Shawn Mc Manus
C2

FMP Area Total Estimated Halibut Discard and Mortality (in net weight pounds)

Total Estimated Halibut Discards

ALL GOA TOTAL		2013				2014			
		Retained	***Discard***	***PSC***	**Total Discard**	**Retained**	***Discard***	***PSC***	**Total Discard**
Hook-and-Line	Halibut Target IFQ	16,228,706	15,583,611		15,583,611	12,011,152	9,968,379		9,968,379
Hook-and-Line	Sablefish Target IFQ	1,818,594	1,442,061	472,893	1,914,954	1,548,868	1,153,809	441,921	1,595,730
Hook-and-Line	Other Targets	61,881	1,596	2,482,032	2,483,628	69,152	16,923	2,971,256	2,988,179
Trawl	All Targets			3,051,138	3,051,138			3,342,258	3,342,258
TOTAL	*All Gear & Targets**	**18,109,181**	*17,027,268*	*6,006,063*	**23,033,331**	**13,629,172**	*11,139,111*	*6,755,435*	**17,894,546**

Total Estimated Halibut Mortality

ALL GOA Mortality		2013				2014			
		Retained	***Discard***	***PSC***	**Total Mortality**	**Retained**	***Discard***	***PSC***	**Total Mortality**
Hook-and-Line	Halibut Target IFQ	16,228,706	2,493,378		2,493,378	12,011,152	1,594,940		1,594,940
Hook-and-Line	Sablefish Target IFQ	1,818,594	158,627	52,018	210,645	1,548,868	126,919	48,611	175,530
Hook-and-Line	Other Targets	61,881	255	273,023	273,278	69,152	2,709	326,626	329,335
Trawl	All Targets			2,032,705	2,032,705			2,302,595	2,302,595
TOTAL	*All Gear & Targets**	**18,109,181**	*2,652,260*	*2,357,746*	**5,010,006**	**13,629,172**	*1,724,568*	*2,677,832*	**4,402,400**

Total Estimated Halibut Discards

ALL BSAI TOTAL		2013				2014			
		Retained	***Discard***	***PSC***	**Total Discard**	**Retained**	***Discard***	***PSC***	**Total Discard**
Hook-and-Line	Halibut Target IFQ	3,691,034	1,012,625		1,012,625	2,730,471	1,441,290		1,441,290
Hook-and-Line	Sablefish Target IFQ	88,338	3,377	104,869	108,246	159,826	13,432	53,758	67,052
Hook-and-Line	Other Targets	3,342		9,792,610	9,792,610	1,012	4,222	8,414,846	8,419,068
Trawl	All Targets			6,342,148	6,342,148			6,186,526	6,186,526
TOTAL	*All Gear & Targets**	**3,782,714**	*1,016,002*	*16,239,627*	**17,255,629**	**2,891,309**	*1,458,944*	*14,655,130*	**16,113,936**

Total Estimated Halibut Mortality

ALL BSAI Mortality		2013				2014			
		Retained	***Discard***	***PSC***	**Total Mortality**	**Retained**	***Discard***	***PSC***	**Total Mortality**
Hook-and-Line	Halibut Target IFQ	3,691,034	162,020		162,020	2,730,471	230,607		230,607
Hook-and-Line	Sablefish Target IFQ	88,338		9,438	9,046	159,826	1,477	4,837	5,284
Hook-and-Line	Other Targets	3,342		894,642	894,642	1,012		754,841	755,517
Trawl	All Targets			5,093,920	4,130,696			5,009,693	4,375,034
TOTAL	*All Gear & Targets**	**3,782,714**	*162,020*	*5,998,000*	**5,196,404**	**2,891,309**	*232,084*	*5,769,371*	**5,366,442**

*Does not include Pot and Jig Gear
Discard column are at-sea discard calulated for trips with retained halibut
PSC column are deliveries with no retained halibut
Halibut discards are based on best available information collected by the North Pacific Observer program. Methods used by observers may overestimate total discards because average weights contain both retained and discarded halibut.

