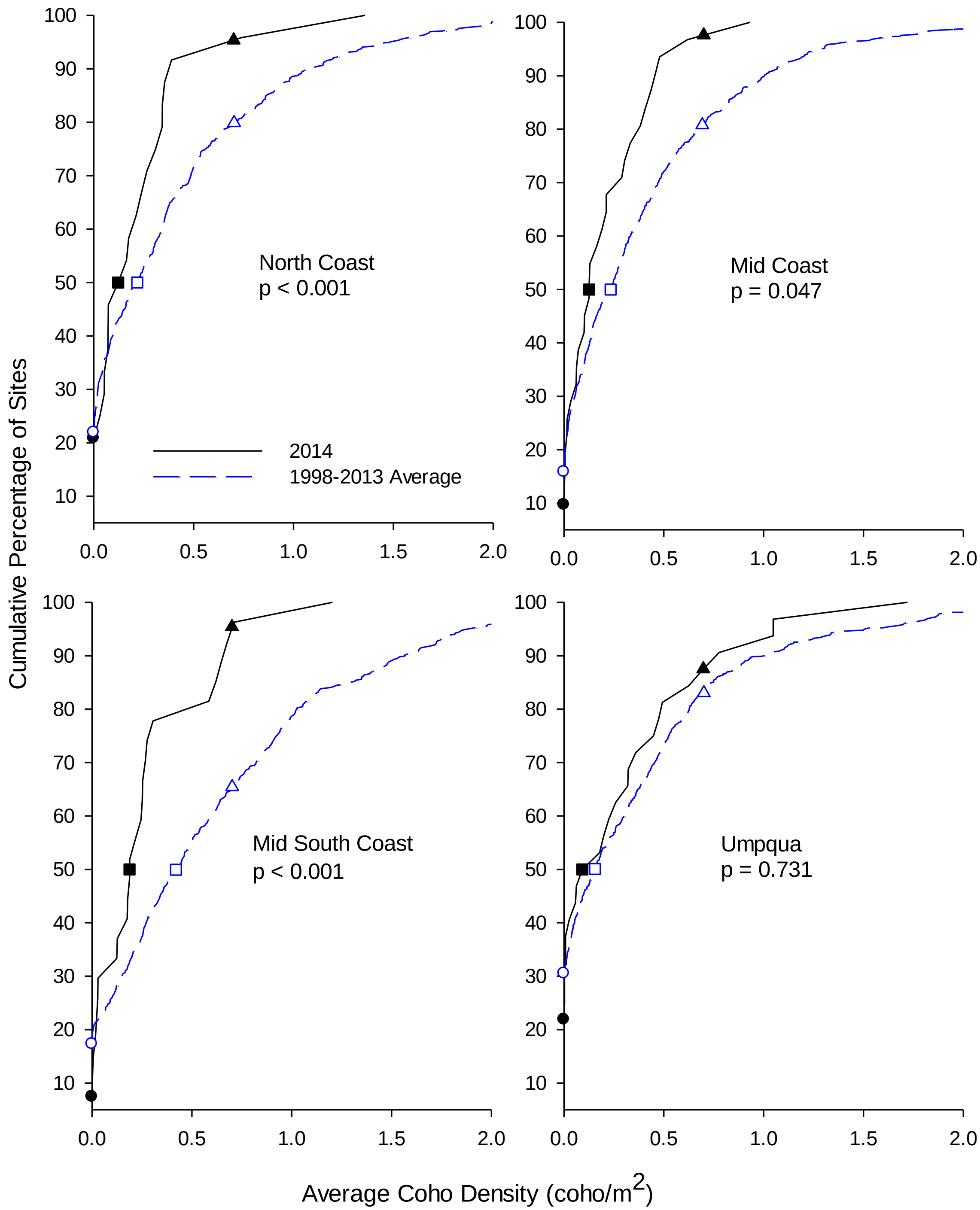

Figure 2. Average coho density CDFs from snorkeled tributary sites for the four monitoring areas of the Oregon Coast Coho ESU comparing 2014 with the average from 1998-2013. P values are for the comparison test of the two curves. The points shown on the curves are the percentage of unoccupied sites (circles), the median density (squares), and the percentage of sites below full seeding (triangles).

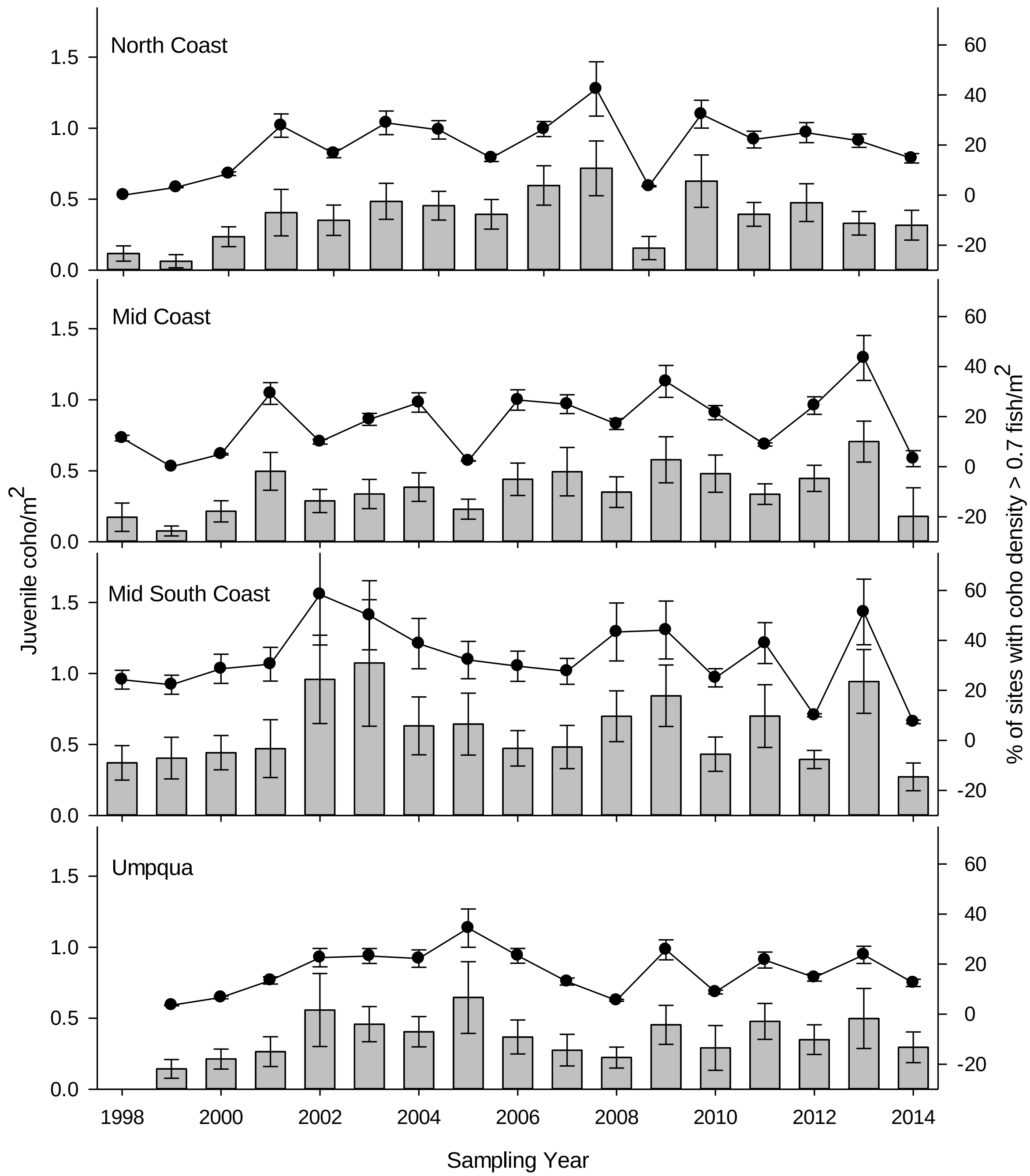

Figure 3. Annual trends in density and full seeding for juvenile coho salmon in monitoring areas of the Oregon Coast Coho ESU, based on snorkel surveys in 1st-3rd order stream reaches. Panels are organized by monitoring strata. Gray bars are for mean average density (coho/meter^2) and black dots are the percent of fully seeded sites.

