Trend Analyses: petitioned species of rockfish in the Puget Sound

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Contents

1 Summary

There have been long-term, ten-fold declines in the rockfish per angler trip in north and south Puget Sound reported by the WDFW creel survey between the late-1970s and 2007. Declines have also been observed in other data surveys such as the WDFW fisheries-independent trawl survey between the late-1980s and early-2000s (60-75%) and in WDFW video surveys over the same period. Fisheries-independent surveys in the Strait of Georgia also shows declines in multiple rockfish species over a similar timeframe. Declines post-2000 are equivocal with the recreational catch data in Puget Sound showing steady declines and other fishery-independent surveys (WDFW trawl survey and REEF dive surveys) not showing declines.

Data were not frequent enough nor species identifications reliable enough to do trend analyses for the individual petitioned species. Instead, the total rockfish trend was estimated and the frequency of the petitioned species within the total rockfish assemblage was evaluated. If a petitioned species has become a smaller fraction of the total rockfish assemblage then this would indicate that that species declined faster than the total rockfish.

The estimates of mean annual rate of change in the total rockfish count ranges from 4-5.5 percent per year decline rate in Puget Sound Proper and 1.5-2 percent per year decline in north Puget Sound. There is strong evidence that Bocaccio rockfish have become a smaller fraction of rockfish assemblage in Puget Sound – from 0.24% of the catch in recreational catch in the 1980s to 0% of the catch in the 1990s. Sightings of Bocaccio rockfish have been rare since 2000 in all surveys. Canary rockfish also appear to have a smaller fraction of the rockfish assemblage - from 1-1.5% of the recreational catch in the 1980s to <1% of the catch in the 1990s. Yelloweye rockfish appear to be a smaller fraction of the catch in north Puget Sound (from 1.9% to 0.65% between the 1980s and 1990s) but represent a larger fraction of the catch in Puget Sound Proper. However the majority of the Yelloweye catch from Puget Sound has been in north Puget Sound (in constrast to Bocaccio and Canary rockfish). Bocaccio, Canary, and Yelloweye rockfish are prized by anglers and there is no reason to believe that declines in relative frequency are due to discarding. All three species are rare in fisheries independent surveys. The proportion of recreational catch represented by Redstripe and Greenstripe rockfish both declined rapidly between the 1980s and 1990s. Redstripe rockfish in particular were common in the recreational catch in the 1980s and is not reported. However, both species appear in fisheries independent surveys post-2000 – sometimes at high densities. This suggests that their absense from the recreational catch data is due to discarding.

Overall this analysis supports rates of decline in Puget Sound (north and south together) for Bocaccio, Canary, and Yelloweye rockfish that are greater than that observed in total rockfish numbers. Thus greater than 1.5-2% in the north and greater than 4-5.5% in the south. These species are already rare (<1-2% of rockfish) in Puget Sound and are projected to become rarer. For Redstripe and Greenstripe rockfish, the different data sources do not agree. They appear infrequently in fisheries-dependent surveys but fisheries-independent surveys indicate that these species can be locally common.

2 Data on rockfish abundance trends in Puget Sound

2.1 Recreational data

The main data available on Puget Sound rockfish trends are from surveys of recreational anglers conducted by Washington Department of Fish and Wildlife (WDFW) (Bargmann, 1977; Buckley, 1967, 1968, 1970; Palsson, 1988; Palsson et al., 2008). These data are collected from punch cards sent in by licensed anglers and from dockside surveys. WDFW extrapolates the rockfish per angler data up to total catch using an estimate of number of trips derived from the salmon recreational fishery (Palsson et al., 2008). The data are reported both for the targeted catch (targeting bottomfish) and the incidental catch (targeting salmon). For the trend analyses here only the data from the targeted fishery were used. The data for Puget Sound Proper (punch card areas 8-13, Figure 1), north Puget Sound (punch card areas 5-7, Figure 1), and all Puget Sound (punch card areas 5-13) are plotted in Figure 2. The raw numbers are given Tables 1, 2, and 3. Note that all sources analyze the same raw data (the WDFW creel survey data), but different adjustments have been made to the data.

Department of Fisheries and Oceans (Canada) has also conducted a creel survey of the recreational fishery in the inside waters in the Strait of Georgia (DFO statistical areas 13-19, 28 and 29). We did not include these data in the trend analyses because the effort data (angler trips) and catch data (total rockfish) that we were able to obtain included both salmon-targeted and groundfish-targeted trips. Information on trends of Bocaccio, Canary, and Yelloweye rockfish in Canadian waters in the Strait of Georgia are included in the subsections on individual species.

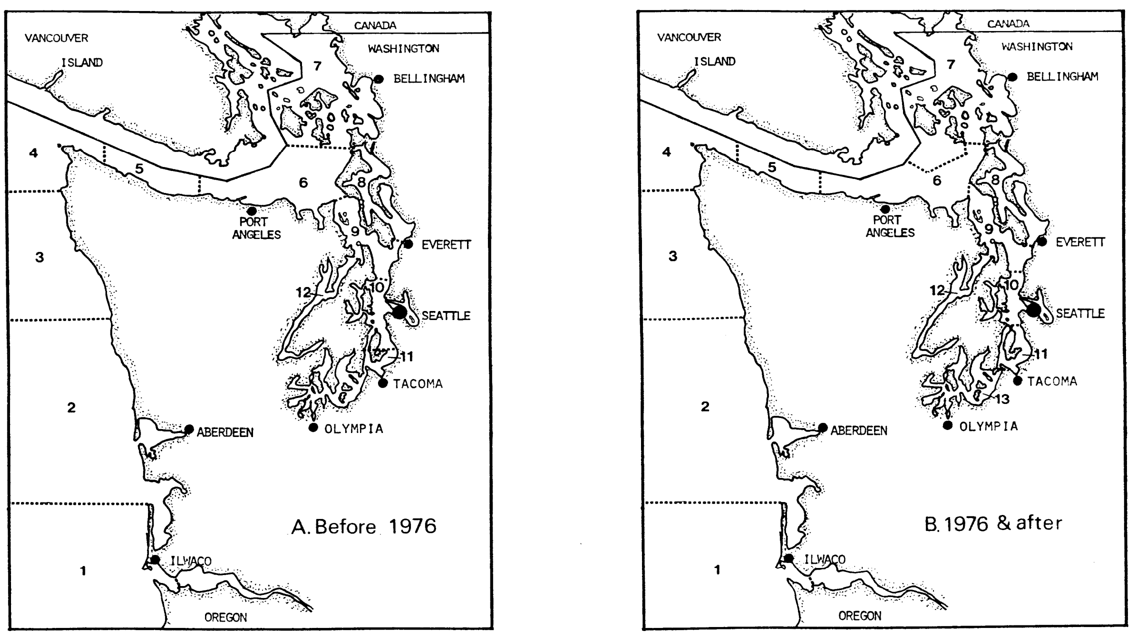


Figure 1: The punch card areas for the WDFW recreational data. These areas were used to define the regions, Puget Sound Proper (areas 8-13) and North Puget Sound (areas 5-7) used in subsequent analyses. Figure from Palsson (1988).

The recreational data have numerous limitations reviewed in Palsson et al. (2008). In particular, during 1994 to 2003, the total catch was still estimated using salmon fishery data, yet restrictions on the salmon fishery lead to limited information from the salmon fishery. In addition, the bag limit on rockfish was lowered from 15 fish in 1983. Since 2000, the bag limit has been 1 rockfish per trip in both the north Puget Sound and Puget Sound Proper. Reduction in bag limit both directly reduces the fish per trip by capping the maximum and may lead to changes in angler targeting leading to reductions in the number of rockfish taken per trip.

To correct for the effects of bag limits and changes in angler targeting, the trend analyses treat each bag limit period as a separate dataset and a scaling parameter to adjust the mean for each period is estimated.

2.2 Commercial data

Commercial data with effort information is available from records on the bottom trawl fishery operating until 1988 (PMFC, 1979; Holmberg, 1967; Schmitt et al., 1991). Effort data (hours trawled) are available from 1955. While other commercial fisheries have been operated in Puget Sound, there was no effort information available. Data for other gears were reported as 'tons per landing', but 'landing' is an inconsistent effort metric so these data are not reported. Due to concerns (in the fisheries literature) about CPUE from commercial fisheries being unrelated to actual population abundances, these data were not used for the trend analyses.

2.3 WDFW trawl survey

Data from the WDFW trawl survey (a fishery independent survey) were included in the trend analysis. The survey is described in Palsson et al. (2008). Examination of the raw trawl samples indicated that the Redstripe rockfish data contain outlier events. In particular, the estimates in 2002 and 2005 in south Puget Sound were increased upward by a single trawl sample in each year with extremely large numbers of Redstripe rockfish. While Redstripe rockfish comprised 1-2% of the survey in 1987, 1989, 1991, and 1996, in 2002 and 2005 they comprised 39% and 48%, respectively. Redstripe rockfish are known to occur in dense aggregations, thus outlier events such as these are not surprising. For the trend analyses, Redstripe rockfish were removed for the calculation of 'total rockfish'. The 'total rockfish' estimated abundances with Redstripe rockfish removed are shown in Table 5.

2.4 REEF dive surveys

Another data source included in the trend analysis is sightings of rockfish by recreational scuba divers throughout the Puget Sound as part of a program by REEF.org (REEF, 2008) that trains recreational divers to identify and record fish species during recreational dives. The data are reported in abundance categories: single = single fish, few = 2-10 fish, many = 11-100 fish, and abundant = 100+ fish. The REEF database was used to determine presence/absence per dive (at any abundance) and also to determine 'min' and 'max' rockfish by using the upper and lower ends of the categories to convert the categorical levels to numerical levels. The data for 'all rockfish' in the REEF database are shown in Table 5. Rockfish (any species) have observed on 70-98% of dives.

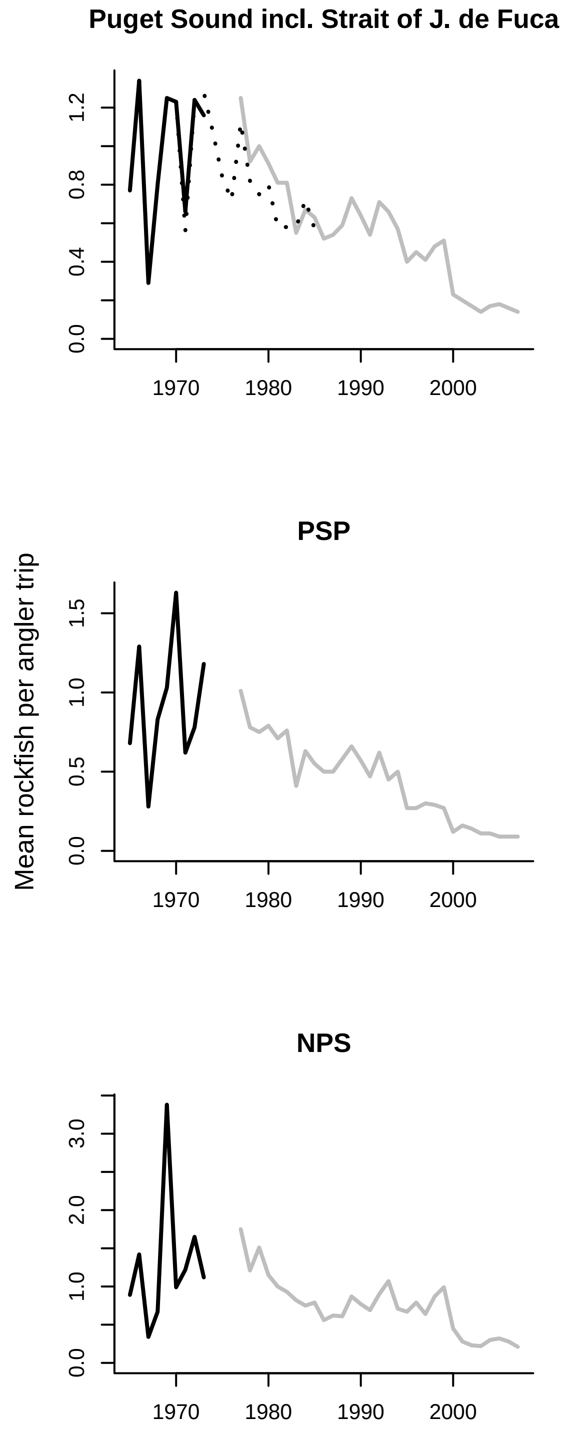


Figure 2: Rockfish per angler trip for the bottomfish-specific recreational fishery. The data are given in Tables 1, 2, and 3. Line colors refer to black) Buckley and Bargmann data, green) Palsson (1988), and red) Palsson et al. (2008).

Table 1: The total rockfish CPUE data from the recreational bottomfish-specific fishery for the whole Puget Sound, including Strait of Juan de Fuca. These data are estimates of average rockfish per trip which are calculated from the total catch in punch card areas 5-13 (6-12 for Buckley and Bargmann source) divided by the total trips in areas 5-13 (or 6-12). For Buckley and Bargmann source, regions 7, 8 and 12 had no data in year 1971 and regions 7 and 8 were missing in year 1973. The Buckley and Bargmann references are Bargmann (1977) and Buckley (1967, 1968, 1970).

Year	Buckley and Bargmann	Palsson et al. (2008)	Palsson (1988)
1965	0.77		
1966	1.34		
1967	0.29		
1968	0.8		
1969	1.25		
1970	1.23		1.23
1971	0.66		0.56
1972	1.24		1.24
1973	1.16		1.28
1974			1.07
1975			0.84
1976			0.72
1977		1.25	1.12
1978		0.92	0.82
1979		1.00	0.75
1980		0.91	0.80
1981		0.81	0.58
1982		0.81	0.58
1983		0.55	0.58
1984		0.67	0.72
1985		0.63	0.57
1986		0.52	
1987		0.54	
1988		0.59	
1989		0.73	
1990		0.64	
1991		0.54	
1992		0.71	
1993		0.66	
1994		0.57	
1995		0.4	
1996		0.45	
1997		0.41	
1998		0.48	
1999		0.51	
2000		0.23	
2001		0.2	
2002		0.17	
2003		0.14	
2004		0.17	
2005		0.18	
2006		0.16	
2007		0.14	

Table 2: The total rockfish CPUE data from the recreational bottomfish-specific fishery for the Puget Sound Proper (south Puget Sound). These data are estimates of rockfish per angler trip and are calculated from the total catch in punch card areas 8-13 divided by the total trips in areas 8-13 (8-12 for Buckley and Bargmann). The Buckley and Bargmann references are Bargmann (1977) and Buckley (1967, 1968, 1970). For year 1971, regions 8 and 12 are missing from the Buckley and Bargmann data and for year 1973, region 8 is missing.

Year	Buckley and Bargmann	Palsson et al. (2008)
1965	0.68	
1966	1.29	
1967	0.28	
1968	0.83	
1969	1.03	
1970	1.63	
1971	0.62	
1972	0.78	
1973	1.18	
1974		
1975		
1976		
1977		1.01
1978		0.78
1979		0.75
1980		0.79
1981		0.71
1982		0.76
1983		0.41
1984		0.63
1985		0.55
1986		0.5
1987		0.5
1988		0.58
1989		0.66
1990		0.57
1991		0.47
1992		0.62
1993		0.45
1994		0.5
1995		0.27
1996		0.27
1997		0.3
1998		0.29
1999		0.27
2000		0.12
2001		0.16
2002		0.14
2003		0.11
2004		0.11
2005		0.09
2006		0.09
2007		0.09

Table 3: The total rockfish CPUE data from the recreational bottomfish-specific fishery for the North Puget Sound. For Palsson et al. (2008) data are the total catch in punch card areas 5-7 divided by the total trips in areas 5-7. For Buckley and Bargmann, the data are total catch in punch card areas 6 and 7 divided by total trips in those areas. The exception is years 1971 and 1973, which are based on data from punch card area 7 only. The Buckley and Bargmann references are Bargmann (1977) and Buckley (1967, 1968, 1970).

