Age composition of scales collected at-sea by California Genetic Stock Identification Collaboration in 2010.

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Introduction

This report describes the data and methods used by the California Department of Fish and Game (CDFG) Ocean Salmon Project (OSP) to determine the age composition of Chinook salmon collected by the California Genetic Stock Identification Collaboration (CA GSI) in 2010. The CA GSI is a workgroup comprised of commercial salmon industry representatives, the California Salmon Council (CSC), CDFG, and the National Marine Fisheries Service-Southwest Fisheries Science Center (SWFSC). Through the use of genetic stock identification and scale aging techniques, the CA GSI study objective was to determine the stock-specific age composition of Chinook salmon contacted in California waters by management area and month. Scales, tissue samples, and other biological data were collected at-sea by commercial trollers under contract with the CA GSI. Fishing occurred during May through September 2010 between Point Conception and the California-Oregon border. Since most of California was closed to commercial salmon fishing during the 2010 season, the primary mode of sampling was non-retention. However, approximately 38 percent of at-sea samples, including all known-age scales, were collected during a limited commercial season in July and August (2010 season structure can be found at www.pcouncil.org). Stock designations included in this report are those assigned to each scale sample by the SWFSC Genetics Laboratory.

Methods

A total of 5,064 scale envelopes were received from the SWFSC Genetics Lab; however 473 samples were not included in this analysis due to various problems (e.g., missing scales, duplicate sample ID numbers) that prohibited a sample from being assigned to a specific stock or sample location and time. Two samples (Rogue River and Upper Columbia Summer Fall) that were read as age 6 were also omitted from this report due to their relative rarity in California ocean salmon fisheries.

Scales from 479 known-age fish were also added to reading assignments to evaluate reader accuracy and potentially correct for bias; these scales were collected by the CDFG's Ocean Salmon Project (OSP) from adipose fin-clipped salmon containing coded-wire tags (CWTs) observed during their dockside monitoring of sport and commercial salmon fisheries in 2010.

Contemporary mounting, digital imaging and digital reading techniques were used. For each sample, approximately 5-10 scales were cleaned and mounted onto a glass slide. Each slide was examined and the best 2-3 scales were digitally imaged using an Olympus Colorview IIIu camera coupled to a transmitted light microscope and Olympus analysis FIVE imaging software. Scale images were randomly sorted into stock-specific reading assignments to reduce reader error associated with reading scales from salmon stocks with varying life history types. The OSP has found that reading scales concurrently from different salmon stocks (specifically run-type) within the Central Valley (CV) increases reader error. When available, known-age CWT samples were included in the stock-specific assignment to evaluate reader accuracy through validation matrices.

Scale samples were read by a single experienced reader and field length data were only taken into consideration after the initial determination of age by the reader. Flain and Glova (1988) demonstrated that aging scales by an individual experienced reader can be more accurate than aging scales using multiple readers. Individual ages were determined from scales by

counting winter annuli, a standard method for scale aging of Pacific salmon (Bugaev 2004). Annuli can be identified as bands of closely spaced or broken circuli. The age compositions in this report are based on direct counts of winter annuli. Age assignments for CV Fall and Klamath Chinook samples collected in September were not adjusted to reflect the use of September 1 as the "birth date" for these stocks in west coast ocean harvest models.

The final age composition for each stock was determined by combining "read" age assignments for unknown-age scales with known-age CWT samples collected at-sea. Although the original study design included correcting for reader bias using a modified maximum likelihood estimator (MLE) based on Kimura and Chikuni (1987), there were insufficient numbers of known-age CWT scales to perform this work for any stock type besides CV fall.

Results

A total of 4,495 unknown-age and 96 known-age CA GSI scales were read from 14 separate stock designations, as assigned by the SWFSC Genetics Lab. Scales from 575 known-age CWT salmon were also read, including supplemental OSP scales used only for reader validation and bias correction purposes. Table 1 summarizes the number of aged CA GSI scales collected by fishing area (based on nearest port) and month. Almost 70% of all samples were taken in Fort Bragg, Eureka, and Bodega Bay and 81% of the scales were collected in July, August and September. More than 53% of all scales were designated by the SWFSC GSI lab as CV fall Chinook (it should be noted that this stock designation also includes Feather River spring and Central Valley late fall Chinook). Rogue River, California Coastal, and Klamath River stocks comprised 16%, 10%, and 9%, respectively, of all CA GSI scales.

Table 2 contains the total age composition by stock designation for all CA GSI samples. For each stock, the total represents the number of unknown-age samples that were successfully read and assigned an age, plus any known-age CWT scales sampled at-sea. Figure 1 shows the total age proportions for CA GSI scales collected in 2010; almost 63% of all scales were determined to be from age-three fish.

Validation matrices evaluating reader accuracy of known-age CWT samples by stock designation can be found in Table 3a-h; however because relatively few known-age CWT scales were collected from stocks other than CV fall, these validation matrices couldn't be used to correct for reader bias on a stock-specific basis. Table 4 provides the number of known- and unknown-age samples by age for each stock designation collected by CA GSI. Table 5 provides the proportions at age for each stock type.

Figures 2a-2h show the stock-specific age composition by fishing area (i.e., nearest port) and month for all CA GSI scales. Age composition by stock are the direct counts of age assignments of unknown-age scales combined with any known-age (CWT) scales collected at-sea. Although there were not enough known-age CWT scales to correct for potential reader bias based on known-age versus read-age validation matrices, Table 6 presents the "read vs corrected" ages for unknown-age CV Fall scales by management area and month utilizing the MLE.

Discussion

While the CWT continues to be the primary tool used for monitoring and managing mixed-stock fisheries on the west coast, the results of this report demonstrate the potential for

using GSI and scale aging techniques to provide supplemental stock distribution information, especially for stocks without representative CWT fish. This study also highlighted the need for additional coordination and planning if these data are to be incorporated in future salmon management.

Tissues and scales were collected at-sea from both legal (≥ 27" total length) and sublegal salmon caught in both open and closed areas of California. However, because most known-age CWT scales collected at-sea and in OSP dockside samples were obtained from legal fish landed in the commercial fishery, the known-age scales weren't representative of the catch. Only 55 age-two CWT samples were collected, of which 73% were obtained from the sport fishery. In addition, all age-two CWTs were from CV fall stocks. If adequate numbers of scales from known-age CWT fish from each age class and stock type had been collected, the MLE could have been used to bias correct the age composition for additional stocks. Given the small change observed in the age proportions by time and area after applying the MLE correction to the CV fall "read" ages, using direct counts to determine the age composition by time and area for all stocks in this study seems to be the best approach given these data constraints.

A dockside sampling program with representative sampling of catch in both commercial and sport fisheries needs to be established if these data are to be used to determine stock- and age-specific estimates of hatchery and natural components in ocean harvest by time and area. The coastwide sampling program must collect scales, combined with tissues, from both fin-clipped and unmarked salmon fish observed in sport and commercial fisheries during the entire season. Estimates of stock-specific age composition through genetic stock identification and scale aging could be applied to the total catch. Removing the hatchery component utilizing CWT data would allow stock- and age-specific estimates of the natural component by time and area to be made. Additionally, minimum sample sizes for utilizing a MLE can also be targeted, allowing for bias correction and increasing the efficiency of the aging work. For stocks without representative CWT releases, an "agreement approach" using two or more readers could be used. Without comprehensive sampling of all ocean harvest, stock- and age-specific estimates of hatchery and natural components by time and area will not be possible.

Literature Cited

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Acknowledgements

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Table 1: Number of CA GSI scales collected at-sea by fishing area (nearest port) and month in 2010.

