

## Addendum to Halibut Assessment Document

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**December 15, 2017**

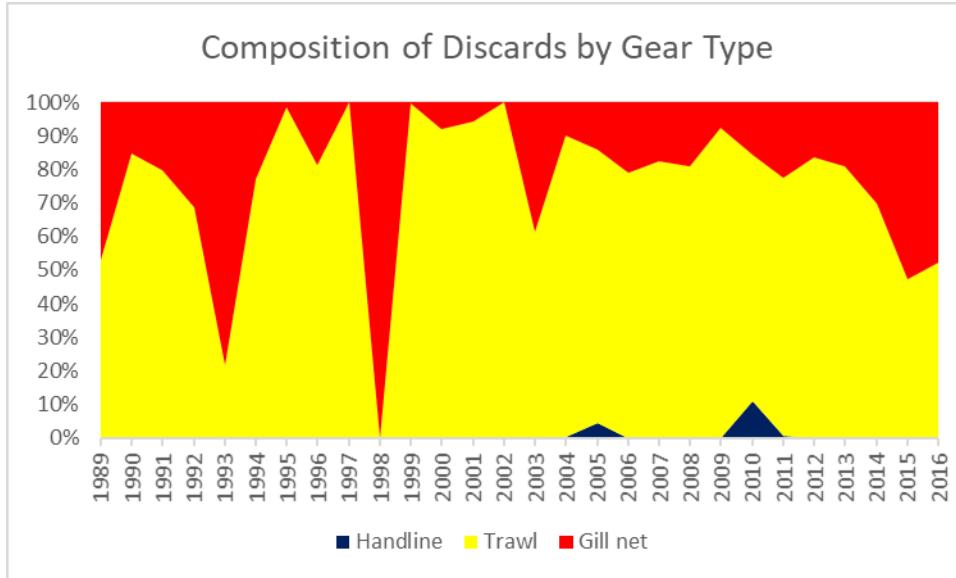
### ***Changes to Discard Estimator***

During the December 14, 2017 SSC peer review meeting for the Halibut assessment an inconsistency in the estimation of total discards was discovered in the current assessments. The previous assessment had estimated total discards using the so-called D2 estimator which is based on a discard per kept all ratio. “Kept all” is the total landings of all species on a given trip. In the Rago 2017 report, the discard ratio was “D3” which is defined as the discards of halibut per trip. In other words, the measure of effort in the D2 estimator is total landings. In the D3 estimator, the measure of effort is the number of trips. The net effect of this change is relatively minor, but for the sake of consistency with previous assessments, the discard time series was updated to reflect an alternative measure of fishing effort. The net effect of these changes is shown in the table below:

<i>Year</i>	<i>Total Discards D3</i>	<i>Total Discards D2</i>	<i>Difference</i>
1989	4.97	3.41	-1.56
1990	13.55	9.81	-3.74
1991	6.93	5.24	-1.69
1992	2.19	1.60	-0.59
1993	1.06	1.24	0.18
1994	3.16	1.40	-1.76
1995	6.34	3.08	-3.27
1996	0.65	0.61	-0.05
1997	1.64	0.60	-1.03
1998	0.10	0.15	0.05
1999	69.10	72.24	3.14
2000	11.87	8.78	-3.09
2001	9.68	9.63	-0.05
2002	20.20	16.43	-3.78
2003	20.15	15.49	-4.66
2004	15.71	18.27	2.55
2005	18.89	14.66	-4.24
2006	22.45	14.42	-8.04
2007	17.27	9.37	-7.90
2008	21.66	11.19	-10.47
2009	17.85	13.13	-4.72
2010	34.69	29.09	-5.60
2011	42.35	40.56	-1.79
2012	52.19	58.49	6.30
2013	56.18	62.94	6.76
2014	34.34	41.18	6.84
2015	46.30	44.69	-1.61
2016	47.40	57.86	10.46
Total	598.91	565.53	-33.37

