Plan B Assessment for Atlantic Halibut

Paul Rago

Webinar with NEFMC Science and Statistical Committee
December 18, 2017

Outline of this Presentation

- Follows the material in
  - “Halibut Assessment for 2017”, Draft, December 1, 2017.
  - “Addendum to Halibut Assessment Document”, December 15, 2017
- Data considerations
- Focuses on methodology used to project catch for 2018
  - Ratio methods and randomization tests to estimate magnitude and significance of changes in relative abundance.
  - Simulation tests of Ratio method
  - Proposed catch adjustment method based on rates of change in indices
  - Simulation tests of FSD method
  - Estimation of uncertainty of forecast
  - Application of method to US and DFO 3NOPs4VWX5Zc Atlantic halibut and IPHC Pacific halibut

Perspectives

- Has the population changed in recent years?
- Is the change significant?
- Is the observed change supported by multiple indices?
- How does the proposed data poor method perform in simulation?
  - Particularly regarding rebuilding
- Are there adverse effects for rebuilding, catches, and accountability measures?
- Does the approach stay within the boundaries of a Plan B assessment?

Data Sources (see Table 1)

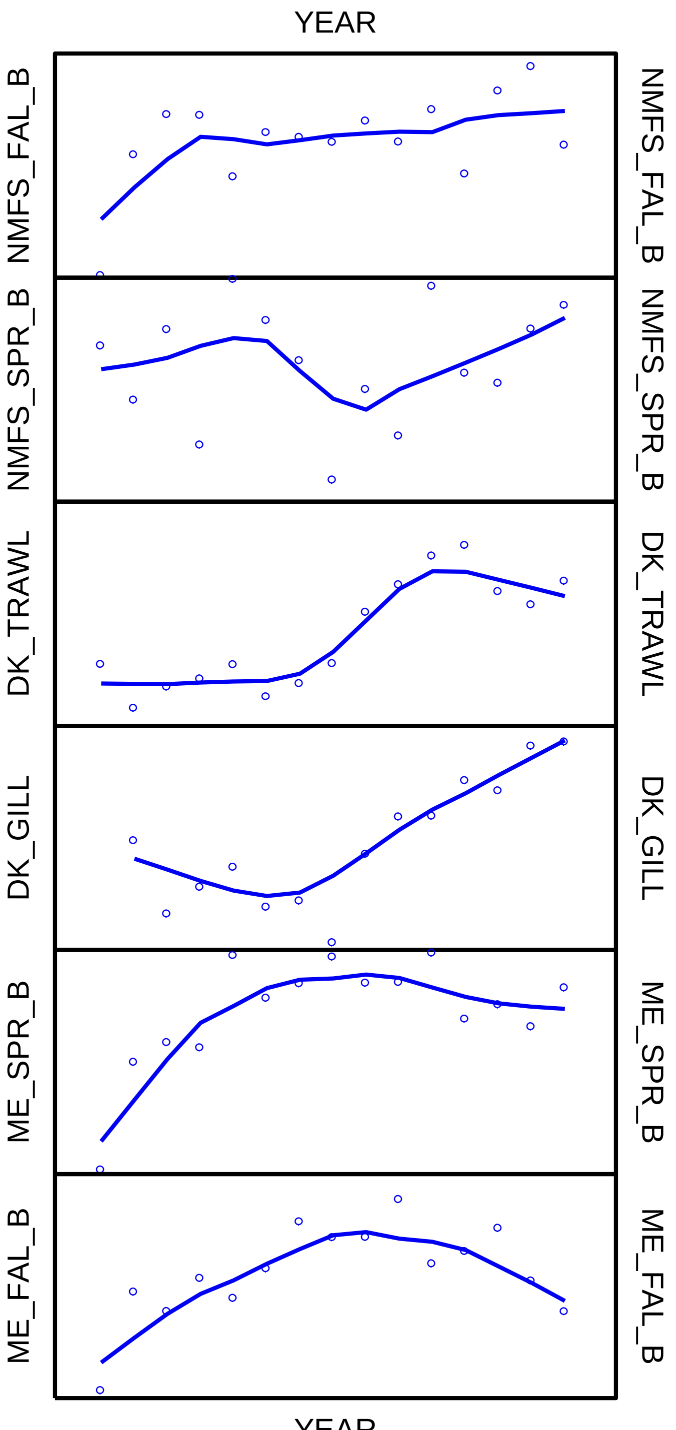
- Landings and Discards with revisions for gear-specific discard mortality
- Abundance Indices USED
  - NEFSC fall bottom trawl survey (*Used in previous assessments*)
  - d/k ratio gill net (*This is used to compute Total Discards*)
  - d/k ratio trawl (*This is used to compute Total Discards*)
- Abundance Indices EXAMINED
  - Maine Standardized CPUE—Hansell et al.
  - Maine Survey indices
  - Maine Commercial Indices from logbooks
  - Maine Sentinel Survey
  - Canadian Surveys and modeled biomass

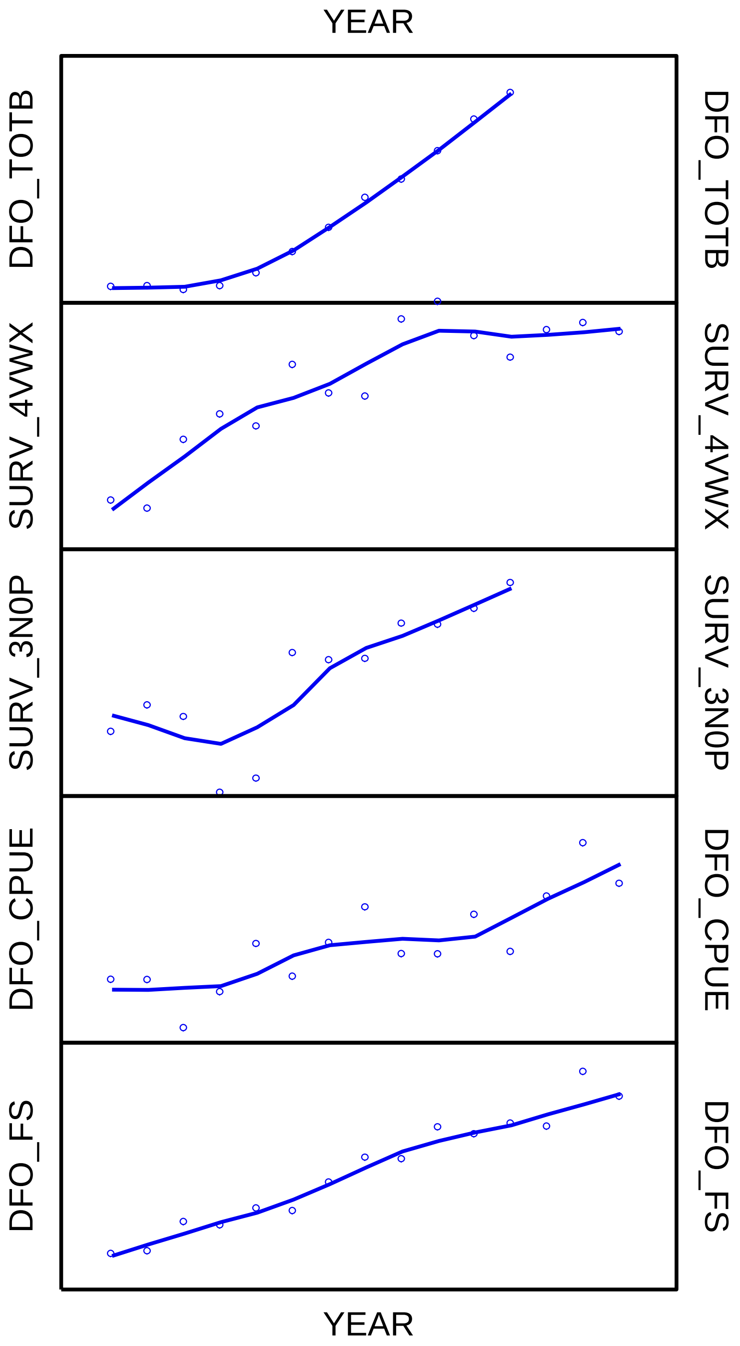
Changes to Catch Data following SSC Review on 12/14/17

- To establish consistency between current discard estimates used in 2017 with those used in 2016, the “D3” estimator was replaced with the “D2” estimator. Effects of this change are shown in next slide.
- Discard mortality rates, derived from averages applied to Pacific halibut (IPHC Annual Report 2017), were applied to US discards.76% mortality for trawls, 10% hook gear. A 30% mortality rate for gill nets was used; based on value used for spiny dogfish.
- To maintain consistency with previous PDT methods, the catch estimate for 2017 included 33 mt of Canadian Landings in Stat Area 5Y and 5Zc.