Port	May	Jun	Jul	Aug	Sep	Total	% Total
Crescent City	0	1	0	0	23	24	1%
Eureka	0	52	117	321	308	798	17%
Fort Bragg	90	161	431	518	458	1,658	36%
Bodega Bay	43	104	388	153	49	737	16%
San Francisco	68	120	47	108	56	399	9%
Half Moon Bay	43	151	64	9	23	290	6%
Santa Cruz	15	18	378	145	89	645	14%
Morro Bay	2	3	10	9	16	40	1%
Total	261	610	1,435	1,263	1,022	4,591	100%
% Total	6%	13%	31%	28%	22%	100%	

Table 2: Age composition of CA GSI scales (unknown and known-age) by stock designation.

	Age					
Stock Designation	**2**	**3**	**4**	**5**	**Total**	**% Total**
Central Valley Fall	613	1,713	123	1	2,450	53%
California Coastal*	32	270	155	6	463	10%
Central Valley Spring	38	34	2	0	74	2%
Sacramento River Winter	3	26	1	0	30	1%
Chetco River*	5	145	173	8	331	7%
Columbia River Spring Creek	0	3	1	0	4	< 1%
Deschutes River	0	2	2	0	4	< 1%
Klamath River*	25	237	166	1	429	9%
Lower Columbia River Fall	0	0	1	0	1	< 1%
Lower Columbia River Spring	0	2	0	0	2	< 1%
Mid-Oregon Coastal	6	24	14	0	44	1%
Rogue River*	33	432	276	11	752	16%
Snake River Fall	0	2	2	0	4	< 1%
Upper Columbia Summer Fall	0	1	1	1	3	< 1%
Total	755	2,891	917	28	4,591	100%

*Denotes instances where known-age CWT stock did not match genetic assignments:
California Coast: Coleman National Fish Hatchery Late Fall, Feather River Hatchery Fall
Chetco River: Rowdy Creek Hatchery fall (2)
Klamath River: Elk River Hatchery
Rogue River: Rowdy Creek Hatchery fall, Coleman National Fish Hatchery fall, Mokelumne River Hatchery fall

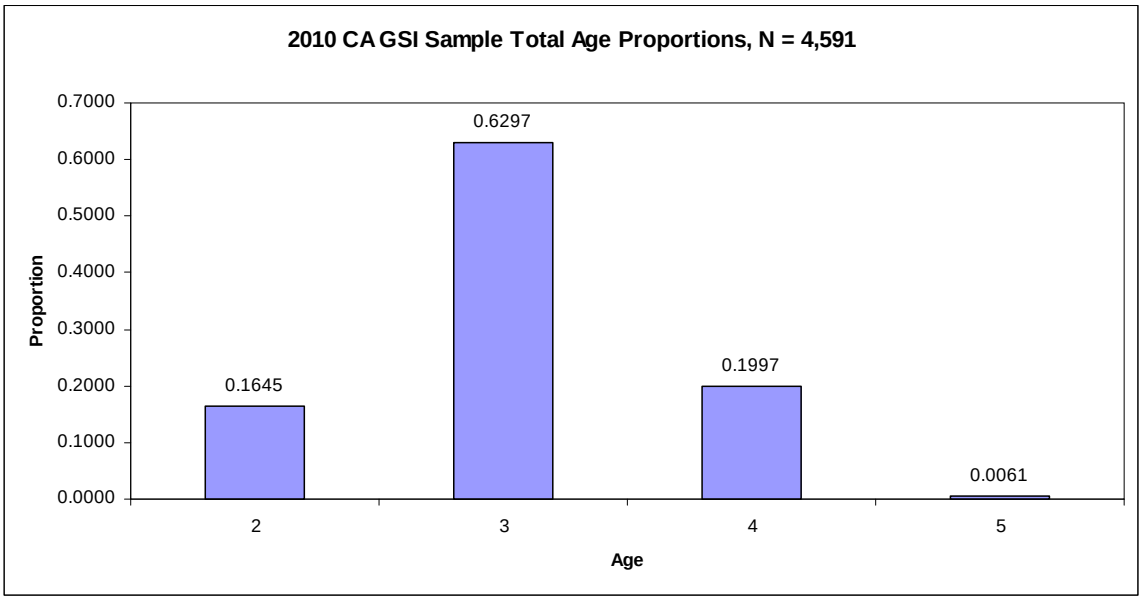


Figure 1: Proportion by age for all known- and unknown-age scales collected at-sea by CA GSI. All stocks are combined and not corrected for reader bias.

Table 3a. 2010 Central Valley Fall scale validation matrices.

Number

Read Age	Known Age 2	3	4	5	Total
2	49	4	0	0	
3	6	392	3	0	
4	0	3	10	0	
5	0	0	0	0	
Total	55	399	13	0	467

Percentage

Read Age	Known Age 2	3	4	5
2	0.891	0.010	0.000	0.000
3	0.109	0.982	0.231	0.000
4	0.000	0.008	0.769	0.000
5	0.000	0.000	0.000	0.000
Total	1.000	1.000	1.000	0.000

*Includes 385 scales sampled dockside by CDFG

Table 3b. 2010 California Coastal scale validation matrices.

Number

Read Age	Known Age 2	3	4	5	Total
2	0	0	0	0	
3	0	29	0	0	
4	0	1	0	0	
5	0	0	0	0	
Total	0	30	0	0	30

Percentage

Read Age	Known Age 2	3	4	5
2	0.000	0.000	0.000	0.000
3	0.000	0.967	0.000	0.000
4	0.000	0.033	0.000	0.000
5	0.000	0.000	0.000	0.000
Total	0.000	1.000	0.000	0.000

*Includes 27 scales sampled dockside by CDFG

Table 3c. 2010 Chetco River scale validation matrices.

Number

Read Age	Known Age 2	3	4	5	
2	0	0	0	0	
3	0	2	1	0	
4	0	0	3	0	
5	0	0	0	0	Total
Total	0	2	4	0	6

Percentage

Read Age	Known Age 2	3	4	5
2	0.000	0.000	0.000	0.000
3	0.000	1.000	0.250	0.000
4	0.000	0.000	0.750	0.000
5	0.000	0.000	0.000	0.000
Total	0.000	1.000	1.000	0.000

*Includes 3 scales sampled dockside by CDFG

Table 3d. 2010 Columbia River Spring Creek scale validation matrices.

Number

Read Age	Known Age 2	3	4	5	
2	0	0	0	0	
3	0	3	0	0	
4	0	0	0	0	
5	0	0	0	0	Total
Total	0	3	0	0	3

Percentage

Read Age	Known Age 2	3	4	5
2	0.000	0.000	0.000	0.000
3	0.000	1.000	0.000	0.000
4	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000
Total	0.000	1.000	0.000	0.000

*All scales sampled dockside by CDFG

Table 3e. 2010 Klamath River scale validation matrices.

Number

Read Age	Known Age 2	3	4	5	Total
2	0	0	0	0	
3	0	22	0	0	
4	0	0	36	0	
5	0	0	0	0	
Total	0	22	36	0	58

Percentage

Read Age	Known Age 2	3	4	5
2	0.000	0.000	0.000	0.000
3	0.000	1.000	0.000	0.000
4	0.000	0.000	1.000	0.000
5	0.000	0.000	0.000	0.000
Total	0.000	1.000	1.000	0.000

*Includes 54 scales sampled dockside by CDFG

Table 3f. 2010 Rogue River scale validation matrices.

Number

Read Age	Known Age 2	3	4	5	Total
2	0	0	0	0	
3	0	7	0	0	
4	0	0	3	0	
5	0	0	0	0	
Total	0	7	3	0	10

Percentage

Read Age	Known Age 2	3	4	5
2	0.000	0.000	0.000	0.000
3	0.000	1.000	0.000	0.000
4	0.000	0.000	1.000	0.000
5	0.000	0.000	0.000	0.000
Total	0.000	1.000	1.000	0.000

*Includes 6 scales sampled dockside by CDFG

Table 3g. 2010 Upper Columbia Summer/Fall scale validation matrices.