Year	Buckley and Bargmann	Palsson et al. (2008)
1965	0.89	
1966	1.42	
1967	0.34	
1968	0.67	
1969	3.38	
1970	0.99	
1971	1.22	
1972	1.65	
1973	1.12	
1974		
1975		
1976		
1977		1.75
1978		1.21
1979		1.51
1980		1.15
1981		1
1982		0.93
1983		0.82
1984		0.75
1985		0.79
1986		0.56
1987		0.62
1988		0.61
1989		0.87
1990		0.77
1991		0.69
1992		0.9
1993		1.07
1994		0.71
1995		0.67
1996		0.79
1997		0.64
1998		0.87
1999		0.99
2000		0.45
2001		0.28
2002		0.23
2003		0.22
2004		0.3
2005		0.32
2006		0.28
2007		0.21

Table 4: The total rockfish CPUE from the commercial bottom trawl data for the whole Puget Sound, including Strait of Juan de Fuca. These data are estimates of pounds (× 1000) of rockfish per hour trawled in PMFC catch area 4A or Washington statistical area 18.

Year	PMFC (1979)	Schmitt et al. (1991)	Holmberg et al. (1967)
1955			13.63
1956			11.22
1957			20.96
1958			14.76
1959			17.51
1960			14.67
1961			13.72
1962	3.97		19.57
1963	9.12		46.80
1964	5.37		21.27
1965	5.19		
1966	3.44		
1967	4.3		
1968	2.53		
1969	2.95		
1970	7.13	8.44	
1971	4.78	3.63	
1972	2.86	3.29	
1973	4.32	4.68	
1974	3.59	4.15	
1975	4.40	4.73	
1976	5.64	6.30	
1977	5.00	5.74	
1978	6.05	7.46	
1979	6.77	11.41	
1980		13.4	
1981		6.47	
1982		5.55	
1983		5.72	
1984		6.59	
1985		5.34	
1986		4.92	
1987		0.94	
1988		3.31	

Table 5: The total rockfish CPUE from the WDFW trawl survey (Palsson et al., 2008) and the REEF dive surveys (REEF, 2008). The WDFW trawl survey is reported as an estimate of abundance in north and south Puget Sound (Puget Sound Proper). The estimate for south Puget Sound is an order of magnitude larger than the estimate for north Puget Sound, which is contrary to our assumptions about the relative abundances in these areas. Therefore, these estimates should be treated as relative abundance indices (like all the other data in this trend analysis). The REEF data are the average minimum abundance of rockfish, any species, recorded in dive locations throughout the south and north Puget Sound. Most of these dives occurred in south Puget Sound.

Year	south puget sound WDFW Trawl Survey	north puget sound WDFW Trawl Survey	south puget sound REEF (2008)	north puget sound REEF (2008)
1987	1265.2	89.9		
1988				
1989	1419.0	96.2		
1990				
1991	470.1	18.3		
1992				
1993				
1994				
1995				
1996	383.2			
1997				
1998			15.62	48.89
1999			9.91	24.00
2000			4.34	22.40
2001		34.70	6.99	8.48
2002	236.20		6.33	19.91
2003			7.78	14.63
2004		51.20	10.25	27.61
2005	249.60		7.58	12.35
2006			8.29	16.95
2007			10.74	16.74
2008			9.14	15.11

3 Species composition trends

Species frequency data has been collected as part of WDFW's monitoring of the recreational fisheries and for a limited number of years for the commercial fisheries. Data prior to 1975 are available from Bargmann (1977) and Buckley (1967, 1968, 1970). From 1975-1986, WDFW published the Washington State Sport Catch Reports (WDF, 5 86) which report estimates of species frequency information in the recreational catch. For 1980-2007, Palsson et al. (2008) Table 7.5 summarizes the species identification data. The data from the commercial fisheries is summarized in Table 6.1 in Palsson et al. (2008).

The precision of the species frequencies may be influenced by small sample sizes. Sample sizes are not reported for the pre-1980 years, however the noise in the early data, especially from the Buckley and Bargmann reports, is suggestive of low sample size. The noise in the early data may also be due to inconsistent identifications or changes in which species were categorized as 'unclassified'. In addition to these limitations, bag limits in the recreational fishery likely have affected the species frequencies in the catch. A bag limit were imposed in 1983, and further reduced in 1994 and 2000. This may have led to discarding of less desirable (smaller) species.

Despite the limitations, the recreational data in particular show some patterns. The three most common species during 1965-2007 in the North Puget Sound (Black, Copper and Quillback) and Puget Sound Proper (Brown, Copper, and Quillback) increased in proportion from 1980 through 1990 and currently comprise approximately 90% of the recreational catch (Figure 3). Four of the five petitioned species (Boccacio, Canary, Greenstriped, and Yelloweye) became progressively less frequent in the recreational catch during the same time period (Figure 3). However, during 1988 to 1993, declines were not seen in the commercial gear that catch Bocaccio rockfish (set line and set net in south Puget Sound), Canary (bottowm trawl and set line in north Puget Sound) and Yelloweye (multiple gear types in north Puget Sound). Thus the commercial data, while much more limited in number of samples than the recreational data, contradicts this pattern of declines in the petitioned species in the 1980s/1990s. Recent data for the commercial fisheries have not been collected to our knowledge.

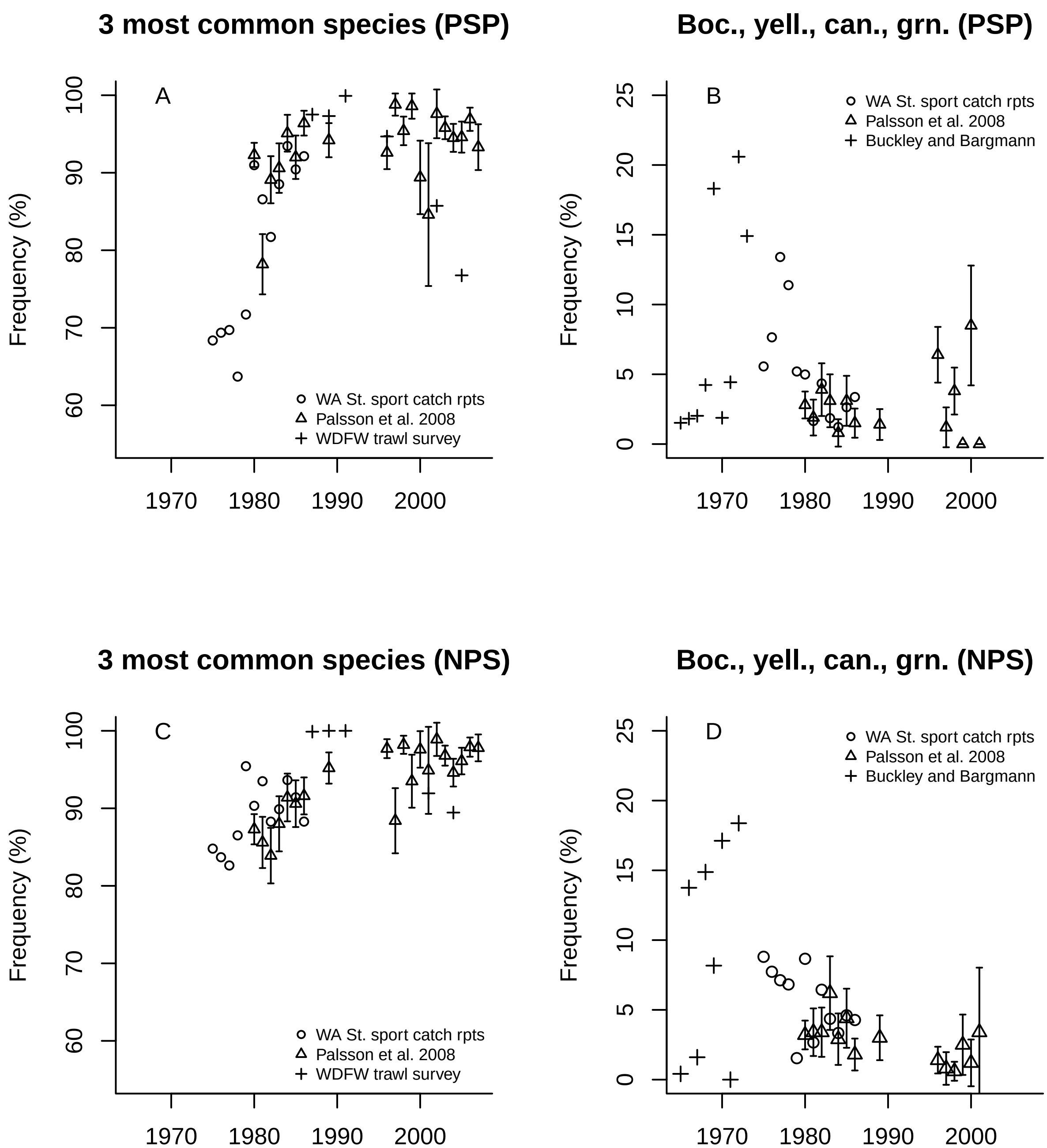


Figure 3: Species frequency data from the recreational bottomfish-specific fisheries in Puget Sound Proper (PSP) and North Puget Sound (NPS). See text for details on the data sources. Approximate 95% confidence intervals were calculated for the frequencies reported in Palsson et al. (2008) using the normal approximation $\hat{p} \pm z_{\alpha/2}\sqrt{\hat{p}(1-\hat{p})/n}$ and sample sizes, n provided by Palsson et al. (2008). Redstripe rockfish has been removed from the data sets when calculating changes in frequencies because of concerns that discarding and high aggregation led to large biases in the recreational and WDFS trawl data, respectively.

3.1 Bocaccio

Bocaccio was infrequently recorded in the recreational catch data reported by Buckley and Bargmann for Puget Sound Proper from the mid-1960s into the early 1970s (Table 6). However, Bocaccio rockfish were reported up to 8-9% of the catch in the late-1970s from the Washington State Sport Catch Reports (WDF, 5 86). The majority of the catch (66%) during 1975-1986 was from punch card area 13 (Figure 6) as reported in the WA Sport Catch Reports); Point Defiance and the Tacoma Narrows were historically reported as local areas of high Bocaccio abundance in punch card area 13. Bocaccio rockfish appear to have declined in frequency, relative to other species, from the 1970s to the 1980s to the 1990s. 1975-1979, Bocaccio rockfish were reported as an average of 4.63% of the catch (sample size unknown; reference WA State Sport Catch Reports). 1980-1989, they were 0.24% of the 8430 rockfish identified (Palsson et al., 2008). From 1996 to 2007, Bocaccio rockfish have not been observed out of the 2238 rockfish identified in the dockside surveys of the recreational catches (Palsson et al., 2008). In a sample this large, the probability of observing at least 1 Bocaccio rockfish would be 99.5% assuming it was at the same frequency (0.24%) as in the 1980s. Bocaccio rockfish have also not been observed in the WDFW fisheries independent trawl surveys (Palsson et al., 2008, Table 7.5).

In conclusion, there is strong support in the data for a decline in the frequency of Bocaccio rockfish relative to other species in Puget Sound Proper. The magnitude of the decline cannot be ascertained since we have no estimates of its current frequency (given that it is not observed at all). We do know that although rare, Bocaccio rockfish are still present in Puget Sound Proper (as of 2001). In the WDFW size surveys, Bocaccio rockfish have been recorded in 1994, 1996, 1997, 1998, (punch card areas 5,6, and 7). The latest record in the size database is 1999 when four fish were recorded (3 from punch card area 13 and one from punch card area 11). There is one report of a Bocaccio rockfish sighting (2-10 fish) in punch card area 11 (central Puget Sound at the Les Davis Pier Artificial Reef in Commencement Bay, Tacoma) in 2001 from a REEF scuba survey. This is the last reported identification we have of Bocaccio rockfish in the Puget Sound Proper.

In North Puget Sound, Bocaccio rockfish have always been rare in the surveys of the recreational fishery (Table 6). In the Strait of Georgia, Bocaccio rockfish have been documented in some inlets, but records are sparse, isolated, and often based on anecdotal reports (COSEWIC, 2002). Bocaccio rockfish have not been noted in any fishery-independent longline, submersible, or jig surveys conducted for bottomfishes throughout the Strait of Georgia over the past two decades (Yamanaka et al., 2004). Furthermore, they do not appear in any recreational catch records, although rockfish were not identified to species until the last decade (DFO, 2008).

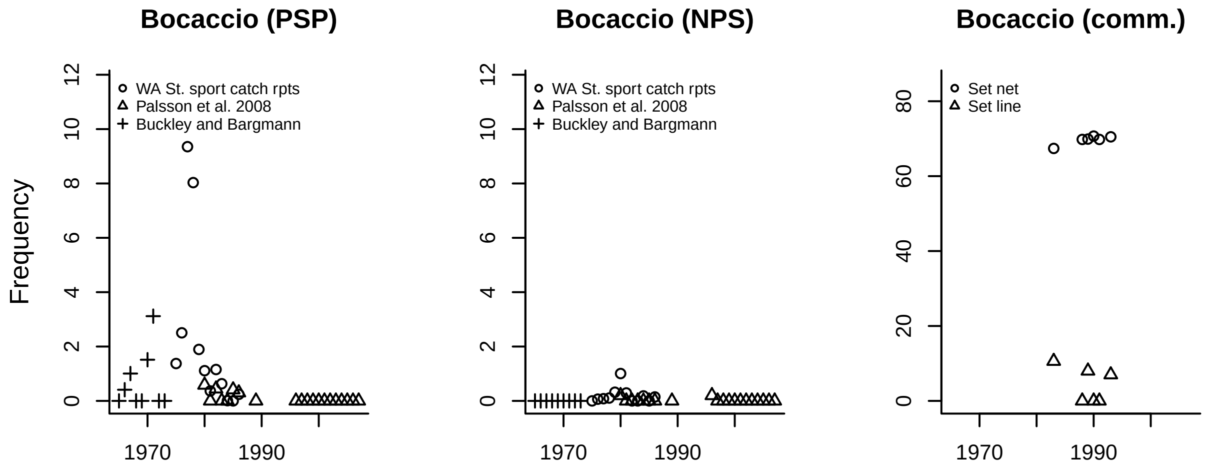


Figure 4: Estimates of the frequency (percent of total catch) for bocaccio rockfish in the recreational catch in Puget Sound Proper (PSP), North Puget Sound (NPS), and in the commercial bocaccio catch from Puget Sound Proper (comm.). Bocaccio rockfish do not appear in the commercial catch records in north Puget Sound.

