

**Observed and Estimated Total Bycatch of Salmon in the 2005-2006  
West Coast Limited-Entry Bottom Trawl Groundfish Fishery**

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**Introduction**

This report summarizes estimates of salmon species bycatch from the limited-entry (LE) bottom trawl groundfish fleet during the calendar years 2005 and 2006. Data sources for this analysis include onboard observer data, trawl logbook data, and landing receipt data (referred to as fish tickets). Using the catch of salmon species and target groundfish weight from observed trawl tows, in conjunction with logbook and fish ticket target groundfish weight, estimates of the total annual bycatch of salmon in the bottom trawl fishery are developed for geographic regions off the US west coast consistent with salmon management. A previous report was provided of total salmon species bycatch from 2002 through 2004 (Hastie 2005). Salmon included in this analysis are chinook (*Oncorhynchus tshawytscha*), coho (*Oncorhynchus kisutch*), chum (*Oncorhynchus keta*), and a category for unspecified salmon species.

The West Coast Groundfish Observer Program (WCGOP) was established in 2001 by NOAA Fisheries (National Marine Fisheries Service, NMFS) (66 FR 20609). All commercial vessels that catch and retain groundfish in the United States Exclusive Economic Zone (EEZ) from 3-200 miles offshore are required to carry an observer when notified to do so by NMFS or its designated agent. The WCGOP coverage plan, which details program goals, vessel selection, observer coverage, and basic data collection, is available at: <http://www.nwfsc.noaa.gov/research/divisions/fram/observer/observersamplingplan.pdf>. The LE bottom trawl fleet is one of WCGOP's highest priorities for observer coverage, which was initiated in September 2001. Since then, WCGOP observers have annually monitored 20-30% of groundfish landings (by weight) in the non-hake LE bottom trawl fishery.

Logbook record-keeping for the LE groundfish trawl fishery is a state-mandated requirement in Washington, Oregon, and California. A common-format logbook is used by all three states and completed logbook information is entered into state agency databases. The electronic logbook data are then submitted to a regional database clearinghouse, the Pacific Coast Fisheries

Information Network (PacFIN), maintained by the Pacific States Marine Fisheries Commission (PSMFC).

Landing receipts, known as fish tickets, are completed by fish-buyers in each port for each delivery of fish by a vessel. Fish tickets are issued to fish-buyers by a state agency and must be returned to the agency for processing. Washington, Oregon, and California each use slightly different formats for their fish tickets. Each state also conducts species-composition sampling for numerous “market” categories reported on fish tickets. Market categories may include several species (e.g. minor shelf rockfish), or may represent individual species where verification of correct species identification is deemed desirable. The fish ticket and species-composition data are also submitted to the PacFIN database. The current analysis uses fish ticket data to which species-composition ratios derived from state port sampling have been applied, so that landed weights are as species specific as possible.

## **Methods**

Salmon bycatch estimates are derived from WCGOP observer data, fish ticket landings data, and trawl logbook data. The observer data used in this analysis are included in two data reports for the LE trawl fishery covering calendar years 2005 and 2006 (NWFSC 2006, 2007). Both of these reports are available at: <http://www.nwfsc.noaa.gov/research/divisions/fram/observer/datareport/index.cfm>. Additional details regarding observer program vessel coverage and trawl data collection are found in the WCGOP data reports. Fish ticket and logbook data for commercial, trawl-endorsed LE vessels using bottom trawl gear are obtained from PacFIN.

The same criteria are applied to data from all three sources (observer, logbook, fish ticket), where appropriate, to ensure that observed bycatch amounts are expanded to the logbook and then fish ticket levels using consistently defined fishing activity. Records meeting the following criteria were not included in the analysis: 1) research landings; 2) logbook tows lacking a recorded depth or latitude; 3) trips/tows where no groundfish were retained; 4) trips/tows where retained Pacific hake (whiting) was greater than 2 mt or comprised more than half of the total weight of retained groundfish; 5) trips/tows containing more than 100 lb of retained shrimp; and 6) tows/trips in which the landed weight of non-groundfish species was greater than that of groundfish species (see Appendix A. for a list of groundfish species).