Number

Read Age	Known Age 2	3	4	5	
2	0	0	0	0	
3	0	0	0	0	
4	0	0	1	0	
5	0	0	0	0	Total
Total	0	0	1	0	1

Percentage

Read Age	Known Age 2	3	4	5
2	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000
4	0.000	0.000	1.000	0.000
5	0.000	0.000	0.000	0.000
Total	0.000	0.000	1.000	0.000

*Lone scale sampled dockside by CDFG

Table 3h. 2010 All Stocks Combined scale validation matrices.

Number

Read Age	Known Age 2	3	4	5	
2	49	4	0	0	
3	6	455	4	0	
4	0	4	53	0	
5	0	0	0	0	Total
6	0	0	0	0	
Total	55	463	57	0	575

Percentage

Read Age	Known Age 2	3	4	5
2	0.891	0.009	0.000	0.000
3	0.109	0.983	0.070	0.000
4	0.000	0.009	0.930	0.000
5	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000
Total	1.000	1.000	1.000	0.000

*Includes 479 scales sampled dockside by CDFG

Table 4: Number of 2010 CA GSI unknown- and known-age scales collected and read by stock designation.

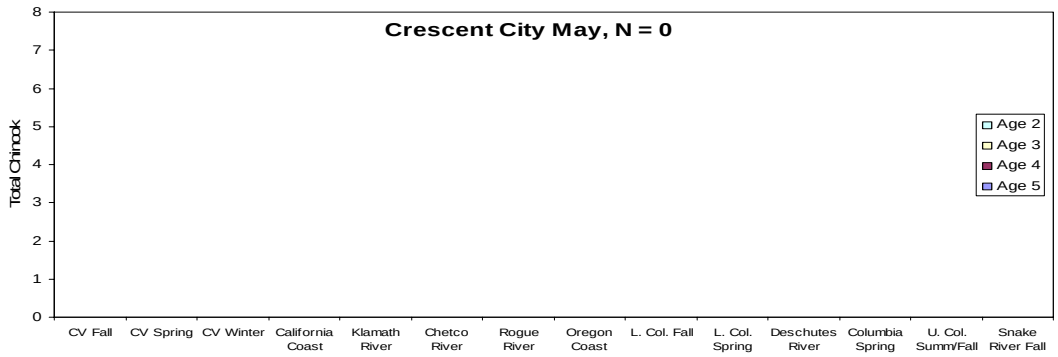
		Age				
Stock Designation		**2**	**3**	**4**	**5**	**TOTAL**
Central Valley Fall	Unknown	612	1,638	117	1	2,368
	Known	1	75	6	0	82
California Coastal	Unknown	32	267	155	6	460
	Known	0	3	0	0	3
Central Valley Spring	Unknown	38	34	2	0	74
	Known	0	0	0	0	0
Sacramento River Winter	Unknown	3	26	1	0	30
	Known	0	0	0	0	0
Chetco River	Unknown	5	143	172	8	328
	Known	0	2	1	0	3
Columbia River Spring Creek	Unknown	0	3	1	0	4
	Known	0	0	0	0	0
Deschutes River	Unknown	0	2	2	0	4
	Known	0	0	0	0	0
Klamath River	Unknown	25	237	162	1	425
	Known	0	0	4	0	4
Lower Columbia River Fall	Unknown	0	0	1	0	1
	Known	0	0	0	0	0
Lower Columbia River Spring	Unknown	0	2	0	0	2
	Known	0	0	0	0	0
Mid-Oregon Coastal	Unknown	6	24	14	0	44
	Known	0	0	0	0	0
Rogue River	Unknown	33	428	276	11	748
	Known	0	4	0	0	4
Snake River Fall	Unknown	0	2	2	0	4
	Known	0	0	0	0	0
Upper Columbia Summer Fall	Unknown	0	1	1	1	3
	Known	0	0	0	0	0

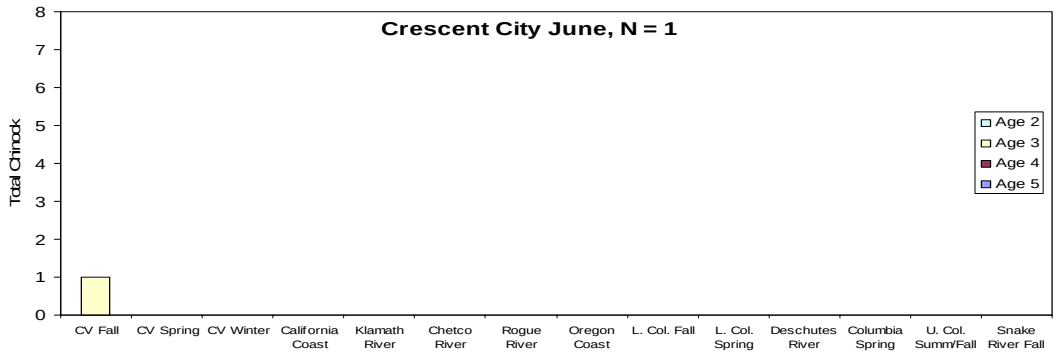
Table 5: Summary of 2010 CA GSI age proportions by stock designation.

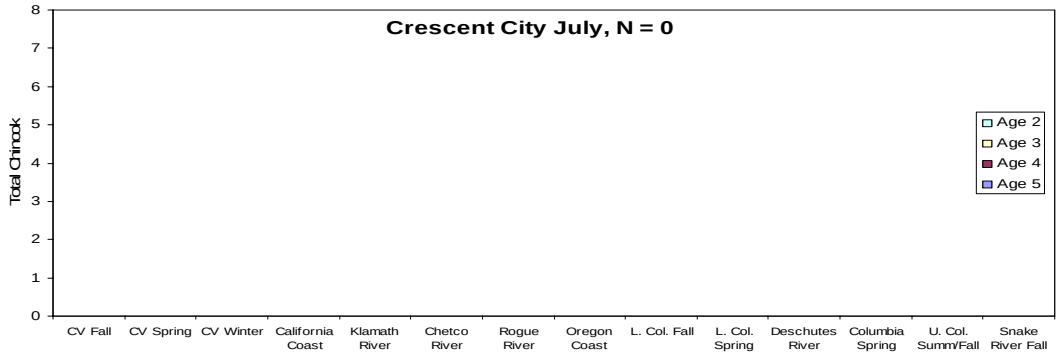
	Proportions at Age			
Stock Designation	**2**	**3**	**4**	**5**
Central Valley Fall	0.2502	0.6992	0.0502	0.0004
California Coastal	0.0691	0.5832	0.3348	0.0130
Central Valley Spring	0.5135	0.4595	0.0270	0.0000
Sacramento River Winter	0.1000	0.8667	0.0333	0.0000
Chetco River	0.0151	0.4381	0.5227	0.0242
Columbia River Spring Creek	0.0000	0.7500	0.2500	0.0000
Deschutes River	0.0000	0.5000	0.5000	0.0000
Klamath River	0.0583	0.5524	0.3869	0.0023
Lower Columbia River Fall	0.0000	0.0000	1.0000	0.0000
Lower Columbia River Spring	0.0000	1.0000	0.0000	0.0000
Mid-Oregon Coastal	0.1364	0.5455	0.3182	0.0000
Rogue River	0.0439	0.5745	0.3670	0.0146
Snake River Fall	0.0000	0.5000	0.5000	0.0000
Upper Columbia Summer Fall	0.0000	0.3333	0.3333	0.3333
Total age proportions	**0.1645**	**0.6297**	**0.1997**	**0.0061**

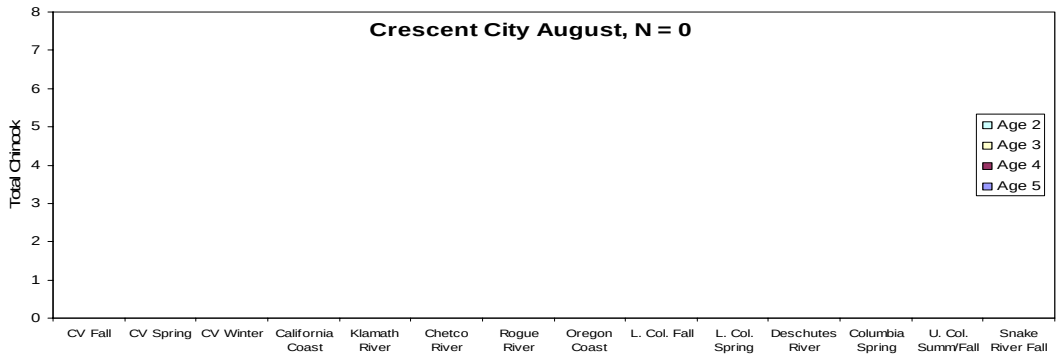
Table 6. Bias-corrected age compositions for CV fall unknown-age scales collected in 2010 by management area and month.