- IFQ Halibut discard mortality rate is 16%
    - *Gilroy, H.L. 2012. Incidental mortality of halibut in the commercial halibut fishery (Wastage). Int. Pac. Halibut Comm. Report of Assessment and Research Activities*
- IFQ Sablefish and Pacific cod discard mortality rate is 11%. Other mortality rates published in the Harvest Specifications

IPHC Area 4 Total Estimated Halibut Discard and Mortality
(in net weight pounds)

Total Estimated Halibut Discards

4A		2013				2014			
		Retained	*Discard*	*PSC*	Total Discard	Retained	*Discard*	*PSC*	Total Discard
Hook-and-Line	Halibut Target IFQ	621,965	*188,538*		188,538	424,542	*246,343*		246,343
	Sablefish Target IFQ	7,996	*3,225*	*2,871*	6,096	21,270	*3,992*	*6,437*	10,429
	Other Targets	1,731	*0*	*3,201,369*	3,201,369	1,012	*4,222*	*2,231,104*	2,235,326
Trawl	All Targets			*1,252,181*	1,252,181			*835,928*	835,928
TOTAL	*All Gear & Targets**	**631,692**	*191,763*	*4,456,421*	**4,648,184**	**446,824**	*254,557*	*3,073,469*	**3,328,026**

Total Estimated Halibut Mortality

4A Mortality		2013				2014			
		Retained	*Discard*	*PSC*	Total Mortality	Retained	*Discard*	*PSC*	Total Mortality
	Halibut Target IFQ	621,965	*30,166*		30,166	424,542	*39,415*		39,415
	Sablefish Target IFQ	7,996	*355*	*258*	613	21,270	*439*	*579*	1,018
	Other Targets	1,731	*0*	*291,996*	291,996	1,012	*676*	*202,732*	203,408
	Trawl			*963,224*	963,224			*634,659*	634,659
TOTAL	*All Gear & Targets**	**631,692**	*30,521*	*1,255,478*	**1,285,999**	**446,824**	*40,530*	*837,970*	**878,500**

Total Estimated Halibut Discards

4B Total		2013				2014			
		Retained	*Discard*	*PSC*	Total Discard	Retained	*Discard*	*PSC*	Total Discard
Hook-and-Line	Halibut Target IFQ	1,282,704	*355,194*		355,194	1,025,116	*542,211*		542,211
	Sablefish Target IFQ	80,342	*152*	*100,325*	100,477	138,556	*9,440*	*47,183*	56,623
	Other Targets	464		*82,171*	82,171			*239,704*	239,704
Trawl	All Targets			*528,439*	528,439			*444,944*	444,944
TOTAL	*All Gear & Targets**	**1,363,510**	*355,346*	*710,935*	**1,066,281**	**1,163,672**	*551,651*	*731,831*	**1,283,482**

Total Estimated Halibut Mortality

4B Mortality		2013				2014			
		Retained	*Discard*	*PSC*	Total Mortality	Retained	*Discard*	*PSC*	Total Mortality
	Halibut Target IFQ	1,282,704	*56,831*		56,831	1,025,116	*86,754*		86,754
	Sablefish Target IFQ	80,342	*17*	*9,029*	9,046	138,556	*1,038*	*4,246*	5,284
	Other Targets	464		*7,552*	7,552			*10,389*	10,389
	Trawl			*406,948*	406,948			*342,193*	342,193
TOTAL	*All Gear & Targets**	**1,363,510**	*56,848*	*423,529*	**480,377**	**1,163,672**	*87,792*	*356,828*	**444,620**

Total Estimated Halibut Discards

4CDE Total		2013				2014			
		Retained	*Discard*	*PSC*	Total Discard	Retained	*Discard*	*PSC*	Total Discard
Hook-and-Line	Halibut Target IFQ	1,786,365	*468,893*		468,893	1,280,813	*652,736*		652,736
	Sablefish Target IFQ			*1,673*	1,673			*138*	138
	Other Targets	1,147		*3,816,807*	3,816,807			*4,720,135*	4,720,135
Trawl	All Targets			*2,056,978*	2,056,978			*2,713,674*	2,713,674
TOTAL	*All Gear & Targets**	**1,787,512**	*468,893*	*5,875,458*	**6,344,351**	**1,280,813**	*652,736*	*7,433,947*	**8,086,683**

Total Estimated Halibut Mortality

4CDE Mortality		2013				2014			
		Retained	*Discard*	*PSC*	Total Mortality	Retained	*Discard*	*PSC*	Total Mortality
	Halibut Target IFQ	1,786,365	*75,023*		75,023	1,280,813	*104,438*		104,438
	Sablefish Target IFQ			*151*	151			*12*	12
	Other Targets	1,147		*349,905*	349,905	0		*430,491*	430,491
	Trawl			*1,667,052*	1,667,052			*2,230,668*	2,230,668
TOTAL	*All Gear & Targets**	**1,787,512**	*75,023*	*2,017,108*	**2,092,131**	**1,280,813**	*104,438*	*2,661,171*	**2,765,609**

*Does not include Pot and Jig Gear
Discard column are at-sea discard calulated for trips with retained halibut
PSC column are deliveries with no retained halibut
Halibut discards are based on best available information collected by the North Pacific Observer program. Methods used by observers may overestimate total discards because average weights contain both retained and discarded halibut.