The process of estimating salmon bycatch begins with summarizing WCGOP observer data and trawl logbook data according to strata. Based on review of the amount and distribution of observed and fleet fishing effort, observer data are stratified by area, depth, and season. Records are separated into four latitudinal regions, three depth zones, and two seasons. The four latitudinal regions are defined as: US waters north of Cape Falcon, Oregon (45.77° N lat.), Cape Falcon to Cape Blanco, Oregon (42.75° N lat.), Cape Blanco to Cape Mendocino, California (40.16° N lat.), and US waters south of Cape Mendocino (Figure 1). The average latitude of reported tow set and end location is used to assign each tow to one of these areas. The depth zones are defined as: depths shallower than 125 fathoms, those between 125 and 250 fathoms, and those deeper than 250 fathoms. Review of the distribution of observed 2005-2006 trawl tows supported the use of these depth zones, which were also used in the previous report of salmon bycatch (Hastie 2005). Seasons were defined by pooling data from January-April and

November-December (bi-monthly periods 1, 2, 6) into a winter season, and data from May-October (bi-monthly periods 3, 4, 5) into a summer season. In order to ensure a robust sample size, a few strata were aggregated across season to an annual timeframe. In 2006, data were aggregated to an annual level in depths shallower than 125 fm and between 125 and 250 fathoms in the area from Cape Blanco to Cape Mendocino, and in depths shallower than 125 fm between Cape Falcon and Cape Blanco. In 2005, data were also aggregated to an annual level in depths shallower than 125 fm from Cape Blanco to Cape Mendocino.

Observed numbers of salmon, by species, and the retained weight of groundfish species targeted by the trawl fleet were summed for each year-area-depth-seasonal stratum. A salmon bycatch ratio is then calculated as the number of salmon divided by the weight of retained groundfish “target” species in each stratum. The groundfish “target” species group includes all flatfish, sablefish, thornyheads, Pacific cod, skates, and spiny dogfish, in both the northern and southern areas, with the addition of slope rockfish in the southern area.

The retained catch of groundfish target species is used as a measure of trawl fishing effort for expanding salmon bycatch from observed trips to the entire LE bottom trawl fleet. The retained weight of groundfish target species is summed from the fleet’s logbook data for each year-area-depth-seasonal stratum. The logbook retained weight of groundfish target species in each stratum is then multiplied by the observed salmon bycatch ratio for the same stratum, producing an initial estimated of the fleet-wide number of salmon caught.

Because logbooks are not submitted for 100% of trawl trips and some records are missing data elements used in this analysis, logbook data do not capture all groundfish bottom trawl fishing effort. As a result, estimated salmon bycatch numbers must be expanded to include landings that are not reported in logbooks. The landed weight of groundfish target species is summed using fish ticket data for each year, state (of landing), and two month period. An expansion ratio for each year-state-period is then calculated by dividing the fish ticket weight by the logbook weight for combined target species. The initial fleet-wide number of salmon, estimated using observer and logbook data, is then multiplied by the expansion ratio, to produce a final estimate of salmon bycatch.

## **Results**

A summary of salmon and groundfish target species catch on observed limited-entry bottom trawl tows during 2005-2006 is provided in Table 1. Only a small percentage of observed tows in this fishery encountered salmon. For those tows that encountered salmon, the major salmon species encountered was chinook. The area north of Cape Falcon accounts for the majority of observed chinook salmon caught in the LE bottom trawl fishery.

The stratification of observer data and fleet-wide logbook target groundfish catch by area, season, and depth is provided in Table 2. No chinook were caught in tows deeper than 250 fathoms. In most cases, higher rates of chinook bycatch were observed in the winter. The highest rate in 2006 was found during the winter in the area south of Cape Mendocino (0.74 chinook per metric ton of target groundfish), and in 2005, during the winter in the area north of

Cape Falcon (0.41 chinook per metric ton of target groundfish). In all other strata, fewer than 0.2 salmon were caught per metric ton of retained target groundfish species.