Average Effect of Change in discard estimator is small over 28 years but is 10.46 mt in 2016

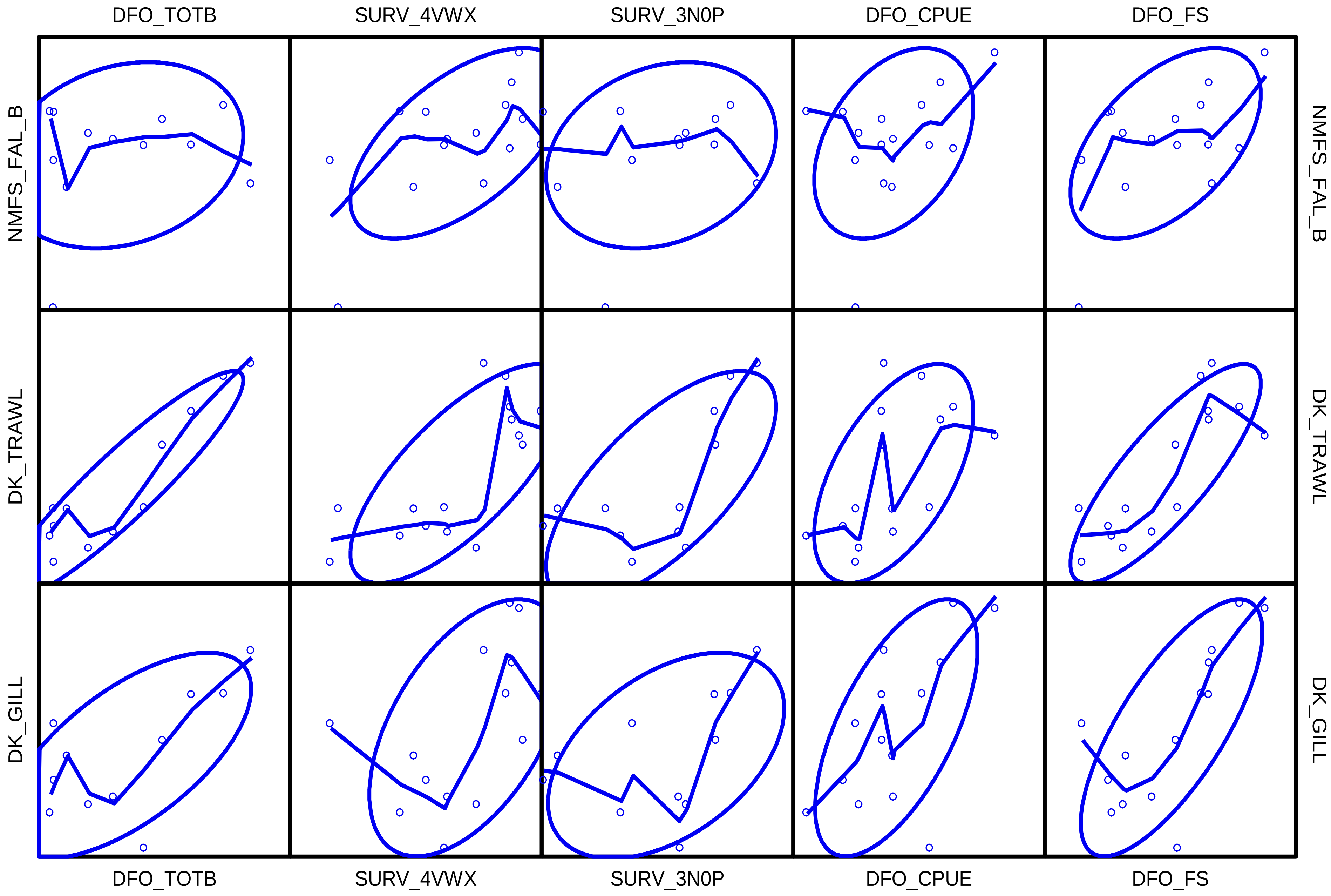
Year	*Total Discards D3*	*Total Discards D2*	*Difference*
1989	4.97	3.41	-1.56
1990	13.55	9.81	-3.74
1991	6.93	5.24	-1.69
1992	2.19	1.60	-0.59
1993	1.06	1.24	0.18
1994	3.16	1.40	-1.76
1995	6.34	3.08	-3.27
1996	0.65	0.61	-0.05
1997	1.64	0.60	-1.03
1998	0.10	0.15	0.05
1999	69.10	72.24	3.14
2000	11.87	8.78	-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





Comparison of time trends in US and Canada relative abundance indices for Atlantic Halibut, 2002-2016. DFO_TOTB is total abundance for Canada stock derived from assessment model.

FIG 7 (LEFT) and 8 (RIGHT) in Report



Comparison of core abundance indices for US and Canada, including results of model SSB for Canada

FIG 9 in Report

Rcrit and Randomization—is the observed trend in one or more indices significant?

- Rcrit is the ratio of the average of the last three observations to the first 3 observations in a time series
- Standardize the indices with respect to their means. This removes effect of scale and allows method to be applied to multiple indices
- Create the sampling distribution of Rcrit by shuffling the original observations and computing a new Rcrit. Do this many times.
- Compute the probability of observing the initial value of the test statistic (Rcrit for the actual time series) by comparing it to the set in the sampling distribution.

Rcrit Simulation Tests

- Key factors to consider
  - True underlying rate of change
  - Observation error of the indices
  - Number of variables available
- RESULTS—Bias is relatively low (<1%) except when
  - Number of variables is low,
  - CV of observations is high,
  - Underlying rate of increase is small
- RESULTS—Ability to detect true change improves as
  - CV of observations decreases
  - Number of indices increases
  - True underlying rate of increase increases.

Rcrit *Applications*

- US—6 candidate indices
- DFO—3 indices AND SSB from an analytical model

Finding the Best Estimate of Rcrit for Multiple Indices?

- ***Problem:*** Best is in the eye of the beholder or the group of scientists gathered on any given day.
- ***Solution:*** Consider all possible models
  - Combination of all possible models of n indices taken m at a time summed over m=1,…, n
  - Comb(6,6)+Comb(6,5)+Comb(6,4)+Comb(6,3)+Comb(6,2)+Comb(6,1)
- 1 + 6 + 15 + 20 + 15 + 6 =63
- Compare alternative models and compute average Rcrit and Pvalue of Rcrit across all possible models.

Changes in catches and indices for US and Canada. See Text table, p.16

	Ratio Definition	Changes in catches			Change in indices			
		Statistic	***Rcrit***	***%/yr***	***Statistic***	***Rcrit***	***%/yr***	***Model***
US	'02-04:'14-16	Rcrit(Catch)	3.227	9.4%	Rcrit(Indices)	3.23	9.4%	(all six indices)
						4.98	13.1%	(DK_g, DK_t, Survey)
						3.52	10.2%	average over 63 models
	'05-07:'14-16	Rcrit(Catch)	2.657	13.0%	Rcrit(Indices)	2.20	10.4%	(all six indices)
						4.11	19.3%	DK_g,DK_t, Survey
						2.44	11.8%	average over 63 models
	'02-04:'11-13	Rcrit(Catch)	2.617	10.1%	Rcrit(indices)	2.893	11.2%	(all six indices)
						5.033	17.5%	(DK_g, DK_t, Survey)
						3.144	12.1%	average over 63 models
Canada	2002-04: 2014-2016	Rcrit(Catch)	2.259	6.5%	Rcrit(Indices)	2.703	7.9%	(two surveys , one CPUE
						2.923	8.6%	average over 6 models
						2.763	8.1%	Analytical model results

Revised model for stock dynamics

- Assume linear model BUT ***r*** and ***h*** vary with time
- $B_{t+1} = B_t + r_t B_t - h_t B_t$ [17]

- $C_t = h_t B_t$ [18]
- $\ln(I_{t+p}) = \left(p\, ln(1 + r - h) \quad + \ln(I_t)\right)$ [29]

- $slope_t = \ln(1 + r_t - h_t)$

Building the First and Second Derivative Model

- Recursive equation for updating catch
  - $C_{t+1} \cong \frac{h_{t+1}}{h_t} e^{slope_t} C_t$ [31]
  - This can be extended to multiple indices
- ***BUT also interested in ability to detect changes in the slope.***
- Therefore need to extend model
  - $\beta(t, n) = slope(x_{t-n+1,} x_{t-n}, \ldots . x_{t-1}, x_t)$
  - $\Delta\beta(t, n) = \beta(t, n) - \beta(t-1, n)$ [34]

Weighting the slope and delta slope components

- Gain factors
  - Kp Gain on proportional rate of change
  - Kd Gain on derivative of change