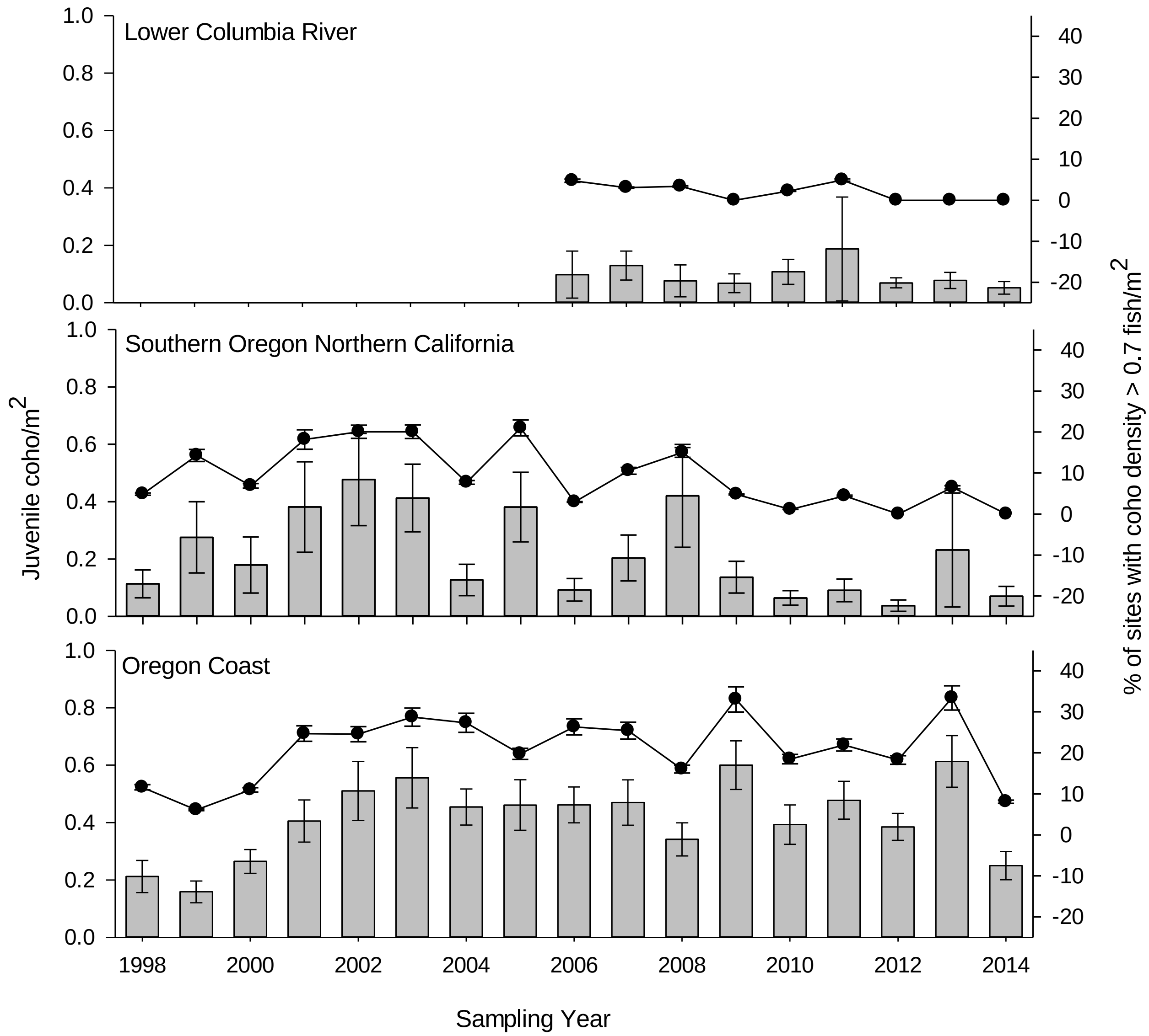

Figure 4. Annual trends in density and full seeding for juvenile coho salmon in Western Oregon Coho ESUs, based on snorkel surveys in 1st-3rd order stream reaches. Gray bars are for mean average density (coho/meter^2) and black dots are the percent of fully seeded sites.

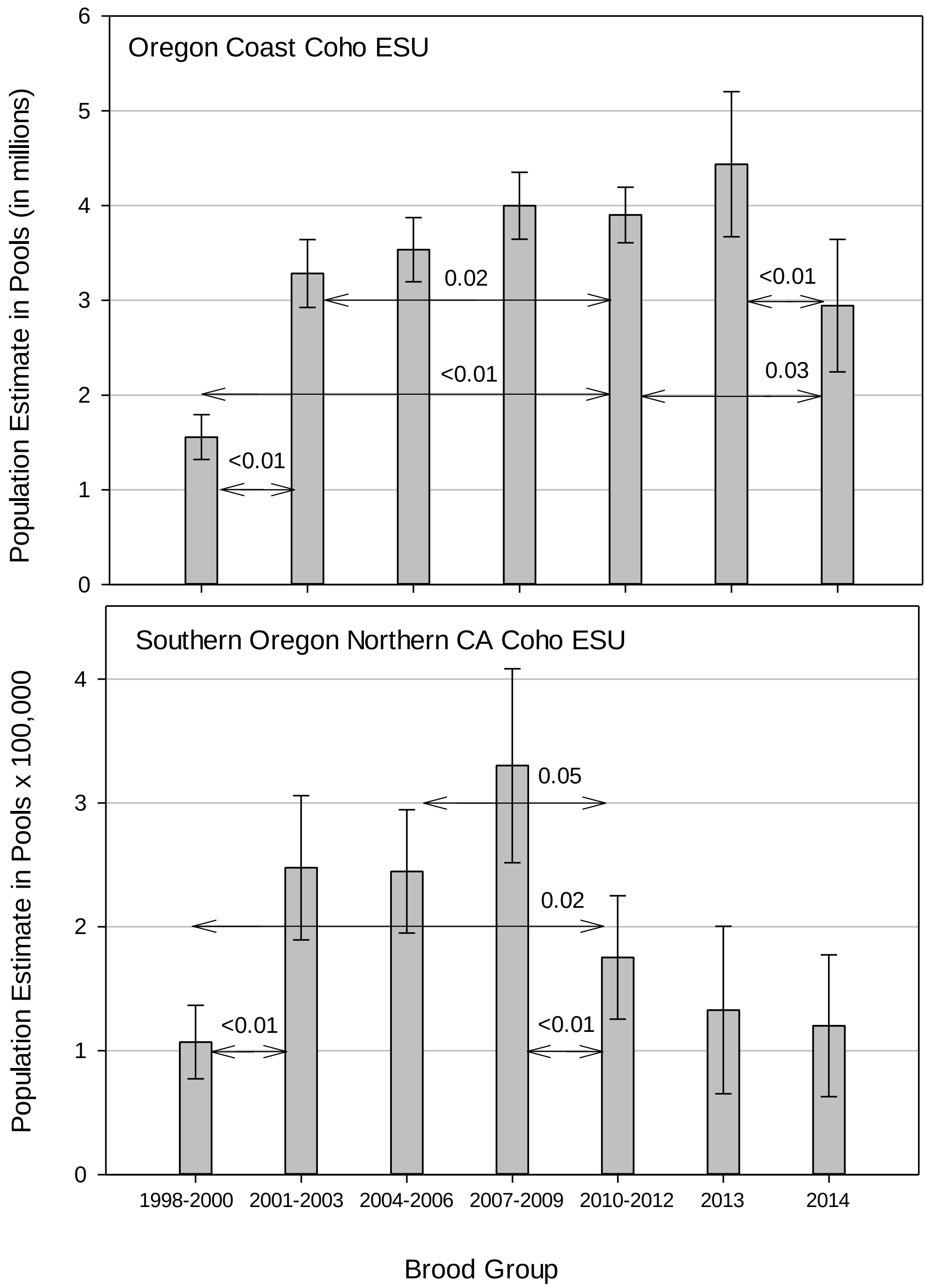

Figure 5. Trends in average pool population estimates of coho by brood group in the Oregon Coast Coho ESU (top panel) and Southern Oregon Northern California Coho ESU (bottom panel). Note the difference in Y-axis scale between the two panels. Gray bars show the population estimate (with 95%CI) for the brood group, p values for comparisons among brood groups are given above each vertical arrow where differences are significant.