Management	May				June				July				August				September			
Area	Age2	Age3	Age4	Age5	Age2	Age3	Age4	Age5	Age2	Age3	Age4	Age5	Age2	Age3	Age4	Age5	Age2	Age3	Age4	Age5
KMZ-CA																				
Read	0	0	0	0	3	37	0	0	2	45	1	0	39	93	3	0	25	30	2	0
Corrected	0	0	0	0	3	37	0	0	2	45	1	0	43	89	3	0	28	27	2	0
Fort Bragg																				
Read	1	14	3	0	5	27	2	0	2	107	16	0	36	181	18	0	54	55	9	0
Corrected	1	13	4	0	5	27	2	0	1	104	20	0	38	175	22	0	60	47	11	0
Bodega Bay																				
Read	4	12	1	0	23	46	5	0	14	86	16	1	47	95	2	0	17	23	4	0
Corrected	4	12	1	0	25	43	6	0	15	81	19	2	52	90	2	0	19	20	5	0
San Francisco																				
Read	20	62	6	0	92	141	3	0	30	54	2	0	25	88	2	0	23	43	6	0
Corrected	22	59	7	0	102	131	3	0	33	51	2	0	27	86	2	0	25	39	7	0
Monterey Bay																				
Read	2	10	1	0	3	12	1	0	30	279	8	0	53	75	1	0	59	12	2	0
Corrected	2	10	1	0	3	12	1	0	30	279	8	0	58	70	1	0	66	4	3	0
South of Sur																				
Read	0	1	1	0	1	2	0	0	0	4	2	0	0	1	0	0	2	3	0	0
Corrected	0	1	1	0	1	2	0	0	0	3	3	0	0	1	0	0	2	3	0	0









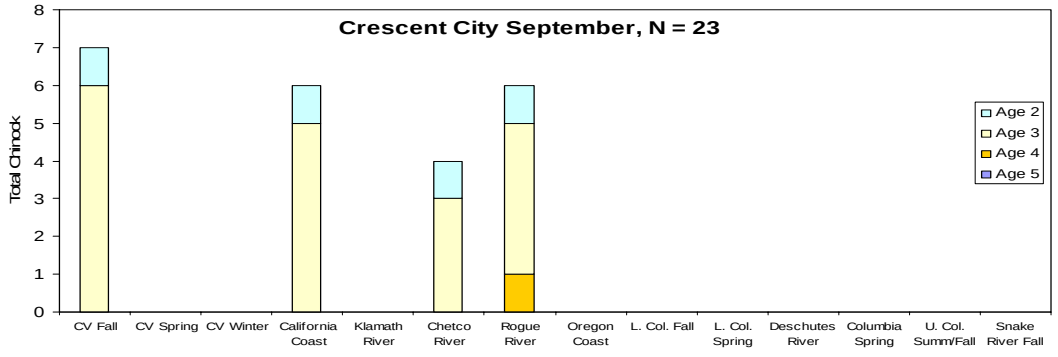
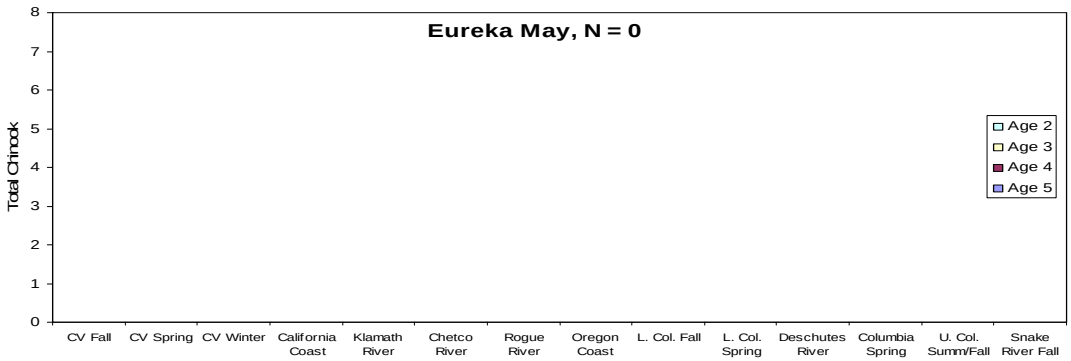
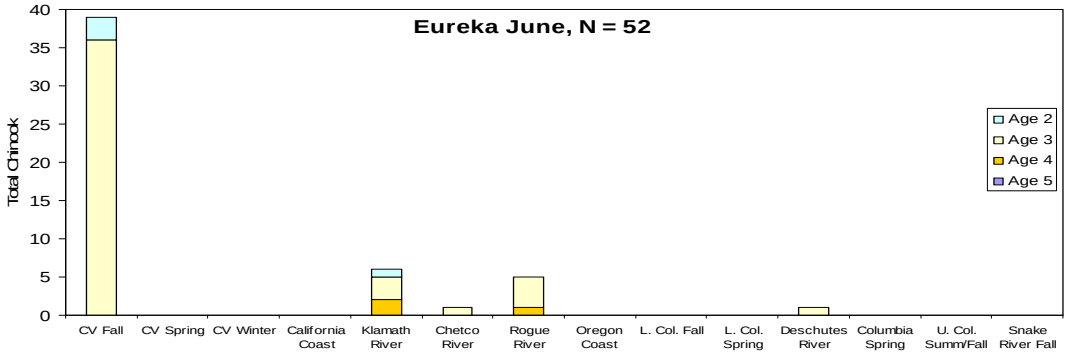
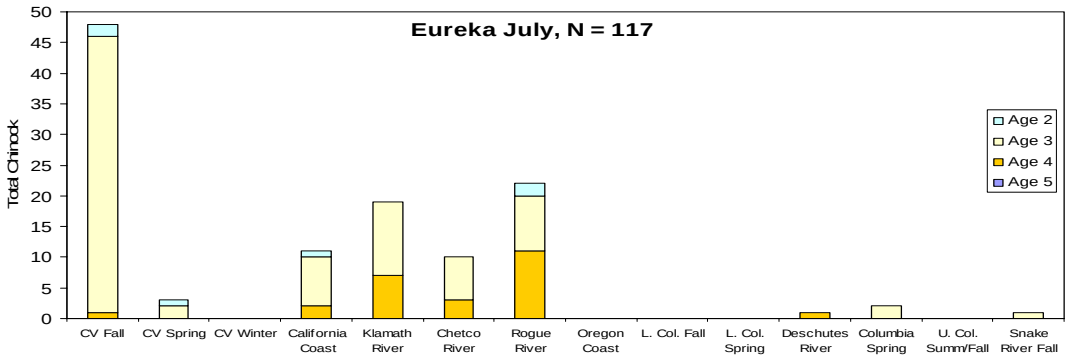
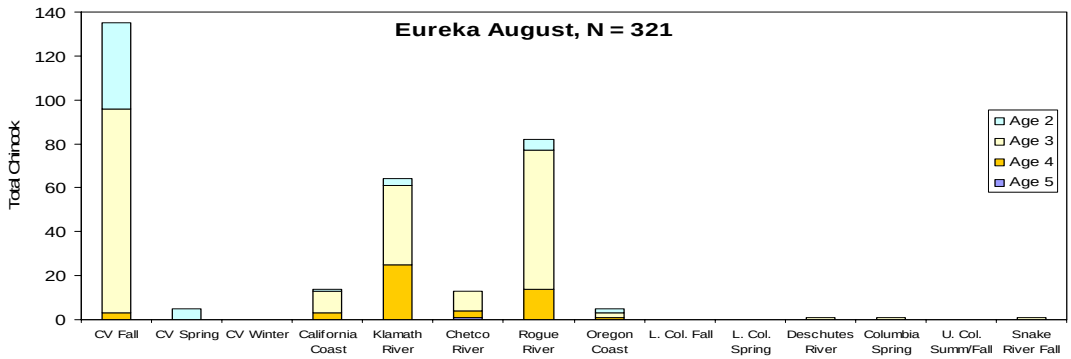