- $C_{t+1} = e^{\left(K_p \beta(t,n) + K_d \Delta\beta(t,n)\right)} C_t$ [35]

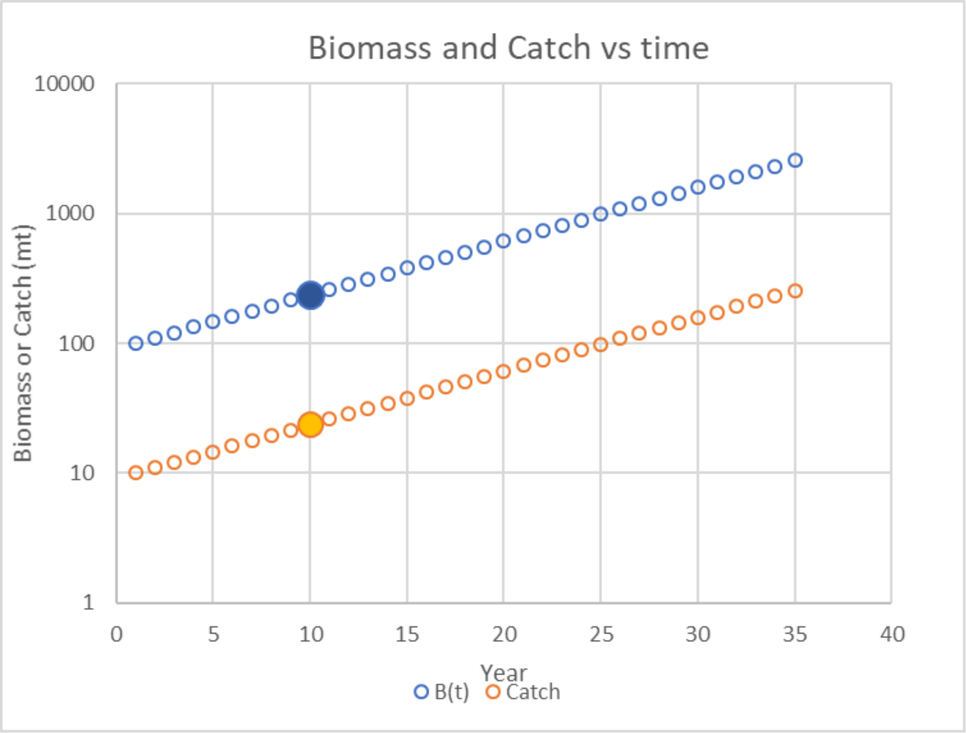
- Equation 35 is the recursive updating equation for catch. Note that when Kp=Kd=0 this becomes a constant status quo catch model.

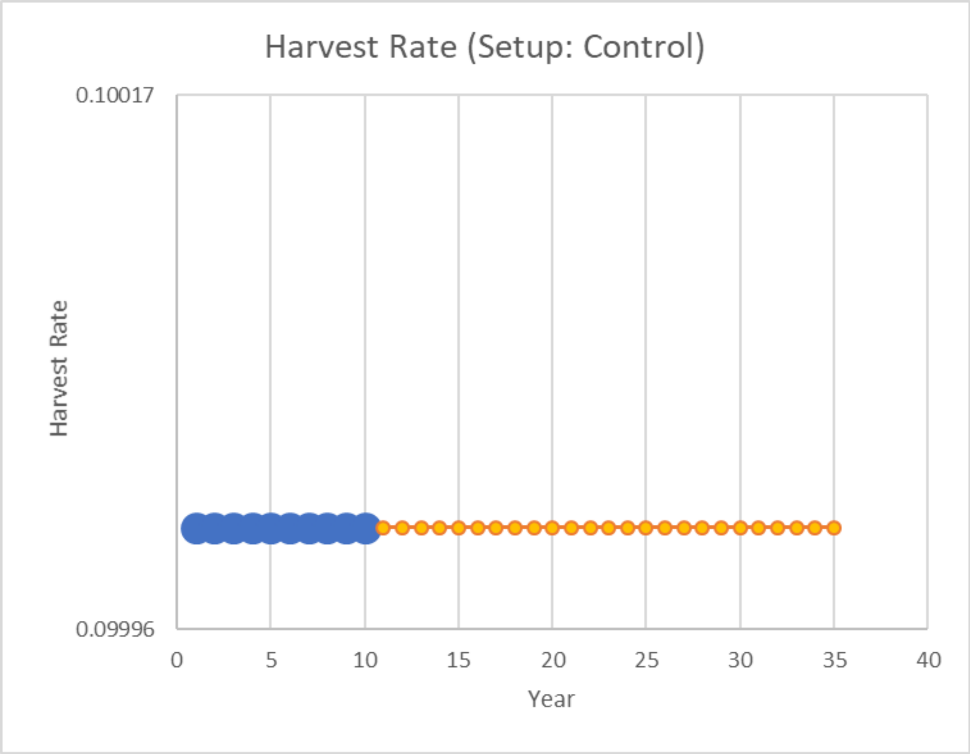
Controllability—Setting the gain factors Kp and Kd: Is it prudent to take all of the increase in relative abundance and translate it to an equivalent increase in catch?

- Why not, it's only fair but--
  - Concerns about lag in signal—based on 5 year window of index observations
  - Possibly bad signal when observation error is high.
  - Longevity suggest that under harvest of halibut will be in the water next year to capture. Therefore can balance tradeoff.
  - Examples from control theory literature (eg. Thermostats) suggest potential instability in process if gain is set too high.
- Many MPA examples consider "slow up, fast down" policies
- Important because of potential changes in productivity over time (***r(t)***). Especially important if stock productivity is declining via slower growth or reduced recruitment

Implications of a FSD policy for Rebuilding

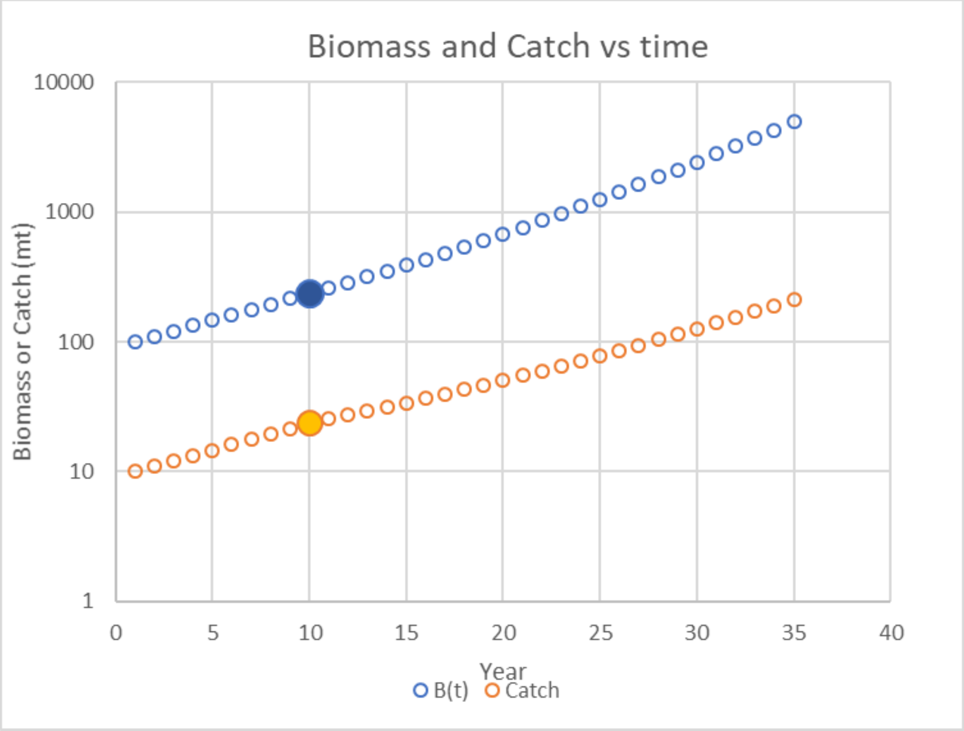
- Simple Conditions
  - {r(t)=0.2, h(t)=0.1 } ➔ population is increasing at rate of 0.1/year
  - Let Kp=1 and Kd=0. Control rule applied at time=10.