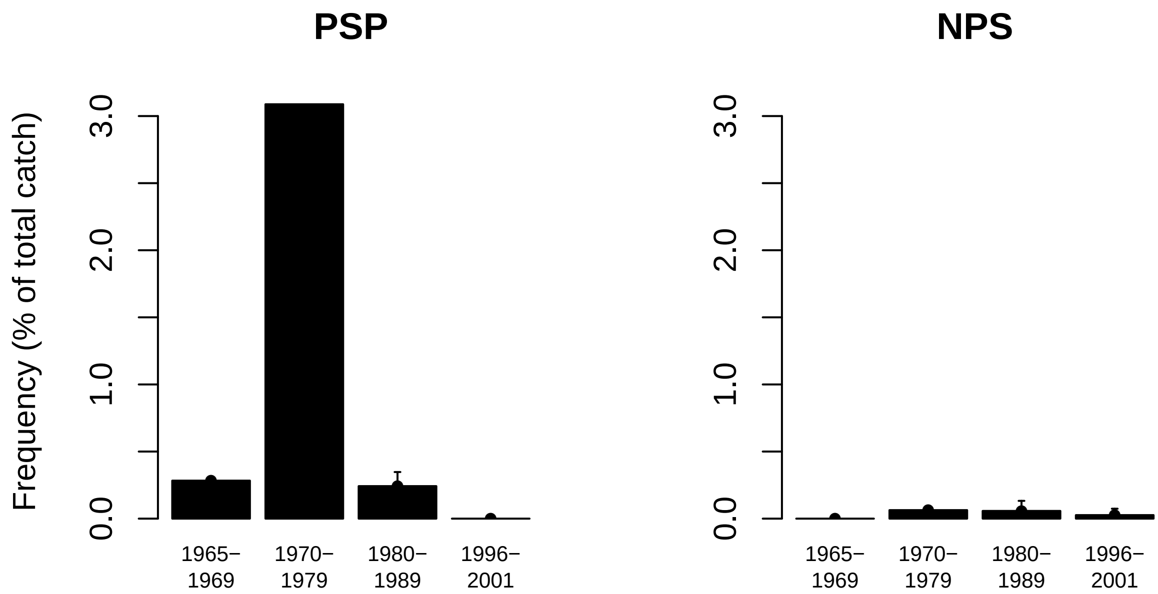


Figure 5: Frequency (percent of total catch) for bocaccio rockfish in the recreational catch in Puget Sound Proper and North Puget Sound averaged across decades. For 1965-69 and 1970-79, we do not have sample sizes (numbers of rockfish identified) and thus confidence intervals cannot be presented. For these years, the numbers are simply the average of the reported fraction each year. For 1980-2001, sample sizes are provided in Palsson et al. (2008). The average frequency is calculated as $\left(\sum_{i=yr1}^{yr2} f_i \times ss_i\right) / \sum_{i=yr1}^{yr2} ss_i$, where f_i is the frequency estimate for year i and ss_i is the sample size in year i. Approximate 95% confidence intervals were calculated from the normal approximation: $\hat{p} \pm z_{\alpha/2}\sqrt{\hat{p}(1-\hat{p})/n}$, where n is the total sample size within a decade.

Proportion of Total Rockfish Caught by Punch Card Area
1975-86 WA Sport Catch Reports

	Punch Card Areas												
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Bocaccio	0.000	0.003	0.006	0.054	0.005	0.012	0.064	0.019	0.015	0.021	0.111	0.024	0.664
Yelloweye RF	0.029	0.115	0.108	0.196	0.053	0.034	0.305	0.024	0.040	0.038	0.016	0.040	0.002
Greenstriped RF	0.000	0.000	0.000	0.004	0.000	0.000	0.013	0.079	0.283	0.362	0.192	0.027	0.041
Canary RF	0.010	0.233	0.049	0.254	0.162	0.049	0.032	0.006	0.019	0.029	0.103	0.006	0.048
Redstripe RF	0.000	0.000	0.000	0.000	0.000	0.000	0.028	0.004	0.008	0.008	0.239	0.006	0.705
Other RF	0.031	0.356	0.010	0.021	0.014	0.008	0.133	0.009	0.031	0.095	0.106	0.013	0.173

Pink - x>0.5
Orange – 0.5>x>0.25
Yellow – 0.25>x>0.1

Figure 6: The proportion of catch (catch in punch card area/total catch in punch card areas 1-13) as reported in the Washington State Sport Catch Reports. Pink shows areas where >50% of catch occurred.

Table 6: The species frequency data for Bocaccio in Puget Sound Proper. These data all come from the recreational fishery and are calculated from dockside surveys in punch card areas 8-13. The 1980-2007 data are in Table 7.5 in Palsson et al. (2008). Reported sample sizes (fish identified) are given in parentheses if available.

Year	WA Sport Catch Rpts	Palsson et al. (2008)	Buckley and Bargmann
1965			0 (NA)
1966			0.41 (NA)
1967			1.01 (NA)
1968			0 (NA)
1969			0 (NA)
1970			1.51 (NA)
1971			3.12 (NA)
1972			0 (NA)
1973			0 (NA)
1974			
1975	1.38 (NA)		
1976	2.5 (NA)		
1977	9.35 (NA)		
1978	8.03 (NA)		
1979	1.89 (NA)		
1980	1.11 (NA)	0.58 (1460)	
1981	0.37 (NA)	0 (1027)	
1982	1.15 (NA)	0.44 (965)	
1983	0.63 (NA)	0 (937)	
1984	0.01 (NA)	0 (985)	
1985	0 (NA)	0.41 (1292)	
1986	0.24 (NA)	0.3 (760)	
1987			
1988			
1989		0 (1004)	
1990			
1991			
1992			
1993			
1994			
1995			
1996		0 (185)	
1997		0 (85)	
1998		0 (133)	
1999		0 (74)	
2000		0 (47)	
2001		0 (26)	
2002		0 (85)	
2003		0 (367)	
2004		0 (322)	
2005		0 (335)	
2006		0 (296)	
2007		0 (283)	

Table 7: The species frequency data for Bocaccio in North Puget Sound. These data all come from the recreational fishery and are calculated from dockside surveys in punch card areas 5-7. The 1980-2007 data are in Table 7.5 in Palsson et al. (2008). Reported sample sizes (fish identified) are given in parentheses if available.

Year	WA Sport Catch Rpts	Palsson et al. (2008)	Buckley and Bargmann
1965			0 (NA)
1966			0 (NA)
1967			0 (NA)
1968			0 (NA)
1969			0 (NA)
1970			0 (NA)
1971			0 (NA)
1972			0 (NA)
1973			0 (NA)
1974			
1975	0 (NA)		
1976	0.06 (NA)		
1977	0.08 (NA)		
1978	0.11 (NA)		
1979	0.32 (NA)		
1980	1.01 (NA)	0.2 (1121)	
1981	0.29 (NA)	0 (434)	
1982	0 (NA)	0 (404)	
1983	0 (NA)	0 (321)	
1984	0.18 (NA)	0 (318)	
1985	0 (NA)	0 (360)	
1986	0.15 (NA)	0 (519)	
1987			
1988			
1989		0 (433)	
1990			
1991			
1992			
1993			
1994			
1995			
1996		0.2 (578)	
1997		0 (223)	
1998		0 (496)	
1999		0 (200)	
2000		0 (162)	
2001		0 (59)	
2002		0 (91)	
2003		0 (715)	
2004		0 (613)	
2005		0 (490)	
2006		0 (513)	
2007		0 (275)	

Table 8: The species frequency data from the commercial catch data for Bocaccio rockfish in Puget Sound Proper. The 1983-1984 data point is reported in Pedersen and Bargmann (1986); it is not clear from this document precisely when the species composition data were collected, however other species identification data are specified as being collected in 1984. This data point is later presented as 1970-1987 in Table 6.1 in Palsson et al. (2008), but the original identifications appear to have been done in a single year. The 1988, 1989, 1990, 1991, and 1993 were from surveys of the commercial catches those years but no identifications have been done on the commercial catch since 1993 (according to Palsson et al. (2008)). Data from commercial gear with which Bocaccio rockfish are not caught are not shown. Blanks indicate missing years not zeros.

Year	Set net	Set line
1983-84	67.4	10.6
1984		
1985		
1986		
1987		
1988	69.8	0.0
1989	69.9	8.0
1990	70.7	0.0
1991	69.8	0.0
1992		
1993	70.5	7.0

3.2 Canary

Canary rockfish occur more consistently in the recreational catch than Bocaccio and Yelloweye rockfish, but are still infrequently observed (typically 1-2% in Puget Sound Proper and 2-5% in north Puget Sound). Like Bocaccio rockfish, Canary rockfish appear to have become less frequent in the recreational catch data since 1965 (Table 9 and 10). From 1980-1989, they were reported at a frequency of 1.1% (sample size 8430) and 1.4% (sample size 3910) in south and north Puget Sound respectively. From 1996-2001, they were reported at a frequency of 0.73% (sample size 550) and 0.56% (sample size 1718) in south and north Puget Sound respectively. The decadal trends along with 95% confidence intervals for the data with sample sizes are shown in Figure 9). Note the early data do not report sample size (number of individuals identified) thus the uncertainty in the early estimates cannot be calculated. Species misidentification should not be a problem for Canary rockfish, but their reported frequency may be affected by non-random reporting of species in the catch in the 1960s and early 1970s. The tables from Buckley and Bargmann (1965-1973) suggest that only a few (2-3) common species were being recorded in some punch card areas.

Since 2002, fishing for Canary rockfish is prohibited and thus no frequency data are available from the recreational fishery since then. Canary rockfish have not been observed in the WDFW fisheries independent trawl surveys Palsson et al. (2008, Table 7.5). In the REEF scuba data REEF (2008), Canary rockfish were not observed in the first three years of the survey, 1998-2000, when the number of dives was 100-130 per year. Since 2001, however, the number of dives per year has increased substantially, to 400-1000 dives per year, and Canary rockfish have been reported consistently since 2001 in 0.5 to 3.6% of dives with no evidence of a temporal decline in sightings (Table 12).

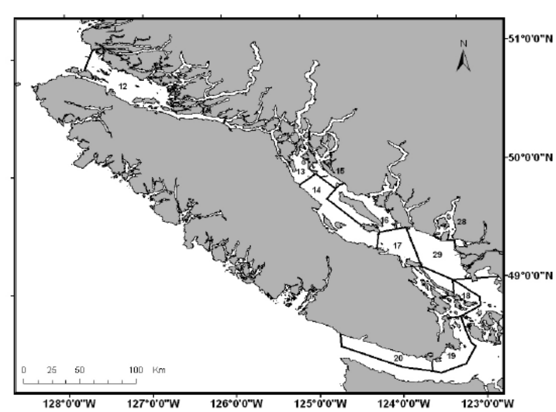


Figure 7: For statistical reporting purposes Department of Fisheries and Oceans Canada has divided the inland waters of British Columbia into statistical areas 12-20 and 28-29. Figure from COSEWIC (2002).

Canary rockfish have been documented in the Strait of Georgia (Figure 7), but the overwhelming research focus is on the large stocks that are commercially harvested off the west coast of Vancouver Island and in Queen Charlotte Strait (COSEWIC in press). The prevalence of this species in recreational fishing in the Strait of Georgia indicates that they are probably well distributed but rare (1% total rockfish catch) in enclosed waters and inlets DFO (2008). However, wide interannual variations in some recreational catch data suggests that catch estimates may be unreliable due to poor species identification and changing bag limits (COSEWIC in press). Recent long-line surveys throughout the Strait of Georgia collected ten canary rockfish individuals from two shallow sets in statistical areas 16 and 17 (Figure 7). All were adults (mean size 529 cm) in post-spawning condition Lochead and Yamanaka (2007). They have also been documented in Georgia Strait jig surveys Yamanaka et al. (2004).

Table 9: The species frequency data for Canary rockfish in Puget Sound Proper. These data all come from the recreational fishery and are calculated from dockside surveys in punch card areas 8-13. The 1980-2007 data are in Table 7.5 in Palsson et al. (2008). Since 2002, no catch of Canary is allowed in the recreational fishery thus no frequency data are available. Reported sample sizes (fish identified) are given in parentheses if available.

Year	WA Sport Catch Rpts	Palsson et al. (2008)	Buckley and Bargmann
1965			0.53 (NA)
1966			0.18 (NA)
1967			0.84 (NA)
1968			3.75 (NA)
1969			6.9 (NA)
1970			0.36 (NA)
1971			0 (NA)
1972			2 (NA)
1973			12.77 (NA)
1974			
1975	1.44 (NA)		
1976	2.06 (NA)		
1977	2.45 (NA)		
1978	1.17 (NA)		
1979	0.78 (NA)		
1980	1.25 (NA)	0.93 (1460)	
1981	0.84 (NA)	0.54 (1027)	
1982	1.23 (NA)	2.11 (965)	
1983	0.24 (NA)	0.66 (937)	
1984	0.52 (NA)	0.63 (985)	
1985	1.77 (NA)	2.16 (1292)	
1986	1.81 (NA)	1.11 (760)	
1987			
1988			
1989		0.7 (1004)	
1990			
1991			
1992			
1993			
1994			
1995			
1996		0 (185)	
1997		0 (85)	
1998		0 (133)	
1999		0 (74)	
2000		8.5 (47)	
2001		0 (26)	

Table 10: The species frequency data for Canary rockfish in North Puget Sound. These data all come from the recreational fishery and are calculated from dockside surveys in punch card areas 5-7. The 1980-2007 data are in Table 7.5 in Palsson et al. (2008). Since 2002, no catch of Canary rockfish is allowed in the recreational fishery thus no frequency data are available. Reported sample sizes (fish identified) are given in parentheses if available.

Year	WA Sport Catch Rpts	Palsson et al. (2008)	Buckley and Bargmann
1965			0 (NA)
1966			12.42 (NA)
1967			1.6 (NA)
1968			10.29 (NA)
1969			7.73 (NA)
1970			0 (NA)
1971			0 (NA)
1972			13.21 (NA)
1973			51.9 (NA)
1974			
1975	6.94 (NA)		
1976	5.23 (NA)		
1977	5.41 (NA)		
1978	3 (NA)		
1979	1.17 (NA)		
1980	2.05 (NA)	1.5 (1121)	
1981	1.43 (NA)	1.8 (434)	
1982	1.27 (NA)	1.71 (404)	
1983	1.61 (NA)	2.21 (321)	
1984	1.54 (NA)	1.3 (318)	
1985	1.88 (NA)	1.9 (360)	
1986	1.87 (NA)	1 (519)	
1987			
1988			
1989		0 (433)	
1990			
1991			
1992			
1993			
1994			
1995			
1996		0.3 (578)	
1997		0.4 (223)	
1998		0.6 (496)	
1999		1 (200)	
2000		1.2 (162)	
2001		0 (59)	

Table 11: The species frequency data from the commercial catch data for Canary rockfish in north Puget Sound. The 1970-1987 data point is from accumulated data over this period. Reference is Palsson et al. (2008, Table 6.1). Data from gear with which Canary rockfish are not caught are not shown.

Year	Bottom trawl	Set line
1983-84	0	0
1984		
1985		
1986		
1987		
1988	0.2	6.0
1989	0.7	3.5
1990	0.0	1.6
1991	2.7	1.2
1992		
1993	0.4	7.4

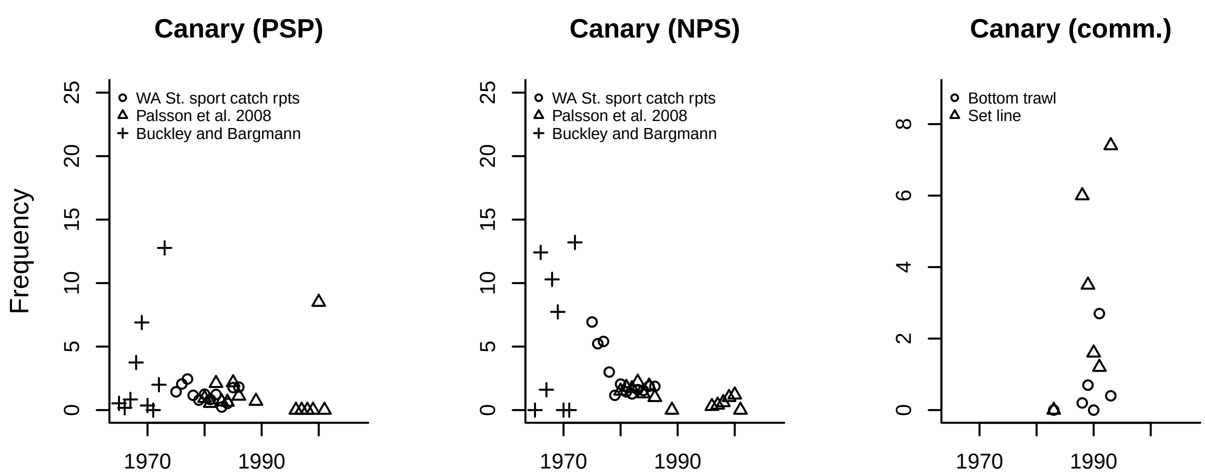


Figure 8: Estimates of the frequency (percent of total catch) for canary rockfish in the recreational catch in Puget Sound Proper (PSP), North Puget Sound (NPS), and in the commercial catch from north Puget Sound (comm.). Canary rockfish do not appear in the commercial catch in Puget Sound Proper. The outlier point (1973 in NPS) for the Buckley and Bargmann data is at 52%.

