1.B. Assessment of walleye pollock in the Bogoslof Island Region

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Executive Summary

Summary of Changes in Assessment Inputs

The 2016 acoustic-trawl survey conducted in March was included in the analysis. Preliminary 2016 survey age composition data were compiled and provided. Two methods for computing the survey average are provided: one using the random-effects and the other using a simple 3-survey average.

Summary of Results

The ABC and OFL levels using Tier 5 values and assuming the random-effects model:

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2016	2017	2017	2018
M (natural mortality rate)	0.3	0.3	0.3	0.3
Tier	5	5	5	5
Biomass (t)	106,000	106,000	434,760	434,760
F_{OFL}	0.300	0.300	0.300	0.300
$maxF_{ABC}$	0.225	0.225	0.225	0.225
F_{ABC}	0.225	0.225	0.12	0.12
OFL (t)	31,800	31,800	130,428	130,428
maxABC (t)	23,850	23,850	97,821	97,821
ABC (t)	23,850	23,850	51,300	51,300
	As determined *last* year for:		As determined *this* year for:	
Status	2014	2015	2015	2016
Overfishing	No	n/a	No	n/a

Response to SSC and Plan Team comments

General and specific comments:

There were no comments pertaining to this Tier 5 assessment

Introduction

Alaska pollock (*Gadus chalcogrammus*) are broadly distributed throughout the North Pacific with largest concentrations found in the Eastern Bering Sea. The Bogoslof region is noted for having distinct spawning aggregations that appear to be independent from pollock spawning in nearby regions. The Bogoslof management district (INPFC area 518) was established in 1992 in response to fisheries and surveys conducted during the late 1980s, which consistently found a discrete aggregation of spawning pollock in this area during the winter. The degree to which this aggregation represents a unique, self-recruiting stock is unknown but the persistence of this aggregation suggests some spawning site fidelity that called for independent management. The Bogoslof region pollock has also been connected with the historical abundance of pollock found in the central Bering Sea (Donut Hole) due to concentrations of pollock that appeared to be moving toward this region prior to spawning (Smith 1981). For the purpose of management within the US zone, pollock from this region are managed separately.

Collectively, pollock found in the Donut Hole and in the Bogoslof region are by convention, considered to be part of the Aleutian Basin stock. Currently, based on an agreement from a Central Bering Sea convention meeting, it is assumed that 60% of the Aleutian Basin pollock population spawns in the Bogoslof region. The actual distribution of Aleutian Basin pollock is unknown and likely varies depending on environmental conditions and the age-structure of the stock. The Bogoslof component of the Aleutian Basin stock is one of three management stocks of pollock recognized in the BSAI region. The other stocks include pollock found in the large area of the Eastern Bering Sea shelf region and those in the Aleutian Islands near-shore region (i.e., less than 1000m depth; Barbeaux et al. 2004). The Aleutian Islands, Eastern Bering Sea and Aleutian Basin stocks probably intermingle, but the exchange rate and magnitude are unknown. The degree to which the Bogoslof spawning component contributes to subsequent recruitment to the Aleutian Basin stock also is unknown. From an early life-history perspective, the opportunities for survival of eggs and larvae from the Bogoslof region seem smaller than for other areas (e.g., north of Unimak Island on the shelf). There is a high degree of synchronicity among strong year-classes from these three areas, which suggests either that the spawning source contributing to recruitment is shared or that conditions favorable for survival are shared. From a biological perspective, the degree to which these management units are reasonable definitions depends on the active exchange among these stocks. If they are biologically distinct and have different levels of productivity, then management should be adjusted accordingly. Bailey et al. (1999) present a thorough review of population structure of pollock throughout the north Pacific region. They note that adjacent stocks were not genetically distinct but that differentiation between samples collected on either side of the N. Pacific was evident.