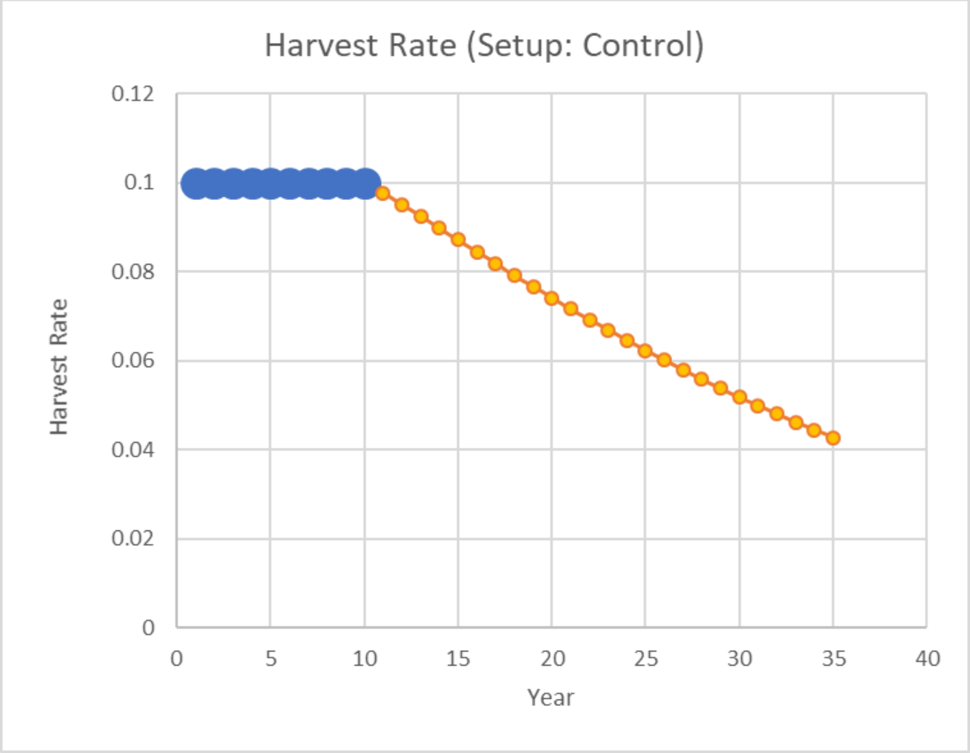


Implications of a FSD policy for Rebuilding

- Simple Conditions
  - {r(t)=0.2, h(t)=0.1 } ➔ population is increasing at rate of 0.1/year
  - Let **Kp=0.75** and Kd=0. Control rule applied at time=10.



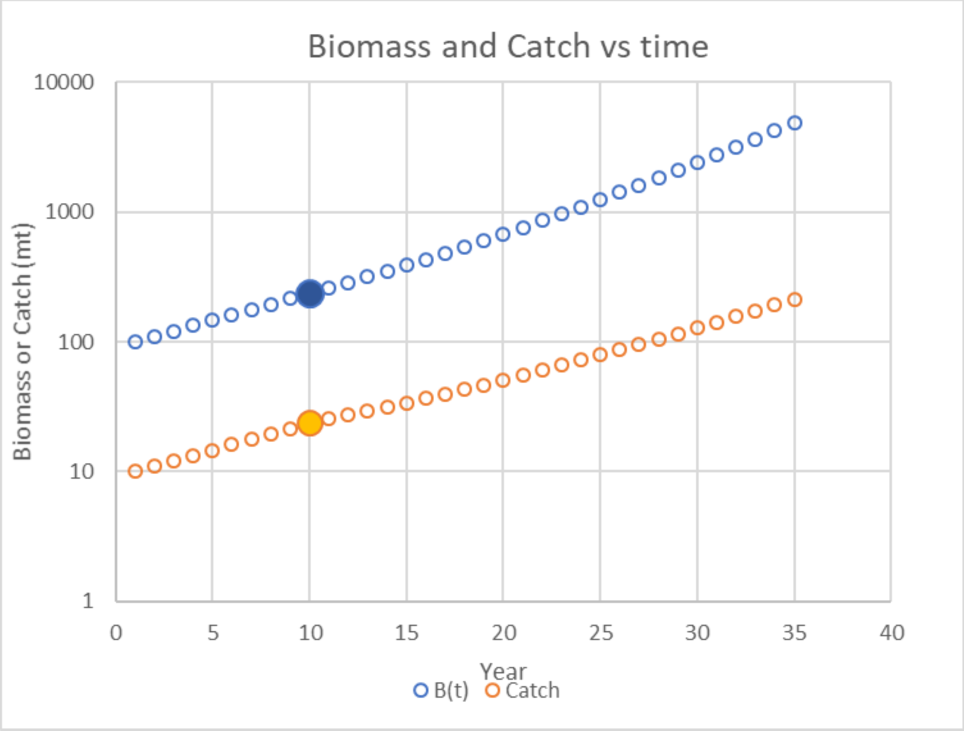
Population growth rate accelerates >0.1

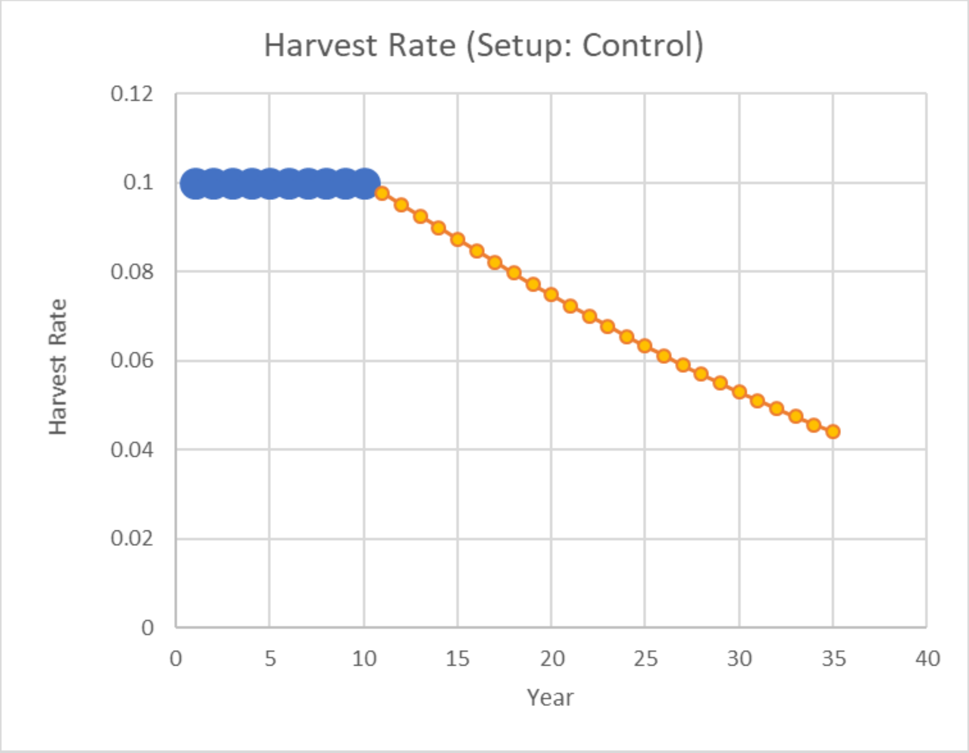


Realized harvest fraction decreases

Implications of a FSD policy for Rebuilding

- Simple Conditions
  - {r(t)=0.2, h(t)=0.1 } ➔ population is increasing at rate of 0.1/year
  - Let **Kp=0.75** and **Kd=0.5**. Control rule applied at time=10. ALMOST no change