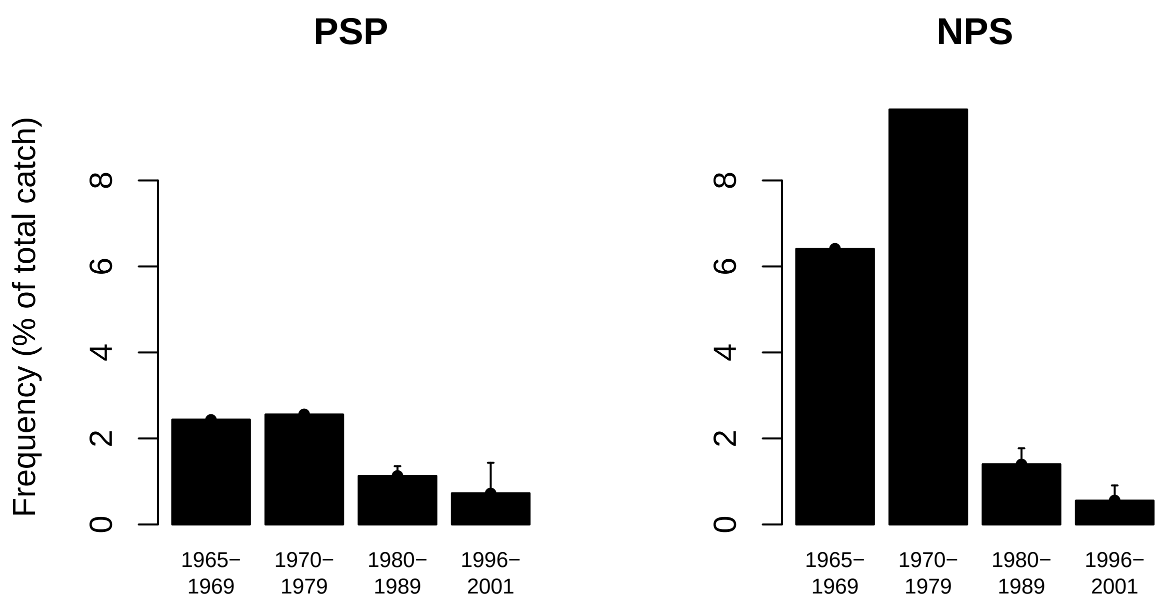


Figure 9: Frequency (percent of total catch) for canary rockfish in the recreational catch in Puget Sound Proper and North Puget Sound averaged across decades. For 1965-69 and 1970-79, we do not have sample sizes (numbers of rockfish identified) and thus confidence intervals cannot be presented. For these years, the numbers are simply the average of the reported fraction each year. For 1980-2001, sample sizes are provided in Palsson et al. (2008). The average frequency is calculated as $\left(\sum_{i=yr1}^{yr2} f_i \times ss_i\right) / \sum_{i=yr1}^{yr2} ss_i$, where f_i is the frequency estimate for year i and ss_i is the sample size in year i. Approximate 95% confidence intervals were calculated from the normal approximation: $\hat{p} \pm z_{\alpha/2}\sqrt{\hat{p}(1-\hat{p})/n}$, where n is the total sample size within a decade.

Table 12: The percent of dives in which Yelloweye rockfish were sighted (at any abundance) from the REEF recreational scuba dive surveys for all dive sites in Puget Sound. The number of dives are given in parentheses

Year	Yelloweye south puget sound	Yelloweye north puget sound
1998	1.05 (95)	0 (27)
1999	0 (95)	0 (8)
2000	0 (93)	0 (15)
2001	0.53 (379)	0 (33)
2002	0.27 (376)	0 (74)
2003	0.71 (421)	0 (51)
2004	1.07 (469)	3.03 (66)
2005	0.47 (428)	0 (54)
2006	0.49 (608)	2.56 (156)
2007	0.6 (826)	2.44 (164)
2008	0 (383)	1.89 (53)

3.3 Yelloweye

Yelloweye rockfish occur more consistently in the recreational catch than Bocaccio rockfish but at lower frequency than Canary rockfish and are still infrequently observed (typically 1-2% in Puget Sound Proper and 2-5% in north Puget Sound). The frequency of Yelloweye rockfish in Puget Sound Proper appears to have increased from a frequency of 0.34% (sample size 8430) in 1980-1989 to a frequency of 2.7% (sample size 550) in 1996-2001 (Figure 10 and Tables 13). There were three recent years (1999-2001) when Yelloweye rockfish were not reported in the recreation catch, however the sample sizes were low these years and zeros are expected for an infrequent species when sample sizes are low.

In North Puget Sound, in contrast, the frequency of Yelloweye rockfish decreased between the 1980s and 1990s in the recreational catch surveys. From 1980-1989, they were reported at a frequency of 1.9% (sample size 3910), and from 1996-2001, they were reported at a frequency of 0.65% (sample size 1718). Since 2002, fishing for Yelloweye rockfish is prohibited and thus no frequency data are available since 2002 from the recreational fishery.

The decadal trends along with 95% confidence intervals for the data with sample sizes are shown in Figure 11. Note the early data do not report sample size (number of individuals identified) thus the uncertainty in the early estimates cannot be calculated. Species misidentification should not be a problem for Yelloweye rockfish, but their frequency may be affected by non-random reporting in the 1960s and early 1970s. The tables from Buckley and Bargmann (1965-1973) suggest that only a few (2-3) common species were being recorded in some punch card areas.

Yelloweye rockfish have been observed infrequently in the WDFW fisheries independent trawl surveys (Tables 13) in Puget Sound Proper, and in north Puget Sound, Yelloweye rockfish were not observed in the WDFW trawl survey in 1987, 1989, 1991, or 2001, but were caught in 2004 (0.65% of the catch). We do not have the sample sizes for the WDFW trawl surveys. In the REEF scuba survey data, Yelloweye rockfish have been sighted consistently throughout the Puget Sound (north and south) since 2001 at a average frequency of 0.5% of dives in the south reporting a sighting of Yelloweye rockfish and 2% of dives in the north reporting a sighting. There is no evidence of a decline in the probability of sightings during dives (Table 12).

In the Strait of Georgia, Yelloweye rockfish are common in the recent recreational catches; the proportion of Yelloweye rockfish in the 2006 and 2005 recreational catch (DFO Canada catch data) was 17.1% and 7.5%, respectively. The high frequency of Yelloweye rockfish in the recreational catch may reflect targeting for this species, as Yelloweye rockfish are small proportion of the rockfish observed in the few fisheries independent surveys that are available. A genetic tagging study in 2003 (Yamanaka et al., 2004), where data were collected from tissue taken from hooks, 1% of samples were Yelloweye rockfish. In a 2003 pilot camera study designed to estimate rockfish biomass, Yamanaka et al. (2004, Table 10), 439 rockfish were observed of which 1 (0.2%) was a Yelloweye rockfish. Another ROV survey in 2004 in the southern Strait of Georgia, identified 105 rockfish species of which 5 (4.8%) were Yelloweye rockfish.

There appears to be limited information on population trends Yelloweye rockfish in the Strait of Georgia. Data from the recreational creel survey conducted by Department of Fisheries and Oceans Canada is of limited value because species composition information and groundfish-targeted effort is lacking; salmon-targeted and groundfish-targets trips are reported together. Submersible surveys were conducted in 1984 and 2003 in statistical areas 12 and 13 in the Strait of Georgia (Yamanaka et al., 2004). Between the two surveys, there was a decline in the mean number of Yelloweye rockfish per transect (8.57 to 4.65) but the difference was not statistically significant. Trend data are also available from the commericial long-line fishery (Yamanaka et al., 2004). These data show generally declining trends in CPUE from the late 1980s through the 1990s, but interpretation is difficult given the effects of market forces and management regulations on commercial fisheries.

Table 13: The species frequency data for Yelloweye rockfish in Puget Sound Proper. The recreational fishery data are calculated from dockside surveys in punch card areas 8-13. The 1980-2007 data are in Palsson et al. (2008, Table 7.5). Since 2002, no catch of Yelloweye rockfish is allowed in the recreational fishery thus no frequency data are available. Note that Redstripe rockfish have been removed from the original data when calculating species frequencies. Reported sample sizes (fish identified) are given in parentheses if available.

Year	WA Sport Catch Rpts	Palsson et al. (2008)	WDFW Trawl Survey	Buckley and Bargmann
1965				0.99 (NA)
1966				0.88 (NA)
1967				0 (NA)
1968				0.44 (NA)
1969				2.43 (NA)
1970				0 (NA)
1971				1.32 (NA)
1972				18.6 (NA)
1973				2.14 (NA)
1974				
1975	0.59 (NA)			
1976	0.71 (NA)			
1977	0.84 (NA)			
1978	0.66 (NA)			
1979	0 (NA)			
1980	1.44 (NA)	0.47 (1460)		
1981	0.29 (NA)	0.86 (1027)		
1982	0.62 (NA)	0.44 (965)		
1983	0.66 (NA)	0.11 (937)		
1984	0.43 (NA)	0 (985)		
1985	0.86 (NA)	0.31 (1292)		
1986	1.32 (NA)	0.1 (760)		
1987			0 (NA)	
1988				
1989		0.3 (1004)	0 (NA)	
1990				
1991			0 (NA)	
1992				
1993				
1994				
1995				
1996		5.92 (185)	2.22 (NA)	
1997		1.2 (85)		
1998		2.3 (133)		
1999		0 (74)		
2000		0 (47)		
2001		0 (26)		
2002		NA (85)	0 (NA)	
2003		NA (367)		
2004		NA (322)		
2005		NA (335)	0.2 (NA)	

Table 14: The species frequency data for Yelloweye rockfish in north Puget Sound in the recreational fishery. Species composition was calculated from dockside surveys in punch card areas 5-7. The 1980-2007 data are in Palsson et al. (2008, Table 7.5). Since 2002, no catch of Yelloweye rockfish is allowed in the recreational fishery thus no frequency data are available. Note that Redstripe rockfish have been removed from the original data when calculating species frequencies.

Year	WA Sport Catch Rpts	Palsson et al. (2008)	WDFW Trawl Survey	Buckley and Bargmann
1965				0.41 (NA)
1966				1.33 (NA)
1967				0 (NA)
1968				1.51 (NA)
1969				0.44 (NA)
1970				17.12 (NA)
1971				0 (NA)
1972				5.17 (NA)
1973				2.41 (NA)
1974				
1975	1.87 (NA)			
1976	2.44 (NA)			
1977	1.63 (NA)			
1978	3.72 (NA)			
1979	0 (NA)			
1980	5.53 (NA)	1.5 (1121)		
1981	0.94 (NA)	1.6 (434)		
1982	5.14 (NA)	1.71 (404)		
1983	2.73 (NA)	4.02 (321)		
1984	1.61 (NA)	1.6 (318)		
1985	2.73 (NA)	2.5 (360)		
1986	2.26 (NA)	0.8 (519)		
1987			0 (NA)	
1988				
1989		3 (433)	0 (NA)	
1990				
1991			0 (NA)	
1992				
1993				
1994				
1995				
1996		0.9 (578)		
1997		0.4 (223)		
1998		0 (496)		
1999		1.5 (200)		
2000		0 (162)		
2001		3.4 (59)	0 (NA)	
2002		NA (91)		
2003		NA (715)		
2004		NA (613)	1.37 (NA)	

Table 15: The species frequency data from the commercial catch data for Yelloweye rockfish in north Puget Sound. The 1970-1987 data point is from accumulated data over this period. Reference is Palsson et al. (2008, Table 6.1). Data from gear with which Yelloweye rockfish are not caught are not shown.

Year	Bottom trawl	Jig	Bottomfish troll	Other troll	Set line	Set net
1983-84	1.1	36.6	47.4	49.7	28.0	2.2
1984						
1985						
1986						
1987						
1988	0.8	28.1	43.4	50.0	49.8	3.2
1989	0.0	39.3	55.6	47.8	72.5	1.9
1990	0.0	39.0		49.3	83.4	
1991	0.3	29.2		50.1	91.9	
1992						
1993	0.0	31.6	50.0	53.1	48.8	2.9

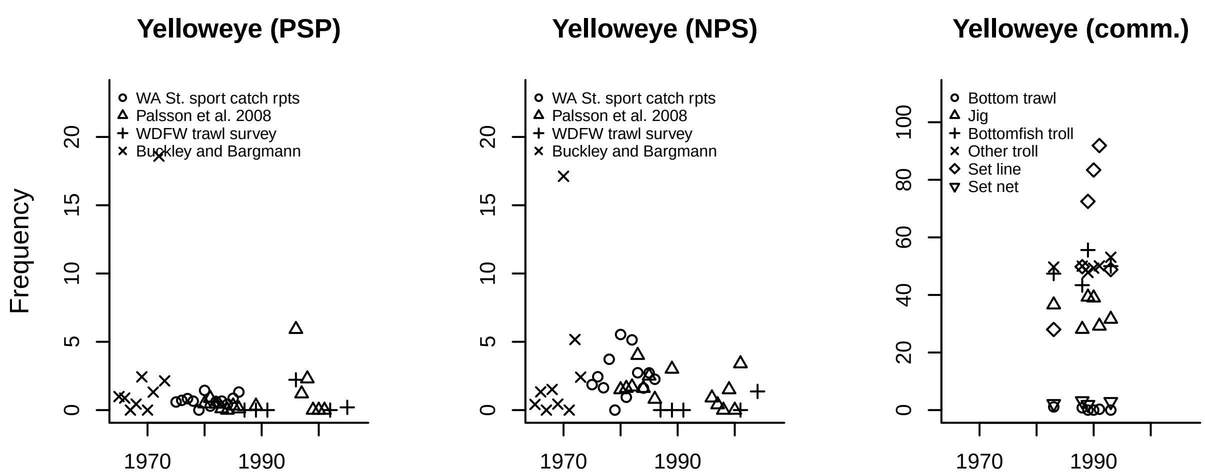


Figure 10: Estimates of the frequency (percent of total catch) for yelloweye rockfish in the recreational catch in Puget Sound Proper (PSP), North Puget Sound (NPS), and in the commercial catch from north Puget Sound (comm.). Yelloweye rockfish do not appear in the commercial catch in Puget Sound Proper.

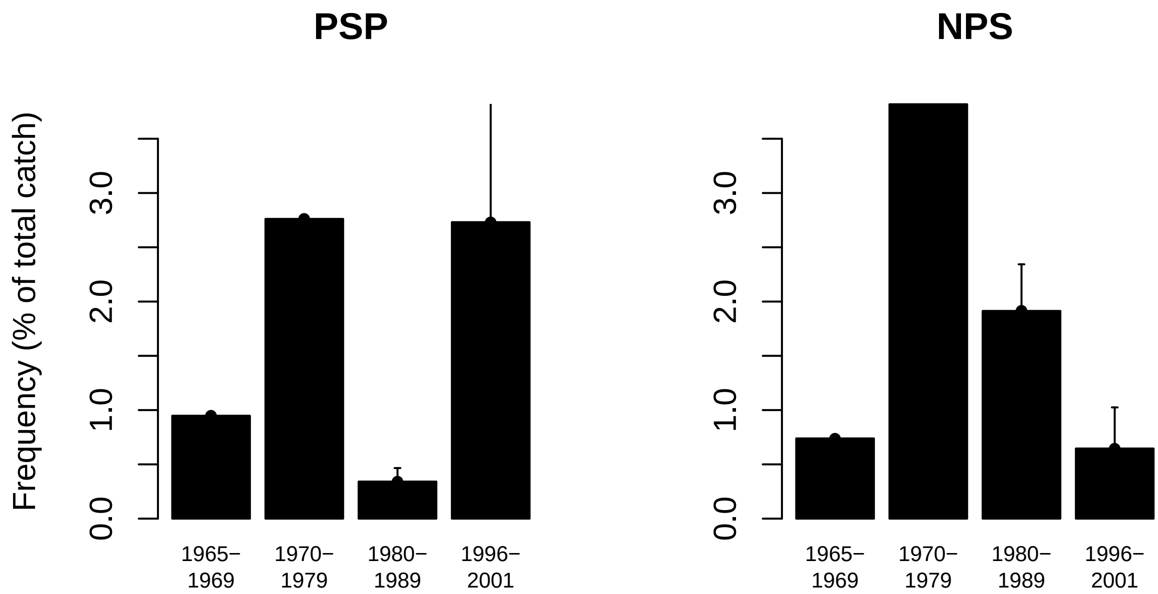


Figure 11: Frequency (percent of total catch) for yelloweye rockfish in the recreational catch in Puget Sound Proper and North Puget Sound averaged across decades. For 1965-69 and 1970-79, we do not have sample sizes (numbers of rockfish identified) and thus confidence intervals cannot be presented. For these years, the numbers are simply the average of the reported fraction each year. For 1980-2001, sample sizes are provided in Palsson et al. (2008). The average frequency is calculated as $\left(\sum_{i=yr1}^{yr2} f_i \times ss_i\right) / \sum_{i=yr1}^{yr2} ss_i$, where f_i is the frequency estimate for year i and ss_i is the sample size in year i. Approximate 95% confidence intervals were calculated from the normal approximation: $\hat{p} \pm z_{\alpha/2}\sqrt{\hat{p}(1-\hat{p})/n}$, where n is the total sample size within a decade.