Some characteristics distinguish Bogoslof region pollock from other areas. Growth rates appear different (based on mean-lengths at age) and pollock sampled in the Bogoslof Island survey tend to be much older. For example, the average percentage (by numbers of fish older than age 6) of age 15 and older pollock observed from the Bogoslof AT surveys (1988-2012) is 18%; in the EBS region (from model estimates), the average from this period is only 2%. The pollock found in winter surveys are generally older than age 4 and are considered distinct from eastern Bering Sea pollock. Further study on stock structure (relating age compositions in adjacent regions) should help understand this possibility. Although data on the age structure of Bogoslof pollock show that a majority of pollock originated from year classes that were also strong on the shelf, 1972, 1978, 1982, 1984, 1989, 1992, 1996, 2000, and 2006. A more recent pattern appears to be that the year-classes differ slightly. For example, the 2008 year-class in the EBS, there has been some indication that there are strong year classes appearing on the shelf may not be occurring the Bogoslof region (there seems to be a strong 2009 year-class). This may be due to age-determination discrepancies or that spawning and subsequent survival rates are diverging. Indications suggest that the 2012 year-class is appearing in this survey (4 year-olds) as has been observed in the EBS shelf region.

Fishery

Prior to 1977, few pollock were caught in the Donut Hole or Bogoslof region (Low and Ikeda 1978). Japanese scientists first reported significant quantities of pollock in the Aleutian Basin in the mid-to-late 1970's, but large-scale fisheries in the Donut Hole only began in the mid-1980's. By 1987 significant components of these catches were attributed to the Bogoslof Island region (Table 1B.1); however, the actual locations were poorly documented. The Bogoslof fishery primarily targeted winter spawning-aggregations but in 1992, this area was closed to directed pollock fishing.

In 1991, the only year with extensive observer data, the fishery timing coincided with the open seasons for the EBS and Aleutian Islands pollock fisheries (the Bogoslof management district was established in 1992 by FMP amendment 17). However, after March 23, 1991 the EBS region was closed to fishing and some effort was re-directed to the Aleutian Islands region near the Bogoslof district. In subsequent years, seasons for the Aleutian Islands pollock fishery were managed separately. Bycatch and discard levels were relatively low from these areas when there was a directed fishery (e.g., 1991). Updated estimates of pollock bycatch levels from other fisheries were small in recent years (Table 1B.2). The increase in pollock bycatch in 2010 (9 t in 2008 to 73 in 2009 and 176 t in 2010) can be attributed to the non-pelagic trawl arrowtooth flounder target fishery. The majority of pollock bycatch in the Bogoslof region continues to be occurring in the non-pelagic trawl arrowtooth flounder target fishery. Catches continue to trend upwards from 57 t in 2013, to over 1,000 t in 2016.

Data

Survey

NMFS acoustic-trawl survey biomass estimates are the primary data source used in this assessment. Since 2000, the values have varied between 292,000 t and 67,000 t. The most recent AT survey of the Bogoslof spawning stock was conducted in March of 2016 (McKelvey and Lauffenburger, In prep; Table 1B.3) and resulted in a biomass estimate of 506,228 t.. The area covered by the survey, tow locations, and relative pollock densities are depicted in Fig. 1B.1 and compared with the 2014 results for contrast. The time series of age composition data from this survey is shown in Tables 1B.4.

Analytical approach

Model Structure

Survey biomass averaging

The model for harvest recommendations was based on using a Tier-5 approach which requires survey estimates of biomass (B_t). In Ianelli et al. (2015) the SSC accepted application of a random effects model of the form:

$$B_t = B_{t-1} e^{\varepsilon_t} \qquad \varepsilon_t \sim N\left(0, \sigma_\varepsilon^2\right)$$

with process errors ε_t estimated as random effects and σ_ε^2 also estimated with the observations and errors from Table 1B.3 included in the likelihood. The model was fit using ADMB (Fournier et al. 2012). This model provides alternative estimates of survey biomass in 2016 which weights the relative influence of past survey estimates between process error variances and that specified as observation errors.