Figure 2a: Stock and age composition for samples collected near Crescent City in May-September 2010









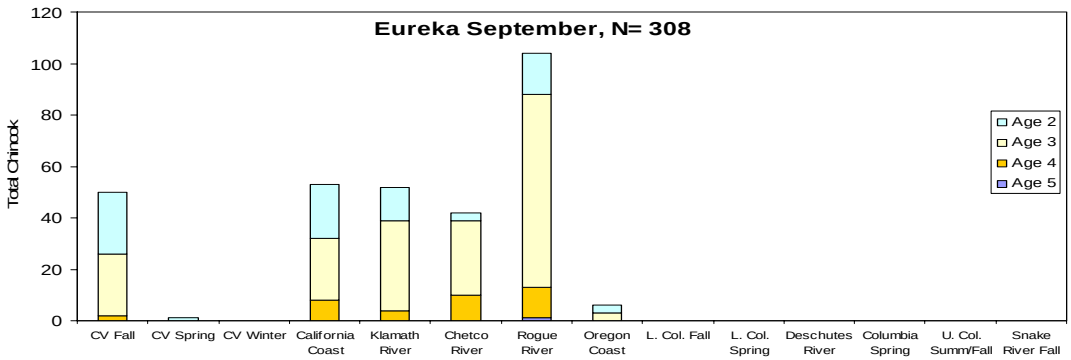


Figure 2b: Stock and age composition for samples collected near Eureka during May-September 2010

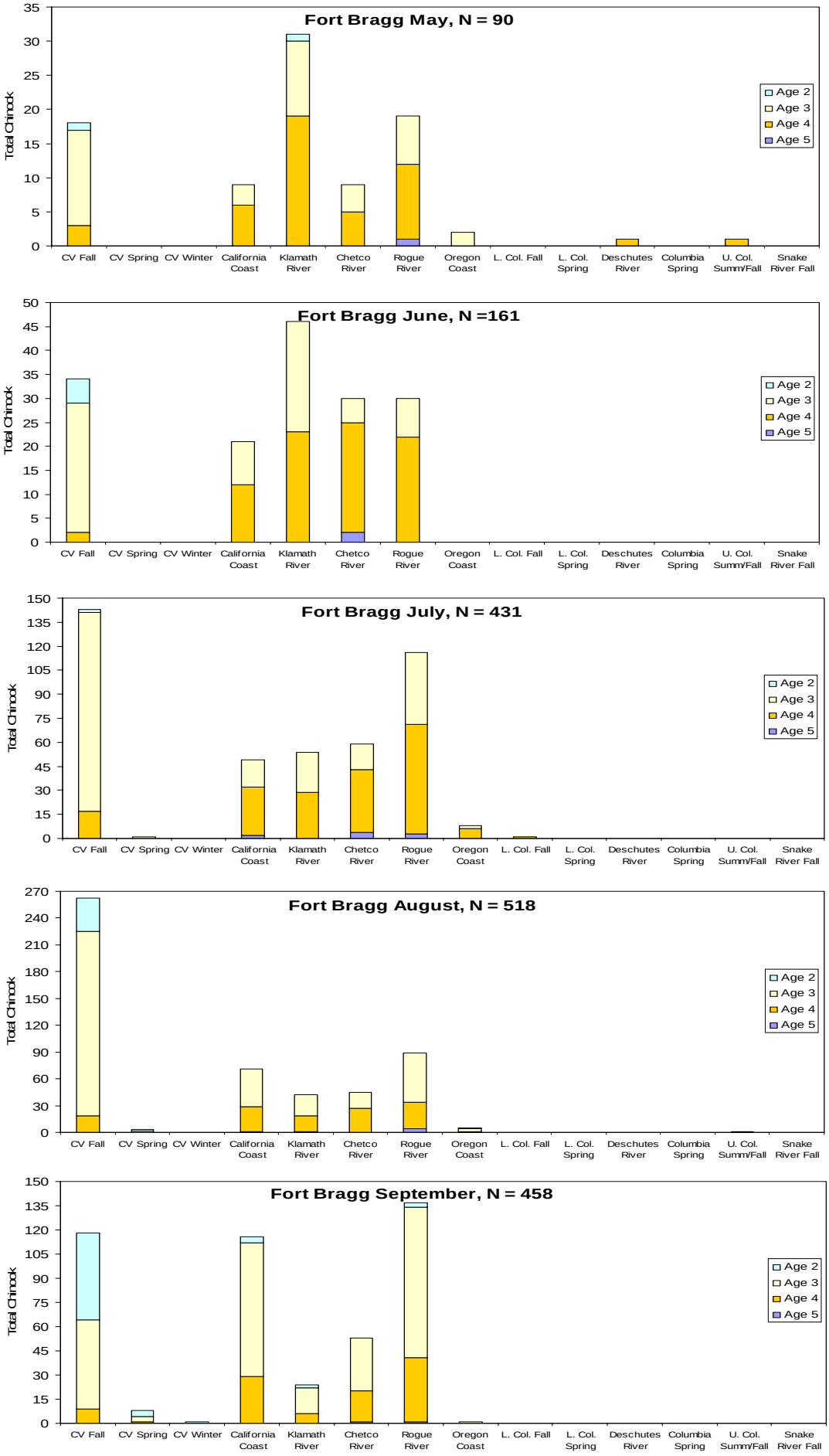
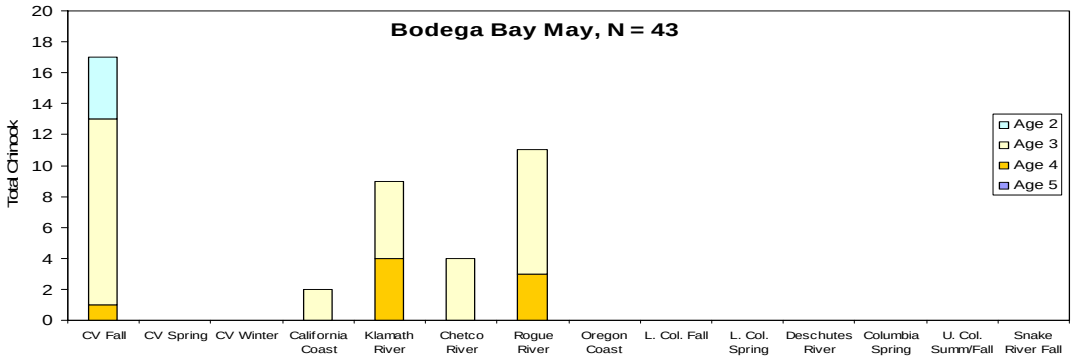
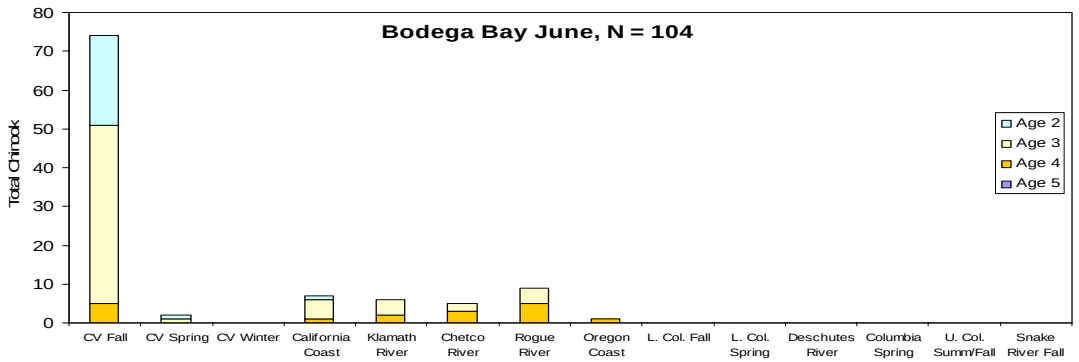
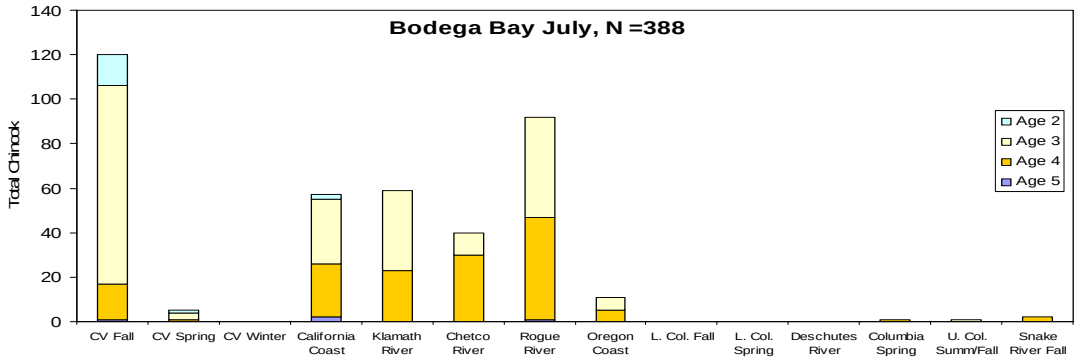
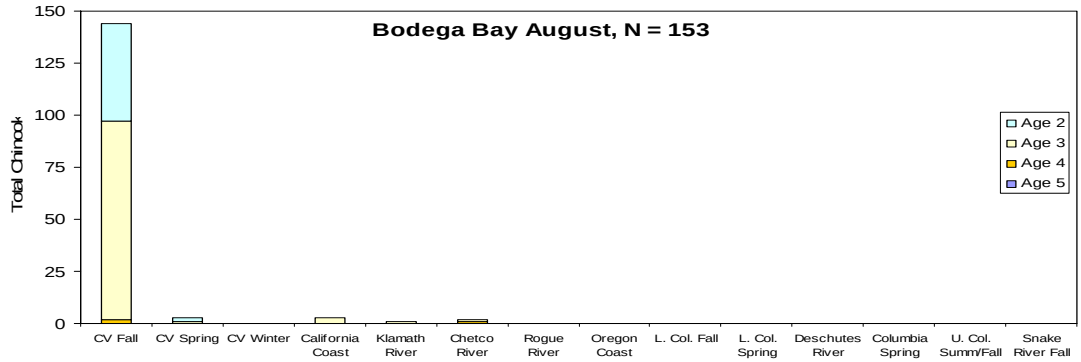


