The following supplement accompanies the article

Changes in California Chinook salmon diet over the past 50 years: relevance to the recent population crash

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Supplementary methods

In 2005, 2006 and 2007, in addition to the Gulf of the Farallones (GOF), a small number of salmon stomach samples were also collected as far south as Santa Cruz (36°57'N, 122°1'W) and as far north as Bodega Bay (38°18'N, 123°3'W). These samples outside the GOF were not excluded since they were extremely uniform in relation to samples within the GOF and only served to reinforce differences in diet diversity between decades (i.e. lower diversity over a larger sampling area in the mid-2000s).

Minor consequences of freezing versus formalin as different salmon stomach storage techniques (slightly smaller volume estimates due to shrinkage in formalin; Duffy & Jackson 1986) were further diminished by our use of a diet index incorporating number and frequency of occurrence of prey in addition to volume, the geometric index of importance (GII). Although use of slightly different techniques may not be ideal, this is commonly encountered when comparing among datasets, including other studies of salmon diet (Brodeur 1991, Brodeur et al. 2007).

Mean annual salmon size range in our study was 424 to 734 mm FL (mean 564 mm; Table S5), corresponding to adult sizes (Daly et al. 2009, Hunt et al. 1999, Wells et al. 2007). Salmon lengths varied significantly from 1955 to 2007 (Quadratic regression of May through August samples: $\beta = -1306.0$, $R^2 = 0.95$, $p < 0.001$, $n = 11$ years), as did weight (see PMFC data 1975 to 2007, available at www.pcouncil.org/salmon/stock-assessment-and-fishery-evaluation-safe-documents/review-of-2011-ocean-salmon-fisheries; linear regression of May through August samples: $\beta = 0.11$, $R^2 = 0.36$, $p = 0.0003$, $n = 32$ years). Salmon size varies with environment (Wells et al. 2007) and we could not control for that, although diet of Chinook salmon in the size class range of our samples was likely not different (see Daly et al. 2009).

For diet analysis, percent frequency of occurrence (%FO) was inferred from 1955 data (Merkel 1957) by scaling mass and number data given in Merkel's Table 2, multiplying this by the total number of stomachs for each prey type, and then dividing this by the monthly stomach sample size. Percent FO was calculated directly from stomach sample data in 1980 to 1986 and 2005 to 2007. In 1955 and 1980 to 1986, total volume (%VOL) was estimated directly from stomach samples. In 2005 to 2007, prey was weighed and weights were then converted to volume using a general but robust conversion factor for volume to weight of 1.1:1.0 (Link & Almeida 2000). Volume percentages were standardized using estimates of gut fullness (Markaida & Sosa-Nishizaki 2003), by multiplying these 2 parameters.

Table S1. *Oncorhynchus tshawytscha.* May–August totals, by year, for number of Chinook salmon stomachs sampled, percent of empty stomachs, and number of prey by group. Note that samples in 1985 were taken only in May and June

Prey	1955	1980	1981	1982	1983	1984	1985	1986	2005	2006	2007
N	387	245	425	544	397	465	265	269	1250	184	134
Empty stomachs (%)	9	3	3	1	11	0.2	0.4	1	20	23	24
Northern anchovy	57	213	390	389	717	936	235	364	1757	259	167
Sebastes spp.	212	117	1186	667	0	478	1222	87	0	0	0
Euphausiid krill	97	13666	2259	25263	8	10272	6698	18101	10769	4065	1663
Pacific sardine	0	0	0	0	0	0	0	0	327	36	20
Cancer megalopae	29	68	1636	1098	2	204	10428	7	106	0	45
Pacific herring	18	12	24	189	27	34	0	4	0	0	0
Market squid	32	2	4	13	1	1	0	2	5	0	0
Other crustaceans	3	8	5	3	74	3	3	0	4	0	0
Other cephalopods	9	1	3	3	1	3	4	2	0	0	0
Other invertebrates	0	4	29	0	2	1	0	0	0	0	0
Other fish	48	4	4	3	17	163	14	5	13	8	2
Unknown fish	129	60	314	82	51	18	6	17	848	108	99
Unidentified	0	0	2	0	0	0	0	0	16	0	1