Parameter estimates

In the 2015 assessment (Ianelli et al. 2015) the estimate of natural mortality was re-evaluated and the value of 0.3 was determined to be a reasonable estimate for this stock given the time series of survey age composition data.

Results

The random-effects method of survey averaging resulted in 434,760 t compared to the 2016 estimate of 506,000 t (Fig. 1B.2). As an alternative method, the three-survey average approach gives an estimate of 228,000 t from which to make the Tier 5 calculations.

Regarding the age-structured model evaluation of natural mortality, the evidence suggests that a higher value is more consistent with the data should be considered as an alternative for use in the Tier 5 calculation. All options are presented in the Harvest Recommendations section below.

Harvest Recommendations

Maximum permissible ABC and OFL estimates for 2017 and 2018 under Tier 5 relies exclusively on the NMFS biennial acoustic trawl survey biomass estimate. Biomass was based on two survey averaging approaches: simple 3-survey mean and a mean estimated from a random-effects model gives:

Description	M	Biomass	ABC	OFL
Random-effects survey average	0.3	434,760	97,821	130,428
3-survey average	0.3	228,000	51,300	68,400

For consistency with past approaches, the maximum permissible ABC is based on the random effects survey average biomass and the natural mortality as estimated in 2015. This results in a maximum permissible Tier 5 ABC of 97,821 t for 2017 and 2018 and an OFL of 130,428 t. The degree of uncertainty in this estimate going forward increases and is fairly substantial (the lower 95% confidence bounds is 133,200 t in 2018. Given this large degree of uncertainty, and the fact that the next survey is scheduled for 2018, we provide an alternative biomass estimate as the average of the three most recent surveys. This results in a biomass estimate of 228,000 t which would provide an ABC of 51,300 t and is our recommendation for 2017 and 2018. The maximum permissible ABC and OFL would remain tied to the random-effects survey averaging approach.

Literature cited

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Table 1B.1 Catch in tons from the Donut Hole and the Bogoslof Island area, 1977-2016.

Year	**Donut Hole (t)**	**Bogoslof Island (t)**	**Total (t)**
1977		11,500	11,500
1978		9,600	9,600
1979		16,100	16,100
1980		13,100	13,100
1981		22,600	22,600
1982		14,700	14,700
1983		21,500	21,500
1984	181,200	22,900	204,100
1985	363,400	13,700	377,100
1986	1,039,800	34,600	1,074,400
1987	1,326,300	377,436	1,703,736
1988	1,395,900	87,813	1,483,713
1989	1,447,600	36,073	1,483,673
1990	917,400	151,672	1,069,072
1991	293,400	316,038	609,438
1992	10,000	241	10,241
1993	1,957	886	2,843
1994		556	556
1995		334	334
1996		499	499
1997		163	163
1998		8	8
1999		29	29
2000		29	29
2001		258	258
2002		1,042	1,042
2003		24	24
2004		<1	<1
2005		<1	<1
2006		<1	<1
2007		<1	<1
2008		9	9
2009		73	73
2010		176	176
2011		173	173
2012		79	79
2013		57	57
2014		428	428
2015		733	733
2016		1,005	1,005

Table 1B.2. Estimated retained, discarded, and total pollock catch (t) from the Bogoslof region. Source: NMFS Regional office Blend database and catch accounting system.

Year	Discarded	Retained	Total
1991	20,327	295,711	316,038
1992	240	1	241
1993	308	578	886
1994	11	545	556
1995	267	66	334
1996	7	492	499
1997	13	150	163
1998	3	5	8
1999	11	18	29
2000	20	10	29
2001	28	231	258
2002	12	1,031	1,042
2003	19	5	24
2004	< 1		< 1
2005	< 1	< 1	< 1
2006	< 1	< 1	< 1
2007	< 1	< 1	< 1
2008	< 1	9	9
2009	6	67	73
2010	53	124	176
2011	23	150	173
2012	5	74	79
2013	< 1	56	57
2014	54	374	428
2015	138	595	733
2016	7	997	1,005

Table 1B.3. Biomass (tons) of pollock as surveyed in the Bogoslof region, 1988-2016. For additional details see McKelvey and Lauffenburger (In prep).