**Table 16. REVISED, using D2 estimator.** Estimated discards by gear type and adjustments for discard mortality rates.

Year	Discard Estimate (mt)				Fraction by Gear			Adjusted for Discard Mortality Rate				
	Handline	Trawl	Gill net	Total	Handline	Trawl	Gill net	Handline	0.1	0.76	0.3	Adj Total
1989	0.00	1.81	1.60	3.41	0.000	0.531	0.469	0.00	1.38	0.48	1.86	
1990	0.00	8.31	1.50	9.81	0.000	0.847	0.153	0.00	6.32	0.45	6.77	
1991	0.00	4.17	1.07	5.24	0.000	0.796	0.204	0.00	3.17	0.32	3.49	
1992	0.00	1.10	0.50	1.60	0.000	0.687	0.313	0.00	0.83	0.15	0.99	
1993	0.00	0.27	0.97	1.24	0.000	0.216	0.784	0.00	0.20	0.29	0.49	
1994	0.00	1.08	0.32	1.40	0.000	0.771	0.229	0.00	0.82	0.10	0.92	
1995	0.00	3.03	0.05	3.08	0.000	0.984	0.016	0.00	2.30	0.01	2.32	
1996	0.00	0.49	0.11	0.61	0.000	0.813	0.187	0.00	0.37	0.03	0.41	
1997	0.00	0.60	0.00	0.60	0.000	1.000	0.000	0.00	0.46	0.00	0.46	
1998	0.00	0.00	0.15	0.15	0.000	0.000	1.000	0.00	0.00	0.05	0.05	
1999	0.00	71.94	0.31	72.24	0.000	0.996	0.004	0.00	54.67	0.09	54.76	
2000	0.00	8.07	0.71	8.78	0.000	0.919	0.081	0.00	6.13	0.21	6.35	
2001	0.00	9.08	0.56	9.63	0.000	0.942	0.058	0.00	6.90	0.17	7.07	
2002	0.00	16.43	0.00	16.43	0.000	1.000	0.000	0.00	12.48	0.00	12.48	
2003	0.00	9.49	6.00	15.49	0.000	0.613	0.387	0.00	7.21	1.80	9.01	
2004	0.01	16.44	1.81	18.27	0.001	0.900	0.099	0.00	12.50	0.54	13.04	
2005	0.63	11.96	2.06	14.66	0.043	0.816	0.141	0.06	9.09	0.62	9.77	
2006	0.00	11.37	3.05	14.42	0.000	0.789	0.211	0.00	8.64	0.91	9.55	
2007	0.03	7.68	1.65	9.37	0.004	0.820	0.176	0.00	5.84	0.50	6.34	
2008	0.00	9.07	2.12	11.19	0.000	0.810	0.190	0.00	6.89	0.64	7.53	
2009	0.00	12.13	1.00	13.13	0.000	0.924	0.076	0.00	9.22	0.30	9.52	
2010	3.15	21.33	4.60	29.09	0.108	0.733	0.158	0.32	16.21	1.38	17.91	
2011	0.19	31.17	9.20	40.56	0.005	0.769	0.227	0.02	23.69	2.76	26.47	
2012	0.00	48.88	9.62	58.49	0.000	0.836	0.164	0.00	37.15	2.88	40.03	
2013	0.25	50.72	11.97	62.94	0.004	0.806	0.190	0.02	38.55	3.59	42.16	
2014	0.00	28.79	12.39	41.18	0.000	0.699	0.301	0.00	21.88	3.72	25.60	
2015	0.00	21.06	23.62	44.69	0.000	0.471	0.529	0.00	16.01	7.09	23.10	
2016	0.00	30.28	27.58	57.86	0.000	0.523	0.477	0.00	23.02	8.27	31.29	



**Fig. 28 Revised, uses D2 estimator.** Estimated proportions of discards by gear type, 1989-2016. Estimates are based on an assumed 100% mortality.

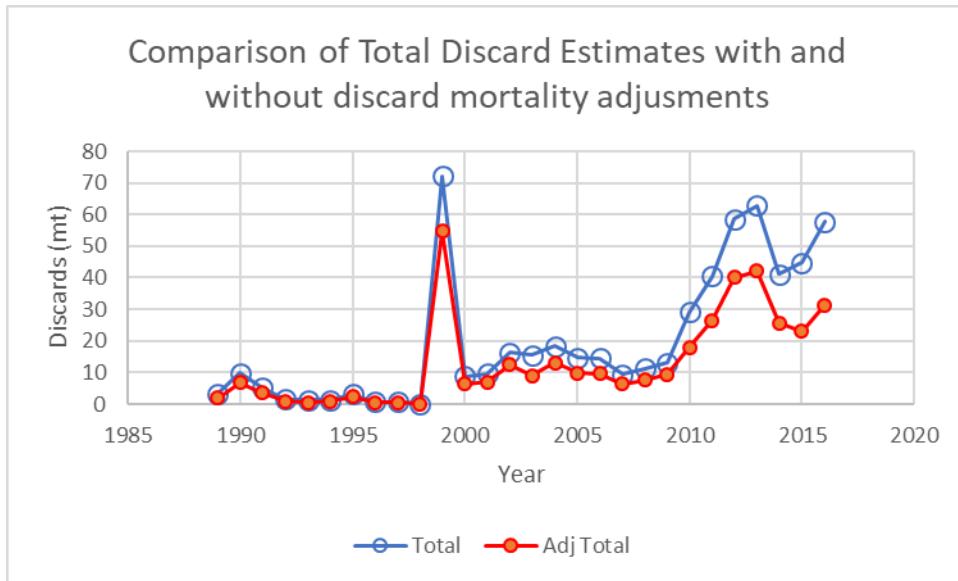


Figure 29 **Revised, uses D2 estimator.** Comparison of total discard estimates based on assumed rates of discard mortality: Trawls 76%, Gill nets 30% and hook gear 10%.

#### ***Changes to Estimates of Total Catch in 2017***

The FSD method applies a proportional change to the total catch based on the slope estimates in the previous year. To estimate the catch for 2018 it is necessary to supply an estimate of total catches in 2017. Because the relative abundance indices are also not available for 2017, the estimate of the slope for 2017 is based on one less year than for 2016. In these model runs this means that the number of data points used in the regression slopes declines from 5 to 4. Hence one would expect the variance of the projection to increase in the 2018 projection.