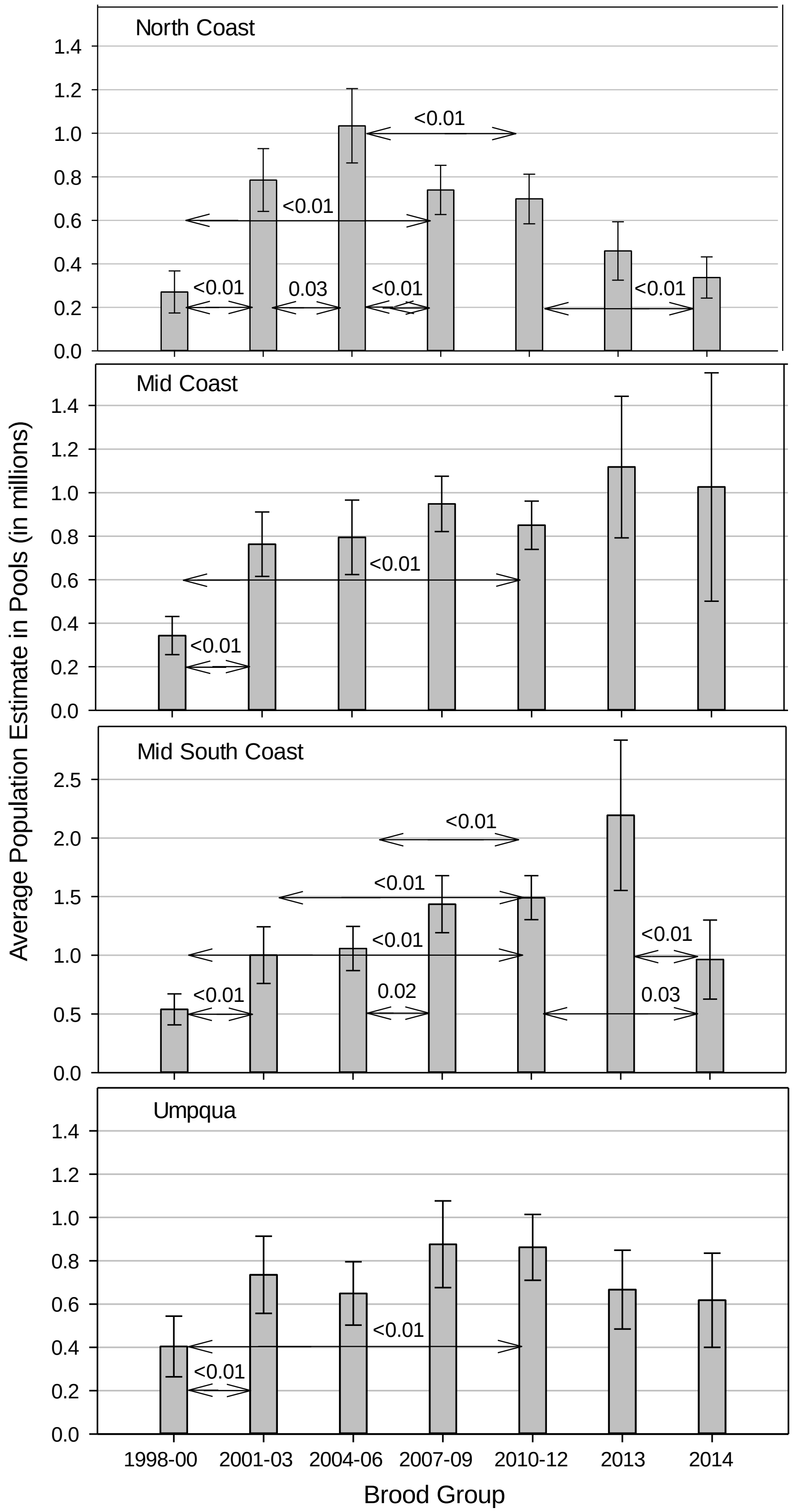

Figure 6. Trends in average pool population estimates of coho by brood group in the four monitoring areas of the OCC ESU. Gray bars show the population estimate (with 95%CI) for the brood group, p values for comparisons among brood groups are given above each vertical arrow where there are significant differences.

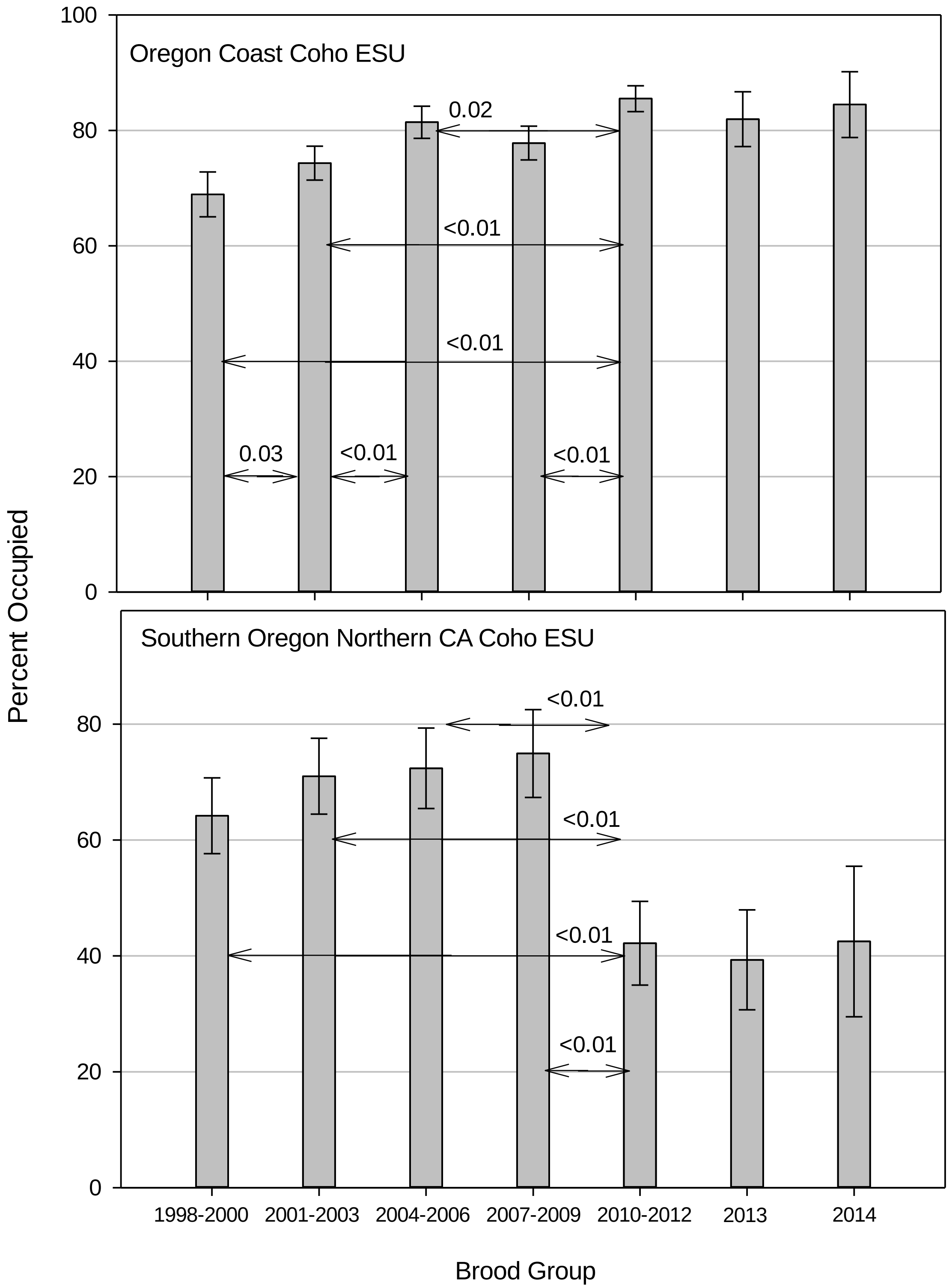

Figure 7. Trends in site occupancy of coho by brood group in the Oregon Coast Coho ESU (top panel) and Southern Oregon Northern California Coho ESU (bottom panel). Gray bars show the percent occupied (with 95%CI) for the brood group, p values for comparisons among brood groups are given above each vertical arrow where there is a significant difference.