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- IFQ Sablefish and Pacific cod discard mortality rate is 11%. Other mortality rates published in the Harvest Specifications

CZ Peggy Parker

Halibut Bycatch Throughout the Range of *Hippoglossus stenopolis*

1. Percent of the halibut bycatch mortality, by regulatory area, that is **under 32-inches,** or sublegal of total mortality. These fish have not yet spawned.

2A	27%
2B	43%
2C	19%
3A	64%
3B	80%
4A	77%
4B	37%
4CDE	76%

2. Total bycatch mortality (all sizes) caught by regulatory area, compared to directed landings, 2014.

Area	*Bycatch Mortality (net pounds)*	*Landings (net pounds)*
2A	70,000	539,000
2B	240,000	5,776,000
2C	10,000	3,295,000
3A	1,640,000	7,347,000
3B	1,230,000	2,824,000
4A	860,000	827,000
4B	390,000	1,089,000
4CDE	4,570,000	1,245,000

Bill Orr
C2 pub Comment
E-copy

ALASKA GROUNDFISH COOPERATVE
JUNE UPDATE

The members of the Alaska Groundfish Cooperative (Fishing Company of Alaska, O'Hara Corporation and Iquique US LLC) recently adopted Halibut Bycatch Rules designed to reduce halibut bycatch mortality by vessels in the Cooperative. These rules are identical to those developed and adopted earlier this year by the Alaska Seafood Cooperative. Fishermen will be instructed in the use of the rules, and their performance reviewed to ensure compliance. The expectation is that bycatch mortality will be reduced with adoption of these rules

These rules cover:

- Halibut avoidance practices on the grounds
  - Test tows
  - Attention to haul composition
  - Shorter tows
  - Moving to avoid halibut abundance
  - Avoiding night tows when bycatch is higher
- Increased communications between participating fishermen
  - On grounds real time communications
  - Weekly bycatch meetings between cooperative members
- Sharing data for fishery performance charts
- Use and further development of excluders
- Deck sorting when practicable

To fully implement the rules, AGC has requested that the ASC work with us to develop an inter cooperative agreement covering the sharing of information on the grounds, providing Sea State with data to enhance fisheries performance charts and the inclusion of FCA in weekly sector meetings to review halibut mortality performance.

Discussions have been initiated with others in the sector on ideas to provide incentives to further reduce bycatch mortality.

Fishing Company of Alaska completed transfer of yellowfin sole to ASC as part of a sector agreement on TAC setting for Atka Mackeral and flatfish.

Fishing Company of Alaska has requested consideration for re-admittance to the Groundfish Forum.

C2 Heather Mann

If pollock and rockfish share remains at 250mt and 5 mt, then the below table shows the TLAS PSC cut options and how they correspond to % cod PSC cut results

PSC AMOUNT CUT	50%	40%	30%	20%	10%
TLAS TOTAL	437.5	525	612.5	700	787.5
pollock stays the same	250	250	250	250	250
rockfish stays the same	5	5	5	5	5
remaining for cod & yellowfin	182.5	270	357.5	445	532.5
cod 73% of remaining	133.343	197.274	261.206	325.137	389.069
yellowfin 27% of remaining	49.1573	72.7258	96.2944	119.863	143.431
cod % cut	71%	56%	42%	28%	14%
yellowfin % cut	71%	56%	42%	28%	14%
total	437.5	525	612.5	700	787.5

John Garvin
C 2

Halibut Bycatch Management Research

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April 26, 2012

Executive Summary

This simulation study examines two potential policy issues for the Pacific halibut fishery: Part 1 explores the potential impacts of reducing halibut bycatch in the Bering Sea and Gulf of Alaska, and Part 2 examines the potential impacts of reducing the minimum size limit in the directed commercial fishery. A sex- age-structured simulation model was developed to account for the dynamics of numbers-at-age, by sex, and biomass of the coastwide population of Pacific halibut. The simulation model was parameterized based on the recent 2011 IPHC stock assessment model and uses model estimates of the numbers-at-age, recruitment, natural mortality, fishing mortality and selectivity to initialize the simulation model from 1996–2011. Three alternative future recruitment scenarios, density-independent and density-dependent growth models are used to simulate a range of alternative scenarios 15 years into the future. Simulation model outputs include, estimates of coastwide exploitable biomass, spawning biomass, commercial yield, discards, wastage, and the value of the directed fishery based on halibut prices in Homer Alaska. The average exploitable biomass, spawning biomass, landed value, or other performance measures, between the years 2020–2025 was used as a summary statistic to compare alternative policy options.