The other major change requested by the PDT was to consider inclusion of 33 mt of landings in 5Y and 5Zc in the US stock area for 2017 catches. The 2017 catches are based on incomplete landings and discard data. Total catches for the 2017 were derived by analysts at the GARFO and NEFSC to be 110.7 mt when 100% discard mortality is assumed. **Adding 33 mt of landings for Canada brings the total to 143.7 mt.** Application of the gear specific discard mortality rates to US discards results in an estimate of 90.0 mt. **In this scenario adding 33 mt of landings for Canada brings the total to 123.0 mt.** These alternative values of 2017 catches were used in the scenarios A and B below.

**SCENARIO A.** Revised with D2 estimator and assuming gear specific discard mortality rates (Trawl=76%, Gill net=30%, hook gear = 10%). Canadian landings of 33 mt are added for 2017 ONLY.

Year	Disards	Landings	Catch
1994	0.92	21.77	22.69
1995	2.32	10.54	12.86
1996	0.41	13.32	13.73
1997	0.46	14.01	14.47
1998	0.05	8.41	8.46
1999	54.76	11.51	66.27
2000	6.35	11.07	17.42
2001	7.07	10.82	17.89
2002	12.48	10.01	22.49
2003	9.01	16.68	25.69
2004	13.04	11.22	24.26
2005	9.77	16.81	26.58
2006	9.55	14.08	23.63
2007	6.34	24.61	30.95
2008	7.53	28.69	36.22
2009	9.52	45.05	54.57
2010	17.91	20.20	38.11
2011	26.47	25.79	52.26
2012	40.03	34.80	74.83
2013	42.16	34.67	76.83
2014	25.60	44.99	70.59
2015	23.10	62.00	85.10
2016	31.29	68.20	99.49

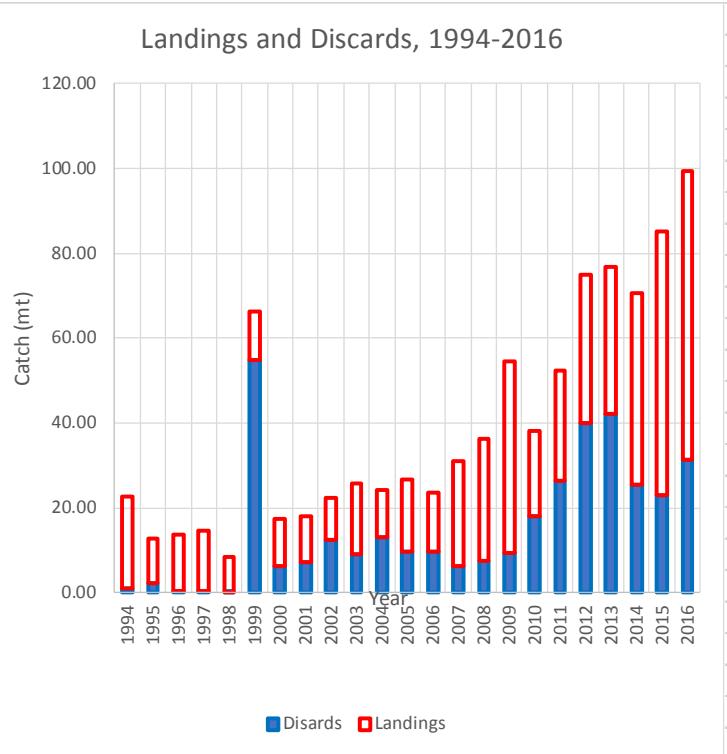


Fig 1A. Landings and discards (mt) for Atlantic halibut in US stock area, 1994-2016, used in this assessment. **Revised with D2 estimator and assuming gear specific discard mortality rates (Trawl=76%, Gill net=30%, hook gear = 10%).**

Table 15A. Summary of derived estimates of catch in 2018 based on the FSD model for alternative values of the gain parameters Kp and Kd. The top table shows the effect of the parameters on estimated catch in mt. The lower table illustrates the effect of the gain parameters on the degree of concordance with historical estimates of observed and predicted catch for the time period 2007 to 2016. Table entries are ratios of the sum of squares difference between observed and predicted to the minimum value. **This is based on catch adjusted for gear-specific discard mortality (90 mt) plus Canadian landings in 2017 of 33 mt for a total =123.0 mt.**