Year	Survey biomass estimates (t)	Survey area (nmi^2)	Relative error
1988	2,395,737	NA	*22%*
1989	2,125,851	NA	*22%*
1990		No survey	
1991	1,289,006	8,411	12%
1992	940,198	8,794	20%
1993	635,405	7,743	9%
1994	490,077	6,412	12%
1995	1,104,118	7,781	11%
1996	682,277	7,898	20%
1997	392,402	8,321	14%
1998	492,396	8,796	19%
1999	475,311	NA	*22%*
2000	301,390	7,863	14%
2001	232,170	5,573	10%
2002	225,712	2,903	12%
2003	197,851	2,993	22%
2004		No survey	
2005	253,459	3,112	17%
2006	240,059	1,803	12%
2007	291,580	1,871	12%
2008		No survey	
2009	110,191	1,803	19%
2010		No survey	
2011		No survey	
2012	67,063	3,656	10%
2013		No survey	
2014	112,070	1,150	12%
2015		No survey	
2016	506,228		10%

Table 1B.4. Estimated survey numbers at age (millions) from the acoustic-trawl surveys used in the age-structured model for Bogoslof pollock (from McKelvey and Lauffenburger In prep).

	4	5	6	7	8	9	10	11	12	13	14	15
1988	-	27.94	326.71	246.84	163.68	350.07	1,200.88	287.82	287.33	201.95	89.24	53.89
1989	6.00	15.00	58.00	363.00	147.00	194.00	91.00	1,105.00	222.00	223.00	82.00	180.00
1991	2.00	12.00	46.00	213.00	93.00	160.00	44.00	92.00	60.00	373.00	119.00	202.00
1992	2.00	27.00	54.00	97.00	74.00	71.00	55.00	57.00	33.00	34.00	142.00	327.00
1993	33.00	17.00	44.00	46.00	48.00	42.00	28.00	51.00	25.00	27.00	42.00	209.00
1994	21.00	86.00	26.00	38.00	36.00	36.00	17.00	27.00	23.00	13.00	9.00	146.00
1995	6.00	75.00	278.00	105.00	68.00	80.00	53.00	54.00	19.00	59.00	32.00	248.00
1996	0.50	6.00	96.00	187.00	85.00	40.00	37.00	24.00	24.00	12.00	36.00	117.00
1997	0.50	4.00	16.00	55.00	88.00	38.00	28.00	16.00	16.00	13.00	7.00	57.00
1998	0.50	11.00	61.00	34.00	70.00	77.00	32.00	25.00	21.00	19.00	18.00	67.00
1999	2.00	5.00	29.00	77.00	34.00	50.00	75.00	29.00	27.00	25.00	16.00	48.00
2000	1.00	6.00	4.00	14.00	30.00	16.00	28.00	45.00	21.00	16.00	11.00	36.00
2001	1.00	14.00	12.00	10.00	10.00	14.00	12.00	18.00	31.00	13.00	7.00	27.00
2002	5.00	3.00	41.00	11.00	8.00	6.00	7.00	8.00	14.00	30.00	9.00	29.00
2003	8.00	6.00	7.00	25.00	11.00	4.00	5.00	4.00	10.00	8.00	26.00	21.00
2005	5.00	81.00	31.00	13.00	11.00	22.00	7.00	3.00	5.00	4.00	5.00	37.00
2006	4.00	55.00	104.00	18.00	6.00	6.00	9.00	3.00	2.00	4.00	5.00	25.00
2007	1.00	8.00	92.00	70.00	17.00	3.00	3.00	8.00	4.00	1.00	5.00	24.00
2009	-	1.00	1.00	7.00	23.00	26.00	8.00	1.00	1.00	1.00	0.44	4.78
2012	0.14	1.38	14.96	9.65	2.24	0.89	2.36	6.74	7.85	1.12	0.20	1.06
2014	1.00	34.00	31.00	11.00	14.00	7.00	3.00	0.50	1.00	5.00	4.00	2.5
2016	147.66	39.58	175.27	381.68	95.58	16.56	7.72	-	1.40	-	-	-