3.4 Greenstriped

Greenstriped rockfish do not occur in the recreational catch data from North Puget Sound and occur very infrequently in the Puget Sound Proper recreational catch data and the WDFW trawl survey. In the mid-1960s to mid-1970s data (Buckley and Bargmann references), Greenstriped rockfish appear much less frequently than in the mid-1970s to mid-1980s (Figure 13). This suggests that Greenstriped rockfish were not being consistently recorded during dockside identifications during the 1960/1970s. From 1975 to 1980 (WDF, 5 86), Greenstriped rockfish were recorded at a 1-2% frequency in Puget Sound Proper (Figure 12, Table 16). After 1980, the frequency of Greenstiped rockfish declined in the recreational data and since 1996 it very rarely appears in the recreational catch data. Bag limits were imposed in 1983 and the bag limit was further reduced in 1994 and 2000. Since Greenstriped rockfish are smaller than other species, the bag limit may lead to discarding and thus under-representation of Greenstriped rockfish in the recreational catch. Greenstriped rockfish appear in a low frequency in the WDFW fisheries independent trawl survey (Table 16), and they were caught in the most recent years of the WDFW trawl survey in Puget Sound Proper (in both 2002 and 2005). Thus although Greenstriped rockfish have been almost entirely absent from the recreational catch from 1999-2007, they are still present in Puget Sound Proper.

Greenstriped rockfish also do not appear in the 2006 and 2005 species composition data from the recreational catch in the Strait of Georgia (DFO Canada creel survey data). However they have appeared in other fishery-independent surveys such as long-line, jig and ROV surveys (Yamanaka et al., 2004, Table 4). In statistical area 13, they were 1.5% of the rockfish caught in a long-line survey (Lochead and Yamanaka, 2007). In the 2005 ROV survey in southern Strait of Georgia (Martin et al., 2006), they comprised 50% of the rockfish observed (52 out of 105 rockfish identified to species).

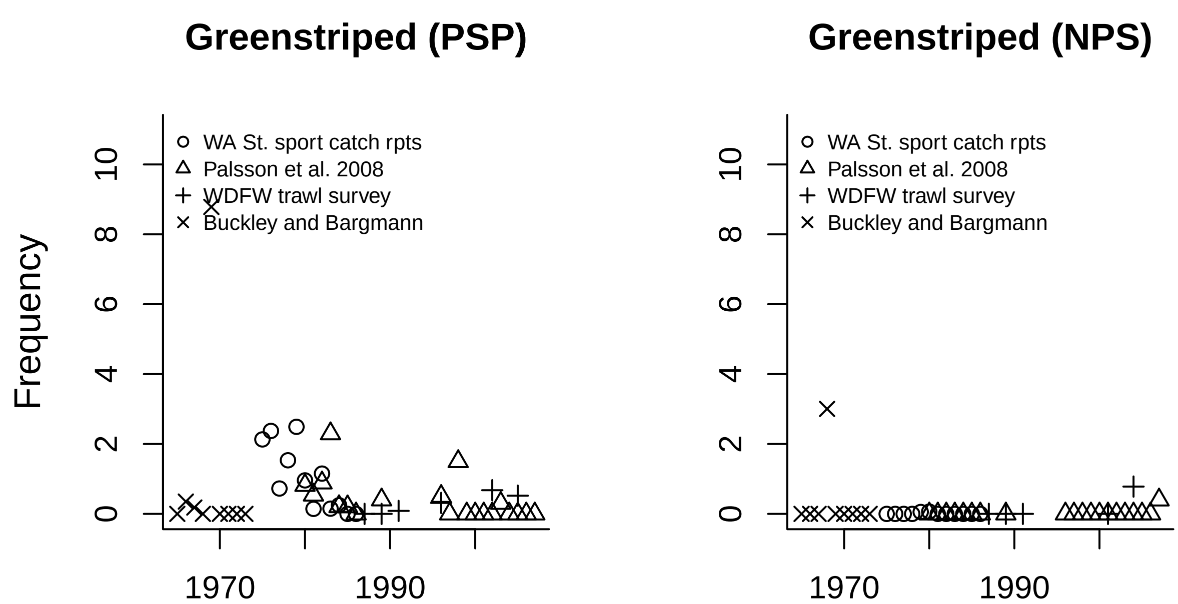


Figure 12: Estimates of the frequency (percent of total catch) for greenstriped rockfish in the recreational catch. Greenstriped rockfish are not recorded in the commercial catches.

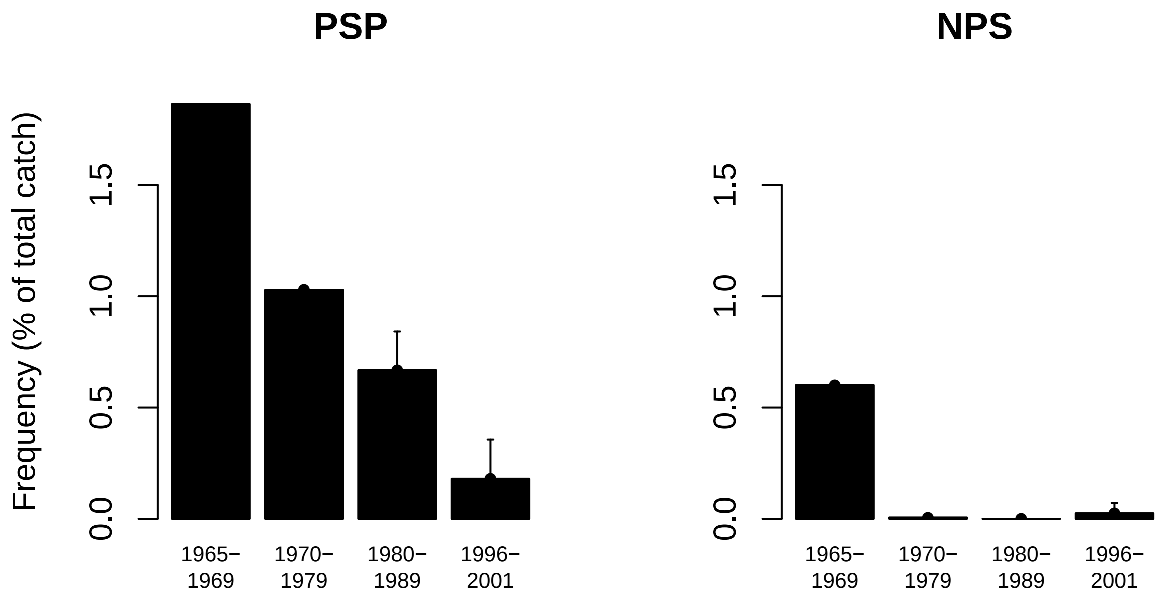


Figure 13: Frequency (percent of total catch) for greenstriped rockfish in the recreational catch in Puget Sound Proper and North Puget Sound averaged across decades. For 1965-69 and 1970-79, we do not have sample sizes (numbers of rockfish identified) and thus confidence intervals cannot be presented. For these years, the numbers are simply the average of the reported fraction each year. For 1980-2001, sample sizes are provided in Palsson et al. (2008). The average frequency is calculated as $\left(\sum_{i=yr1}^{yr2} f_i \times ss_i\right) / \sum_{i=yr1}^{yr2} ss_i$, where f_i is the frequency estimate for year i and ss_i is the sample size in year i. Approximate 95% confidence intervals were calculated from the normal approximation: $\hat{p} \pm z_{\alpha/2}\sqrt{\hat{p}(1-\hat{p})/n}$, where n is the total sample size within a decade.

Table 16: The species frequency data for greenstriped rockfish in Puget Sound Proper. These data all come from the recreational fishery and are calculated from dockside surveys in punch card areas 8-13. The 1980-2007 data are in Palsson et al. (2008, Table 7.5).

Year	WA Sport Catch Rpts	Palsson et al. (2008)	WDFW Trawl Survey	Buckley and Bargmann
1965				0 (NA)
1966				0.35 (NA)
1967				0.18 (NA)
1968				0 (NA)
1969				8.78 (NA)
1970				0 (NA)
1971				0 (NA)
1972				0 (NA)
1973				0 (NA)
1974				
1975	2.13 (NA)			
1976	2.37 (NA)			
1977	0.73 (NA)			
1978	1.53 (NA)			
1979	2.49 (NA)			
1980	0.96 (NA)	0.82 (1460)		
1981	0.14 (NA)	0.54 (1027)		
1982	1.15 (NA)	0.89 (965)		
1983	0.15 (NA)	2.3 (937)		
1984	0.25 (NA)	0.21 (985)		
1985	0 (NA)	0.21 (1292)		
1986	0 (NA)	0 (760)		
1987			0 (NA)	
1988				
1989		0.4 (1004)	0 (NA)	
1990				
1991			0.09 (NA)	
1992				
1993				
1994				
1995				
1996		0.5 (185)	0.31 (NA)	
1997		0 (85)		
1998		1.5 (133)		
1999		0 (74)		
2000		0 (47)		
2001		0 (26)		
2002		0 (85)	0.68 (NA)	
2003		0.3 (367)		
2004		0 (322)		
2005		0 (335)	0.52 (NA)	
2006		0 (296)		
2007		0 (283)		

Table 17: The species frequency data for greenstriped rockfish in North Puget Sound. These data all come from the recreational fishery and are calculated from dockside surveys in punch card areas 5-7. The 1980-2007 data are in Palsson et al. (2008, Table 7.5).

Year	WA Sport Catch Rpts	Palsson et al. (2008)	WDFW Trawl Survey	Buckley and Bargmann
1965				0 (NA)
1966				0 (NA)
1967				0 (NA)
1968				3 (NA)
1969				0 (NA)
1970				0 (NA)
1971				0 (NA)
1972				0 (NA)
1973				0 (NA)
1974				
1975	0 (NA)			
1976	0 (NA)			
1977	0 (NA)			
1978	0 (NA)			
1979	0.05 (NA)			
1980	0.07 (NA)	0 (1121)		
1981	0 (NA)	0 (434)		
1982	0 (NA)	0 (404)		
1983	0 (NA)	0 (321)		
1984	0 (NA)	0 (318)		
1985	0 (NA)	0 (360)		
1986	0 (NA)	0 (519)		
1987			0 (NA)	
1988				
1989		0 (433)	0 (NA)	
1990				
1991			0 (NA)	
1992				
1993				
1994				
1995				
1996		0 (578)		
1997		0 (223)		
1998		0 (496)		
1999		0 (200)		
2000		0 (162)		
2001		0 (59)	0 (NA)	
2002		0 (91)		
2003		0 (715)		
2004		0 (613)	0.78 (NA)	
2005		0 (490)		
2006		0 (513)		
2007		0.4 (275)		

3.5 Redstripe

Redstripe rockfish do not occur in the catch data from North Puget Sound. In Puget Sound Proper, however, Redstripe rockfish appeared frequently in the recreational catch (between 1-14%) during 1980 to 1985 (Figure 14, Table 18). Previous to that, from 1965 to 1979, Redstripe rockfish appeared much less frequently (< 1%) (Buckley and Bargmann references and Washington State Sport Catch Reports). It is not know if Redstripe rockfish were being consistently recorded during dockside identifications in the 1960/1970s, but its absense suggests that it may not have been. After 1985, the frequency of Redstripe rockfish declined in the recreational data and since 1996, it does not appear in the catch data. A bag limit was imposed in 1983 and the bag limit was further reduced in 1994 and 2000. Since Redstripe rockfish are smaller than other species, bag limits may lead to discarding and thus under-representation of Redstripe rockfish in the recreational catch. In the 1980s and 1990s, Redstripe rockfish appeared at a low frequency (< 1.5%) in the WDFW trawl survey (Table 18), however in 2002 and 2005, Redstripe rockfish comprised 39 and 48% of the individuals caught, respectively. Examination of the individual trawl samples however indicates that this was caused by outlier trawl samples in each of those years and which suggests that these high estimates are not indicative of an actual increases in abundance in recent years. Nonetheless, the WDFW trawl survey indicates that Redstripe rockfish are present and in places locally abundant in the Puget Sound but are no longer, for whatever reason, being recorded in the dockside surveys of the recreational catch.

Redstripe rockfish do appear in the 2006 and 2005 species composition data from the recreational catch (DFO Canada creel survey data) for the Strait of Georgia statistical areas 13-20, 28-29. They comprised 0.08% and 0.1% of the recreational rockfish catch, respectively. They have appeared in other fishery-independent surveys such as charter and jig surveys (Yamanaka et al., 2004, Table 4) although these surveys included area 12 and it is unclear if Redstripe rockfish were collected farther south. Redstripe rockfish did not appear in the 2004 long-line survey of statistical area 13 (only in area 12) (Lochead and Yamanaka, 2007). Two Redstripe rockfish (out of 105 rockfish recorded to species) were reported in a 2005 ROV survey in southern Strait of Georgia (Martin et al., 2006).

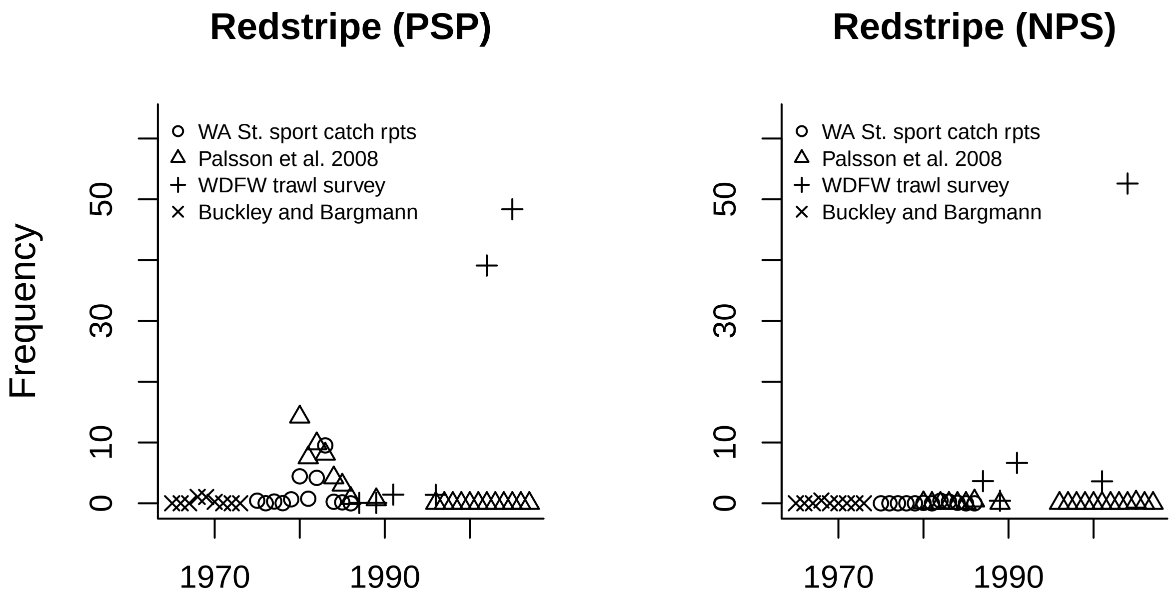


Figure 14: Estimates of the frequency (percent of catch) for redstripe rockfish.