Reducing non-directed fishery bycatch by 50% in the Bering Sea Aleutian Island (BSAI) or the Gulf of Alaska (GOA) had very little impact on the simulated coastwide estimates of exploitable biomass, or spawning biomass. The levels of bycatch reduction were redistributed to the directed fishery; about 90% of the reduced bycatch was recovered by the commercial fishery assuming the same 2011 coastwide selectivities from the 2011 IPHC assessment. Yield loss ratios in the directed commercial fishery were mainly less than 1; the current age/size composition of the stock and the selectivity of the commercial and bycatch gears determine the yield loss ratio. The largest source of mortality in the coastwide stock is the directed commercial fishery.

Reducing the size limit from the current 32 inches to 29 or 26 inches, resulted in an increase in simulated estimates of exploitable biomass. This increase was associated with a reduction in the mortality associated with the commercial wastage. In the simulations, impacts of other users (bycatch, recreational, and personal use) of the halibut resource was assumed constant based on the 2011 harvest values. Decreasing the size limits lowers the overall coastwide landed value because the composition of the catch has a much higher proportion of small low value halibut (assuming $5.00 per pound for halibut in the 5-10 pound size category). The real economic gains to be made in the directed fishery are associated with reduced cost of fishing because fewer sublegal sized fish are discard. Expected proportions of fish caught that are of sublegal size are 60% with a 32 inch size limit and 9% with a 26 inch size limit.

Acknowledgments

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I would also like to thank Bruce Leaman, Steven Hare, Juan Valero, Ray Webster, Gregg Williams and Lara Erikson from the International Pacific Halibut Commission for providing an office to work in, data, code and discussion about bycatch and size limits in the Halibut fishery.

Contents

Executive Summary i
Acknowledgements i
Contents iv
List of Figures vii
List of Table viii

I Impacts of bycatch & wastage on halibut yield **1**

1.1 Introduction 2
1.1.1 Overview of total mortality in the IPHC model 2
1.2 Simulation Model 3
1.2.1 Overview of the simulation model 3
1.2.2 Calculating setline fishery catch share 7
1.2.3 Calculating area specific fishing mortality rates 7
1.2.4 Model outputs 8
1.3 Simulation Scenarios 9
1.4 Alternative policy options 10
1.5 Results 10
1.5.1 Effects of bycatch reduction on EBio 13
1.5.2 Effects of bycath reduction on Spawning biomass 13
1.5.3 Effects of bycatch reduction on commercial yield 15
1.5.4 Effects of bycatch reduction on commercial wastage 15
1.6 Discussion 16

II Effects of reduced minimum-size limits on yield, spawning biomass, and wastage. **19**

2.1 Introduction 20
2.2 Methods 21
2.2.1 Joint probability model for retention 21
2.2.2 Simulation scenarios 22
2.3 Results 23
2.3.1 Impacts of MSL on exploitable biomass 23
2.3.2 Impacts of MSL on commercial yield 23

2.3.3 Impacts of MSL on commercial wastage 24
2.3.4 Impacts of MSL on economic value 24
2.4 Discussion 28
References 30

III Appendices 31
A.1 Input files for the Simulation Model 32
B.2 Model Description 37
B.2.1 Simulation model input 38
B.2.2 Analytical description 39
B.2.3 Model outputs 42

List of Figures

1.1 Observed mean length-at-age for female (a) and male (c) halibut in the IPHC research surveys between 1996 and 2011. Fitted lines are the von Bertalanffy growth model with the boundaries based on a 10% coefficient of variation in the asymptotic length. Estimated parameters for females are $L_\infty = 148.06$, $k = 0.0915$, and for males $L_\infty = 105.73$, $k = 0.1275$. Panels b (female) and d (male) show the length-weight relationship used in the model, along with the empirical catch weight-at-age data used in the IPHC assessment (open circles). 5

