

22. Assessment of the Octopus Stock Complex in the Bering Sea and Aleutian Islands

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Executive Summary

The Bering Sea/Aleutian Islands octopus complex is assessed on a biennial stock assessment schedule with full assessments provided in even years. In odd years we present an executive summary to recommend harvest levels for the next two years. The last full assessment was conducted in 2014 (Conners *et al.* 2014 , <http://www.afsc.noaa.gov/REFM/Docs/2014/BSAIOcto.pdf>).

Through 2010, octopuses were managed as part of the BSAI “other species” complex, along with sharks, skates, and sculpins. Historically, catches of the other species complex were well below TAC and retention of other species was small. However, due to recent increased market values, retention of some of the other species complex members increased. Beginning in 2011, the BSAI Fisheries Management Plan was amended to provide separate management for sharks, skates, sculpins, and octopus and set separate catch limits for each species group. Catch limits for octopus for 2011 and 2012 were set using Tier 6 methods based on the maximum historical incidental catch. In 2012, a new methodology based on consumption of octopus by Pacific cod was introduced (Conners *et al.* 2012); this method was accepted and used for 2013-2015. The same method is recommended for use in 2016-2017. The consumption estimate has not been revised from 2012; the authors plan to revisit this calculation for the full 2016 assessment.

In this assessment, all octopus species are grouped into one assemblage. At least seven species of octopus are found in the BSAI. The species composition of the octopus community is not well documented, but data indicate that the giant Pacific octopus *Enteroctopus dofleini* is most abundant in shelf waters and predominates in commercial catch. Octopuses are taken as incidental catch in trawl, longline, and pot fisheries throughout the BSAI; a portion of the catch is retained or sold for human consumption or bait. The highest octopus catch rates occur in Pacific cod fisheries around Unimak Pass, in reporting areas 517, 519, and 509. The Bering Sea and Aleutian Islands trawl surveys produce estimates of biomass for octopus, but these estimates are highly variable and do not sample the same sizes of octopus caught by industry. Examination of size frequency data from surveys and fisheries shows that both commercial and survey trawls catch predominantly small animals (<5 kg), while commercial pot gear catches or retains only larger animals (10-20 kg). In general, the state of knowledge about octopus in the BSAI is poor. A number of research studies and special projects have been initiated in recent years to increase knowledge for this assemblage.

Summary of Changes in Assessment Inputs

Changes in the input data

Survey data have been updated with the 2015 Bering Sea shelf survey results. There was no slope survey in 2014 or 2015. Incidental catch has been updated to include catch for the entirety of 2014 and for 2015 through October 24, 2015.

Changes in the assessment methodology

There are no changes to the assessment methodology. The Pacific cod consumption estimate has not been updated from previous years; a large number of cod stomach samples are scheduled to be processed this year and the consumption estimator will be re-calculated for the 2016 assessment.

Summary of Results

The total catch for 2014 and the preliminary 2015 catch have been added to Table 1. The catch of octopus in the fall 2014 was very high, and the final total catch for that year was 422 tons. Incidental catch for 2015 through October 24 is 335 tons, similar to previous years. The TAC for octopus in 2015 was set at 400 t. The retained percentage of octopus in 2014 was 25% overall; the retained catch for the first part of 2015 is only 17%. Bering Sea shelf survey estimates of biomass were low in 2014 at 2,351 t, but the estimated shelf biomass for 2015 was much larger, at 5,363 t (Table 2).

The current data are not sufficient for a model-based assessment. From 2006 through 2010, stock assessments of octopus presented both Tier 5 and Tier 6 estimates of OFL and ABC. The SSC and Plan Teams discussed the difficulties in applying groundfish methodologies to octopus and have agreed to treat octopus as a Tier 6 species, owing to inadequate data for estimating Tier 5 parameters. There are no historical catch records for octopus. Estimates of incidental catches from 1997-2015 are available, but do not represent catch under any directed fishery. The SSC and the BSAI Plan Team approved an alternative methodology for setting octopus catch limits in the BSAI. This method uses a predation-based estimate of total natural mortality and a logistic fisheries model to set the OFL equal to a highly conservative estimate of total natural mortality; the OFL and ABC from this approach are much higher than the historical incidental catch. This approach was used to set catch limits for 2014 and 2015 and is brought forward without change (consumption estimates have not been recalculated) for 2016 and 2017. The authors and Plan Team note that the standard Tier 6 approach based on the incidental catch would yield an overly conservative limit. The current methodology is based on extensive diet data and includes estimation of uncertainty in calculations.