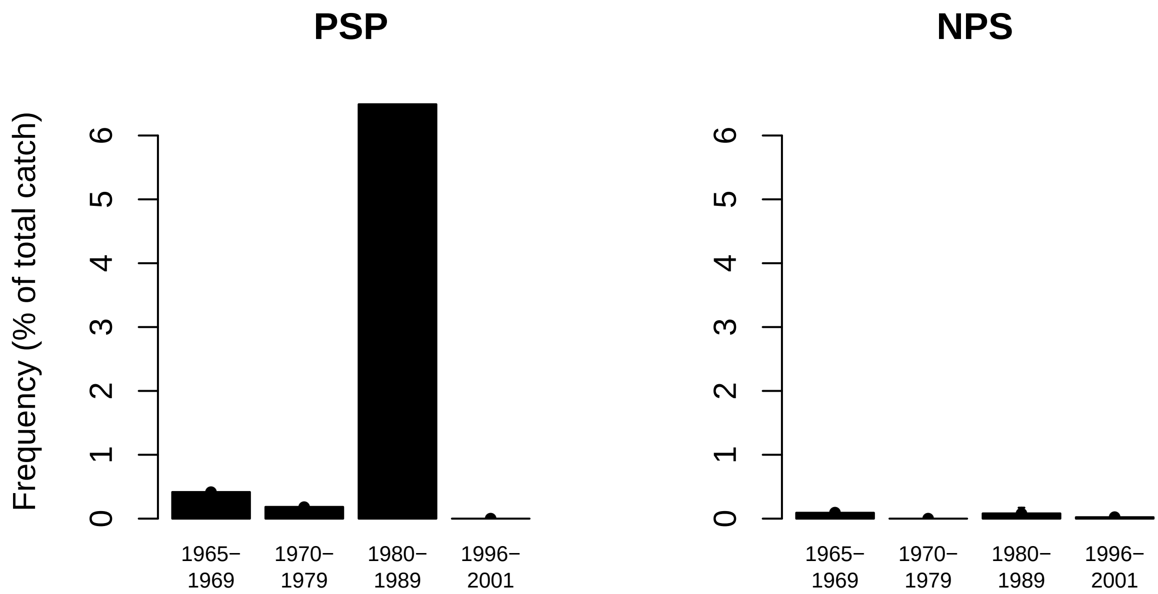


Figure 15: Frequency (percent of total catch) for redstripe rockfish in the recreational catch in Puget Sound Proper and North Puget Sound averaged across decades. For 1965-69 and 1970-79, we do not have sample sizes (numbers of rockfish identified) and thus confidence intervals cannot be presented. For these years, the numbers are simply the average of the reported fraction each year. For 1980-2001, sample sizes are provided in Palsson et al. (2008). The average frequency is calculated as $\left(\sum_{i=yr1}^{yr2} f_i \times ss_i\right) / \sum_{i=yr1}^{yr2} ss_i$, where f_i is the frequency estimate for year i and ss_i is the sample size in year i. Approximate 95% confidence intervals were calculated from the normal approximation: $\hat{p} \pm z_{\alpha/2}\sqrt{\hat{p}(1-\hat{p})/n}$, where n is the total sample size within a decade.

Table 18: The species frequency data for Redstripe rockfish in Puget Sound Proper. These data all come from the recreational fishery and are calculated from dockside surveys in punch card areas 8-13. The 1980-2007 data are in Palsson et al. (2008, Table 7.5).

Year	WA Sport Catch Rpts	Palsson et al. (2008)	WDFW Trawl Survey	Buckley and Bargmann
1965				0 (NA)
1966				0 (NA)
1967				0 (NA)
1968				1.05 (NA)
1969				1.03 (NA)
1970				0.24 (NA)
1971				0 (NA)
1972				0 (NA)
1973				0 (NA)
1974				
1975	0.43 (NA)			
1976	0.01 (NA)			
1977	0.29 (NA)			
1978	0.02 (NA)			
1979	0.65 (NA)			
1980	4.44 (NA)	14.2 (1460)		
1981	0.75 (NA)	7.5 (1027)		
1982	4.19 (NA)	9.8 (965)		
1983	9.53 (NA)	8.1 (937)		
1984	0.25 (NA)	4.2 (985)		
1985	0.16 (NA)	3 (1292)		
1986	0 (NA)	0.8 (760)		
1987			0.06 (NA)	
1988				
1989		0.6 (1004)	0.06 (NA)	
1990				
1991			1.43 (NA)	
1992				
1993				
1994				
1995				
1996		0 (185)	1.39 (NA)	
1997		0 (85)		
1998		0 (133)		
1999		0 (74)		
2000		0 (47)		
2001		0 (26)		
2002		0 (85)	39.11 (NA)	
2003		0 (367)		
2004		0 (322)		
2005		0 (335)	48.37 (NA)	
2006		0 (296)		
2007		0 (283)		

Table 19: The species frequency data for Redstripe rockfish in north Puget Sound. These data all come from the recreational fishery and are calculated from dockside surveys in punch card areas 5-7. The 1980-2007 data are in Palsson et al. (2008, Table 7.5).

Year	WA Sport Catch Rpts	Palsson et al. (2008)	WDFW Trawl Survey	Buckley and Bargmann
1965				0 (NA)
1966				0 (NA)
1967				0 (NA)
1968				0.46 (NA)
1969				0 (NA)
1970				0 (NA)
1971				0 (NA)
1972				0 (NA)
1973				0 (NA)
1974				
1975	0 (NA)			
1976	0 (NA)			
1977	0 (NA)			
1978	0 (NA)			
1979	0 (NA)			
1980	0.07 (NA)	0.1 (1121)		
1981	0 (NA)	0 (434)		
1982	0.43 (NA)	0 (404)		
1983	0.27 (NA)	0 (321)		
1984	0.09 (NA)	0 (318)		
1985	0 (NA)	0 (360)		
1986	0 (NA)	0.4 (519)		
1987			3.64 (NA)	
1988				
1989		0 (433)	0.41 (NA)	
1990				
1991			6.63 (NA)	
1992				
1993				
1994				
1995				
1996		0 (578)		
1997		0 (223)		
1998		0 (496)		
1999		0 (200)		
2000		0 (162)		
2001		0 (59)	3.61 (NA)	
2002		0 (91)		
2003		0 (715)		
2004		0 (613)	52.59 (NA)	
2005		0.2 (490)		
2006		0 (513)		
2007		0 (275)		

4 Estimates of rockfish trends in Puget Sound

4.1 Synopsis of the trend analysis

A trend analysis based on a time series analysis of count data was performed on the data for total rockfish in Puget Sound Proper and north Puget Sound. This type of analysis is standard for population time series data (Dennis et al., 1991), however, the analysis used recent advances to deal with observation error in the data (Holmes, 2001; Lindley, 2003; Holmes and Fagan, 2002; Holmes et al., 2007; Dennis et al., 2006) and combines information from multiple time series into a single analysis. These analyses were used to estimate the trend parameter (mean annual population growth rate) and the 2 variance parameters (process and observation variance) which govern forecasts of future trends and interpretation of past trends.

It is important to realize that the common species (Copper, Quillback, Brown, and Black rockfish) form ca. 90% of the total rockfish assemblage in the different data sources used in the trend analysis. The goal of the trend analysis is to determine the 1965-2008 trend in total rockfish, in other words what the actual population rate of decline has been from 1965-2008. This analysis does not make any assumptions about the composition of total rockfish; it is known that the frequency of the common species relative to each other has changed. The estimated trend for total rockfish is used to make inferences about the petitioned species by looking for evidence that the frequency of the petitioned species has increased (or decreased) in the total rockfish assemblage. If a petitioned species has remained constant percentage of the "total rockfish" category in a given data source, it can inferred that the petitioned species has shown a similar trend to the total rockfish trend.

Quantitative estimates for the individual five species in the current petition were *not* generated because the low and erratic sampling of the catches in many years, particularly early years, provides insufficient yearly estimates for the petitioned species.

4.2 Problems with analyzing composite and CPUE data

The total rockfish time series is a composite of multiple species, and it is well-known that making inferences about individual species from composite catch per unit effort data is problematic. The main problems can be summarized are 1) The trend in the total catch will be dominated by the most abundant species and the signal from infrequent species is lost, 2) Catch-per-unit effort data from fisheries are strongly influenced by targeting and by changes in the efficiency of gear and fish-locating technology. Switching of the targeted species occurs as one species declines, and this means that the trends in "multispecies" catch-per-unit data may have little relation to the individual species, and 3) Changes in management will change, sometimes dramatically, the targeting for a group (such as rockfish) and discarding of individual species. This means that "total rockfish" CPUE may not be actually measuring rockfish abundance (if there are changes in the targeting of rockfish relative to other groundfish species). It also means that the actual trends may be masked if fishers continually move to new, under-fished, locations as the population declines. The following approaches were used to limit these recognized problems.

To address problem 2, CPUE data from the commercial bottom-trawl (1965-1980) were not used. These were the only commercial data with good effort information (hours trawled), but it is known that there were many changes in gear (such as fish-location electronics) that were leading to increases in the catch-per-hour trawled. Also rockfish catch in commercial data is highly susceptible to changes in which species are targeted (and whether rockfish are targeted) and to discarding. The data from the recreational fishery (since it is not market-driven) is assumed to be less susceptible to these factors. Also the spatial scale at which the recreational fishery has been monitored is much finer than the commercial fishery, and this helps us determine if there have been targeting changes.

To address problem 3, the recreational data were split into time periods with constant bag limits and the trend line was fit to each segment separately. The slope of the trend line is forced to be equal between segments, but the intercept is allowed to change. This means that if the catch-per-trip drops after the bag limit is changed, that bag-limit induced drop does not influence the estimated trend. This allows us to estimate a single long-term trend from data with different bag limits.

Problem 1 cannot be addressed by changes in the analysis (or data used). It should be kept in mind that the estimated trends are the trends for the most common species, not the petitioned species. The trend for the common species is used to make inferences about the magnitude of trend in the the petitioned species by looking for changes in the frequency of the petitioned species relative to the common species. Thus, the evidence for changes in the frequency of the petitioned species in the recreational catch, WDFW trawl surveys and REEF dive surveys was examined. If the petitioned species are not declining as fast as the "total rockfish" time series, then their frequency should be increasing relative to other more common species. They should become less frequent if they are instead declining faster. A problem with this approach is that many of the petitioned species occur at frequencies of 0.5-3% of the catch. The sample sizes for the species identifications have been too small to detect even a 4-fold increase in frequency from, say, from 1 to 4%. A second concern is that Greenstriped and Redstripe rockfish may be especially susceptible to being discarded when bag limits are low and that the WDFW trawl estimates for this species have been strongly influenced by sample size and outlier events. More fishery independent surveys of Greenstriped and Redstripe rockfish in Puget Sound are needed.

4.3 Methods

4.3.1 Summary of the methods

The basic idea is to use maximum-likelihood to fit a trend model simultaneously to different data sources. The different data sources are assumed to be measuring the same population process but in different ways. In our case, they are all measuring "total rockfish" but may be measuring different segments of the population (e.g. different age/size segment or a different region of Puget Sound). Their observation variances can be different and how they scale relative to the total population will be different.

A series of different analyses were done using different assumptions about the structure of the data:

- Data from different sources (recreational, scuba dive, trawl survey) were either allowed to to be sampling from different population trajectories or were assumed to be measuring the same trajectory. The mean population growth rate for different trajectories was identical, but the trajectories would appear different due to chance.
- Data from different regions (Puget Sound Proper versus north Puget Sound) were either allowed to to be sampling from different population trajectories or were assumed to be measuring the same trajectory. The assumption of one trajectory for south and north Puget Sound would mean that movement by the common species was high enough to synchronize the south and the north.
- Data from the recreational fishery when the bag limit was 1 fish was included or left out of the analysis.
- Only the recreational fishery data were analyzed versus including the WDFW trawl survey and the REEF surveys in the analysis.

In all cases, the measurement variance were assumed to be different for the recreational data reported in Bargmann and Buckley data, the recreational catch data reported in Palsson et al. (2008), the WDFW trawl survey data, and the REEF dive survey data.

4.3.2 The model

To characterize population growth, a discrete-time Gompertz model was used to model density-dependent population dynamics. This model can approximate most common types of density-dependence (Ives et al., 2003). The stochastic Gompertz equation written in log-space is

$$\mathbf{X}_t = a + b\mathbf{X}_{t-1} + \mathbf{E}_t \tag{1}$$

where $\mathbf{X}_t$ is a $m \times 1$ vector of log population density (or density index such as CPUE) for each population trajectory at time step t. The number of population trajectories depends on the assumptions about the structure of the data. If the data are all assumed to be measuring the same trajectory, then $m = 1$. If each data source is assumed to measure a separate trajectory, them m is the number of data sources. a is the mean annual population growth rate and is the same across all trajectories. b represents the strength of density dependence and was assumed to be the same across all trajectories. $\mathbf{E}_t$, termed the process error, represents the random deviations in population change from time step to time step for each of the m trajectories at time t. E represents the *real* deviations in population change which are not equal to the observed deviations since the observed deviations also have observation error added. Because population change is a multiplicative process, it is additive in log space. Additive stochastic processes lead to normal errors. Thus, E is a random normal variate with a mean of zero and variance σ^2. Equation 1 is a multi-variate auto-regressive, first order, or MAR(1), process.

The true population process exists but cannot be seen; instead, it is observed, and these observations are governed by an observation process. We can write a general observation process for a MAR(1) process as

$$\mathbf{Y}_t = \mathbf{D} + \mathbf{X}_t + \boldsymbol{\epsilon}_t \tag{2}$$

where $\mathbf{Y}_t$ is an $n \times 1$ vector of the n observed time series, each of which is observing with different observation variance and scaling the population trajectory or trajectories (depending on the assumptions about m). $\boldsymbol{\epsilon}_t$ is an $n \times 1$ vector representing the observation errors, which have some statistical distribution with a mean of 0 and an $n \times n$ covariance matrix $\mathbf{R}$. The $n \times 1$ vector $\mathbf{D}$ represents bias in observation errors, and the off-diagonal elements of $\mathbf{R}$ represent the spatial correlation between the observation errors for the n observed time series. $\mathbf{D}$ allows us to model differences in observability (or catchability) of different data sources (i.e. gear types or fisheries). For our analysis, we assume that the errors across the different data sources have independent and unique variances and biases; thus the $\mathbf{R}$ and $\mathbf{D}$ matrices are:

$$\mathbf{R} = \begin{bmatrix} \eta_1^2 & 0 & \cdots & 0 \\ 0 & \eta_2^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \eta_n^2 \end{bmatrix} \mathbf{D} = \begin{bmatrix} d_1 \\ d_2 \\ \vdots \\ d_n \end{bmatrix} \tag{3}$$

4.3.3 Model fitting and parameter estimation

Equations 1 and 2 together form a state-space model for the observations of the stochastic total rockfish process. 'State-space' is a statistical term referring to a model with an unseen state process (in our case, the state process is the true total rockfish trajectory) combined with a observation process. It is a standard term in time-series analysis for the type of auto-regressive model that is being used in this analysis and has a long history within the field of time series analysis.

Given time series of total rockfish indices $(\mathbf{Y}_1, \mathbf{Y}_2, \ldots \mathbf{Y}_T)$ from a set of n data sources, the goal is to estimate the mean population growth rate a and process variance σ^2 that describe the total rockfish trajectories. We use a traditional maximum-likelihood estimation method for this type of state-space model: a Kalman filter combined with an Expectation-Maximization Algorithm (Shumway and Stoffer, 2006).