		Kp									
		136.46	0	0.3	0.4	0.5	0.6	0.75	0.8	0.9	1
Kd	0	122.7	127.2	128.7	130.3	131.9	134.2	135.1	136.7	138.3	
	0.25	123.7	128.2	129.8	131.4	132.9	135.3	136.2	137.8	139.5	
	0.5	124.7	129.3	130.9	132.4	134.0	136.5	137.3	138.9	140.6	
	0.75	125.7	130.4	131.9	133.5	135.1	137.6	138.4	140.1	141.8	
	1	126.8	131.4	133.0	134.6	136.2	138.7	139.5	141.2	142.9	
	1.25	127.8	132.5	134.1	135.7	137.4	139.8	140.7	142.4	144.1	
	1.5	128.9	133.6	135.2	136.8	138.5	141.0	141.8	143.6	145.3	
	1.75	129.9	134.7	136.3	138.0	139.6	142.2	143.0	144.7	146.5	
	2	131.0	135.8	137.4	139.1	140.8	143.3	144.2	145.9	147.7	
	2.25	132.1	136.9	138.6	140.2	141.9	144.5	145.4	147.1	148.9	
	2.5	133.2	138.0	139.7	141.4	143.1	145.7	146.6	148.3	150.1	
	2.75	134.2	139.2	140.8	142.5	144.3	146.9	147.8	149.5	151.3	
	3	135.4	140.3	142.0	143.7	145.4	148.1	149.0	150.8	152.6	
	3.25	136.5	141.5	143.2	144.9	146.6	149.3	150.2	152.0	153.8	
	3.5	137.6	142.6	144.3	146.1	147.8	150.5	151.4	153.3	155.1	
	3.75	138.7	143.8	145.5	147.3	149.1	151.8	152.7	154.5	156.4	
	4	139.9	145.0	146.7	148.5	150.3	153.0	153.9	155.8	157.7	
		min (C(2018))=		123.7	max(C(2018))=		157.7				

		Ratio of (SSQ-Min(SSQ)) to Minimum SSQ								
		Kp								
		0	0.3	0.4	0.5	0.6	0.75	0.8	0.9	1
Kd	0	0.22	0.15	0.14	0.13	0.12	0.12	0.12	0.12	0.13
	0.25	0.05	0.01	0.00	0.00	0.00	0.02	0.02	0.04	0.06
	0.5	0.08	0.06	0.06	0.07	0.09	0.12	0.13	0.16	0.20
	0.75	0.35	0.36	0.37	0.40	0.43	0.48	0.50	0.55	0.61
	1	0.91	0.96	0.99	1.03	1.08	1.16	1.19	1.26	1.34
	1.25	1.82	1.93	1.98	2.04	2.11	2.23	2.28	2.38	2.48
	1.5	3.18	3.36	3.43	3.52	3.62	3.79	3.85	3.98	4.12
	1.75	5.08	5.34	5.45	5.57	5.70	5.93	6.01	6.18	6.36
	2	7.64	8.00	8.15	8.31	8.49	8.78	8.89	9.11	9.35
	2.25	10.99	11.48	11.67	11.89	12.12	12.50	12.63	12.92	13.22
	2.5	15.30	15.95	16.21	16.49	16.78	17.27	17.44	17.80	18.18
	2.75	20.77	21.63	21.96	22.31	22.69	23.30	23.52	23.97	24.44
	3	27.65	28.75	29.17	29.62	30.10	30.86	31.13	31.69	32.28
	3.25	36.21	37.62	38.15	38.71	39.31	40.26	40.60	41.30	42.03
	3.5	46.80	48.58	49.25	49.95	50.69	51.88	52.29	53.15	54.06
	3.75	59.83	62.06	62.89	63.77	64.69	66.15	66.66	67.72	68.83
	4	75.78	78.57	79.60	80.68	81.82	83.62	84.25	85.55	86.90