Figure 2c: Stock and age composition for samples collected near Fort Bragg during May-September 2010









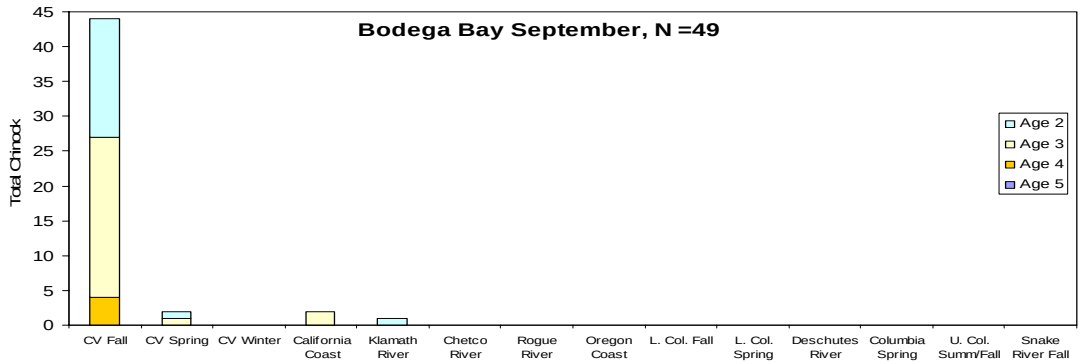


Figure 2d: Stock and age composition for samples collected near Bodega Bay during May-September 2010

