

Environmental Component and The Pacific Sardine Harvest Guideline

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The Coastal Pelagic Species Fisheries Management Plan (CPS FMP) Harvest Guideline is computed through a formula. (#2 Harvest Guideline) The formula uses an environmental component. This component is based on the sea surface temperature (C) recorded at Scripps Pier, La Jolla CA. using a three-year running average. (Figure 6.)

A Fraction is determined for use in the formula. (#3 Fraction) Using this fraction with the formula (#2 Harvest Guideline) determines the sardine harvest. The harvest fraction is capped at a 15% rate and falls to a 5% rate. (Figure 11)

We believe there are four major faults with the environmental component, fraction and harvest guideline.

1. The use of the sea surface temperature at Scripps Pier does not reflect the health of the entire sardine region.
2. The cutoff temperature, which affects the exploitation rate of 15% to 5%, is arbitrary and capricious.
3. The sharp drop from 15% harvest to 5% harvest is careless and severally affects the industry dependent on the sardine.
4. The harvest cap of 15% in the Oregon and Washington fisheries is constrictive. The fishery is not fishing on juveniles. Oregon and Washington fish on an age class of sardine about three years and older, then California. The fraction for Oregon and Washington fish should be 30% as the mackerel fishery is, not 15% going to 5%.

We have modeled the historic harvest using the CPS FMP. The model uses the average yearly temperatures at Scripps Pier, three year running average and a breakdown of what the harvest rate would have been for those years. This model shows the formula would have severally restricted some years we know were expansion years (1916 – 1936, 3.3 Fishing Industry) If the Harvest Guideline formula is allowed to continue, using the environmental component as is, we can expect years of a 5% harvest on a fishery that may be expanding. This is negligent to the industry dependent on sardine.

Fraction Formula

Fraction	Number	T2	Number	Temp at S	Number
15.13%	0.24864981	296.1841	8.190043975	17.21	67.4558326
15.00%	0.24864981	296.0670836	8.190043975	17.2066	67.4558326
11.38%	0.24864981	292.41	8.190043975	17.1	67.4558326
10.00%	0.24864981	290.8559703	8.190043975	17.0545	67.4558326
6.10%	0.24864981	285.61	8.190043975	16.9	67.4558326
5.09%	0.24864981	283.9225	8.190043975	16.85	67.4558326
5.00%	0.24864981	283.7708703	8.190043975	16.8455	67.4558326

Historic harvest using CPS formula

Year	Temp at Scripps Pier	3 rear running average	15% harvest Rate <17.2066	Between	5% harvest rate >16.8455	Growing stock	Landings
1916						X	CAL
1917	16.68					X	CAL
1918	17.35					X	CAL
1919	16.87			1		X	CAL
1920	16.55	16.967		1		X	CAL
1921	16.55	16.923			1	X	CAL
1922	16.48	16.657			1	X	CAL
1923	17.36	16.527			1	X	CAL
1924	16.55	16.797			1	X	CAL
1925	17.01	16.797		1		X	CAL
1926	18.07	16.973				X	CAL
1927	16.87	17.210	1			X	CAL
1928	16.73	17.317	1			X	CAL&CN
1929	17.18	17.223	1			X	CAL&CN
1930	17.45	16.927		1		X	CAL&CN
1931	18.5	17.120		1		X	CAL&CN
1932	16.31	17.710	1			X	CAL&CN
1933	15.65	17.420	1			X	CAL&CN
1934	17.52	16.820			1	X	CAL&CN
1935	16.71	16.493			1	X	CAL&CN
1936	17.61	16.627			1	X	CAL&CN
1937	17.04	17.280	1			X	CA CN & OR
1938	16.68	17.120		1		X	CA CN & OR
1939	17.18	17.110		1		X	WA CA CN & OR
1940	17.36	16.967		1		X	WA CA CN & OR
1941	17.66	17.073		1		X	WA CA CN & OR
1942	17.01	17.400	1			X	WA CA CN & OR
1943	17	17.343	1			X	WA CA CN & OR
1944	16.49	17.223			1	X	WA CA CN & OR
1945	16.61	16.833			1	X	WA CA CN & OR
1946	16.83	16.700			1	X	WA CA CN & OR
1947	16.88	16.643			1	X	WA CA CN & OR
1948	16.08	16.773			1	X	WA CA CN & OR
1949	16.53	16.597			1	X	WA CA CN & OR
		16.497			1	X	WA CA CN & OR