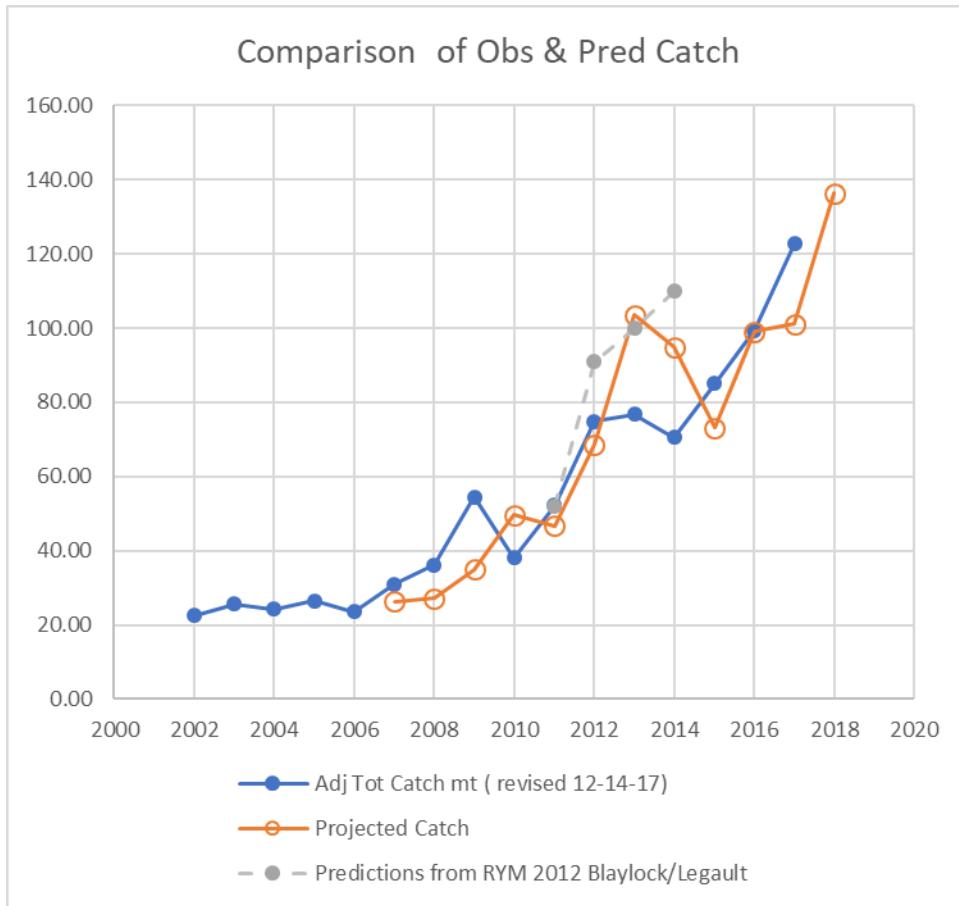


Figure 20A. Comparison of observed vs predicted catches based on the FSD model applied to US stock area. Forecasts from RYM application (Blaylock and Legault, 2012) are included for comparison. The gain parameters for proportional and derivative were set at  $K_p=0.75$  and  $K_d=0.50$ , respectively. **This is based on catch adjusted for gear-specific discard mortality (90 mt) plus Canadian landings in 2017 of 33 mt for a total =123.0 mt.**

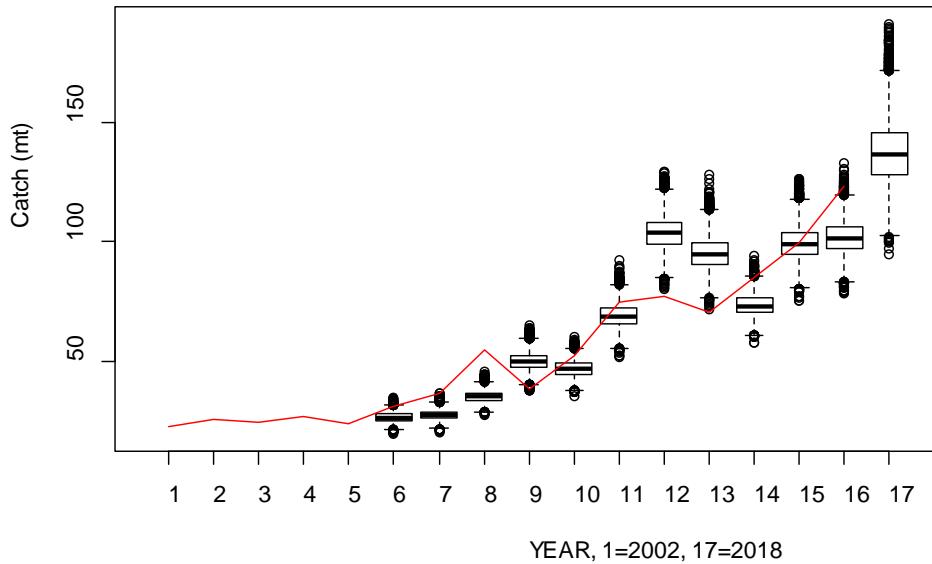


Figure 21A. Comparison of observed and predicted distribution of catches for FSD model applied to the US stock area. Uncertainty estimates are based on a parametric bootstrap method described in the text. The gain parameters for proportional and derivative were set at  $K_p=0.75$  and  $K_d=0.50$ , respectively. **This is based on catch adjusted for gear-specific discard mortality (90 mt) plus Canadian landings in 2017 of 33 mt for a total =123.0 mt.**

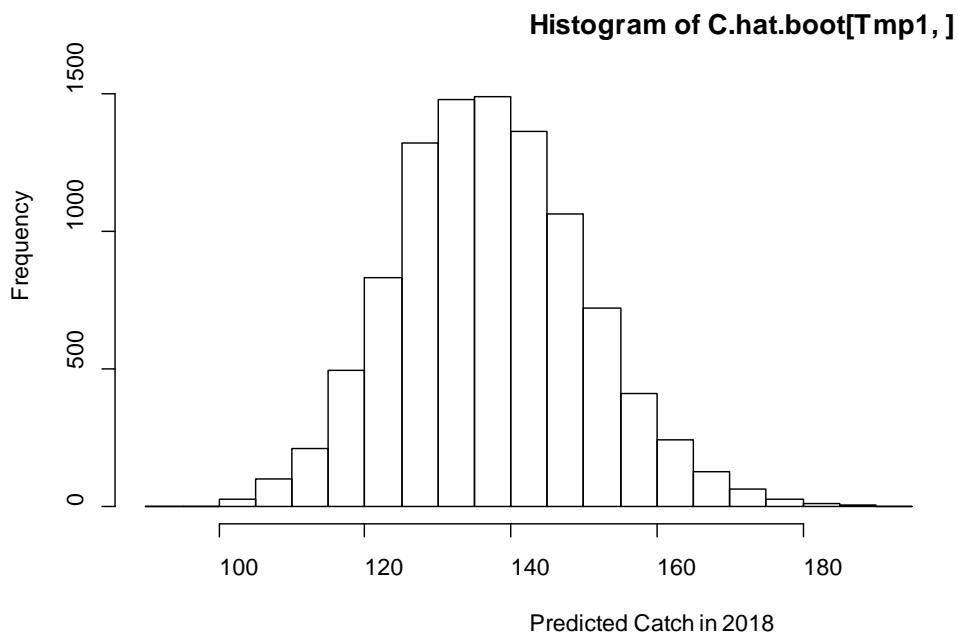


Figure 22A. Sampling distribution of predicted catch for 2018 based on parametric bootstrap method with 10,000 replications. **This is based on catch adjusted for gear-specific discard mortality (90 mt) plus Canadian landings in 2017 of 33 mt for a total =123.0 mt.**