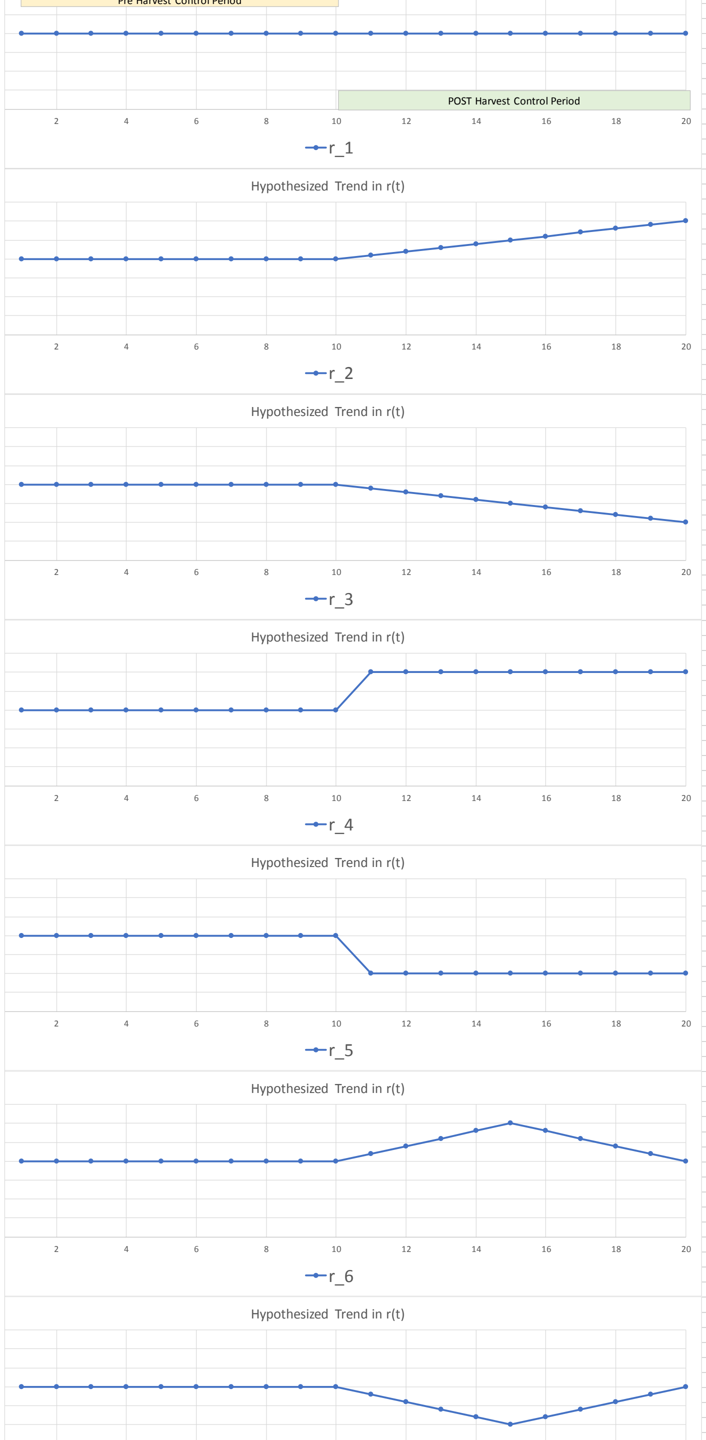
Population growth rate accelerates >0.1

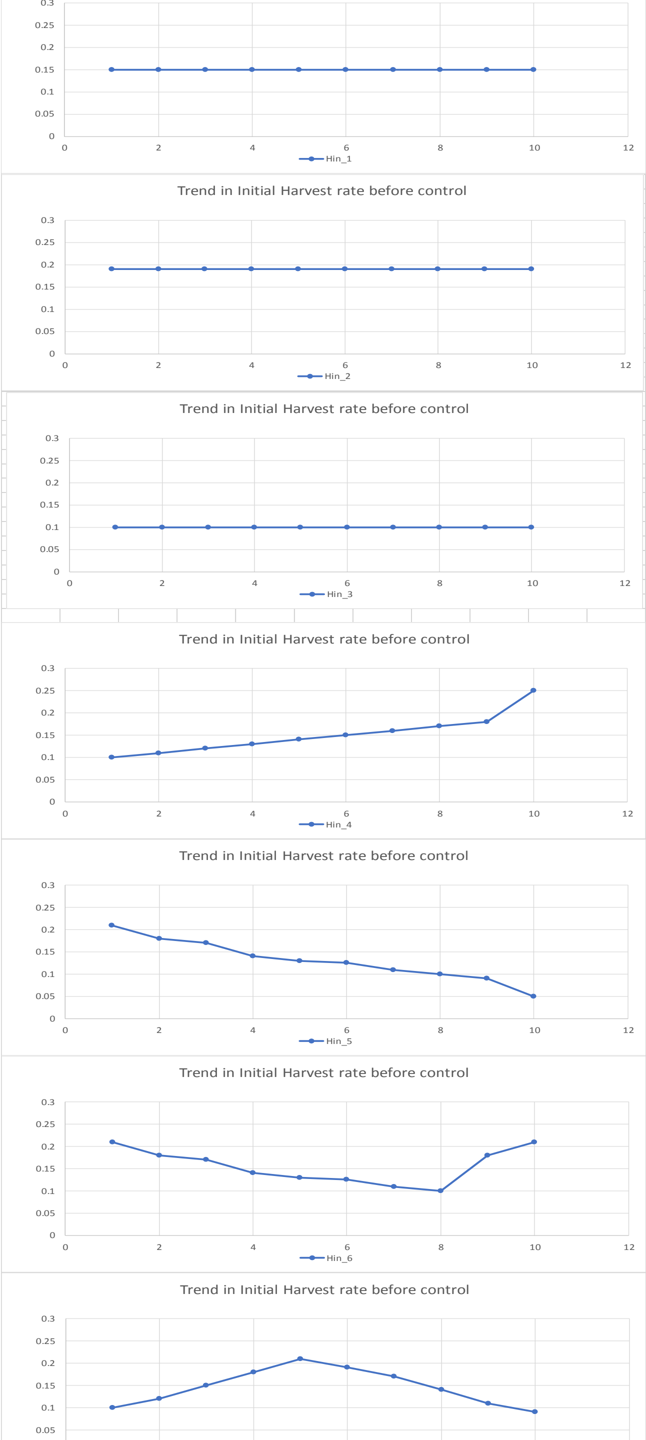
Realized harvest fraction decreases

OK, the model handles the slow-pitch softball-type problems. But of course, we don’t know what the future holds and only have modest information about the initial conditions.

- So it is helpful to simulate various control strategies for different assumptions about the:
  - Intrinsic rate of increase *[7 scenarios]*
  - Harvest rate in the initial (pre-control) period *[7 scenarios]*
  - Variability of observations *[2 levels]*
  - Number of indices available *[2 levels]*
  - Number of years used to estimate slope *[2 levels]*
  - Alternative weighting factors for proportional and derivative gain (Kp, Kd) *[4 x 4 combinations]*

Temporal Change in intrinsic rate of growth r(t). See Fig. 16





Temporal Change in initial harvest rate h(t) prior to implementation of the control rule governed by FSD.

See Fig. 17

Interpreting FSD Simulation Results

- “Best” control strategy is based on establishing tradeoffs between multiple objectives
  - Average # of overfishing events
  - Average catch
  - CV of catch
  - Simulation failures—overshoots on catch
  - Net rate of population growth during the period where the FSD control is applied

Key Results of Simulation Runs

6,272 scenarios, 50 20-yr simulations for each scenario.
{10-yr pre-control: 10-yr control rule}

See Table 14. Text table p.26

- Average number of overfishing events increased as proportional gain ***Kp*** and ***CV*** of observations increased. Highest percentage of overfishing events was less than 32%
- Average Catch during control period increased as ***Kp*** and ***Kd*** increased.
- Variation of catch increased as ***Kp, Kd*** and ***CV*** of observations increased.
- Expected growth rate of population decreased as greater fraction of realized growth was harvested (ie. ***Kp*** and ***Kd*** increased).
- Fraction of overshoots in projected catch (ie model catch exceeds population size) is primarily influenced by ***h(t)*** and ***r(t)*** scenario. Biggest concern is declining ***r(t)*** during the control period. (see text table p. 26)

Application of FSD to US stock

- Used 3 core indices:
  - NEFSC fall survey weight per tow
  - d/k ratio for gill nets
  - d/k ratio for trawls
- Examined fit over a range of Kp and Kd gain factors