An overview of the annual numbers of salmon bycatch associated with the LE bottom trawl fishery is provided in Table 3. Fleet-wide estimated bycatch of chinook fell by nearly an order of magnitude from 2005 to 2006. Dramatic reductions were observed in each of the areas north of Cape Mendocino, California. Estimates for both chinook and coho increased modestly from 2005 to 2006 in the area south of Cape Mendocino. For comparison, chinook salmon bycatch in the Pacific hake fishery is also shown.

A summary of the number of tows having specific numbers of observed chinook is presented in Table 4. In most of the year-area strata, the majority of tows with salmon contained only one fish. Only 3 tows were observed in which more than 8 chinook were caught.

## References

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Table 1.--Summary of salmon and groundfish target species catch on observed limited-entry bottom trawl tows during 2005-2006, by area, species, and year.

	2005	2006
<b>North of Cape Falcon</b>		
Number of observed tows	1,836	1,357
number with salmon	21	5
percentage with salmon	1.1%	0.4%
Total salmon catch in observed tows		
chinook (# of fish)	115	8
coho (# of fish)	1	0
chum (# of fish)	0	0
unspecified (# of fish)	0	0
retained target groundfish (mt)	2,067	1,229
<b>Cape Falcon - Cape Blanco</b>		
Number of observed tows	802	697
number with salmon	15	1
percentage with salmon	1.9%	0.1%
Total salmon catch in observed tows		
chinook (# of fish)	35	1
coho (# of fish)	0	0
chum (# of fish)	0	0
unsp. salmon (# of fish)	0	0
retained target groundfish (mt)	997	914
<b>Cape Blanco - Cape Mendocino</b>		
Number of observed tows	341	350
number with salmon	4	1
percentage with salmon	1.2%	0.3%
Total salmon catch in observed tows		
chinook (# of fish)	16	1
coho (# of fish)	0	0
chum (# of fish)	0	0
unsp. salmon (# of fish)	0	0
retained target groundfish (mt)	644	652
<b>South of Cape Mendocino</b>		
Number of observed tows	613	517
number with salmon	1	4
percentage with salmon	0.2%	0.8%
Total salmon catch in observed tows		
chinook (# of fish)	1	8
coho (# of fish)	0	4
chum (# of fish)	0	0
unsp. salmon (# of fish)	0	0
retained target groundfish (mt)	689	443

Table 2.--Estimated numbers and bycatch ratios of chinook salmon caught on observed tows and logbook target species weight from limited-entry groundfish bottom trawl vessels during 2005-2006, by area, season, and depth.

Area	Season	<= 125 fm					125.1 - 250 fm					> 250 fm				
		# of obs. tows	Catch on obs. tows with salmon				# of obs. tows	Catch on obs. tows with salmon				# of obs. tows	Catch on obs. tows with salmon			
			Number of chinook	Target groundfish (mt)	# chinook / mt of groundfish	Logbook mt of target groundfish		Number of chinook	Target groundfish (mt)	# chinook / mt of groundfish	Logbook mt of target groundfish		Number of chinook	Target groundfish (mt)	# chinook / mt of groundfish	Logbook mt of target groundfish
<b>2005</b>																
North of Cape Falcon	winter	188	1	132	0.008	361	141	114	276	0.413	1079	172	0	380	0	1148
	summer	1183	0	1138	0	4335	83	0	81	0	281	69	0	59	0	232
	Total	1371	1	1271	0.001	4696	224	114	357	0.320	1359	241	0	439	0	1380
Cape Falcon - Cape Blanco	winter	66	4	45	0.089	73	155	28	278	0.101	809	126	0	242	0	809
	summer	273	0	239	0	1103	74	3	81	0.037	296	108	0	112	0	543
	Total	339	4	284	0.014	1176	229	31	359	0.086	1105	234	0	354	0	1352
Cape Blanco - Cape Mendocino	winter						47	14	95	0.148	627	78	0	198	0	907
	summer						21	0	44	0	274	109	0	214	0	823
	Total	86	2	93	0.021	635	68	14	138	0.101	901	187	0	412	0	1730
South of Cape Mendocino	winter	27	0	4	0	78	79	0	119	0	310	121	0	220	0	837
	summer	222	1	88	0.011	356	43	0	65	0	238	121	0	193	0	820
	Total	249	1	92	0.011	434	122	0	183	0	548	242	0	413	0	1657
<b>2006</b>																
North of Cape Falcon	winter	125	2	49	0.041	161	88	5	165	0.033	836	94	0	200	0	987
	summer	933	1	656	0.002	3744	53	0	97	0	457	64	0	62	0	277
	Total	1058	3	705	0.004	3905	141	5	262	0.021	1293	158	0	262	0	1264
Cape Falcon - Cape Blanco	winter						150	1	229	0.004	1134	84	0	172	0	846
	summer						60	0	78	0	386	121	0	205	0	928
	Total	282	0	231	0	1075	210	1	306	0.003	1520	205	0	377	0	1775
Cape Blanco - Cape Mendocino	winter											56	0	127	0	645
	summer											134	0	275	0	1176
	Total	70	0	74	0	682	90	1	176	0.006	793	190	0	402	0	1821
South of Cape Mendocino	winter	44	7	10	0.735	47	23	0	27	0	233	35	0	54	0	457
	summer	200	1	63	0.016	274	82	0	78	0	198	133	0	212	0	801
	Total	244	8	72	0.111	321	105	0	105	0	430	168	0	265	0	1258