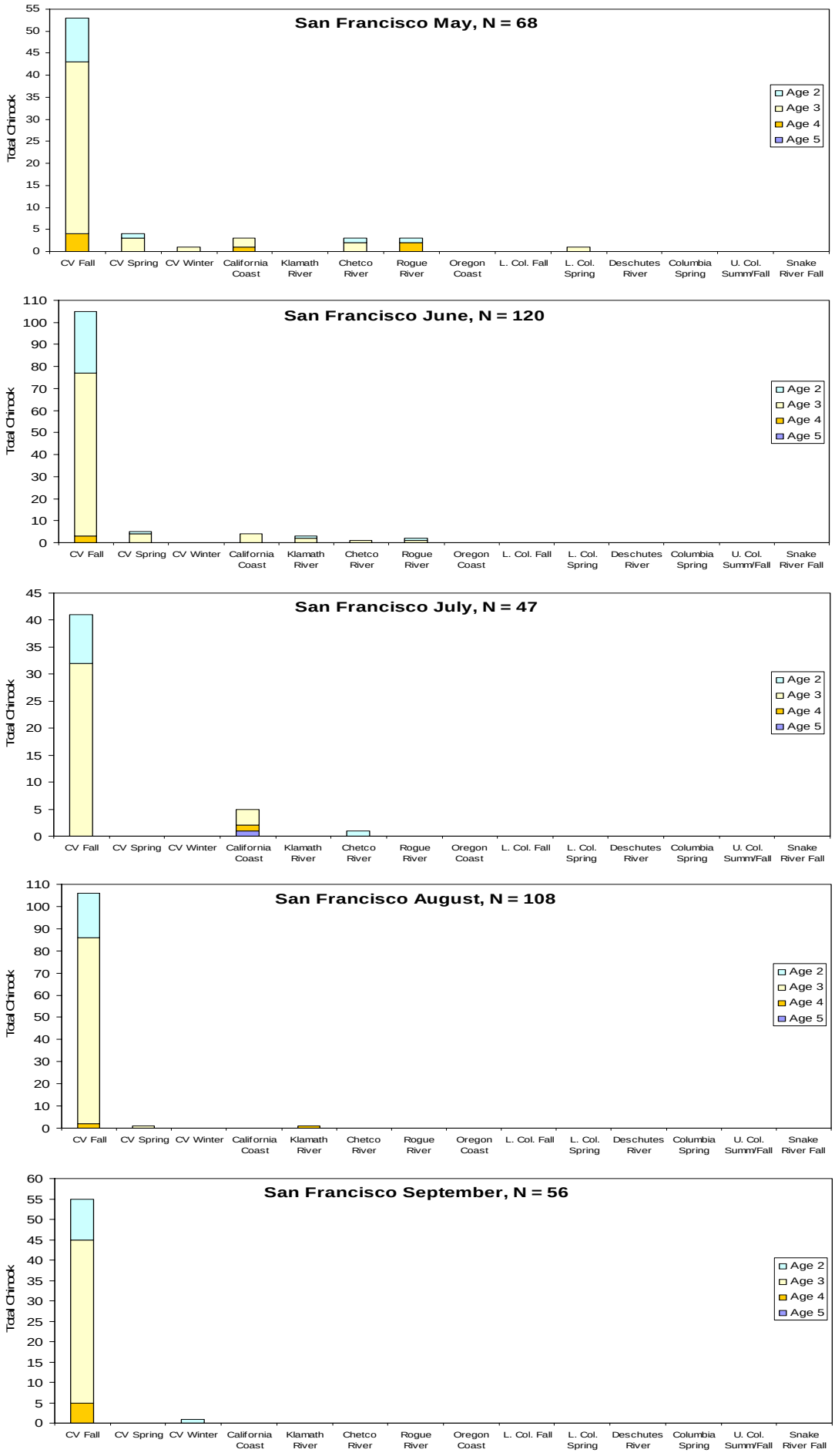
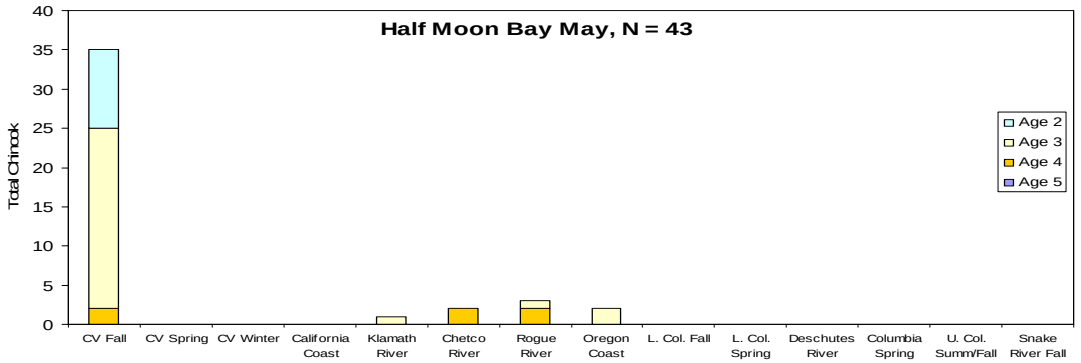
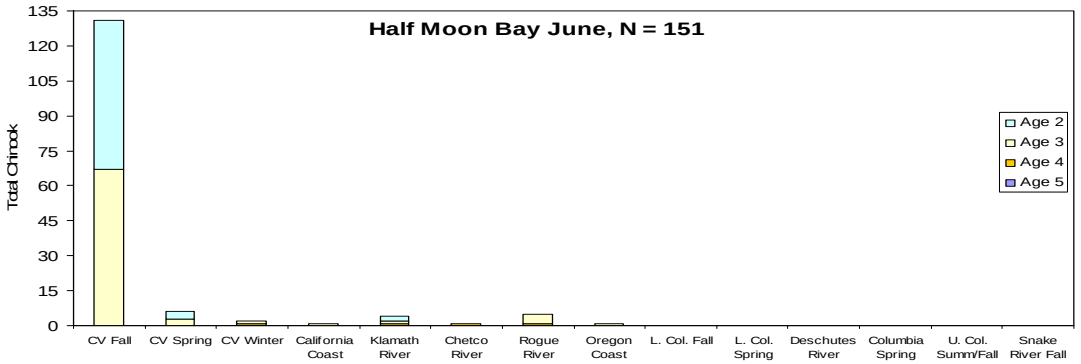
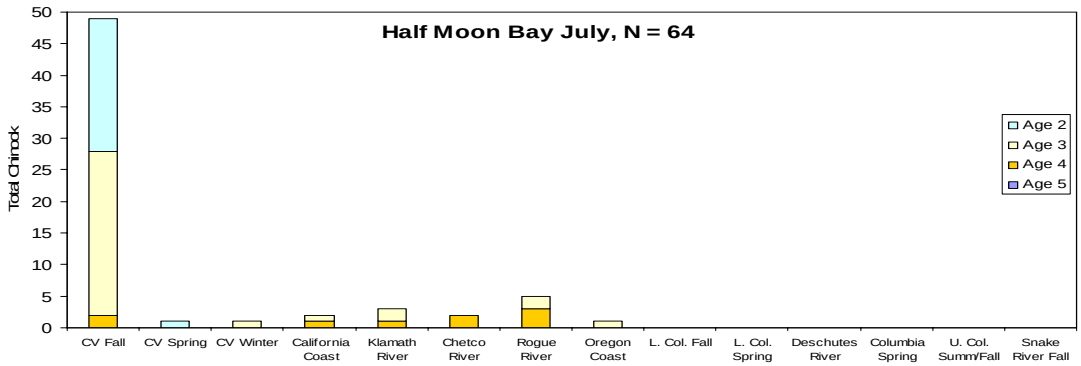
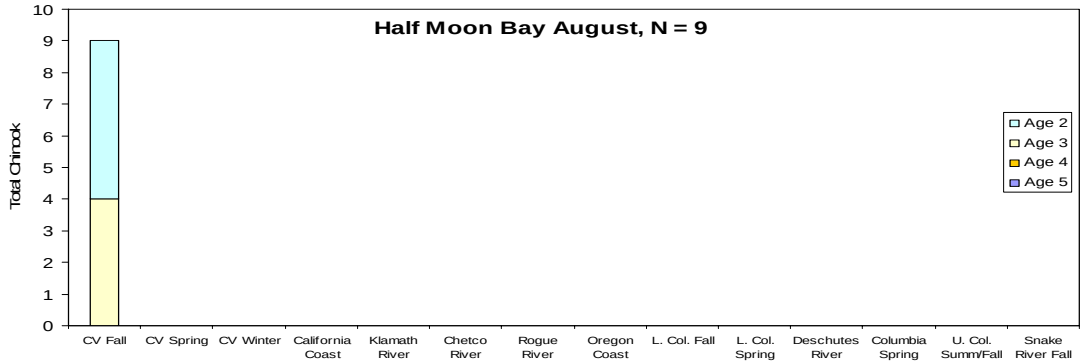


Figure 2e: Stock and age composition for samples collected near San Francisco during May-September 2010









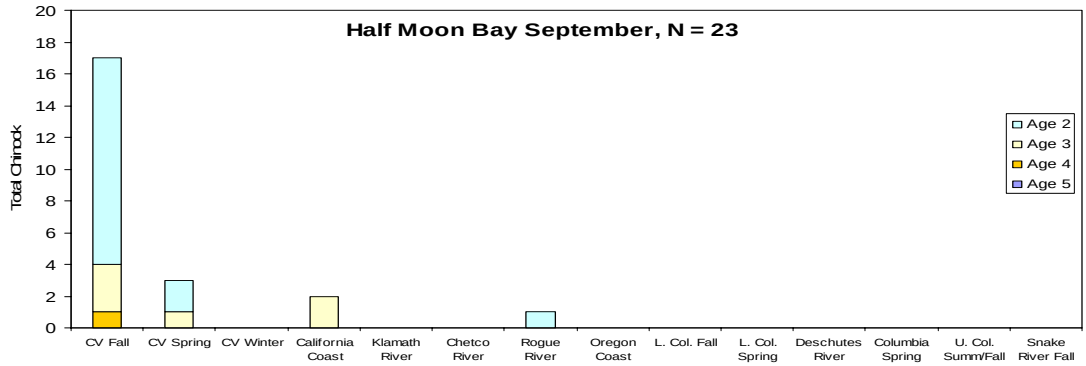


Figure 2f: Stock and age composition for samples collected near Half Moon Bay during May-September 2010