Projected catches by year are given in Fig. 21A and the sampling distribution of projected catch in 2018 is shown in Fig. 22A. The sampling percentile statistics for this distribution are

1%	5%	10%	25%	50%	75%	90%	95%	99%
109.02	117.10	121.18	128.33	136.78	145.72	154.09	159.75	170.72

The bootstrap mean of projected catch is 137.35 mt with a CV=0.095.

**SCENARIO B. Revised with D2 estimator and assuming 100% discard mortality rates for all gears. Canadian landings of 33 mt are added for 2017 ONLY.**

Year	Disards	Landings	Catch
1994	1.40	21.77	23.17
1995	3.08	10.54	13.62
1996	0.61	13.32	13.93
1997	0.60	14.01	14.61
1998	0.15	8.41	8.56
1999	72.24	11.51	83.75
2000	8.78	11.07	19.85
2001	9.63	10.82	20.45
2002	16.43	10.01	26.44
2003	15.49	16.68	32.17
2004	18.27	11.22	29.49
2005	14.66	16.81	31.47
2006	14.42	14.08	28.50
2007	9.37	24.61	33.98
2008	11.19	28.69	39.88
2009	13.13	45.05	58.18
2010	29.09	20.20	49.29
2011	40.56	25.79	66.35
2012	58.49	34.80	93.29
2013	62.94	34.67	97.61
2014	41.18	44.99	86.17
2015	44.69	62.00	106.69
2016	57.86	68.20	126.06

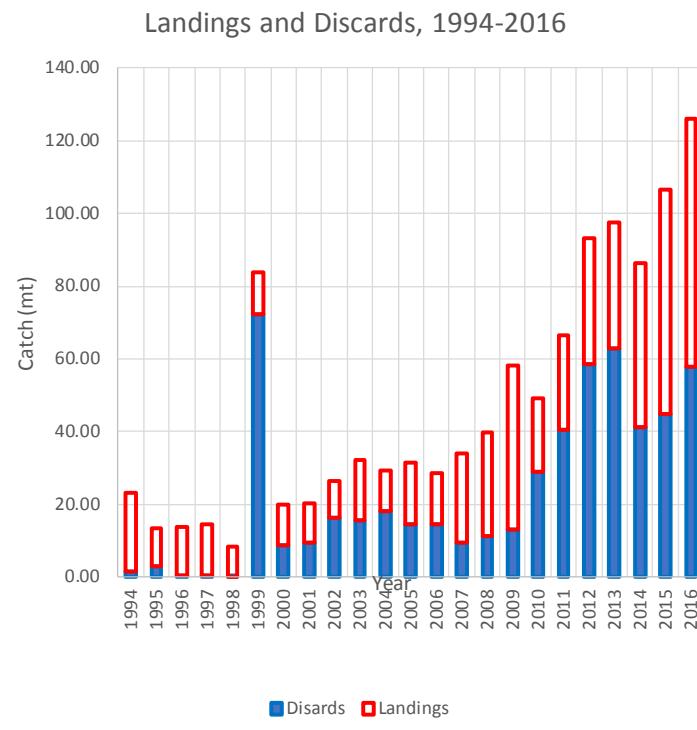


Fig 1B. Landings and discards (mt) for Atlantic halibut in US stock area, 1994-2016, used in this assessment. **Revised with D2 estimator and assuming 100% mortality.**

Table 15B. Summary of derived estimates of catch in 2018 based on the FSD model for alternative values of the gain parameters Kp and Kd. The top table shows the effect of the parameters on estimated catch in mt. The lower table illustrates the effect of the gain parameters on the degree of concordance with historical estimates of observed and predicted catch for the time period 2007 to 2016. Table entries are ratios of the sum of squares difference between observed and predicted to the minimum value. **This is based on catch for 100% discard mortality (110.7mt) plus Canadian landings in 2017 of 33 mt for a total =143.7 mt**