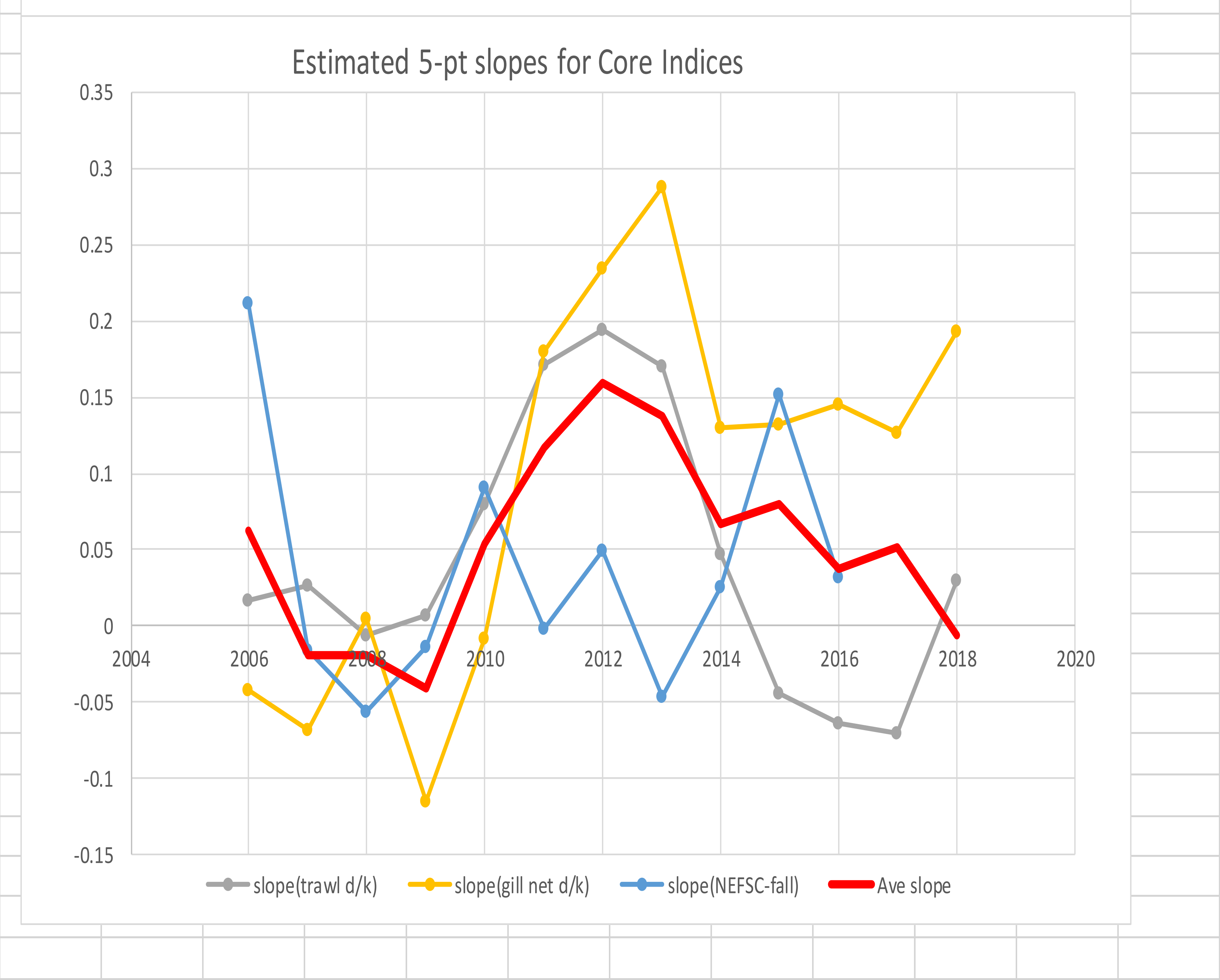


Figure 18 in Report (bottom)