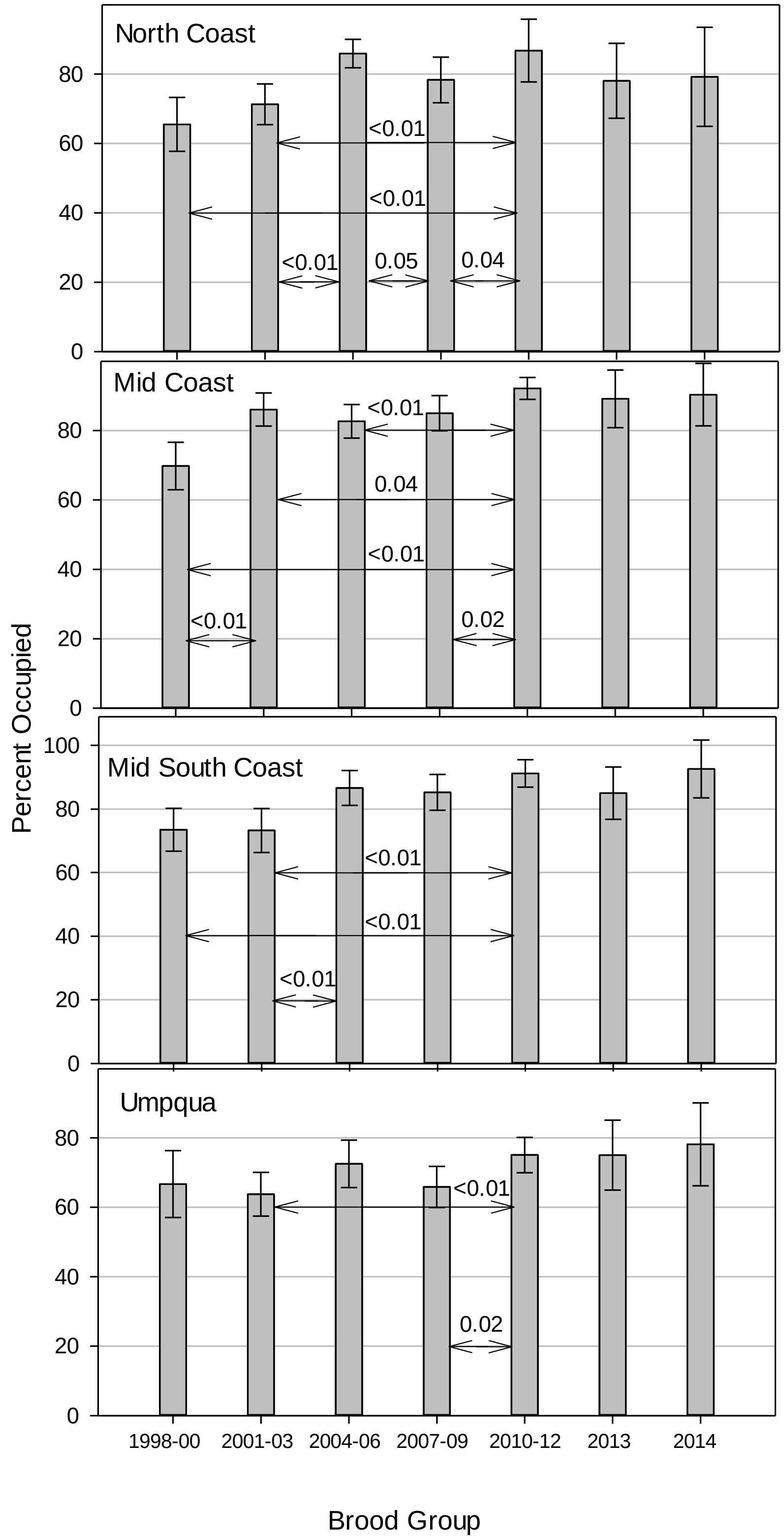

Figure 8. Trends in site occupancy of coho by brood group in the four Oregon Coast Coho Monitoring Areas. Gray bars show the percent occupied (with 95%CI) for the brood group, p values for comparisons among brood groups are given above each vertical arrow where there is a significant difference.

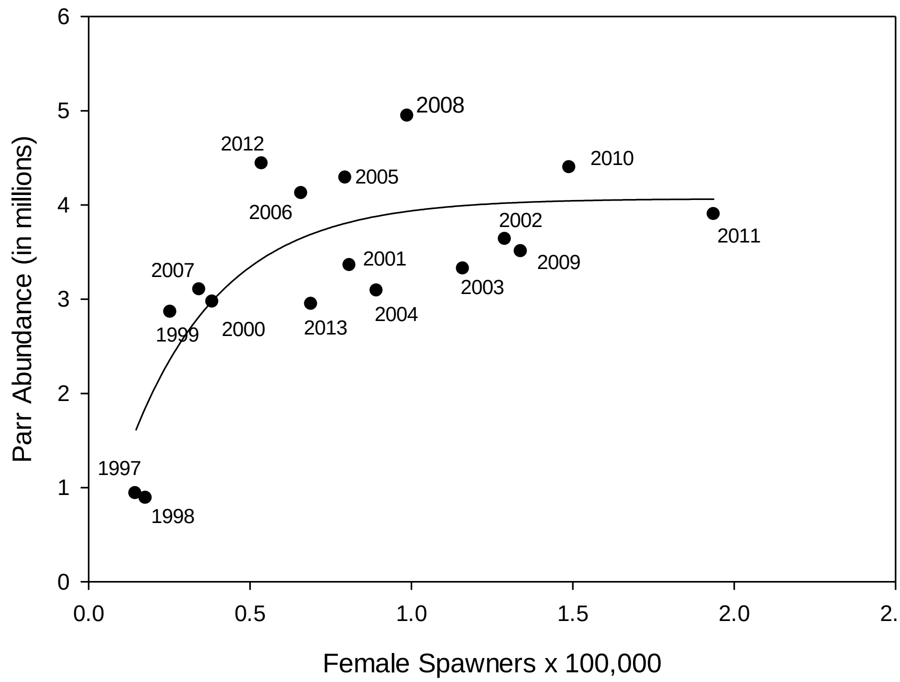

Figure 9. The relationship between parr abundance in pools and the number of female spawners which produced them. Parr numbers are from un-calibrated visual estimates in pools that met snorkeling criteria. Brood year is given for each data point.