		Kp								
159.81		0	0.3	0.4	0.5	0.6	0.75	0.8	0.9	1
Kd	0	143.7	149.0	150.8	152.6	154.4	157.2	158.2	160.1	162.0
	0.25	144.9	150.2	152.0	153.8	155.7	158.5	159.5	161.4	163.3
	0.5	146.1	151.4	153.2	155.1	157.0	159.8	160.8	162.7	164.7
	0.75	147.3	152.7	154.5	156.4	158.3	161.1	162.1	164.0	166.0
	1	148.5	153.9	155.8	157.7	159.6	162.4	163.4	165.4	167.4
	1.25	149.7	155.2	157.1	158.9	160.9	163.8	164.8	166.8	168.8
	1.5	150.9	156.5	158.3	160.3	162.2	165.1	166.1	168.1	170.2
	1.75	152.2	157.7	159.6	161.6	163.5	166.5	167.5	169.5	171.5
	2	153.4	159.0	161.0	162.9	164.9	167.8	168.9	170.9	173.0
	2.25	154.7	160.3	162.3	164.2	166.2	169.2	170.2	172.3	174.4
	2.5	155.9	161.7	163.6	165.6	167.6	170.6	171.6	173.7	175.8
	2.75	157.2	163.0	164.9	166.9	169.0	172.0	173.1	175.1	177.3
	3	158.5	164.3	166.3	168.3	170.3	173.4	174.5	176.6	178.7
	3.25	159.8	165.7	167.7	169.7	171.7	174.9	175.9	178.0	180.2
	3.5	161.1	167.0	169.0	171.1	173.1	176.3	177.4	179.5	181.7
	3.75	162.5	168.4	170.4	172.5	174.6	177.7	178.8	181.0	183.1
	4	163.8	169.8	171.8	173.9	176.0	179.2	180.3	182.4	184.6
		min (C(2018))=		144.9	max(C(2018))=		184.6			

		Kp								
159.81		0	0.3	0.4	0.5	0.6	0.75	0.8	0.9	1
Kd	0	0.22	0.15	0.14	0.13	0.12	0.12	0.12	0.13	0.15
	0.25	0.05	0.01	0.00	0.00	0.01	0.02	0.03	0.05	0.08
	0.5	0.11	0.10	0.10	0.11	0.13	0.17	0.19	0.23	0.28
	0.75	0.46	0.48	0.50	0.53	0.57	0.64	0.66	0.72	0.79
	1	1.16	1.23	1.27	1.32	1.38	1.48	1.52	1.61	1.70
	1.25	2.29	2.43	2.49	2.56	2.65	2.80	2.85	2.97	3.10
	1.5	3.96	4.17	4.27	4.37	4.49	4.70	4.77	4.93	5.10
	1.75	6.28	6.59	6.72	6.87	7.03	7.30	7.40	7.61	7.83
	2	9.39	9.82	10.00	10.20	10.41	10.77	10.89	11.16	11.45
	2.25	13.46	14.05	14.29	14.54	14.82	15.28	15.44	15.78	16.14
	2.5	18.69	19.47	19.78	20.11	20.47	21.05	21.25	21.68	22.14
	2.75	25.32	26.34	26.74	27.16	27.62	28.35	28.61	29.15	29.72
	3	33.64	34.96	35.46	36.00	36.57	37.49	37.81	38.48	39.19
	3.25	44.00	45.68	46.32	46.99	47.70	48.84	49.25	50.08	50.95
	3.5	56.81	58.93	59.72	60.56	61.45	62.87	63.36	64.39	65.47
	3.75	72.55	75.21	76.20	77.25	78.34	80.09	80.70	81.97	83.29
	4	91.82	95.14	96.37	97.66	99.01	101.16	101.91	103.46	105.08