4.3.4 How is this different than just fitting a line through the log data?

Fitting a line through the log abundance data means that one is using a model where variability is only due to observation error, whereas our models have both variability due to observation error and variability due to annual changes in the population growth rate.

Observation error only models give estimates of *What happened?*. Process plus observation error models give estimates of the underlying population dynamics (the process variance) and are used to forecast *What will happen?* (if the past dynamics continue). Both types of models are used by population analysts and the choice depends on the purpose of the analysis. Models with process variance are also used to ask *Could these data have been produced by a population with a different underlying mean population growth rate?* (that is, did the population increase just by a few chance good years, when it normally would be declining?).

It is important to recognize that ***the trend estimates will be the same*** for both models. What changes are the variance estimates and thus the estimates of confidence intervals on the trend estimate. In particular, the confidence intervals become wider when process variance is included. The estimates of the future population size will also be very different – the median future population size will be the same but the variance of the projections will be very different. The variance is zero for the observation error only model and is process variance $\times$ forecast length for the model with both variance sources.

4.4 Data used for trend analyses

The data used for each analysis are shown in Figures 16 and 17. The different analyses were

PSP-R Puget Sound Proper using only the recreational fish per angler trip for bottomfish-specific trips.

PSP-RT Puget Sound Proper using the recreational fish per angler trip for bottomfish-specific trips and the WDFW trawl survey data. The REEF survey data was not used since these data were not strictly Puget Sound Proper.

PS-R Puget Sound (Puget Sound Proper plus north Puget Sound) using only the recreational fish per angler trip for bottomfish-specific trips.

PS-RTS Puget Sound (Puget Sound Proper plus north Puget Sound) using the recreational, trawl survey, and REEF survey data.

NPS Trend estimates using data from North Puget Sound alone are shown in the trend figure for comparison, but the data are not shown in this document.

Data that are treated as monitoring the same segment of the population have the same color. The numbering shows which data are allowed to have different biases relative to the population. This allows for example, the data from the 1-bag limit period to have a lower scaling relative to the population. It has a lower scaling because the maximum fish per trip has been capped (by the bag limit) at 1.

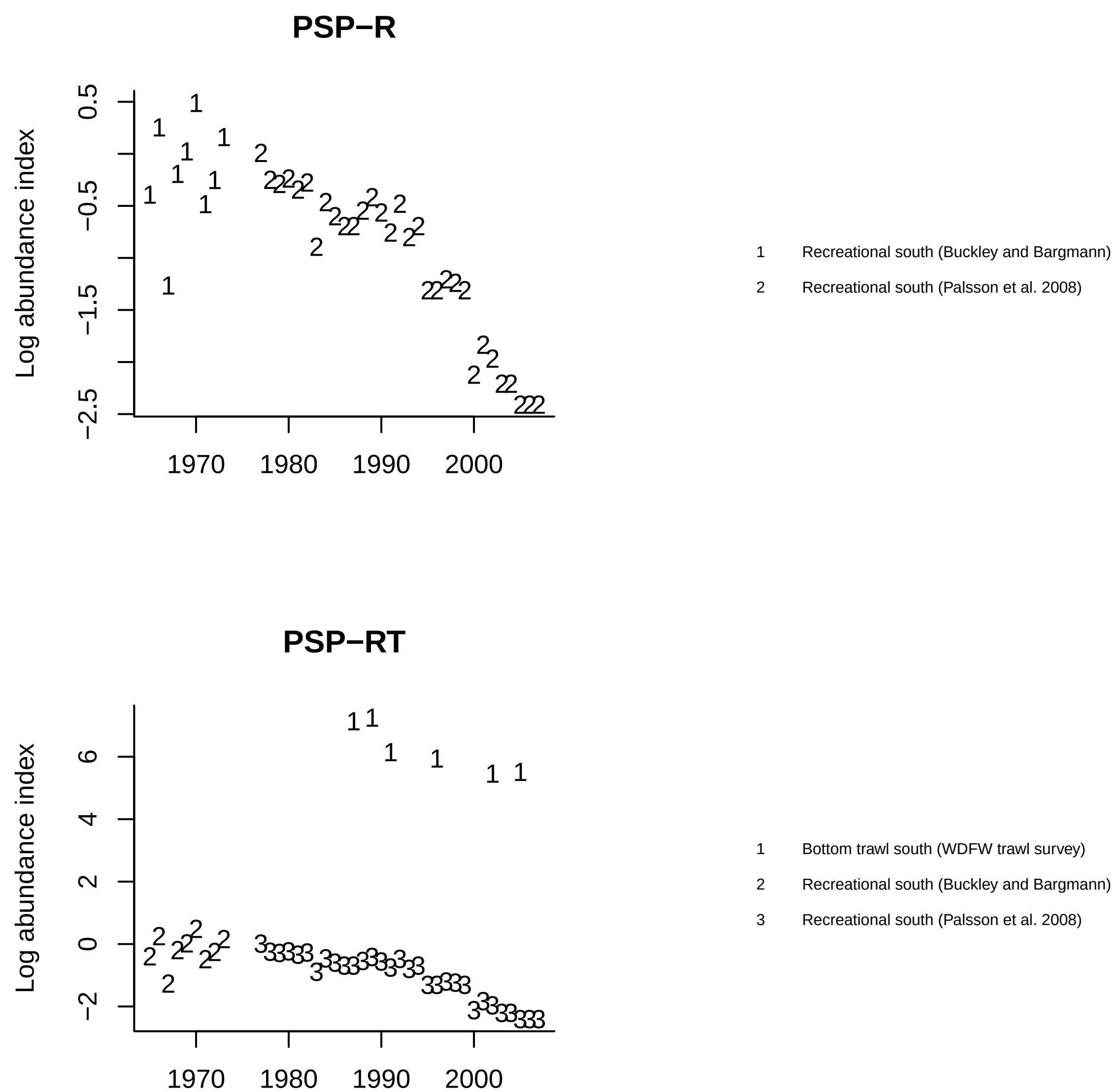
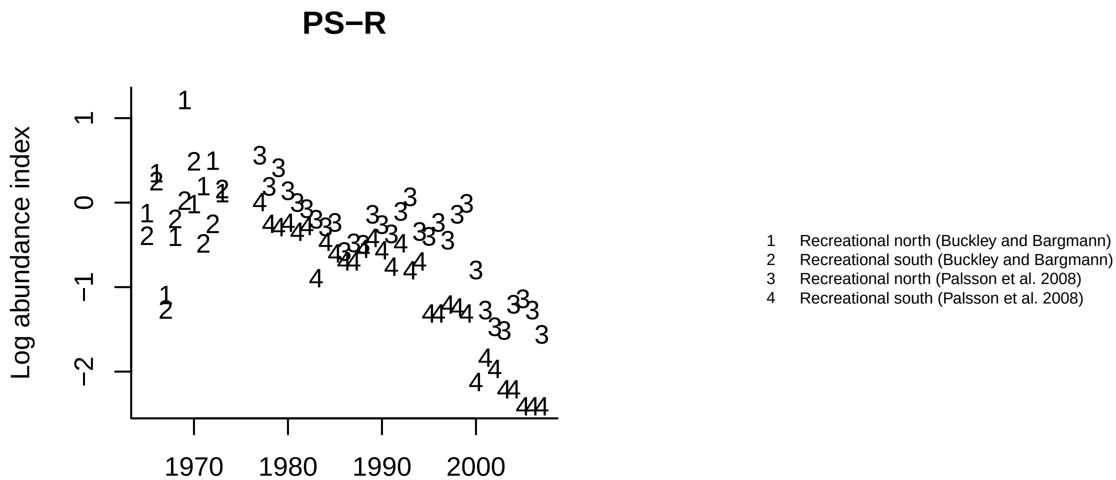


Figure 16: The data used for the two Puget Sound Proper analyses. The different colors show which data were treated as separate (but not independent) population trajectories. Each trajectory has the same mean population growth rate (a parameter) because over the long-term one segment of a population cannot have a different trend than another segment. But over the short-term, different population segments can certainly have different trajectories. Modeling the recreational, trawl, and scuba data (bottom panel) as its own trajectory allows that each segment of the population could have different process variance and a different short-term trajectory and trend. The recreational data for 1977-82 (bag = 15), 1983-93 (bag = 10 north/5 south), 1994-99 (bag = 5 north/3 south) and 2000-2007 (bag =1) are allowed to have independent intercepts so that they can scale relative to each other and adjust for the effect of the bag limit on the mean catch.



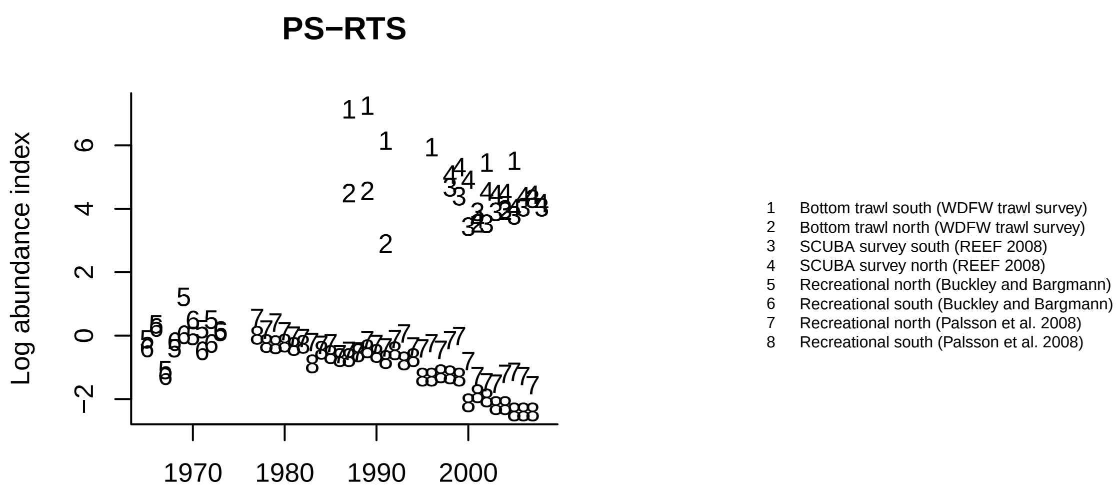


Figure 17: The data used for the Puget Sound (north plus south) analyses. The different colors show which data were treated as separate (but not independent) population processes. See comments on the previous figure.

4.5 Long-term mean population growth estimates

Figure 18 shows the estimates of the long-term mean population growth rate for the period 1965-2007 by region. Estimates are shown for different assumptions about the underlying structure of the population and the data from different data sources (recreational, trawl survey, scuba survey).

The assumption of one population trajectory means that there is one population trajectory and all the data sources are sampling that same trajectory. Their estimates will be different because data sources have different levels of observation error and are scaled differently relative to the total rockfish abundance. The latter means that (fish per angler trip in north Puget Sound) = $x\times$ abundance while (scuba sightings per dive in south Puget Sound) = $y\times$ abundance' and $x \neq y$.

For the 'All Puget Sound' analysis, the assumption of one population trajectory means that the most common rockfish in Puget Sound are moving sufficiently to cause mixing throughout the Puget Sound, and as such data collected in the north and south Puget Sound should be highly correlated. This assumption is unsupported by the data as evidenced by the different trends in the north and south (the upper and middle panels). These estimates are shown by the black symbols in the lower panel. They are plotted for completeness, but little weight should be given to these estimates.

For a single region, north or south Puget Sound, the assumption of one population trajectory means that the different data sources are sampling the same population trajectory. This translates to either sampling the same segment of the total rockfish assemblage or that each segment of the assemblage is assumed to be behaving similarly over the short-term. This is a poor assumption if different surveys are sampling a different age, size, or species segment of the total rockfish assemblage AND these segments are behaving differently (different trends). It is likely that the hook and line recreational data, WDFW bottom trawls and REEF dive data are sampling different population segments and different segments of the rockfish community, however it is unclear whether the additional model complexity from assuming separate population trajectories for each data source is warranted given the limited data from the WDFW trawl survey and the REEF surveys.

The recreational data since 2000 is from a fishery with a 1 bag limit on rockfish. In addition to the 1 bag limit, other regulations have been added incrementally: restriction of the season and rules against discarding undesirable rockfish. After the 1 bag limit was imposed, the trend in the rockfish per angler trip decreased from increasing to flat in the north and from flat to decreasing in the south. Arguments can be made that these data should be excluded from the analysis. The estimates marked with B show the effect of excluding these data from the analysis. As would be expected, the trend estimates increase if the bag=1 data are excluded.

Lastly, estimates were run with and without the WDFW trawl survey data and the REEF dive survey data in order to show how the estimates change with the inclusion of other data sources. However, there is no reason to believe these data are uninformative or invalid thus they should be included in the analysis. If it is believed they are sampling substantially different segments of the rockfish community then they can be included using the 'data sources are independent' assumption (red symbols).

Formal model selection approaches will not be helpful in resolving which assumptions are best because they cannot give information on whether the 1 bag limit data, trawl data or REEF data should be excluded. Model selection can be used to look at the support for using one population process versus different processes for regions and gears. This type of analysis was used to make an argument against the one shared trajectory assumption across north and south Puget Soudn for the 'All Puget Sound' analysis.

4.6 Estimated model fits

Figures 19 and 20 show the estimated trajectories with the rescaled data. When there are multiple data sources for a single population trajectory, the model estimates the best scaling (i.e. how to move the data up or down on the y-axis) to fit a shared population trajectory. In particular, note that the recreational data with different bag limits are assumed to measure the same population trajectory, but have a different scaling.

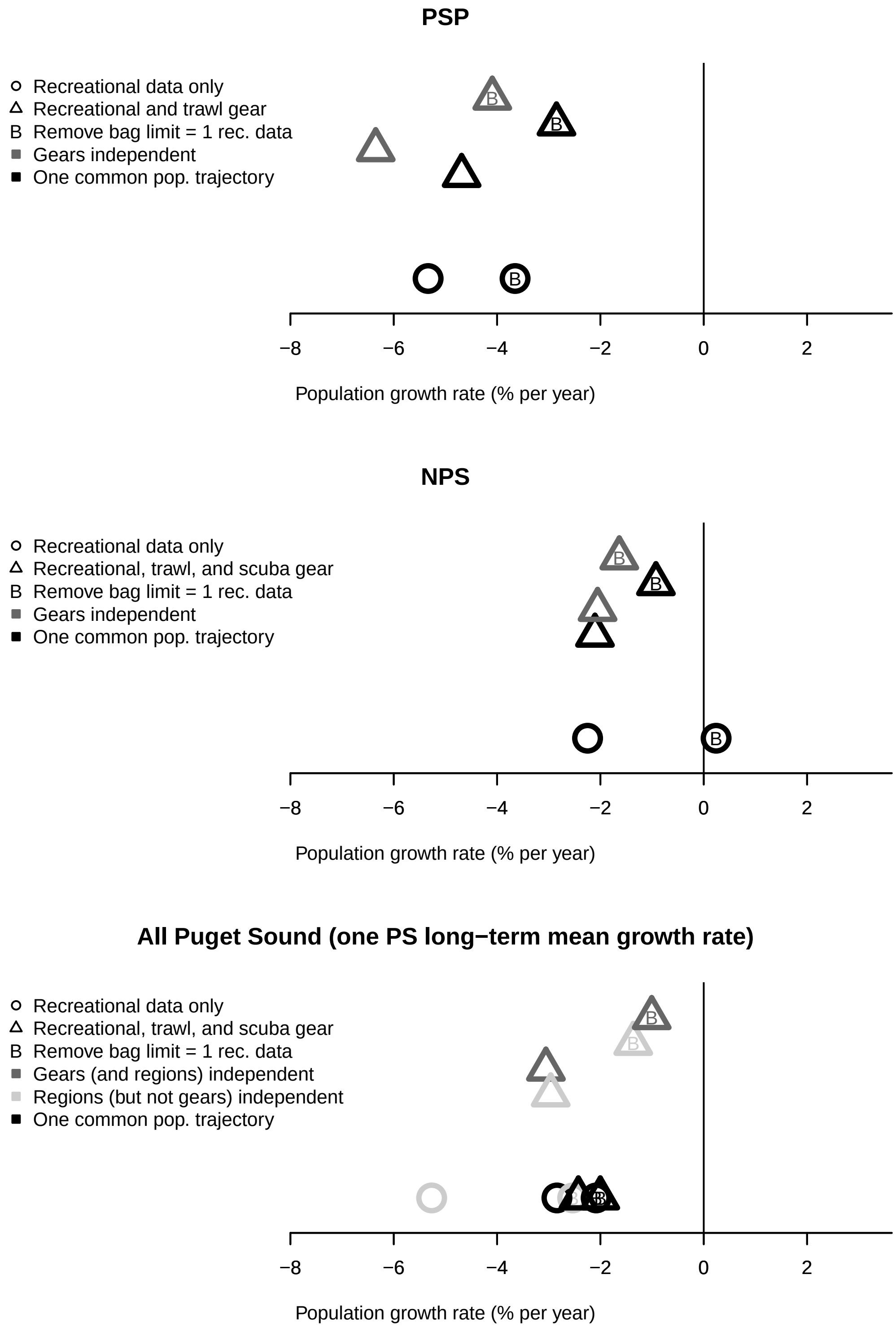


Figure 18: Estimates of the rate of population growth (or decline if negative) for 1965-2007 using the recreational, trawl and REEF survey data. The colors and symbols denote different assumptions in the model (see legends). The height on the y-axis expresses the subjective assessment of the support for the assumptions behind each model. See text for a discussion of the assumptions and which are supported by the data.