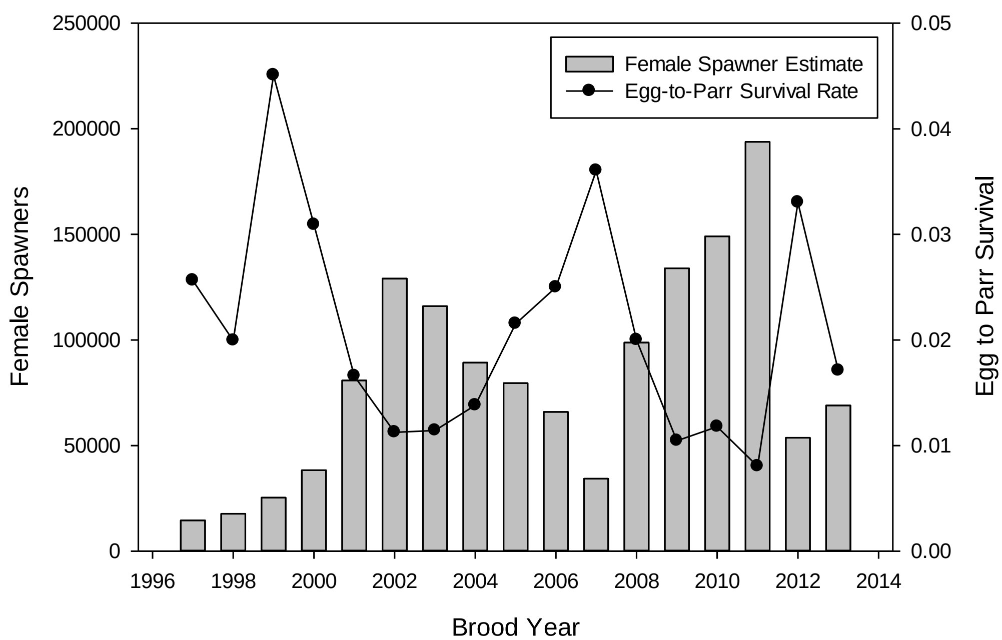

Figure 10. Percent egg-to-parr survival and the abundance of female spawners by brood year in the Oregon Coast Coho ESU.

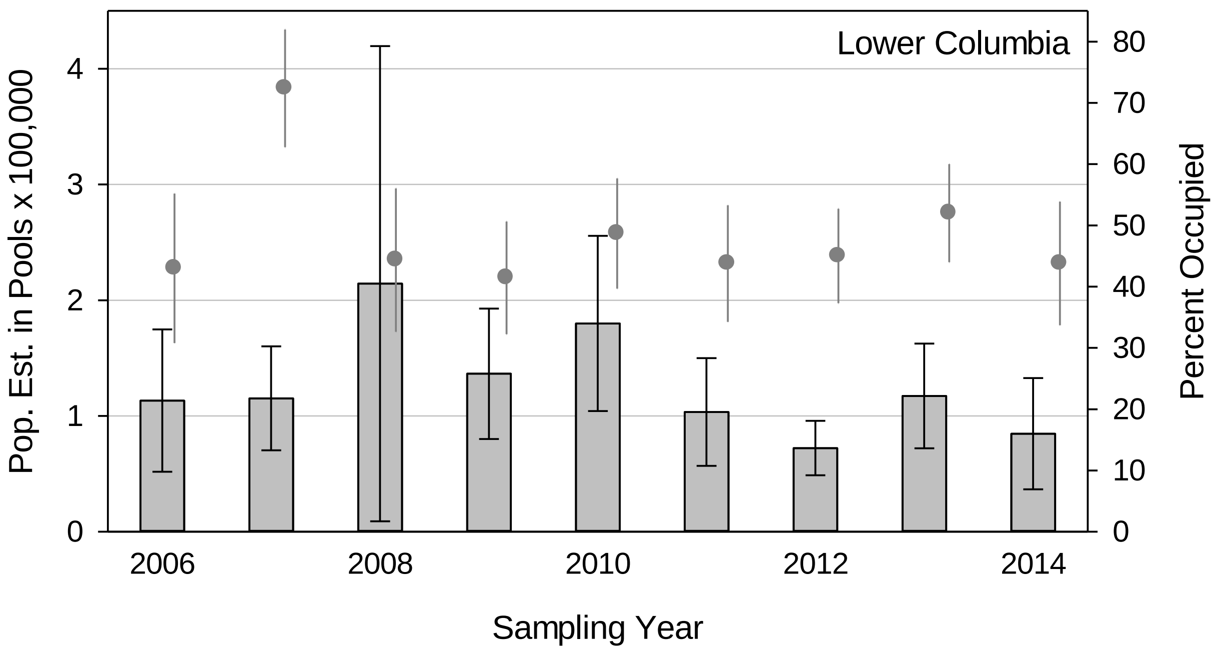

Figure 11. Trends in pool population estimates and site occupancy of coho by sampling year in the Lower Columbia River ESU. Gray bars show the population estimate (with 95% CI) for the year, gray dots (with 95%CI) show the percent of occupied sites.

Oregon Coast Steelhead

For the DPS, densities in 2014 were similar to the average from 2002-2013 and lower than the 2013 estimate (Figure 12). Pool frequencies (Figure 12) in 2014 were similar to the 2013 estimate and higher than the average for the DPS from 2002-2013.

Pool population estimates in 2014 were similar to the average for the DPS from 2002-2013 and to the 2013 estimate (Figure 13). The 2014 pool population estimate was also similar to the average estimate for 2010-2013 steelhead brood group. Site occupancy (Figure 14) in 2014 was the highest recorded and was higher than the estimate in 2013. The 2014 site occupancy estimate for the DPS was higher than the average from 2002-2013, but similar to the 2010-2013 steelhead brood group. The last four years (2011-2014) have had the 4 highest steelhead site occupancies.

Klamath Mountain Province Steelhead

In 2014 steelhead density was higher than the record low estimate in 2013 and similar to the average from 2002-2013 (Figure 12). Pool frequency in 2014 for the DPS was similar to both the 2013 estimate and the average of the estimates from 2002-2013.

Pool population estimates in 2014 were lower than the 2013 estimate but similar to the average of the estimates for the DPS from 2002-2013. Pool population estimates in 2014 were similar to the 2010-2013 steelhead brood group (Figure 13). The point estimate for site occupancy in 2014 was the second lowest recorded, but similar to the estimate in 2014 and the average for the 2010-2013 brood group (Figure 14). Occupancy for the 2010-2013 brood group is similar to the two preceding groups.

Density and site occupancy were higher in the Non-Rogue portions of the DPS (Table 3).

Lower Columbia River/Southwest Washington Steelhead

The two steelhead DPSs in the Lower Columbia River had similar density estimates (Table 3). In the LCR the 2014 density estimate was similar to the estimate in 2013 and to the average density for the DPS, but with a low p-value of 0.06. In the SWW DPS the 2014 density estimate was similar to the estimate in 2013 and to the average from 2006-2013.

Pool Frequencies in the two DPSs for 2014 were similar to the average since 2006 and similar to 2013 (Figure 12).Pool population estimates (Figure 15) for LCR and SWW were similar to the average of the estimates for the DPSs and to 2013 estimates. Site occupancy (Figure 15) in 2014 for the LCR was the highest recorded. In SWW, site occupancy in 2014 was similar to the average for the DPS and similar to 2013.

Table 3. Distribution and density estimates for juvenile steelhead ≥90cm in fork length from snorkel surveys in western Oregon wadeable streams, summer 2014.

	Distribution			Density	
Monitoring Area	Site Occupancy	Mean Pool Frequency	95% CI	Mean Average Pool Density (sthd/m^2)	95% CI
North Coast	96%	57%	± 18%	0.042	± 33%
Mid Coast	97%	47%	± 19%	0.039	± 34%
Mid South	96%	53%	± 17%	0.024	± 42%
Umpqua	72%	30%	± 20%	0.016	± 35%
KMP Rogue	81%	54%	± 20%	0.061	± 40%
KMP South Coast	100%	68%	± 13%	0.043	± 23%
Lower Columbia	89%	44%	± 22%	0.015	± 32%
Southwest WA	68%	32%	± 32%	0.021	± 46%