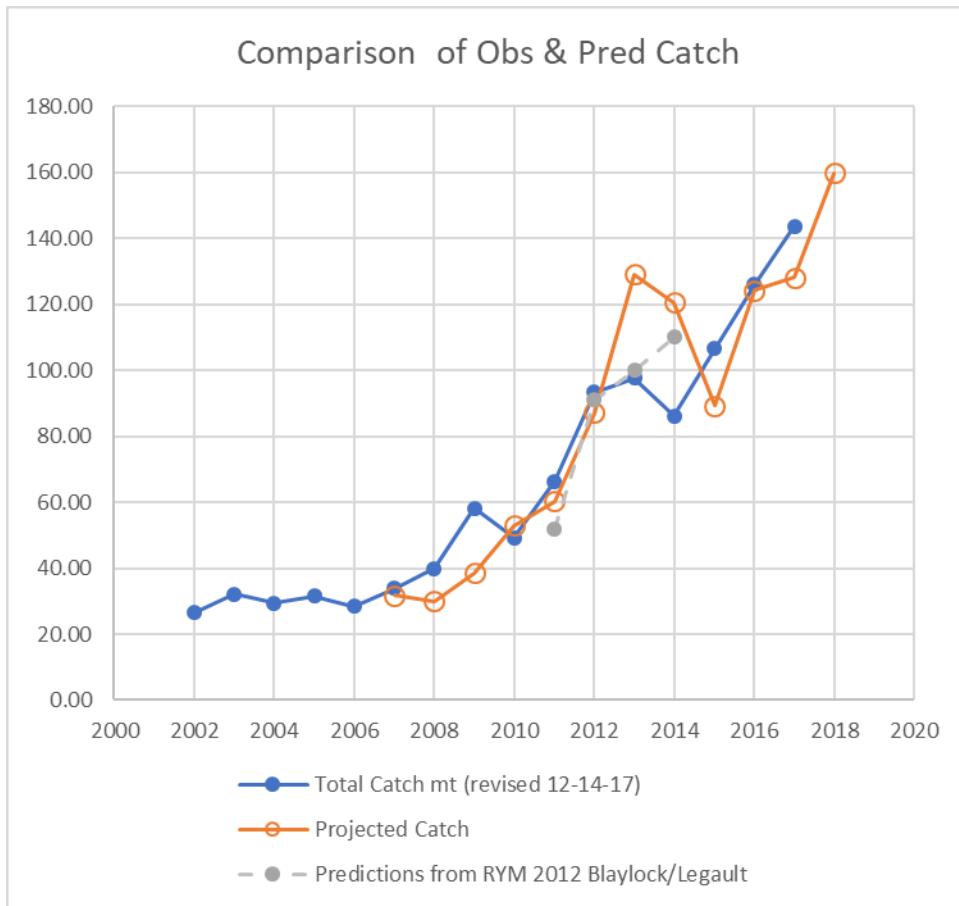


Figure 20B. Comparison of observed vs predicted catches based on the FSD model applied to US stock area. Forecasts from RYM application (Blaylock and Legault, 2012) are included for comparison. The gain parameters for proportional and derivative were set at  $K_p=0.75$  and  $K_d=0.50$ , respectively. **2017 catch = 143.7 (includes 33 mt for Canada. This is based on catch for 100% discard mortality).**

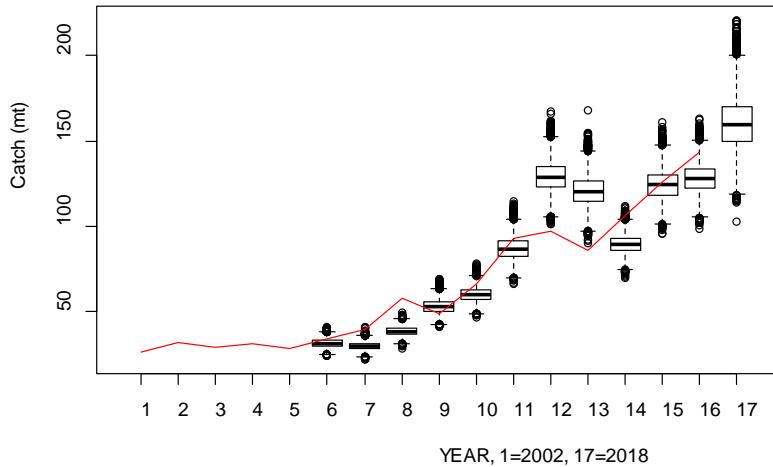


Figure 21B. Comparison of observed and predicted distribution of catches for FSD model applied to the US stock area. Uncertainty estimates are based on a parametric bootstrap method described in the text. The gain parameters for proportional and derivative were set at  $K_p=0.75$  and  $K_d=0.50$ , respectively.. .

**2017 catch = 143.7 (includes 33 mt for Canada). This is based on catch for 100% discard mortality.**

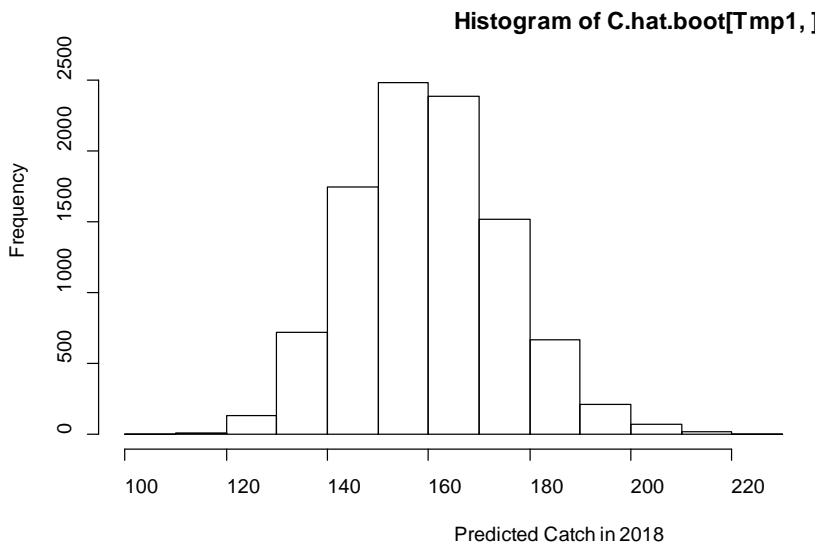


Figure 22B. Sampling distribution of predicted catch for 2018 based on parametric bootstrap method with 10,000 replications. **2017 catch = 143.7 (includes 33 mt for Canada). This is based on catch for 100% discard mortality.**

Projected catches by year are given in Fig. 21B and the sampling distribution of projected catch in 2018 is shown in Fig. 22B. The sampling percentile statistics for this distribution are

1%	5%	10%	25%	50%	75%	90%	95%	99%
128.56	136.53	140.98	149.56	159.61	170.00	179.78	186.20	199.11

The bootstrap mean of projected catch is 160.17 mt with a CV=0.095.