Quantity	As estimated or <i>specified last year for:</i>		As estimated or <i>recommended this year for:</i>	
	2014	2015	2016	2017
Tier 6 (consumption estimate)				
OFL (t)	3,452	3,452	3,452	3,452
Maximum permissible ABC (t)	2,589	2,589	2,589	2,589
ABC (t)	2,589	2,589	2,589	2,589
Status	As determined <i>last year for:</i>		As determined <i>this year for:</i>	
	2013	2014	2014	2015
Overfishing	n/a	n/a	n/a	n/a

Responses to SSC and Plan Team Comments on Assessments in General

Meetings of the Plan Teams in September 2015 and the SSC in December 2014 and October 2015 had no general comments that apply to the octopus assessment.

Responses to SSC and Plan Team Specific to this Assessment

In December 2014, the SSC approved continued use of the alternative Tier 6 consumption approach for the octopus complex and expressed continued interest in octopus research and development of a stage-

structured model. Meetings of the plan teams in September 2015 and the SSC in October 2015 had no comments specific to the octopus assessment.

Harvest recommendations

We recommend that octopus be managed conservatively due to the poor state of knowledge of the species, life history, distribution, and abundance of octopus in the BSAI, and due to their important role in the diet of Steller sea lions. Continued monitoring and catch accounting for the octopus complex is essential. Efforts to set appropriate overfishing limits for octopus will continue to be limited by poor information on octopus abundance. Further research is needed in several areas before octopus could be managed by a quantitative stock assessment model.

Several possible methods for setting catch limits for octopus have been proposed in previous assessments (Connors and Jorgensen 2007, 2008; Connors and Conrath 2009, 2010, Connors *et al.* 2012, 2014). In 2012, the Plan Team and SSC recommended using biological reference points derived from consumption estimates for Pacific cod. The total consumption of octopus (t/year) estimated for the EBS is shown in Figure 2. Estimates of annual predation mortality by Bering Sea cod on octopus range from <200 to almost 20,000 tons; the larger values have a high level of uncertainty. The majority of the annual estimates, however, lie in the range of 3,000 to 6,000 tons. The geometric mean of all of the annual estimates is 3,452 tons, which is a full order of magnitude higher than the estimated rate of fishery catch of octopus.

This estimate of total natural mortality (N) can then be combined with the general logistic fisheries model that forms the basis of Tier 5 assessments (Alverson and Petreyra 1969, Francis 1974) to set $OFL = N$ and $ABC = 0.75 * OFL$. Because the logistic model assumes equilibrium, we propose using a mean over all of the years of available data to estimate N . Because the posterior distribution of the estimates is right-skewed (higher variability at higher values), we have used geometric means both to form the annual estimates from the posterior distribution and to take the long-term average of the annual estimates. When this method is used, the resulting catch limits are $OFL = 3,452$ t and $ABC = 2,589$ t. This number is considerably higher than the current or historical incidental octopus catch, and similar to the estimate based on survey biomass.

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Table 1. Estimated catch (t) of all octopus species in state and federal waters. 1997-2002 estimated from blend data. 2003-2015 data from AK Regional Office Catch Accounting System, as provided October 24, 2015. Catch is shown separately for the two target fisheries that have the highest rate of incidental octopus catch, Pacific cod and flatfish. The estimated percentage of total catch retained is shown for 2003-2015.

Year	Target Species			Total	% Retained
	P cod	FlatF	Other		
1997	160	86	3	248	
1998	168	13	9	190	
1999	310	14	2	326	
2000	359	57	3	418	
2001	211	9	7	227	
2002	334	21	19	374	
2003	211	34	19	269	38%
2004	279	45	246	338	24%
2005	311	17	10	338	64%
2006	332	5	14	351	55%
2007	156	7	9	181	39%
2008	196	11	8	212	37%
2009	58	10	6	72	23%
2010	162	11	6	177	33%
2011	565	9	14	587	6%
2012	127	4	8	86	17%
2013	218	2	4	223	21%
2014	405	17	7	422	25%
2015*	267	21	12	335	17%

*The 2015 data includes only part of the year, January – October 24, 2015.

Table 2. Biomass estimates in tons for octopus (all species) from AFSC bottom trawl surveys.

Year	EBS Shelf Survey Biomass	EBS Slope Survey Biomass	AI Survey Biomass
1982	13,076	180	
1983	3,517		440
1984	2,647		
1985	2,582	152	
1986	510		781
1987	7,813		
1988	9,935	138	
1989	4,910		
1990	11,619		
1991	8,114	61	1,148
1992	5,611		
1993	1,588		
1994	2,479		1,728
1995	2,928		
1996	1,804		
1997	255		1,219
1998	1,285		
1999	832		
2000	2,031		775
2001	5,908		
2002	2,525	979	1,384
2003	8,244		
2004	4,957	1,957	4,099
2005	10,219		
2006	1,903		3,060
2007	2,278		
2008	1,174	815	
2009	1,028		
2010	820	621	3,075
2011	3,554		
2012	2,567	1,421	2,779
2013	1,810		
2014	2,351		2,762
2015	5,363		