Historic harvest using CPS formula

Year	Temp at Scripps Pier	3 rear running average	15% harvest Rate	Between	5% harvest rate	Growing stock	Landings
1950	16.4	16.337			1		
1951	16.62	16.517			1		
1952	16.28	16.433			1		
1953	16.25	16.383			1		
1954	16.86	16.463			1		
1955	16.49	16.533			1		
1956	16.37	16.573			1		
1957	17.36	16.740			1		
1958	17.85	17.193		1			
1959	18.37	17.860	1				
1960	16.62	17.613	1				
1961	16.53	17.173		1			
1962	16.24	16.463			1		
1963	16.96	16.577			1		
1964	16.43	16.543			1		
1965	16.52	16.637			1		
1966	17.01	16.653			1		
1967	16.93	16.820			1		
1968	16.94	16.960		1			
1969	16.65	16.840			1		
1970	16.63	16.740			1		
1971	16.19	16.490			1		
1972	16.88	16.567			1		
1973	16.46	16.510			1		
1974	16.47	16.603			1		
1975	15.53	16.153			1		
1976	17.26	16.420			1		
1977	17.26	16.683			1		
1978	17.42	17.313	1				
1979	16.85	17.177		1			
1980	16.62	16.963		1			
1981	17.62	17.030		1			
1982	17.12	17.120		1			
1983	17.97	17.570	1			X	Cal
1984	18.31	17.800	1			X	Cal
1985	17.21	17.830	1			X	Cal

Historic harvest using CPS formula

Year	Temp at Scripps Pier	3 rear running average	15% harvest Rate	Between	5% harvest rate	Growing stock	Landings	
1986	17.72	17.747	1			X	Cal	
1987	17.56	17.497	1			X	Cal	
1988	16.99	17.423	1			X	Cal	
1989	17.18	17.243	1			X	Cal	
1990	17.88	17.350	1			X	Cal	
1991	16.97	17.343	1			X	Cal	
1992	18.24	17.697	1			X	Cal	
1993	18.27	17.827	1			X	Cal	
1994	18	18.170	1			X	Cal	
1995						X	Cal	
1996						X	Cal	
1997						X	Cal	
1998		18.450	1			X	Cal CN	
1999		18.200	1			X	Cal CN	
2000		17.800	1			X	CA CN & OR	
2001		17.050	1			X	WA CA CN & OR	
2002		17.300	1			X	WA CA CN & OR	
2003			1			X	WA CA CN & OR	
2004			1			X	WA CA CN & OR	
Totals for years							83	
			31	16	36			
			37.35%	19.28%	43.37%			

Note: 2002 was threatened with a reduced harvest because of the environmental component. The cutoff temperature is 17.2066 thus 2002 was close to being restricted from the 15% rate of harvest.

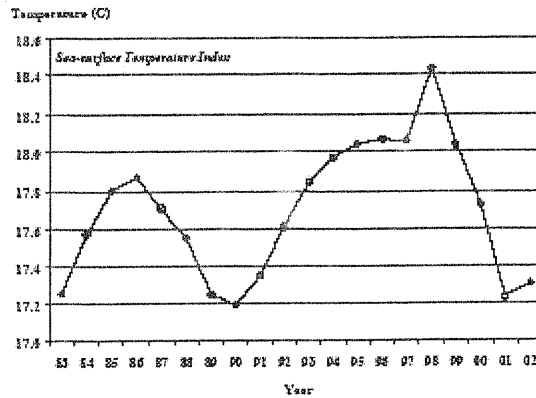


Figure 6. Time series of sea-surface temperature (C) recorded at Scripps Pier, La Jolla, CA (1983-02). Annual estimates reflect 3-year 'running' averages, see Jacobson and MacCall (1995).

