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Updated Forage Ratio Estimates for 2000 and 2008

Brian Fadely
Jim Ianelli
Angie Grieg
Martin Dorn
Lowell Fritz
Libby Logerwell

Steller sea lion consumption

Steller sea lion consumption requirements were estimated following the analysis used in NMFS (2001), but updated with more recent information on population structure, diet composition, and prey quality. Similarly, the consumption requirements for 2000 presented in NMFS (2001) were recalculated using the recent estimates of prey composition and quality, and of likely age-sex distributions based on new survival data. As in NMFS (2001), the bioenergetic model of Winship (2001), and subsequently described in Winship et al. (2002), served as the basis for estimating Steller sea lion consumption requirements. In contrast to the 2001 model which took a consumption estimate for the western stock and stratified that among the three regions, here an age-structured population estimate was calculated for each region to calculate region-specific requirements.

Annual Steller sea lion diet composition estimates were taken from Winship et al. (2003). From that table, the Gulf of Alaska proportions were used directly, the “Eastern Aleutian Islands” proportion was used for the Bering Sea, and the “Central Aleutian” and “Western Aleutian” Island proportions were averaged to derive the Aleutian Island estimate used in this analysis. The estimate was applied throughout the year, and thus did not vary by season. Proportions of gadids and Atka mackerel in the diet on an annual basis were assumed to be: Gulf of Alaska 66.5% gadids and 0.3% Atka mackerel; Eastern Bering Sea 32.9% gadids and 30.7% Atka mackerel; and Aleutian Islands 15% gadids and 65.2% Atka mackerel. Prey energy densities were taken as the midpoint between the low-high ranges presented in Winship et al. (2003) and varied by season but not region.

Age-sex structured population estimates for each area were calculated using estimates of age-sex-region specific survival through age 9 from brand-sighting studies initiated in 2000 (NMML, unpublished data; assumed slowly declining survival for females and faster declining survival for males for ages 9+ for a stable age distribution (Calkins and Pitcher 1982; Trites and Larkin 1992), an initial natality schedule from the central Gulf of Alaska from the 1970s (Holmes et al. 2007), the pup production estimate in each region for 2009, and the estimated population rate of change from 2000 to 2008 for non-pups in each region. Lotka population models for each region were constructed using the region-sex-age specific survivorships, and tuned to the 2009 pup count and non-pup population growth rate in each

region by changing age-specific natality. For the Aleutian Island region (where there are no recent age-specific survival data), Ugamak Island survival data were used and sex-specific survival factors (along with a natality factor) were estimated to fit the overall regional growth rate in the 2000s and the 2009 pup production estimate.

Regional annual groundfish consumption was estimated by calculating the monthly energy requirement for each age-sex group from the models of Winship et al. (2002), multiplying by the numbers of sea lions within each group (described above), and converted to a biomass requirement based on the diet composition, quality, and assimilation efficiency then summed across an entire year. Estimates of annual groundfish consumption for 2000 are shown as:

A) As presented in the 2001 Biological Opinion (NMFS 2001). Regional estimates were obtained by stratifying an estimate for annual pollock, cod and Atka mackerel consumption by the entire western stock of Steller sea lions.

B) The 2000 annual consumption estimate using the 2010 model, which allowed derivation of region-specific consumption estimates and used survival data not available in 2000 to create an age-sex structure for the sea lion populations.

Fish biomass

Trawl survey data from the three regions: Gulf of Alaska (GOA), eastern Bering Sea (EBS), and Aleutian Islands (AI) for the Aleutian Islands were used to characterize the distribution of pollock, Pacific cod, Atka mackerel biomass in summer. The surveys are divided into strata that reflect depth, habitat, and management area. For each stratum, the area proportion of area that fell within critical habitat was computed. Area-swept biomass estimates from each stratum were then allocated proportionally according to the area within critical habitat. To reduce the effect of sampling errors associated with trawl sampling for relatively small strata, the three most relevant years were used as shown in the third row of Table 1 along with area-swept biomass estimates by species (inside of CH, total, and percentage inside CH). As an alternative consideration, the proportion of summer biomass in critical habitat expanded to the stock assessment (where available) by regions is given in Table 2.

Estimates of biomass of all groundfish species in the Eastern Bering Sea are from the annual stock assessments (Ianelli pers. com.). Estimates of groundfish in the Aleutian Islands are from trawl survey biomass data, the 2008 value was based on the average between the 2006 and 2010 surveys (Ianelli pers. com.). Estimates of groundfish biomass in the Gulf of Alaska are from an ecosystem model (Gaichas pers. com.).

Table 1. Average trawl survey biomass estimates within critical habitat (and the percentage of the total biomass) for the three management regions. Note that for the Gulf of Alaska and the Aleutian Islands the data are on a biennial basis. *Note sub-totals may be subject to rounding error.*

Region:		Aleutian Islands		EBS		GOA	
Year:		2000	2008	2000	2008	2000	2008
Survey years used:		1997, 2000, 2002	2004, 2006, 2010	1999-2001	2007-2009	1996, 1999, 2001	2005, 2007, 2009
Inside	Atka mackerel	504,751	735,179	11	25	99,954	69,982
CH	Pacific cod	87,684	163,693	58,098	46,354	210,878	236,456
t	Pollock	194,126	207,308	282,329	185,416	324,790	270,408
	Total	786,562	1,106,180	340,438	231,795	635,623	576,846
All	Atka mackerel	606,640	880,434	55	199	190,671	106,288
Area	Pacific cod	100,107	176,386	663,664	576,518	367,393	431,350
t	Pollock	209,688	225,027	4,428,009	3,020,546	526,606	467,016
	Total	916,434	1,281,846	5,091,728	3,597,262	1,084,671	1,004,654
In	Atka mackerel	83%	84%	20%	12%	52%	66%
CH	Pacific cod	88%	93%	9%	8%	57%	55%
%	Pollock	93%	92%	6%	6%	62%	58%
	Total	86%	86%	7%	6%	59%	57%

Table 2. Estimated summer biomass in critical habitat based on stratum-specific trawl-survey apportionments of biomass (averaged over the three most recent surveys, Table 1) and applied to the survey estimate (shaded cells) or biomass estimates for 2000 and 2008 from the 2009 SAFE reports (unshaded).