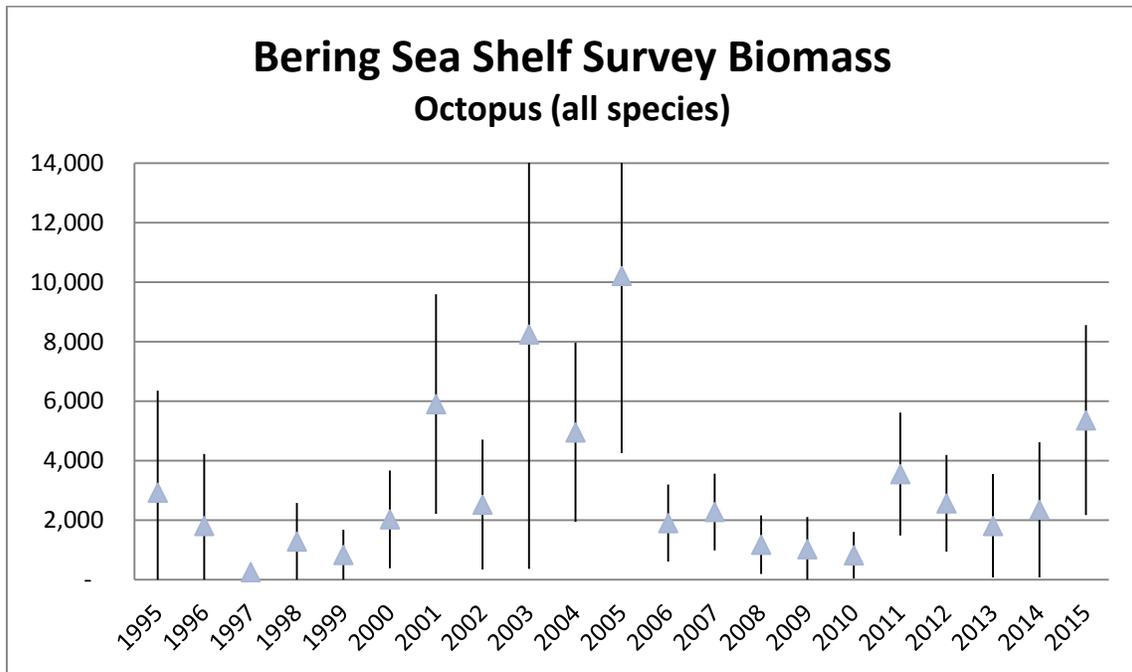


Figure 1. Biomass estimates of octopus (all species) from the Bering Sea shelf survey, with 95% confidence intervals shown.

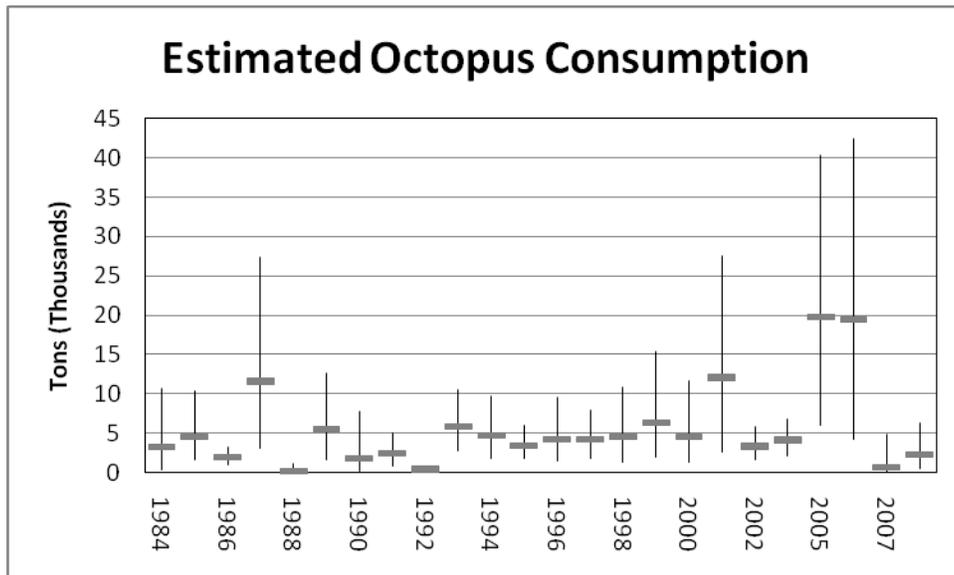


Figure 2. Estimated consumption of octopus by Bering Sea Pacific cod, 1984-2008. Error bars show 95% confidence intervals of posterior distribution; solid bars are annual hyperbolic means.

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