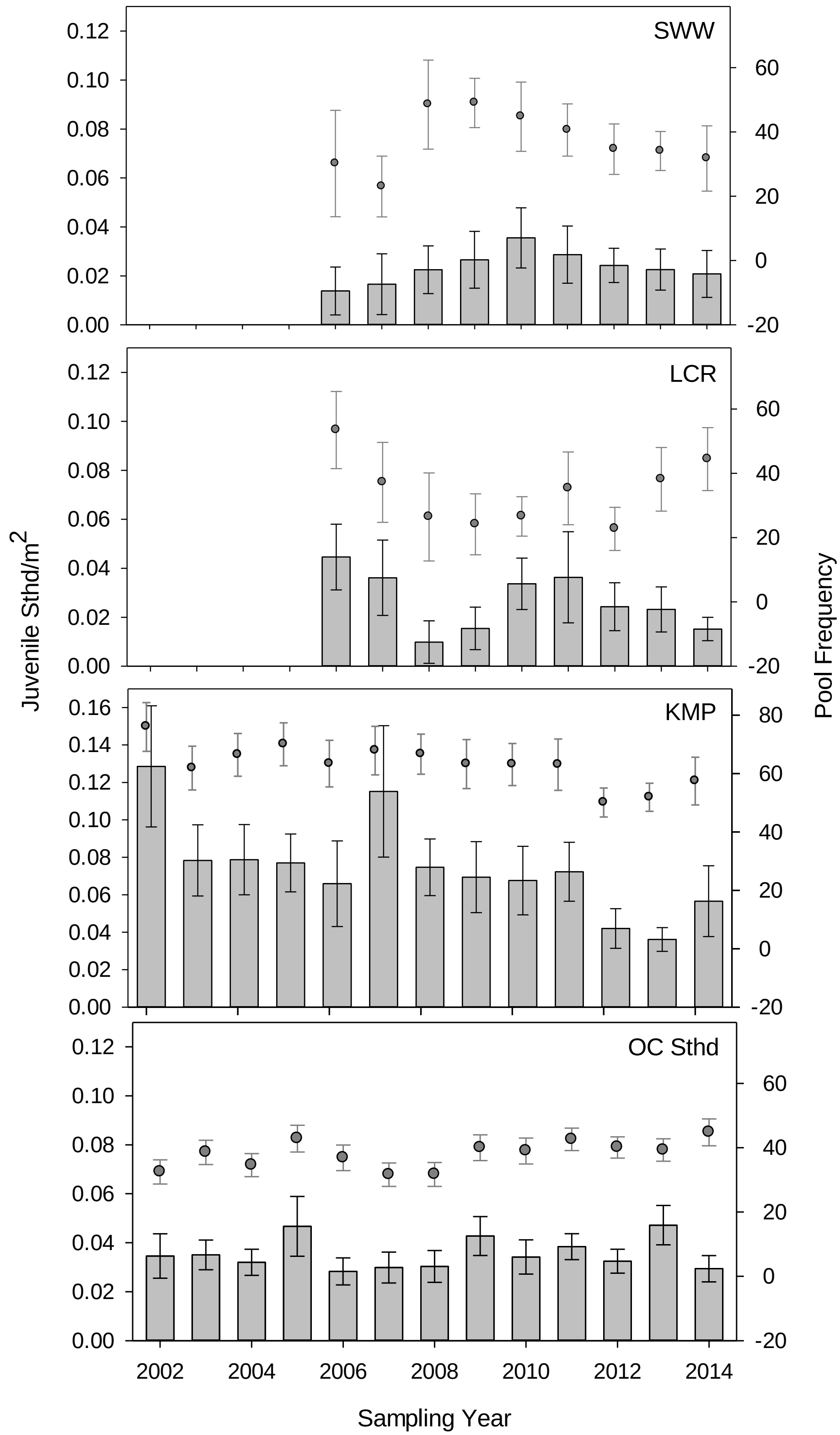

Figure 12. Annual trend in mean density (bars) and pool frequency (dots) metrics for steelhead in the four Distinct Population Segments, based on snorkel surveys in 1st-3rd order streams. Error Bars are the 95% CI. Note density scale difference for the KMP.

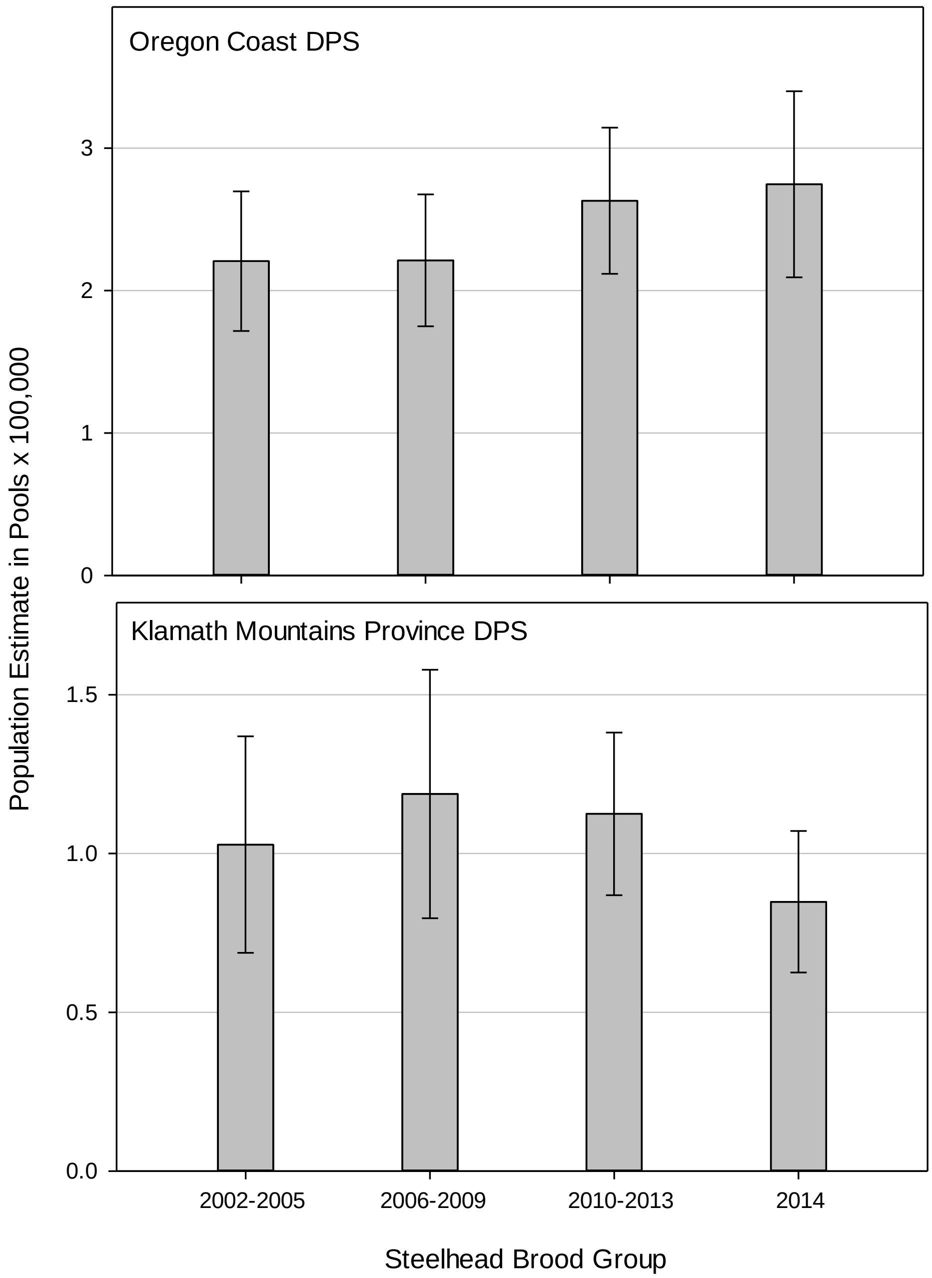

Figure 13. Trends in pool population estimates of steelhead juveniles by brood group in the Oregon Coast DPS (top panel) and the Klamath Mountains Province DPS (bottom panel). Gray bars show the population estimate with the 95% CI for the brood group.