Note: Winter season includes bi-monthly periods 1, 2, 6 (January-April; November-December); summer season includes bi-monthly periods 3, 4, 5, (May-October).

Table 3.--Estimated total numbers of salmon caught incidentally by the limited-entry groundfish bottom trawl fleet, during 2005-2006, by area, season, and species.

Season <sup>1</sup>		Chinook		Coho	
		2005	2006	2005	2006
North of Cape Falcon	winter	572	36	5	0
	summer	0	6	0	0
	Total	572	42	5	0
Cape Falcon - Cape Blanco	winter	97	5	0	0
	summer	12	0	0	0
	Total	108	5	0	0
Total North of Cape Blanco	Total	680	47	5	0
Cape Blanco - Cape Mendocino	winter	100	4	0	0
	summer	15	1	0	0
	Total	115	5	0	0
South of Cape Mendocino	winter	0	39	0	0
	summer	4	5	0	19
	Total	4	44	0	19
Total South of Cape Blanco	Total	119	49	0	19
Coastwide	Total	799	96	5	19
Pacific Hake Trawl Fishery <sup>2</sup>	Total	11,916	3,975		

Season <sup>1</sup>		Chum		Unspecified Salmon	
		2005	2006	2005	2006
North of Cape Falcon	winter	0	0	0	0
	summer	0	0	0	0
	Total	0	0	0	0
Cape Falcon - Cape Blanco	winter	0	0	0	0
	summer	0	0	0	0
	Total	0	0	0	0
Total North of Cape Blanco	Total	0	0	0	0
Cape Blanco - Cape Mendocino	winter	0	0	0	0
	summer	0	0	0	0
	Total	0	0	0	0
South of Cape Mendocino	winter	0	0	0	0
	summer	0	0	0	0
	Total	0	0	0	0
Total South of Cape Blanco	Total	0	0	0	0
Coastwide	Total	0	0	0	0

<sup>1</sup>Winter season includes bi-monthly periods 1, 2, 6 (January-April; November-December); summer season includes bi-monthly periods 3, 4, 5, (May-October).