Three Core Indices

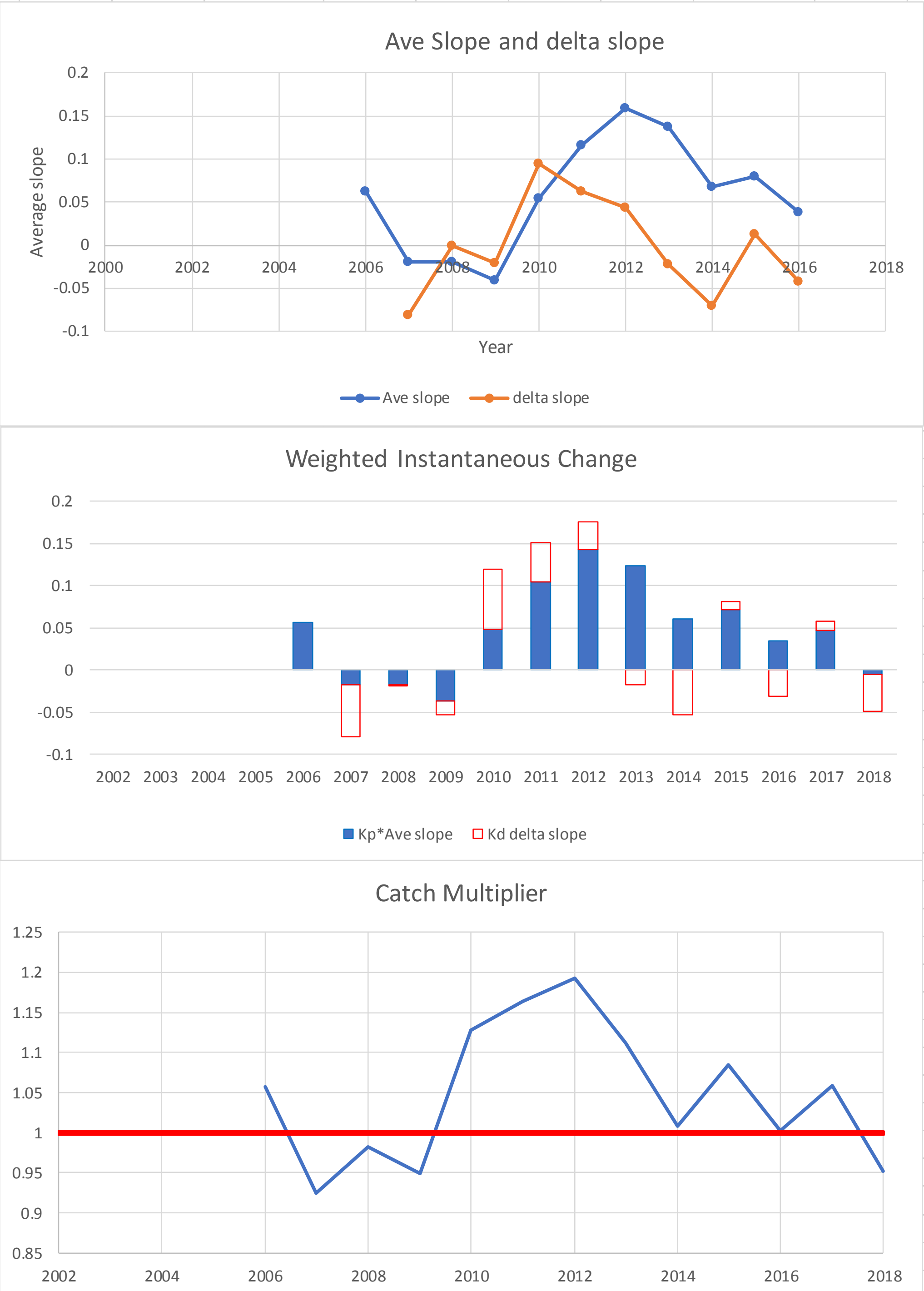


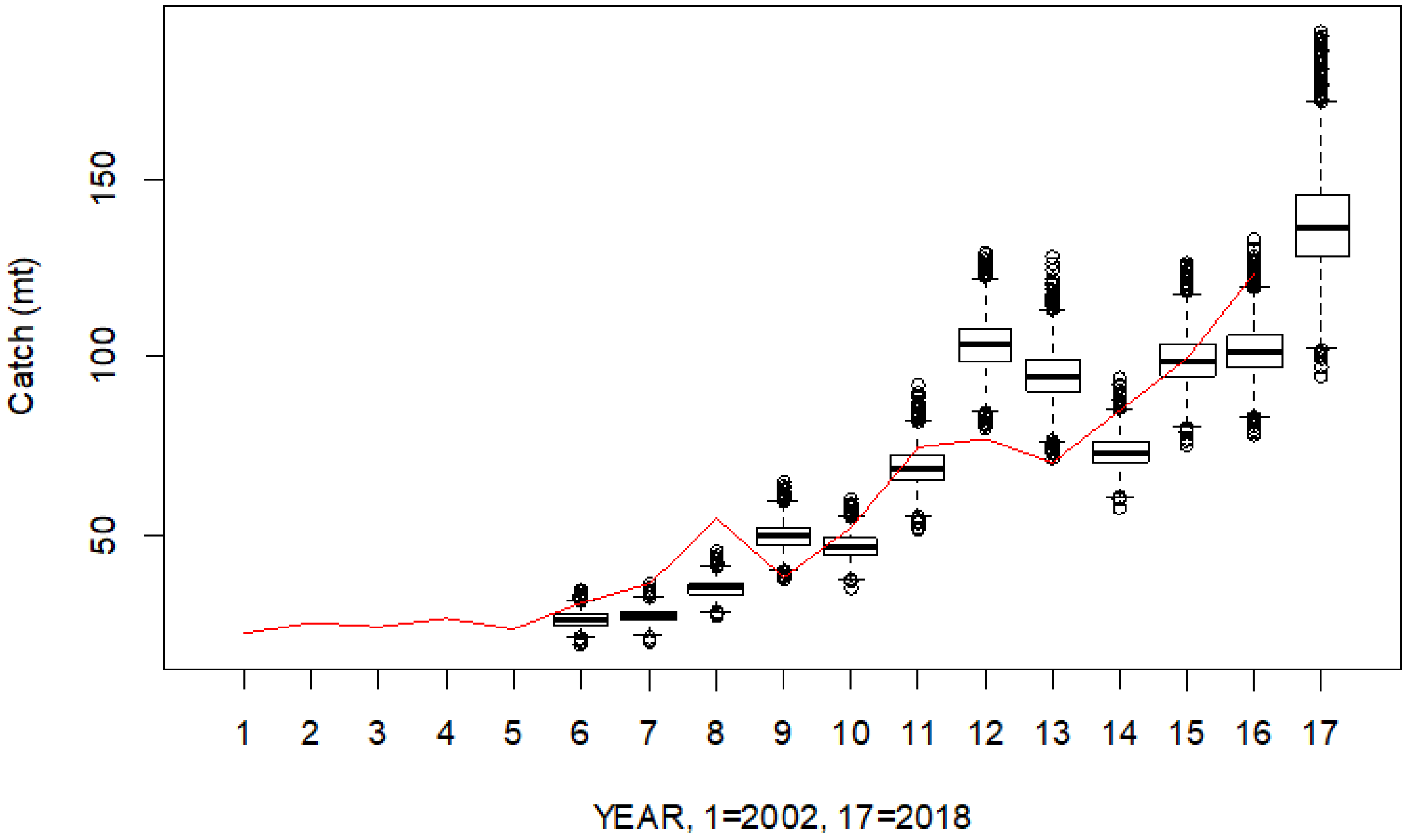
Figure 19 in Report

Bootstrap Method for Projections

- $Irand_{k,j,t} \sim LogNormal(Iobs_{j,t}, \sqrt{CV_{j,t}^{2} + 1}\,)$
- Apply to 3 core indices
  - d/k gill net
  - d/k trawl
  - NEFSC Fall Survey weight per tow
- Replicate 10,000 times
- Compute sampling distribution of forecasts at each step

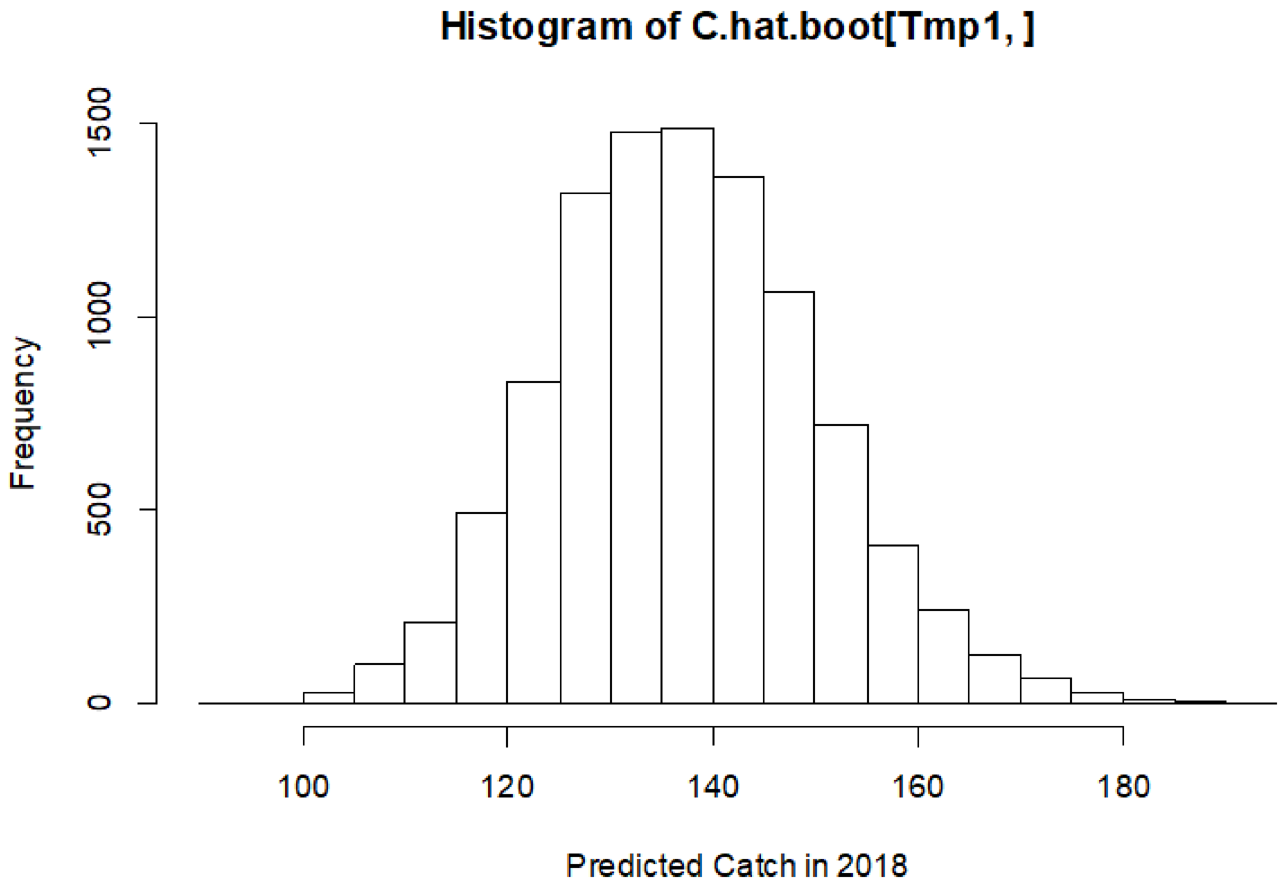
Uncetainty estimates for FSD projections

Figure 21A in Addendum Report. **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.** Adjustments for Canadian landings are NOT made in years prior to 2017



Projected Catch (mt) distribution for 2018

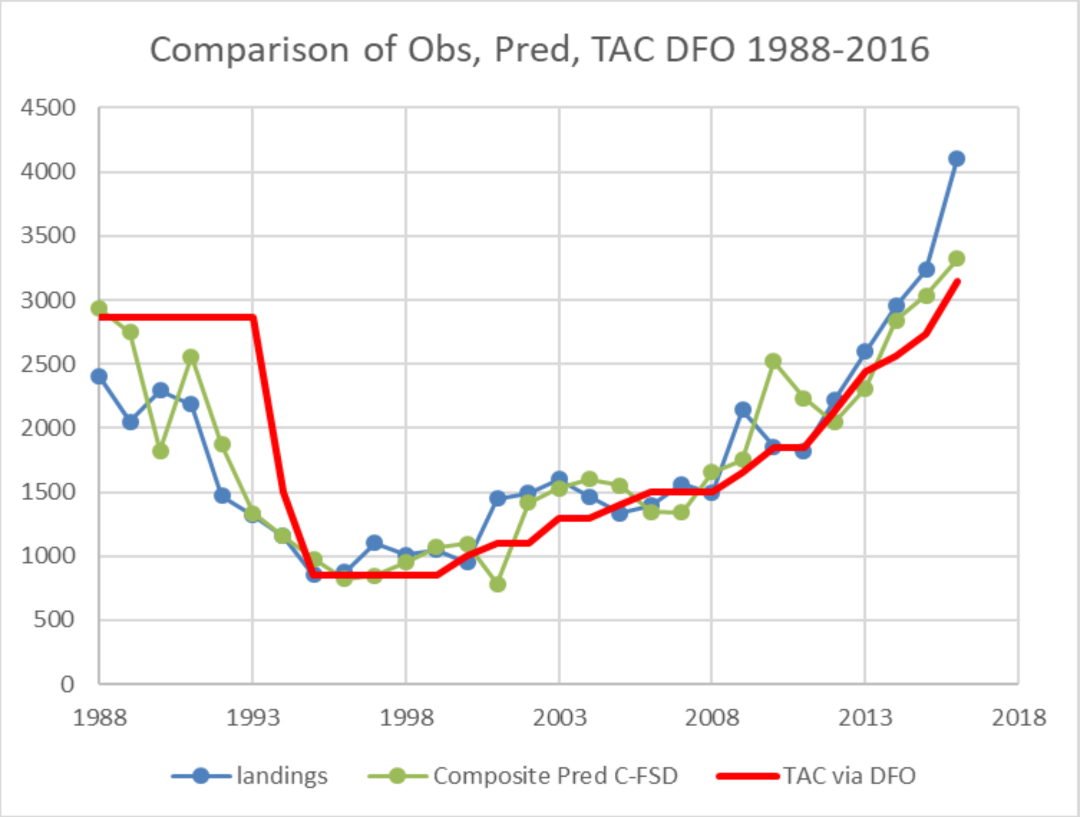
Figure 22A in Addendum Report **This is based on catch adjusted for gear-specific discard mortality (90 mt) plus Canadian landings in 2017 of 33 mt for a total =123.0 mt.**



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.