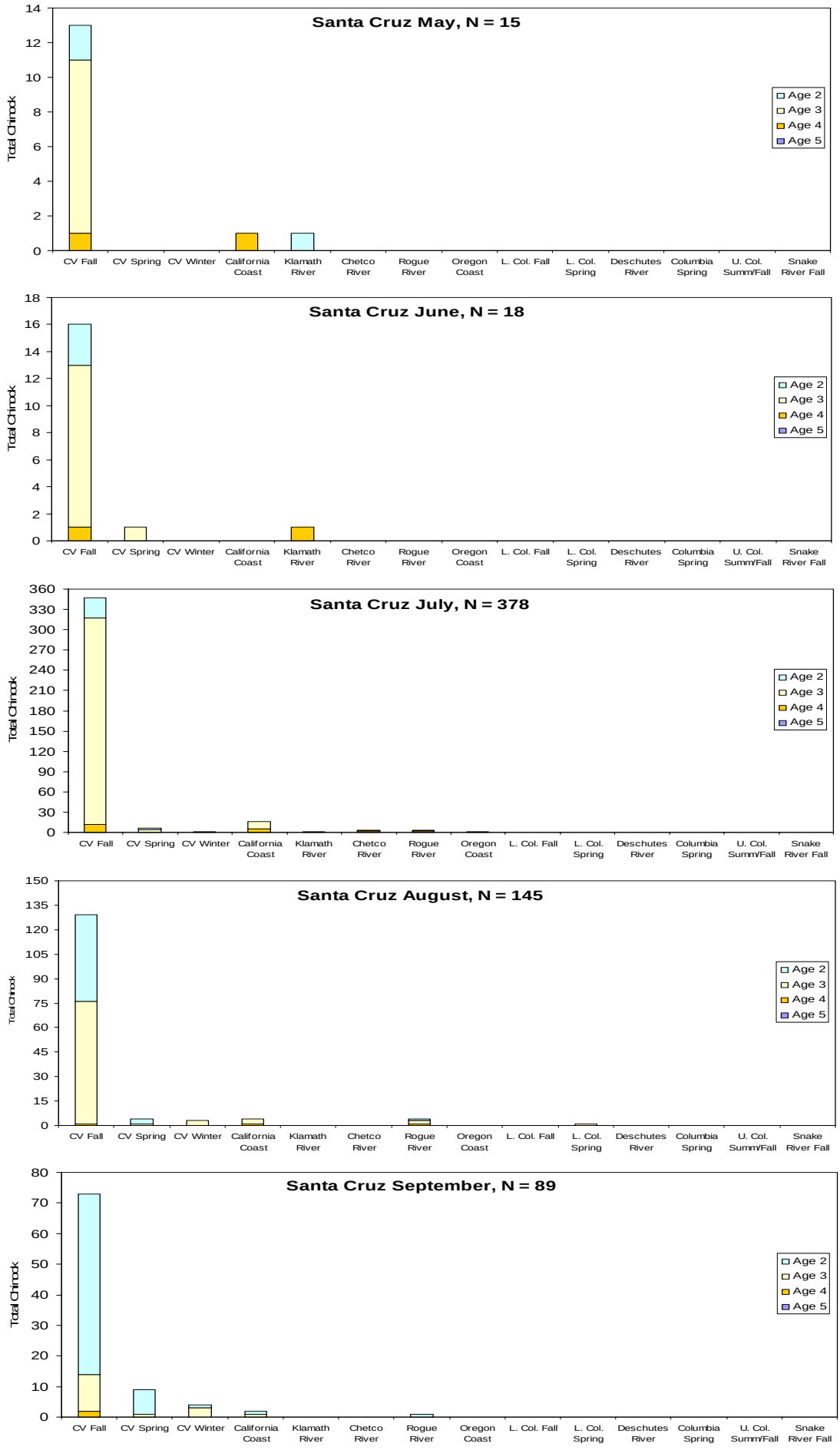


Figure 2g: Stock and age composition for samples collected near Santa Cruz during May-September 2010

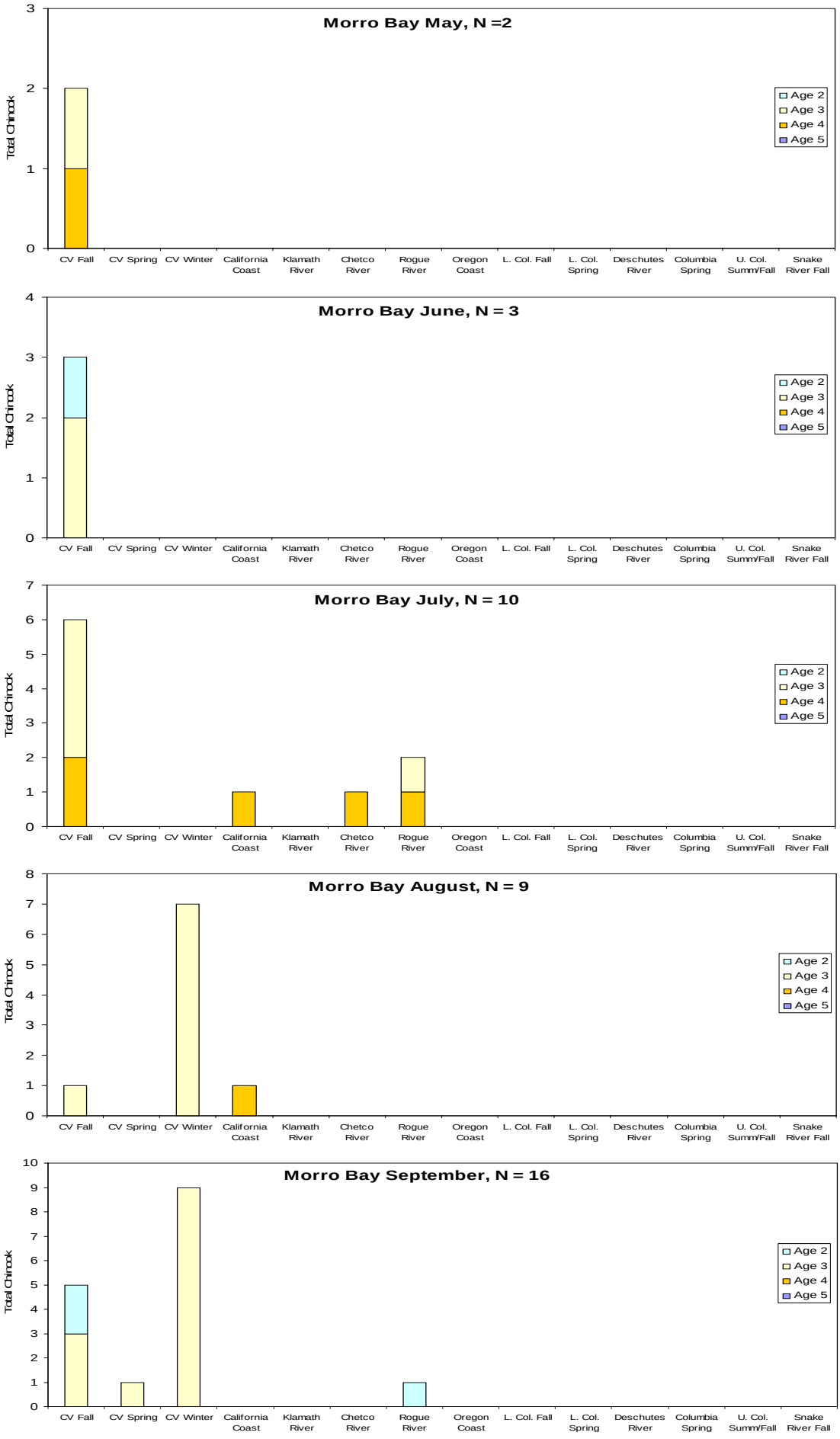


Figure 2h: Stock and age composition for samples collected near Morro Bay during May-September 2010