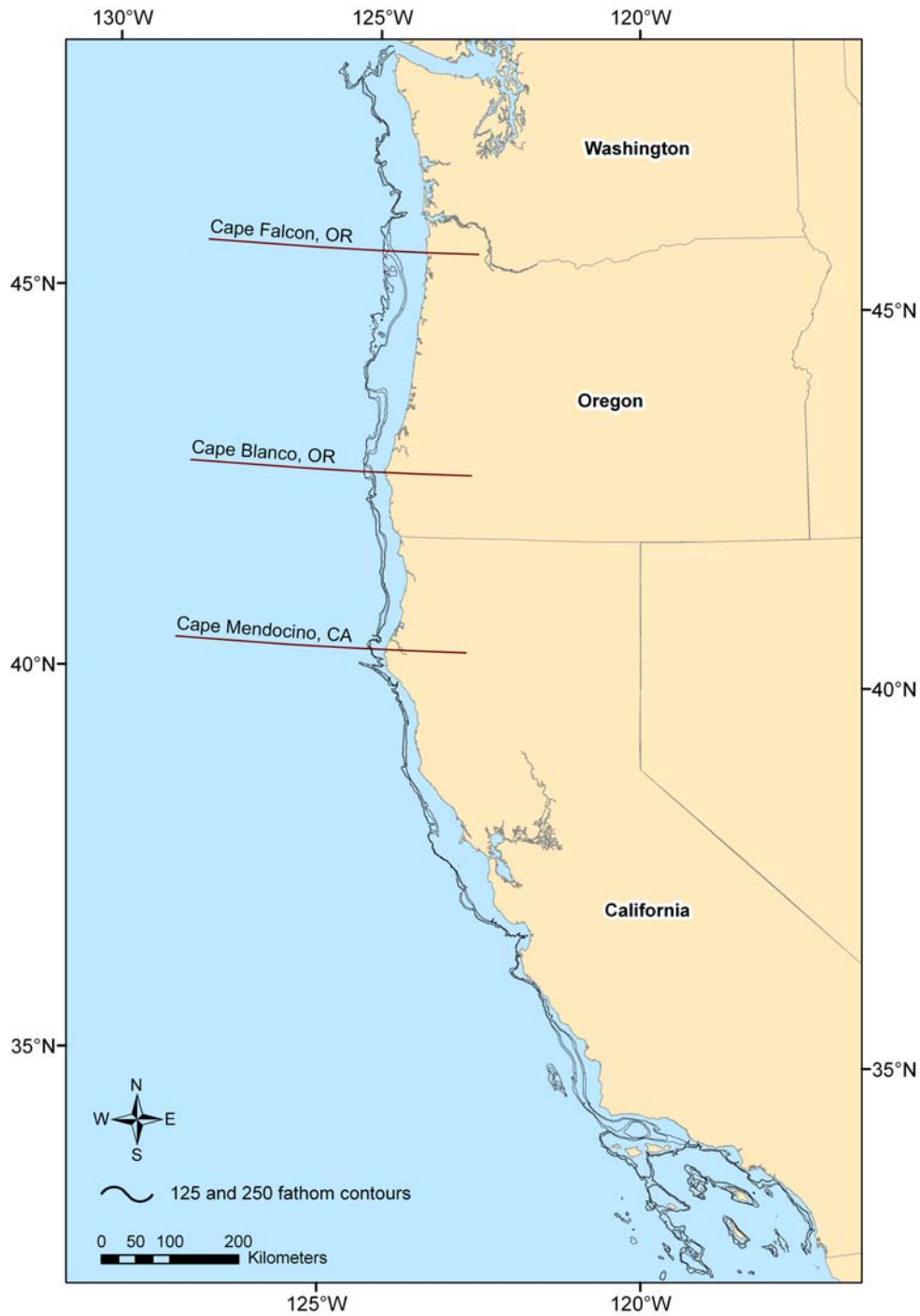
<sup>2</sup>Pacific hake trawl fishery chinook estimates were obtained from summary reports by the Northwest Regional Office for all sectors coastwide (NMFS 2006, 2007).



Table 4.--Tow frequency distribution of the estimated number of chinook per observed tow, by year and area.