1.2 Age-based selectivity coefficients for female and male halibut for the setline fishery (a), U32 (b), O32 (c), the recreational and personal use fisheries (d). 6

1.3 Relationship between asymptotic length $l_\infty^{(h)}$ for females (a) and males (b) and cohort density. Under density-dependent growth, $l_\infty^{(h)}$ decreases with increasing density (solid line) and density independent growth (dotted line). 10

1.4 Example of simulation model output for the exploitable biomass under poor, average and good recruitment. The thick grey line is the exploitable biomass output from the IPHC wobblesq assessment conducted at the end of the 2011 fishing season. 12

1.5 Simulated weight-at-age for halibut under low recruitment densities (red), average recruitment densities (black), and high recruitment densities (blue). 12

1.6 Simulated coastwide exploitable biomass under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for the Status Quo scenarios (left), 50% bycatch reduction in BSAI (middle), and 50% bycatch reduction in the GULF (right). Poor, average, and good recruitment scenarios denoted with, red, black and blue lines, respectively. . 13

1.7 Simulated coastwide female spawning biomass under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for the Status Quo scenarios (left), 50% bycatch reduction in BSAI (middle), and 50% bycatch reduction in the GULF (right). Poor, average, and good recruitment scenarios denoted with, red, black and blue lines, respectively. The thick grey reference line corresponds to 30% of unfished spawning biomass. 14

1.8 Simulated coastwide commercial yield under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for the Status Quo scenarios (left), 50% bycatch reduction in BSAI (middle), and 50% bycatch reduction in the GULF (right). Poor, average, and good recruitment scenarios denoted with, red, black and blue lines, respectively. 15
1.9 Simulated coastwide commercial yield loss ratios under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for the Status Quo scenarios (left), 50% bycatch reduction in BSAI (middle), and 50% bycatch reduction in the GULF (right). Poor, average, and good recruitment scenarios denoted with, red, black and blue lines, respectively. 16
1.10 Simulated coastwide wastage from the commercial fishery under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for the Status Quo scenarios (left), 50% bycatch reduction in BSAI (middle), and 50% bycatch reduction in the GULF (right). Poor, average, and good recruitment scenarios denoted with, red, black and blue lines, respectively. 17
2.11 Example of retention- and discard-at-age probabilities for a given growth curve over 32 inch (left) 29 inch (middle) and 26 inch (right) minimum size limit. . 22
2.12 Effects of MSL on exploitable biomass under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for 32 inch (left), 29 inch (middle), and 26 inch (right) size limits. Poor, average, and good recruitment are denoted by red, black and blue lines, respectively. Value on each panel corresponds to 2020-2025 average over 3 recruitment hypotheses. 23
2.13 Effects of MSL on commercial yield under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for 32 inch (left), 29 inch (middle), and 26 inch (right) size limits. Poor, average, and good recruitment are denoted by red, black and blue lines, respectively. Value on each panel corresponds to 2020-2025 average over 3 recruitment hypotheses. 24
2.14 Effects of MSL on commercial wastage under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for 32 inch (left), 29 inch (middle), and 26 inch (right) size limits. Poor, average, and good recruitment are denoted by red, black and blue lines, respectively. Value on each panel corresponds to 2020-2025 average over 3 recruitment hypotheses. 25
2.15 Fraction of captured fish discarded in the commercial fishery under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for 32 inch (left), 29 inch (middle), and 26 inch (right) size limits. Poor, average, and good recruitment are denoted by red, black and blue lines, respectively. Value on each panel corresponds to 2020-2025 average over 3 recruitment hypotheses. 25

2.16 Landed value for the commercial fisher under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for 32 inch (left), 29 inch (middle), and 26 inch (right) size limits. Poor, average, and good recruitment are denoted by red, black and blue lines, respectively. Value on each panel corresponds to 2020-2025 average over 3 recruitment hypotheses. 26
2.17 Value of commercial wastage under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for 32 inch (left), 29 inch (middle), and 26 inch (right) size limits. Poor, average, and good recruitment are denoted by red, black and blue lines, respectively. Value on each panel corresponds to 2020-2025 average over 3 recruitment hypotheses. 27
2.18 Value of all commercial sublegal size fish under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for 32 inch (left), 29 inch (middle), and 26 inch (right) size limits. Poor, average, and good recruitment are denoted by red, black and blue lines, respectively. Value on each panel corresponds to 2020-2025 average over 3 recruitment hypotheses. 27
B.19 Probability of retention and discarding a halibut with a 32 inch size limit in place. 42