#2 Harvest Guideline

$$HG_{2003} = (\text{TOTAL STOCK BIOMASS}_{2002} - \text{CUTOFF}) \cdot \text{FRACTION} \cdot \text{U.S. DISTRIBUTION},$$

where HG_{2003} is the total U.S. (California, Oregon, and Washington) harvest guideline recommended for 2003, $\text{TOTAL STOCK BIOMASS}_{2002}$ is the estimated stock biomass (ages 1+) from the current assessment conducted in 2002 (see above), CUTOFF is the lowest level of estimated biomass at which harvest is allowed, FRACTION is an environment-based percentage of biomass above the CUTOFF that can be harvested by the fisheries (see below), and U.S. DISTRIBUTION is the percentage of $\text{TOTAL STOCK BIOMASS}_{2002}$ in U.S. waters.

#3 Fraction

The value for FRACTION in the MSY control rule for Pacific sardine is a proxy for F_{msy} (i.e., the fishing mortality rate that achieves equilibrium MSY). Given F_{msy} and the productivity of the sardine stock have been shown to increase when relatively warm-water ocean conditions persist, the following formula has been used to determine an appropriate (sustainable) FRACTION value:

$$\text{FRACTION or } F_{\text{msy}} = 0.248649805(T^2) - 8.190043975(T) + 67.4558326,$$

where T is the running average sea-surface temperature at Scripps Pier, La Jolla, California during the three preceding years. Ultimately, under Option J (PFMC 1998), F_{msy} is constrained and ranges between 5% and 15% (Figure 11).

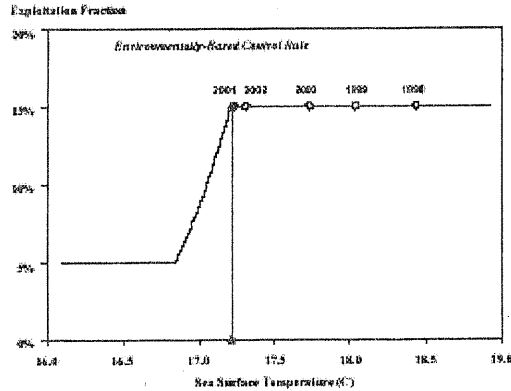


Figure 11. Environmentally-based harvest rate control rule for Pacific sardine as specified in the Coastal Pelagic Species Fishery Management Plan (PFMC 1998). For any given year, sea surface temperature (X-axis) is the running average sea surface temperature at Scripps Pier (La Jolla, CA) during the three preceding years. The exploitation fraction (Y-axis), which can range between 5-15%, is an explicit part of the algorithm used to determine the annual harvest guideline (quota) for the coastwide U.S. fishery – see Table 4. Open circles illustrate the sea surface temperature and exploitation fraction for recent years (1998-2002).

3.3 Fishing Industry

The sardine fishery was first developed in response to demand for food during World War I. Landings increased from 1916 to 1936, and peaked at over 700,000 mt. The Pacific sardine supported the largest fishery in the western hemisphere during the 1930s and 1940s, with landings along the coast in British Columbia, Washington, Oregon, California, and Mexico. The fishery declined, beginning in the late 1940s and with some short-term reversals, to extremely low levels in the 1970s. There was a southward shift in the catch as the fishery decreased, with landings ceasing in the northwest in 1947 through 1948, and in San Francisco in 1951 through 1952. Sardine were primarily used for reduction to fish meal and oil, and as canned food, with small quantities taken for live bait. An extremely lucrative dead bait market developed in central California in the 1960s.

In the early 1980s, sardine began to be taken incidentally with Pacific (chub) mackerel and jack mackerel in the Southern California mackerel fishery and was primarily canned for pet food, although some were canned for human consumption. As sardine continued to increase in abundance, a small directed fishery was reestablished in California in 1986. As biomass continued to increase, the directed fishery was expanded. During the 1990s, landings averaged almost 42,000 short tons per year. By the late 1990s the sardine fishery had expanded coastwide, with active fisheries off Oregon, Washington, and British Columbia.