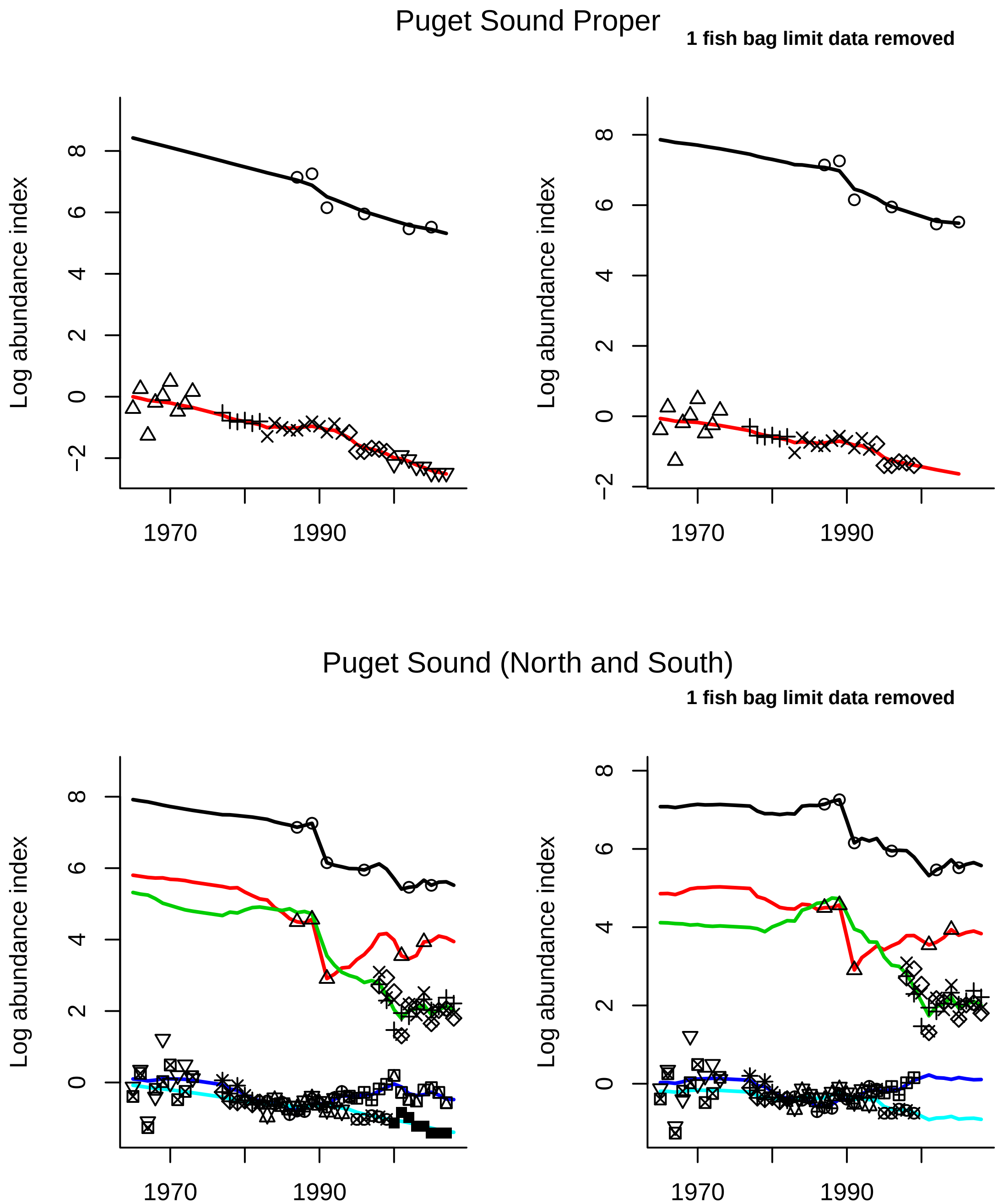


Figure 19: The model estimates for the total rockfish trajectories measured by each data source for the analysis where different data sources are allowed to be measuring independent realizations of the population process. Mathematically, each gear i is modeled as $log(X_{t,i}) = a + log(X_{t-1,i}) + e_{t,i}; log(Y_{t,i}) = log(X_{t,i}) + g_{t,i}$ trajectory, where a is the shared mean population growth term (same across data sources), $e_{t,i}$ are the independent process error terms which are drawn from a normal with mean 0 and variance σ_i, and $g_{t,i}$ are the observations errors data source i. The goal of the analysis is to find the shared a that is most consistent with all the data. The analyses with and without the 1 fish bag limit data are shown.

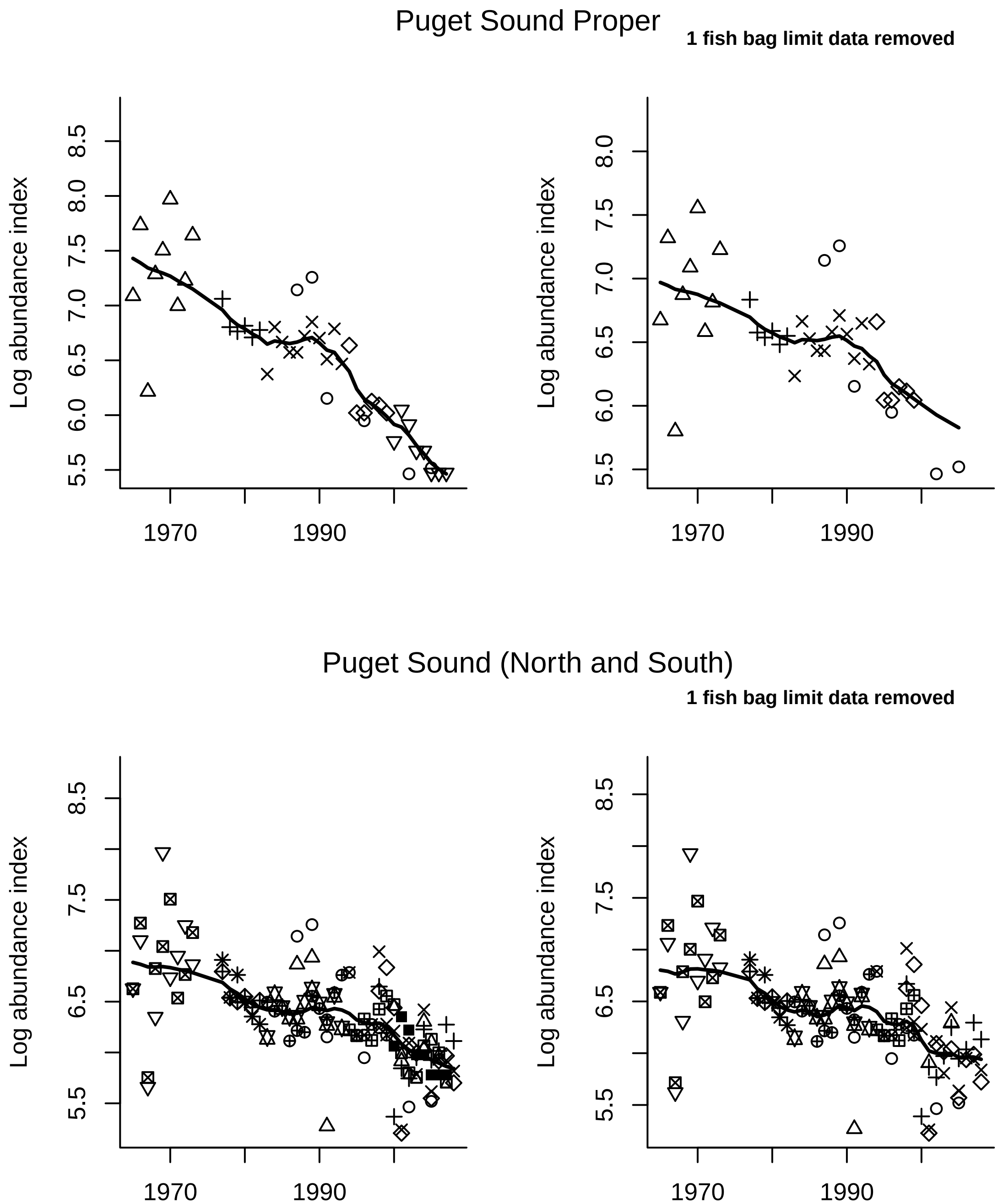


Figure 20: The model estimates for the 'total rockfish' trajectories measured by each data source for the analysis where different data sources are forced to be measuring the same population process. Mathematically, each gear i is modeled as $log(X_t) = a + log(X_{t-1}) + e_t; log(Y_{t,i}) = log(X_t) + g_{t,i}$ trajectory, where a is the mean population growth term for the single population process, e_t are the independent process error terms drawn from a normal with mean 0 and variance σ, and $g_{t,i}$ are the observation errors for data source i. The goal of the analysis is to find the population trajectory that is most consistent with all the data. The analyses with and without the 1 fish bag limit data are shown.

A Supplementary section 1: Issues pertaining to the species composition data

Washington State Sport Catch Reports (1975-1986) The data from these reports total bottomfish catch by hook and line by punch card area. The data are presented by species and include all five species of rockfish in the petition. The report does not include catch by divers or shore/pier anglers). No information is provided on the methods by which the numbers were derived, however we assume that data are derived from punch card catches as data >1980 are adjusted downward to account for statistical bias from methodology (as is done in other reports working with punch card data). No distinction is made between bottomfish specific vs bottomfish catches incidental to salmon fishery. In many years, some punch card areas are listed with only 2 or 3 rockfish species with no listing for "Other rockfishes", whereas the same areas have many more species in later surveys. This suggests that data were recorded on species in an idiosyncratically and inconsistently. The large amount of noise in the frequency data suggests the same. Note that harvest numbers of some species (e.g., Bocaccio and Canary rockfish) are much higher than in any subsequent published reports.

Bargmann (1977) and Buckley (1967, 1968, 1970) These reports summarize bottomfish specific and incidental (salmon angler) catch of bottomfish in catch areas 4-12 by month in 1965-73 using punch card data. The total catch estimates are derived from formulas used to estimate bottomfish angler effort and catch from the more thorough sampling done for the salmon fishery. The data cover only hook and line catch and do not cover dock, jetty, or shore anglers. The species data shows many of the same patterns seen in the Washington State Sport Catch Reports, which suggests that species reporting was not being done in a consistent fashion from year to year or punch card area to area. Indeed, the authors note that positive identification of individual rockfish species is spotty in some areas and often noted as "Rockfish". However the "Rockfish" category was not consistently reported every year. The reports include all five species in the petition, although this varies greatly between years and catch record areas.

Palsson, W. A. 1988 This publication is a comprehensive summary of catch data from 1970-1985 and includes all the petitioned species (except Greenstriped and Redstripe rockfish, which were presumably pooled into misc/unidentified rockfish). The publication includes data previously published by Bargmann (Bargmann, 1977). The "Estimation Procedures" section of the publication reviews the many limitations of Puget Sound data, including relatively low sampling percentages (as compared to coastal fisheries), large increments of unidentified rockfish, and dependence of total catch estimates on expansion factors from the recreational salmon fishery. As in previous publications, the estimates do not include catch by divers, shore and pier anglers. Catch estimates since 1981 for catch areas 5-13 were adjusted downward by multiplying 0.833 following previously established punch card methodology to correct for the assumed bias of 20% in the punch card samples. Species composition data reported from WDFW dockside samplers were modified using species compositions from the MRFSS sampling data, when available, because these were considered more reliable. The corrections involved identifications pooled over six years of survey data. These species composition correction factors are not included in the document.

Palsson, W.A., T. Tsou, G.G. Bargmann, R.M. Buckley, J.E. Westttt, M.L. Mills, Y.W. Cheng, and R.E. Pacunski. Draft document (2008). This publication is a comprehensive review of the history, data sources, research, management, trends, and conservation efforts associated with rockfish resources in Puget Sound. Recreational rockfish catch by species (including all petitioned species except Bocaccio) is presented from 2004-2007 in terms of pounds of fish harvested or released in two major management regions (north and south Puget Sound). The text provides a summary of species composition information (section 6.4.2.2) that highlights range of reliable species composition information for recreational species, and also includes some discussion of MRFSS data collection procedures (see below), with graphs of MRFSS species composition by north and south Puget Sound management regions (Figures 6.9 and 6.10); the five petitioned species are presumably pooled into "other rockfish" category.

Species composition estimates from commercial fisheries are presented in Tables 6.1 and 6.2. This includes the 1970-1986 observations described in Pedersen and Bargmann (1986) (and used in Schmitt et al. (1991)). The tables also include subsequent observations from 1988, 1989, 1991, and 1993, when the last commercial rockfish compositions were taken. Information on the sample sizes and distribution of these samples is not given.

Marine Recreational Fisheries Statistical Survey (MRFSS). This is a federal survey occurring in Washington State from 1980-86, 1989, and 1996-2002 that used telephone and creel surveys to estimate state-wide catch and effort for boat and shore-based recreational fisheries, including harvest by SCUBA divers. It also estimated released and discarded catch, and entails extensive training of samplers in marine species identification. The MRFSS survey catch estimates for bottomfish are notably different than the estimates of the WDFW survey that were derived using salmon fishery data. This may be associated with the collection of fewer interviews and difficulties in apportioning harvest by coast/Puget Sound. We have not yet been able to review these data extensively for the BRT.

WDFW trawl survey data. Palsson et al. (2008) These data provide catch records, biological data, and trawl effort/location from annual surveys throughout Puget Sound from 1987-2008 (>1500 trawls). The data includes records for four species of the petitioned species (no Bocaccio rockfish), including biological records (length/wgt info) for Canary (n=25), Greenstriped (n=481), Redstripe (n=484), and Yelloweye (n= 10) rockfish. Effort is distributed unevenly at various levels over all geographic areas over time. This complicates temporal density/abundance trend estimation of some species. In addition, the sample sizes are low relative to the infrequent and clumped occurrence of the petitioned species. This leads to high sensitivity to outliers. Specifically, the high Redstripe rockfish estimates in recent years are driven by outlier trawls (single trawl samples with high numbers of Redstripe rockfish).

Schmitt, C., S. Quinnell, M. Rickey, and M. Stanley 1991 This source contains commercially trawled species weight by area for Bocaccio, Yelloweye, and Canary rockfish for 1970 to 1987. However, note that all numbers are based on a single percent composition estimate made in one year (Pedersen and Bargmann, 1986) that was then applied to all the "Rockfish" category of landings from 1970-87.

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