Number of chinook in tow	North of Cape Falcon		Cape Falcon - Cape Blanco		Cape Blanco - Cape Mendocino		South of Cape Mendocino		Coast-wide	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
None	1,815	1,352	787	696	337	349	612	514	3,551	2,911
Any	21	5	15	1	4	1	1	3	41	10
% with any	1.2%	0.4%	1.9%	0.1%	1.2%	0.3%	0.2%	0.6%	1.2%	0.3%
1	5	4	8	1	2	1	1	2	16	8
2	4		3						7	0
3	3		1						4	0
4	3	1							3	1
5	1		1						2	0
6	2		1		1			1	4	1
7			1						1	0
8					1				1	0
9									0	0
10									0	0
11									0	0
12									0	0
13									0	0
14									0	0
15	2								2	0
16									0	0
17									0	0
20									0	0
21									0	0
22									0	0
23									0	0
24									0	0
25									0	0
26									0	0
28									0	0
30									0	0
31									0	0
32									0	0
33									0	0
34	1								1	0

Figure 1. Geographic latitudinal regions and depths utilized in salmon bycatch estimation from the limited-entry bottom trawl groundfish fishery.



## **Appendix A. Common and scientific names of species included in the Groundfish Fishery Management Plan.**

### **SHARKS**

Big skate, *Raja binoculata*  
California skate, *R. inornata*  
Leopard shark, *Triakis semifasciata*  
Longnose skate, *R. rhina*  
Soupfin shark, *Galeorhinus zyopterus*  
Spiny dogfish, *Squalus acanthias*

### **RATFISH**

Ratfish, *Hydrolagus colliei*

### **MORIDS**

Finescale codling, *Antimora microlepis*

### **GRENADIERS**

Pacific rattail, *Coryphaenoides acrolepis*

### **ROUNDFISH**

Cabazon, *Scorpaenichthys marmoratus*  
Kelp greenling, *Hexagrammos decagrammus*  
Lingcod, *Ophiodon elongatus*  
Pacific cod, *Gadus macrocephalus*  
Pacific whiting, (hake) *Merluccius productus*  
Sablefish, *Anoplopoma fimbria*

### **FLATFISH**

Arrowtooth flounder, (turbot) *Atheresthes stomias*  
Butter sole, *Isopsetta isolepis*  
Curlfin sole, *Pleuronichthys decurrens*  
Dover sole, *Microstomus pacificus*  
English sole, *Parophrys vetulus*  
Flathead sole, *Hippoglossoides elassodon*  
Pacific sanddab, *Citharichthys sordidus*  
Petrale sole, *Eopsetta jordani*  
Rex sole, *Glyptocephalus zachirus*  
Rock sole, *Lepidopsetta bilineata*  
Sand sole, *Psettichthys melanostictus*  
Starry flounder, *Platichthys stellatus*

**Appendix A continued. Common and scientific names of species included in the Groundfish Fishery Management Plan.**

**ROCKFISH**

(includes all genera and species of the family Scopaenidae, even if not listed, that occur in the Washington, Oregon, and California area)

**Species that are managed with individual Optimum Yields for at least a portion of the Pacific Fishery Management Council area**

Bocaccio, *S. paucispinis*  
Canary rockfish, *Sebastes pinniger*  
Chilipepper, *S. goodei*  
Cowcod, *S. levis*  
Darkblotched rockfish, *S. crameri*  
Longspine thornyhead, *Sebastolobus altivelis*  
Pacific ocean perch, *S. alutus*  
Shortbelly rockfish, *S. jordani*  
Shortspine thornyhead, *Sebastolobus alascanus*  
Splitnose rockfish, *S. diploproa*  
Widow rockfish, *S. entomelas*  
Yelloweye rockfish, *S. ruberimus*  
Yellowtail rockfish, *S. flavidus*

**Minor Rockfish Species**

North of 40°10' N. lat.

South of 40°10' N. lat.

Minor Nearshore Rockfish

Black, *Sebastes melanops*  
Black-and-yellow, *S. chrysomelas*.  
Blue, *S. mystinus*  
Brown, *S. auriculatus*  
Calico, *S. dalli*  
China, *S. nebulosus*  
Copper, *S. caurinus*  
Gopher, *S. carnatus*  
Grass, *S. rastrelliger*  
Kelp, *S. atrovirens*  
Olive, *S. serranoides*  
Quillback, *S. maliger*  
Treefish, *S. serriceps*

Black, *Sebastes melanops*  
Black-and-yellow, *S. chrysomelas*  
Blue, *S. mystinus*  
Brown, *S. auriculatus*  
Calico, *S. dalli*  
California scorpionfish, *Scorpaena guttata*  
China, *Sebastes nebulosus*  
Copper, *S. caurinus*  
Gopher, *S. carnatus*  
Grass, *S. rastrelliger*  
Kelp, *S. atrovirens*  
Olive, *S. serranoides*  
Quillback, *S. maliger*  
Treefish, *S. serriceps*

**Appendix A continued. Common and scientific names of species included in the Groundfish Fishery Management Plan.**

North of 40°10' N. lat.