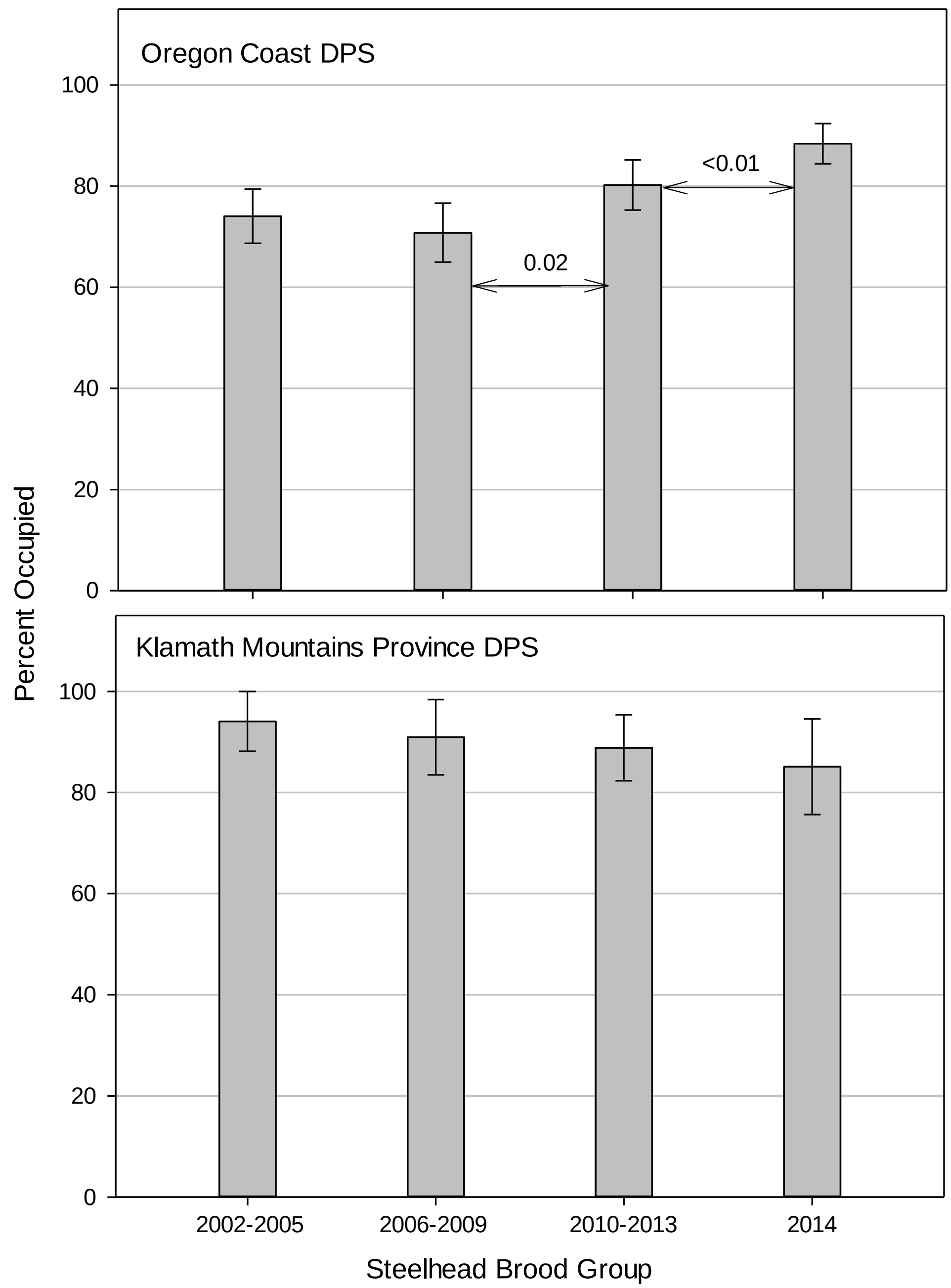

Figure 14. Trends in site occupancy for steelhead by brood group in the Oregon Coast DPS (top panel) and Klamath Mountains Province DPS (bottom panel). Gray bars show the percent occupied (with 95% CI) for each brood group, p values for comparison are given above the vertical arrows when there is a significant difference.

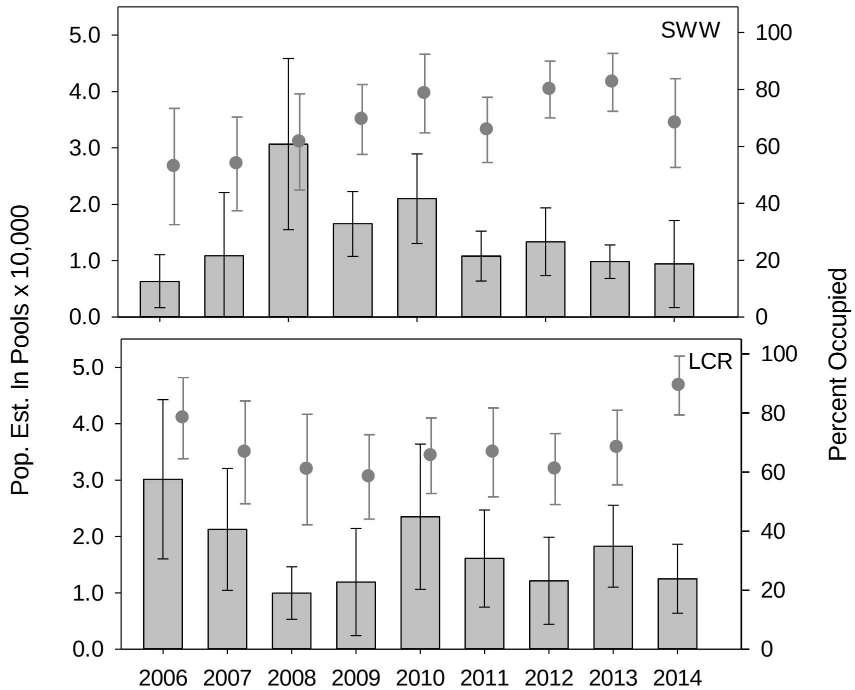

Figure 15. Annual trend in population estimates from pools (gray bars) and site occupancy (dots) for steelhead based on surveys in 1st-3rd order streams in the two lower Columbia River DPS. Error bars show the 95% CI.

ESU/DPS Comparisons

Coho

The Oregon Coast Coho ESU had the broadest coho distribution (based on occupancy rates, Figures 8 and 12) and the highest density estimates (Figure 5). The Lower Columbia River ESU had a lower density estimate than the SONCC, and occupancy estimates were similar in the SONCC and LCR. Population estimates in pools are not directly comparable because the number of stream kilometers differs among the ESUs.

Steelhead

Density was highest in the KMP. Densities in for the Coast DPS were higher than in the LCR and SWW, which were similar to each other. For the first time since monitoring began in the DPS in 2006, the LCR had the highest point estimate for steelhead site occupancy. Site occupancies were similar in the LCR, OC and KMP DPS, which were all higher than in SWW. The KMP had the highest pool frequency estimate. Pool Frequencies in the OC and LCR were similar and the estimate in SWW was lower than in the other DPSs. Population estimates in pools are not directly comparable because the number of stream kilometers differs among the DPSs.

Effects of Pool Depth on Snorkel Counts

The Smith River Steelhead and Coho Monitoring Verification Study (Constable and Suring, under review.) indicated a large portion of the summer coho and steelhead rearing populations are often found in pools that did not meet the pre 2010 snorkeling criterion of ≥40 cm in maximum depth. Data from removal estimates (electrofishing with block nets) shows pools ≥40cm max depth contained an average of 46% of the coho population and 68% of the steelhead population in the study area. The yearly difference ranged from 31% to 61% for coho and 49% to 82% for steelhead. Population estimates in pools ≥40 cm (based on removal estimates and expanded to the basin) related moderately to total population estimates (for coho $R^2 = 0.791$, $p= 0.007$; for steelhead relation was stronger ($R^2 = 0.918$, $p= 0.001$). Lowering the maximum depth criterion to ≥20 cm allowed an average of 74 % of the coho population and 79% of the steelhead population to be sampled by electrofishing with a yearly range of 61 - 82% for coho and 54 - 91% for steelhead. Population estimates from pools ≥20 cm had a strong and significant relationship with total population estimates (for coho $R^2 = 0.974$, $p< 0.001$ and for steelhead $R^2 = 0.936$, $p< 0.001$). The Smith River study did not include snorkel estimates in pools below 40 cm in depth and we were unable to estimate observation probability of coho and steelhead in the small pool category for visual counts.

As a result of the study, we lowered maximum depth criterion for snorkel pools to ≥20 cm in 2010. This change will be monitored for survey effort, accuracy and repeatability, and influences on occupancy, density and population estimates. Results from 2013 are reported below. As more data are collected, future reports will provide a more detailed analyses and comparisons between the two depth criteria.