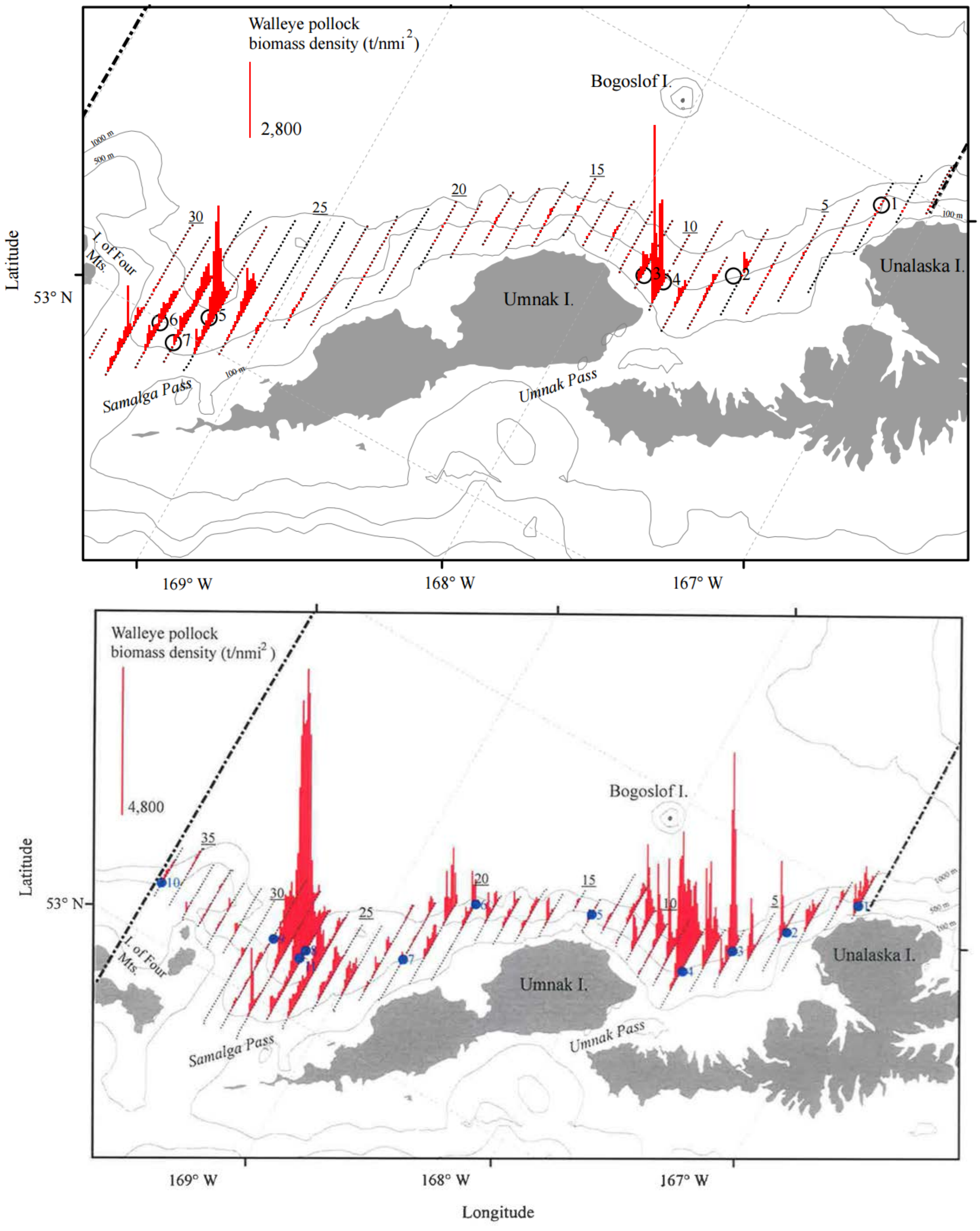

Figure 1B.1. Distribution of pollock biomass (t/nmi^2) observed along transects during the winter 2014 (top) and 2016 (bottom) acoustic-trawl survey. Transect numbers are underlined; trawl haul locations are indicated by circles.