Table S2. *Oncorhynchus tshawytscha.* Percent frequency occurrence of prey in Chinook salmon stomachs in summer (May–Aug) of 1955, 1980–1986, and 2005–2007

General group	1955	1980	1981	1982	1983	1984	1985	1986	2005	2006	2007
Northern anchovy	16%	37%	36%	29%	75%	67%	30%	51%	51%	47%	45%
Sebastes spp.	60%	14%	46%	27%	0%	21%	53%	9%	0%	0%	0%
Euphausiid krill	27%	35%	12%	49%	1%	16%	28%	41%	6%	8%	9%
Pacific sardine	0%	0%	0%	0%	0%	0%	0%	0%	18%	15%	10%
Cancer megalopae	8%	4%	3%	3%	1%	3%	30%	1%	0.2%	0%	4%
Pacific herring	5%	5%	5%	13%	6%	5%	0%	1%	0%	0%	0%
Market squid	9%	1%	1%	2%	0%	0%	0%	1%	0.3%	0%	0%
Other crustaceans	1%	2%	1%	1%	12%	1%	1%	0%	0.2%	0%	0%
Other cephalopods	3%	0%	1%	1%	0%	1%	1%	1%	0%	0%	0%
Other invertebrates	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%
Other fish	14%	2%	1%	1%	3%	2%	3%	1%	1%	4%	2%
Unknown fish	37%	21%	47%	17%	36%	7%	4%	11%	38%	29%	42%
Unidentified	0%	1%	71%	4%	46%	12%	11%	6%	1%	0%	1%

Table S3. *Oncorhynchus tshawytscha.* Percent volume of prey in Chinook salmon stomachs in summer (May–Aug) of 1955, 1980–1986, and 2005–2007

General group	1955	1980	1981	1982	1983	1984	1985	1986	2005	2006	2007
Northern anchovy	13%	49%	49%	41%	81%	57%	20%	42%	66%	59%	60%
Sebastes spp.	44%	7%	32%	14%	0%	17%	35%	6%	0%	0%	0%
Euphausiid krill	21%	31%	2%	30%	0%	8%	21%	38%	4%	12%	9%
Pacific sardine	0%	0%	0%	0%	0%	0%	0%	0%	27%	27%	28%
Cancer megalopae	2%	0.3%	1%	1%	0.02%	0.03%	24%	0.001%	0.004%	0%	0.02%
Pacific herring	5%	5%	7%	7%	7%	4%	0%	1%	0%	0%	0%
Market squid	10%	0.4%	1%	3%	0.5%	0.01%	0%	0.2%	0.1%	0%	0%
Other crustaceans	0%	0.2%	0.001%	0.01%	1%	0.04%	0.01%	0%	0%	0%	0%
Other cephalopods	0%	0.2%	0.1%	0.2%	0.04%	0.01%	0.2%	0.01%	0%	0%	0%
Other Invertebrates	0%	0.002%	0.002%	0%	0.1%	0.0004%	0%	0%	0%	0%	0%
Other fish	2%	2%	1%	0.1%	2%	4%	0.1%	0.1%	1%	4%	0%
Unknown fish	2%	6%	3%	2%	4%	7%	0.1%	8%	7%	9%	10%
Unidentified	0%	0.1%	3%	0.4%	4%	3%	0.2%	4%	5%	0%	3%

Table S4. *Oncorhynchus tshawytscha.* Monthly sample sizes for May–August Chinook salmon stomachs.

Low sample sizes did not represent lack of sampling effort, but simply low numbers of salmon captured during those months. Note that samples in 1985 were taken only in May and June

Year	May	June	July	August
1955	71	119	88	109
1980	29	71	86	59
1981	97	118	155	55
1982	151	149	127	117
1983	217	142	35	3
1984	93	187	175	10
1985	194	71	n/d	n/d
1986	58	69	92	50
2005	179	388	458	225
2006	55	82	18	29
2007	53	34	38	9

Table S5. *Oncorhynchus tshawytscha.* Mean annual size (fork length; FL) of Chinook salmon sampled (1955, 1980–1986, and 2003–2007)

Year	May–Aug FL (mm)
1955	668
1980	518
1981	478
1982	484
1983	424
1984	473
1985	512
1986	497
2005	711
2006	706
2007	734

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