2000				
Region	Biomass in critical habitat			
	Atka mackerel	Pacific cod	Pollock	Total
Gulf of Alaska	504,751	213,494	353,404	612,320
Eastern Bering Sea	11	128,337	614,135	742,026
Aleutian Islands	349,125	210,878	180,251	602,502

2008				
Region	Biomass in critical habitat			
	Atka mackerel	Pacific cod	Pollock	Total
Gulf of Alaska	735,179	260,671	349,144	659,442
Eastern Bering Sea	25	80,316	233,815	309,806
Aleutian Islands	429,751	236,456	268,371	836,779

Forage ratios

The resulting forage ratios and multipliers for 2000 and 2008 are shown in Tables 3 and 4. Table 3 shows the ratios calculated from sea lion consumption of walleye pollock, Pacific cod and Atka mackerel and all groundfish biomass from all areas. This most closely duplicated the forage ratio estimates presented in NMFS (2001). Table 4 shows the ratios calculated from sea lion consumption and biomass of walleye pollock, Pacific cod and Atka mackerel in Critical Habitat only. The groundfish biomass, sea lion

consumption, and forage ratios in the Aleutian Islands by management area are presented in Tables 5 and 6.

Table 3. Forage required by Steller sea lions (walleye pollock, Pacific cod and Atka mackerel only) and all groundfish biomass in all areas for the Aleutian Islands, Eastern Bering Sea and Gulf of Alaska for the years 2000 and 2008, in metric tons. Sea lion consumption (A) and fish biomass are as presented in the 2001 Biological Opinion (NMFS 2001). Sea lion consumption (B) used the 2010 model, which allowed derivation of region-specific consumption estimates and used survival data not available in 2000 to create an age-sex structure for the sea lion populations, and 2010 fish biomass estimates.

	2000				2008			
	SSL annual consumption (A)	Fish biomass	Ratio	Multiplier	SSL annual consumption	Fish biomass	Ratio	Multiplier
Aleutian Islands	130,296	1,468,608	0.090	11	105,153	2,742,811	0.038	26
Eastern Bering Sea	41,508	18,517,619	0.002	446	72,047	14,493,089	0.005	201
Gulf of Alaska	213,695	3,630,482	0.060	17	230,072	5,551,756	0.041	24

	2000				2008			
	SSL annual consumption (B)	Fish biomass	Ratio	Multiplier	SSL annual consumption	Fish biomass	Ratio	Multiplier
Aleutian Islands	109,960	2,066,348	0.053	19	105,153	2,742,811	0.038	26
Eastern Bering Sea	51,314	16,514,082	0.003	322	72,047	14,493,089	0.005	201
Gulf of Alaska	166,432	4,393,419	0.038	26	230,072	5,551,756	0.041	24

Table 4. Forage required by Steller sea lions and walleye pollock, Pacific cod and Atka mackerel biomass in Critical Habitat for the Aleutian Islands, Eastern Bering Sea and Gulf of Alaska for the years 2000 and 2008, in metric tons. Sea lion consumption (B) used the 2010 model, which allowed derivation of region-specific consumption estimates and used survival data not available in 2000 to create an age-sex structure for the sea lion populations.

	2000				2008			
	SSL annual consumption (B)	Fish biomass	Ratio	Multiplier	SSL annual consumption	Fish biomass	Ratio	Multiplier
Aleutian Islands	109,960	602,502	0.18	5	105,153	836,779	0.13	8
Eastern Bering Sea	51,314	742,026	0.07	14	72,047	309,806	0.23	4
Gulf of Alaska	166,432	612,320	0.27	4	230,072	659,442	0.35	3

Table 5. Summer bottom-trawl survey estimates of groundfish biomass (t) by year and average for the Aleutian Islands region 541.

Groundfish species	2002	2004	2006	Average
Atka mackerel	190,817	244,043	350,206	261,689
Pacific ocean perch	109,795	137,112	190,752	145,886
Giant grenadier	204,524	181,188	154,988	180,233
Walleye pollock	54,634	112,040	69,996	78,890
Arrowtooth flounder	49,105	42,263	126,923	72,764
Pacific cod	25,241	51,851	43,349	40,147
Pacific halibut	18,481	22,639	18,248	19,789
Kamchatka flounder	21,729	11,287	16,157	16,391
Northern rockfish	3,242	10,375	22,982	12,200
Other	56,178	63,712	96,345	72,078
	733,745	876,511	1,089,946	900,067

Table 6. Summary of ratios of biomass of all groundfish and biomass of pollock, Pacific cod and Atka mackerel with estimates of sea lion consumption by Aleutian Islands management region.

Area	All groundfish (kt)	Consumption (kt/yr)	Ratio	Pollock, cod, Atka mackerel (kt)	Ratio
543	721.7	17.8	40.6	464.5	26
542	702.3	53	13.2	285.3	5
541	900.0	59.5	15.1	267.2	4

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