DFO 3NOPs4WX5Zc halibut stock



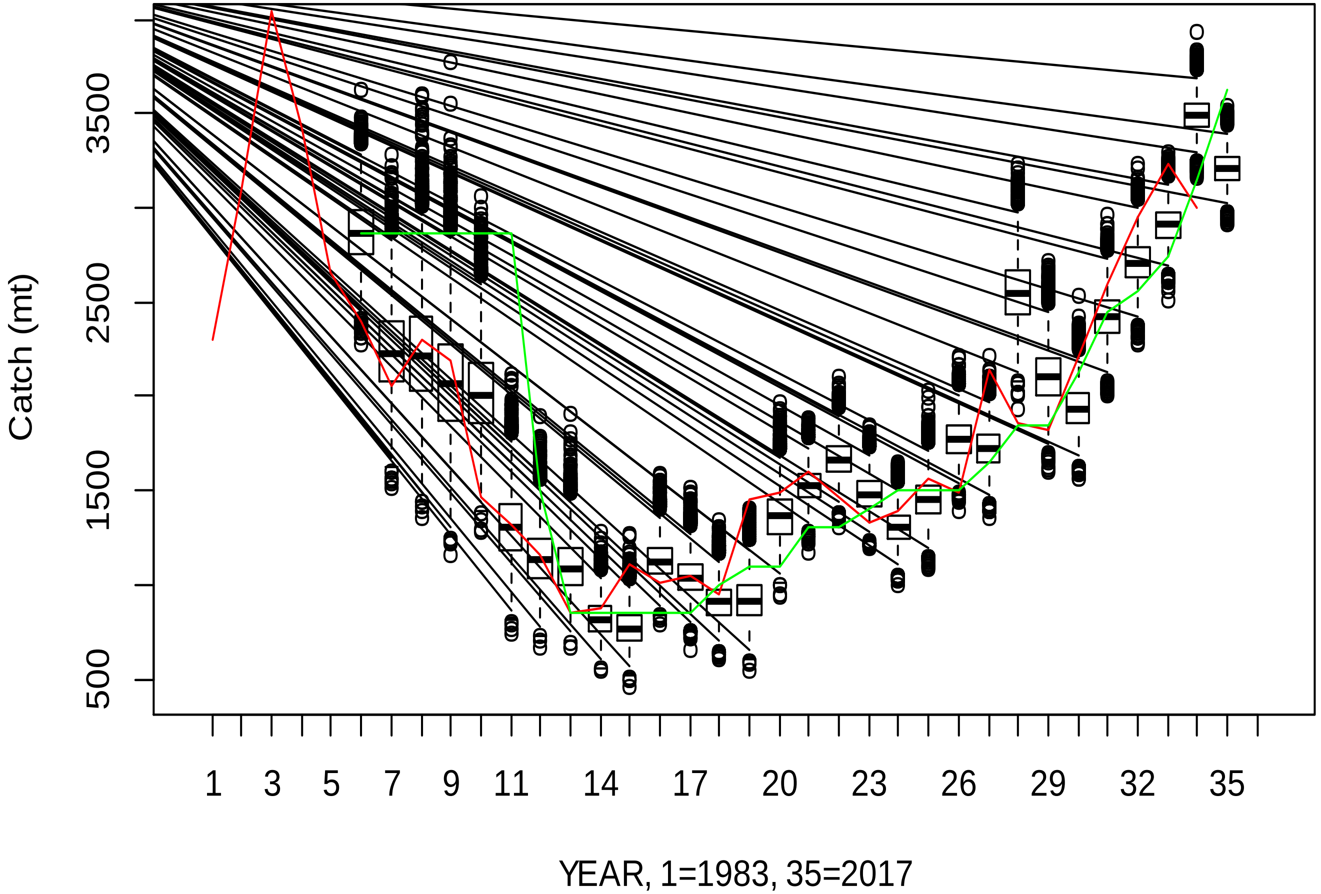


Figure 23 in Report

Appendix 2. Figure 2.1 in Report

Application to IPHC Pacific Halibut

- Used same indices as used in IPHC assessment
- Assumed that observed catches were very close to TAC
- Residuals tend to be small in recent years, less than 10% of actual catch

Application of FSD to IPHC Pacific halibut.

Assumed 20% CV for research survey; 30% Commercial survey.

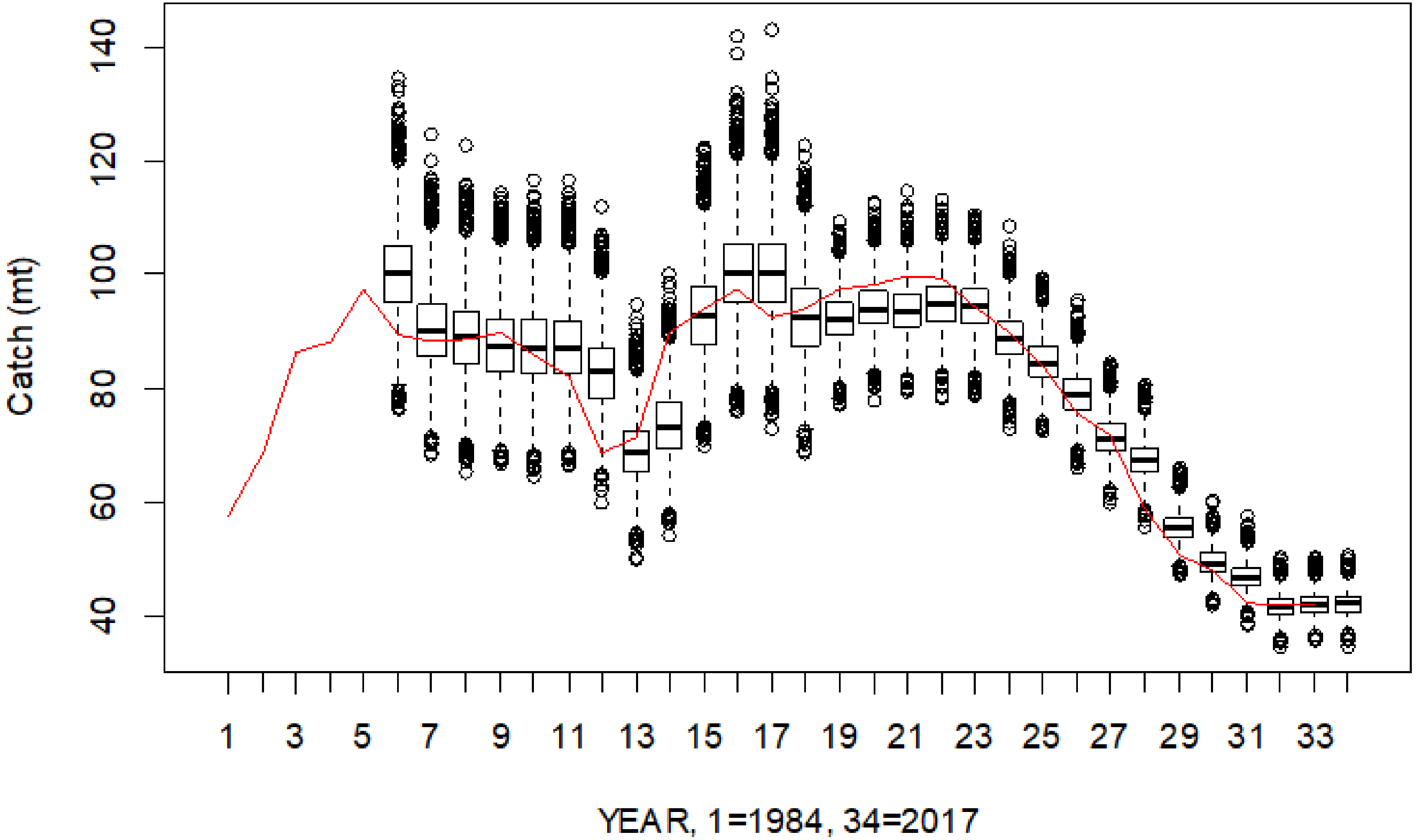


Figure 25 in Report

Summary

- Rcrit method may be useful for other stocks. Allows consideration of non-commensurate indices.
- FSD method does not introduce new data but uses d/k as measure of relative abundance.
- Proposed Model uses a MPA-like approach for updating catches
  - Tests with simulations
  - Compares performance with two other halibut stocks.
- Method builds on the GB cod approach and examines the likely consequences for a population managed under such a policy.
- Use of Kp=0.75 and Kd=0.5 is consistent with Council’s historic risk policy and will not increase relative F or impede rebuilding IF conditions remain constant. IF conditions do change, use of recommended gain factors provides some protection against overfishing and high variability of inter-annual catches

Questions?