Survey Effort

Lowering the maximum depth criteria allowed an additional 959 pools to be snorkeled in 2014. One site in the Lower Columbia did not have pools that were ≥40 cm in maximum depth, but contained a single pool that was ≥20 cm in maximum depth. With the new criterion, the status of this site would change from non-target to target (Table 1).

Distribution

Lowering the depth criterion allowed surveyors to observe coho and steelhead in four sites where they would not have been observed under the previous criterion. These sites had pools that were both ≥20 cm in maximum depth and ≥40 cm in maximum depth, but coho (2 sites) and steelhead (2 sites) were only observed in pools that were <40cm in maximum depth. The lower depth criteria resulted in slightly increased site occupancy estimates in these areas over those given in Table 2 and Table 3. These results were consistent with results from previous years. Coho and steelhead were not observed in the Lower Columbia site where all pools were <40cm in depth.

Average pool frequency decreased when depth criteria was adjusted to include more shallow pools. The decrease was ≤5% in all Monitoring Areas and strata for coho and the decrease averaged less than 10% for steelhead.

Density

In the past 4 years coho density estimates decreased in most Monitoring Areas when the lower depth criterion was applied. In most cases this was less than a 10% decrease. In 2014 coho densities increased by 1-3% in most Monitoring Areas when the lower criterion was applied. In the LCR ESU densities increased by 5%.

In 2014, as in the past 4 years, steelhead density estimates decreased with the lower depth criterion. For the Oregon Coast DPS, densities decreased by approximately 8%. In the KMP densities decreased 14% and in the LCR and SWW the decrease was 8% and 10%, respectively.

Pool Population Estimates

Pool population estimates with the different depth criteria from surveys in 2014 are displayed for coho in Table 4 and steelhead in Table 5. These estimates represent the number of fish in pools from un-calibrated visual counts and should not be interpreted as total population estimates. Paired t-tests from pools ≥40cm and pools ≥20cm indicate that including the shallower pools produces, on average, a 14% larger population estimate for coho ($p = 0.017$) and a 8% larger population estimate for steelhead ($p = 0.018$). These results are consistent with those from 2013. In the past 3 years the increase in pool population estimates was most pronounced in the Mid Coast for both coho and steelhead. In 2014 the increase in pool population estimates was most pronounced in the Umpqua for both species. The majority of coho and steelhead in 2014 were observed in pools ≥40cm deep.

Results of resurveys from 2010-2012 (resurveys were not fully completed in 2013 and 2014 due to budget restrictions) indicate that including pools between the ≥40cm depth criteria and the ≥20cm depth criteria has little impact of the variability of coho and steelhead counts between surveyors.

Thus far the yearly variability for the coho population in each MA and ESU estimated by surveys in pools ≥40cm in depth has generally tracked with the variability estimated by surveys in pools ≥20cm in depth (Figure 16). Population estimates including pools that met the 20cm depth criterion produced proportionally smaller 95% confidence intervals for coho and steelhead estimates in most Monitoring Areas (Tables 4 and 5).

As more data are collected we will provide additional analyses that address the differences in pool size criteria. Of specific interest to our monitoring efforts are variations in site occupancies and in the percentage of the population that is distributed in pools that are less than 40cm in depth and how these impact our sensitivity to trend detection.

Table 4. Comparison of total estimates of coho in snorkel pools using a maximum depth of ≥20 cm and those using a maximum depth of ≥40 cm.

Monitoring Area	2014 Coho Estimates				
	Pools ≥ 20cm Max Depth		Pools ≥40cm Max Depth		95% CI Difference
	Estimate	95% CI	Estimate	95% CI	
North Coast	389,333	31%	337,136	28%	-3%
Mid Coast	1,166,854	45%	1,025,977	51%	6%
Mid South Coast	1,123,437	34%	963,062	35%	1%
Umpqua	769,059	37%	617,845	44%	7%
SONCC	125,041	47%	120,085	48%	1%
Lower Columbia	92,955	53%	84,705	57%	4%

Table 5. Comparison of total estimates of steelhead in snorkel pools using a maximum depth of ≥20 and those using a maximum depth of ≥40 cm.

Monitoring Area	2014 Steelhead Estimates				
	Pools ≥ 20cm Max Depth		Pools ≥ 40cm Max Depth		95% CI Difference
	Estimate	95% CI	Estimate	95% CI	
North Coast	59,985	36%	51,744	41%	5%
Mid Coast	145,820	39%	132,749	43%	4%
Mid South Coast	58,252	32%	53,432	35%	3%
Umpqua	41,269	26%	36,747	27%	1%
KMP Rogue	48,040	42%	45,810	44%	2%
KMP South Coast	39,287	36%	38,967	36%	0%
Lower Columbia DPS	12,623	48%	12,495	49%	1%
Southwest WA DPS	9,595	81%	9,411	82%	1%

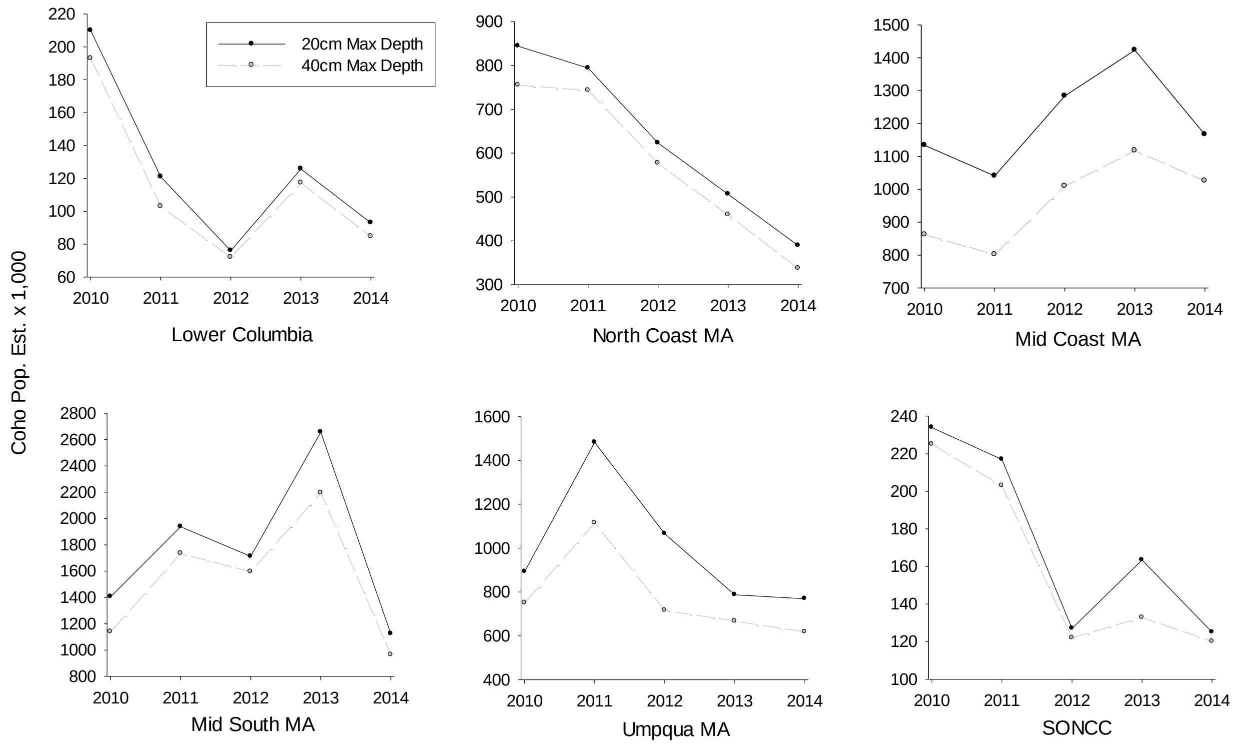

Figure 16. Trends in the coho rearing population from 2010 to 2014 based on the ≥20cm pool depth criteria (solid black line) and the ≥40cm pool depth criteria (dashed grey line).

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