South of 40°10' N. lat.

Minor Shelf Rockfish

Bronzespotted, *S. gilli*  
 Bocaccio, *S. paucispinis*  
 Chameleon, *S. phillipsi*  
 Chilipepper, *S. goodei*  
 Cowcod, *S. levis*  
 Dwarf-red, *S. rufianus*  
 Flag, *S. rubrivinctus*  
 Freckled, *S. lentiginosus*  
 Greenblotched, *S. rosenblatti*  
 Greenspotted, *S. chlorostictus*  
 Greenstriped, *S. elongatus*  
 Halfbanded, *S. semicinctus*  
 Honeycomb, *S. umbrosus*  
 Mexican, *S. macdonaldi*  
 Pink, *S. eos*  
 Pinkrose, *S. simulator*  
 Pygmy, *S. wilsoni*  
 Redstriped, *S. proriger*  
 Rosethorn, *S. helvomaculatus*  
 Rosy, *S. rosaceus*  
 Silvergrey, *S. brevispinus*  
 Speckled, *S. ovalis*  
 Squarespot, *S. hopkinsi*  
 Starry, *S. constellatus*  
 Stripetail, *S. saxicola*  
 Swordspine, *S. ensifer*  
 Tiger, *S. nigorcinctus*  
 Vermilion, *S. miniatus*  
 Yelloweye, *S. ruberrimus*

Bronzespotted, *S. gilli*  
 Chameleon, *S. phillipsi*  
 Dwarf-red, *S. rufianus*  
 Flag, *S. rubrivinctus*  
 Freckled, *S. lentiginosus*  
 Greenblotched, *S. rosenblatti*  
 Greenspotted, *S. chlorostictus*  
 Greenstriped, *S. elongatus*  
 Halfbanded, *S. semicinctus*  
 Honeycomb, *S. umbrosus*  
 Mexican, *S. macdonaldi*  
 Pink, *S. eos*  
 Pinkrose, *S. simulator*  
 Pygmy, *S. wilsoni*  
 Redstriped, *S. proriger*  
 Rosethorn, *S. helvomaculatus*  
 Rosy, *S. rosaceus*  
 Silvergrey, *S. brevispinus*  
 Speckled, *S. ovalis*  
 Squarespot, *S. hopkinsi*  
 Starry, *S. constellatus*  
 Stripetail, *S. saxicola*  
 Swordspine, *S. ensifer*  
 Tiger, *S. nigorcinctus*  
 Vermilion, *S. miniatus*  
 Yelloweye, *S. ruberrimus*  
 Yellowtail, *S. flavidus*

Minor Slope Rockfish

Aurora, *S. aurora*  
 Bank, *S. rufus*  
 Blackgill, *S. melanostomus*  
 Darkblotched, *S. crameri*  
 Redbanded, *S. babcocki*  
 Rougheyeye, *S. aleutianus*  
 Sharpchin, *S. zacentrus*  
 Shortraker, *S. borealis*  
 Splitnose, *S. diploproa*  
 Yellowmouth, *S. reedi*

Aurora, *S. aurora*  
 Bank, *S. rufus*  
 Blackgill, *S. melanostomus*  
 Darkblotched, *S. crameri*  
 Pacific ocean perch (POP), *S. alutus*  
 Redbanded, *S. babcocki*  
 Rougheyeye, *S. aleutianus*  
 Sharpchin, *S. zacentrus*  
 Shortraker, *S. borealis*  
 Yellowmouth, *S. reedi*