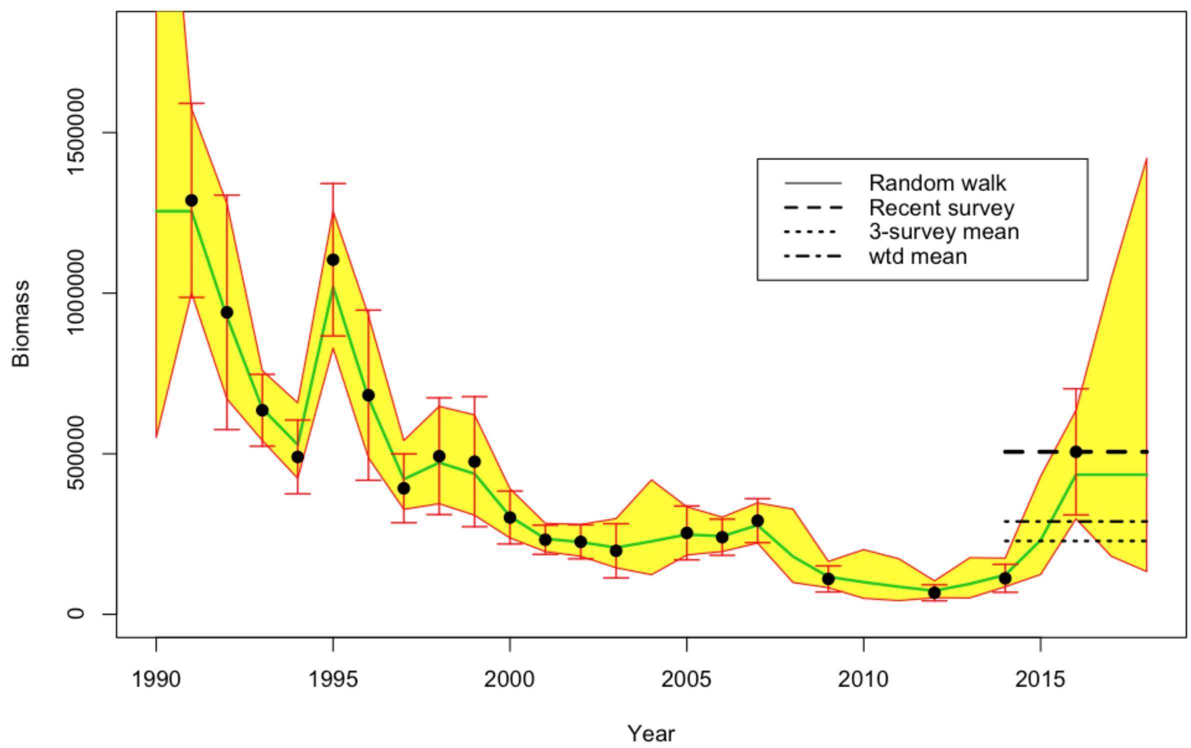

Figure 1B.2. Bogoslof Island pollock survey estimates fitted to a process error model for averaging recruitment. The shade represents the approximate 90% confidence interval from the model.