List of Tables

1.1 Summary calculations for model output 8
1.2 The 2011 area apportionment, harvest rates, and observed landings for U32, O32, recreational (sport) and personal use. These catch levels were assumed constant into the future with the exception of area 2B, where 88% and 12% of the available CEY is allocated to the commercial and recreational fishery, respectively. 11
2.3 Summary of simulated performance measures for three alternative size limit policies averaged over 3 recruitment levels and 2 alternative hypthoses about halibut growth. 28
A-1 List of symbols, units and description of variables for the simulation model. . 39
A-2 Analytical description of the sex-based age-structured model used for simulation projections. 41

Part I

Impacts of bycatch & wastage on halibut yield

Overarching objective: Investigate the effects of halibut bycatch and wastage in the GOA and BSAI fisheries on halibut yield and spawning biomass.

1.1 Introduction

To examine the effect of halibut bycatch and wastage in the Gulf of Alaska (GOA) and Bering Sea Aleutian Island (BSAI) fisheries, a sex- and age-structured simulation model was developed to simulate halibut exploitable biomass, spawning biomass, yield and wastage in the directed fishery in response to alternative bycatch limits in all other fisheries that incidentally harvest halibut. The simulation model is conditioned on the output of the IPHC annual assessment model (wobblesq) and the model structure is very similar in the components of catch that are removed from the system. In the IPHC assessment model, coastwide removals are aggregated into 5 catch categories that represent the commercial and IPHC research catches, bycatch and wastage in two size categories (U32 and O32), recreational fisheries, and personal use including subsistence harvest.

1.1.1 Overview of total mortality in the IPHC model

Key to understanding the simulation model developed for this report are the various components of the age-specific total mortality rate that are set up in the IPHC assessment model. The IPHC model is set up such that total instantaneous sex- age-specific total mortality rates are used to propagate the estimated numbers-at-age over time. Specifically, the sex-age-specific mortality rate is set up as follows:

$$Z_{h,i,j} = M_h + \sum_k F_{h,i,j,k}$$
$$Z_{h,i,j} = M_h + \sum_k f_{h,i,k} s_{h,i,j,k}$$

where h is an index for sex, i is an index for year, j is an index for age, and k is an index for fishing fleet. This is a separable model for sex- age-specific total mortality where the year effect (fishing mortality $f_{h,i,k}$) is estimated for each gear in each year, and the age effect (selectivity $s_{h,i,j,k}$) is a piece-wise linear function of average length-at-age. The natural mortality rates M_h are assumed to be independent of age and do not vary over time. For each fishing gear there is a total of I+1 fishing mortality parameters and 16 estimated selectivity parameters. These are determined by fitting the model to catch-at-age data.

There are five specific fishing fleets (i.e., $k = 5$) in the model and the corresponding catch is aggregated (in some cases disaggregated by sex):

1. Commercial setline and IPHC research,
2. U32 bycatch and wastage,
3. O32 bycatch and wastage,

4. recreational sport fishery,

5. personal use (subsistence fishery).

The U32 and O32 bycatch and wastage are not broken down into specific gear types for specific areas, and to the best of my knowledge, all of this aggregation of the catch data and age-composition is done through a pre-processing of the available data.

In order to accurately represent the age-specific total mortality rates in the simulation model, the annual age/sex specific fishing mortality rate parameters for each gear and the length-based selectivity parameters were used to calculate the total mortality rates in the simulation model. These model parameters were made available by the IPHC commission staff.

Another key component to the IPHC assessment model is the mean length-at-age and mean weight-at-age data. Estimates of exploitable biomass (EBio) and spawning biomass (SBio) from the model is the product of the estimated numbers-at-age (sex) and the empirical weight-at-age that is vulnerable to the coast-wide selectivity in the setline fishery. These empirical data were made available for use in this simulation model herein. In addition to selectivity, weight- and length-at-age data, the calculation of EBio also involves the use of an age-misclassification matrix (smearing). The algorithm for this age-smearing was made available, but was not implemented due to time constraints.

1.2 Simulation Model

A detailed analytical description of the simulation model is provided in Appendix B.2. The following is a summary description of specific model outputs that are used to describe the impacts of bycatch and wastage on halibut biomass, yield, spawning biomass and wastage, as well as, the corresponding size/age composition. Ultimately, a decision table is constructed where the expected outcome (performance measure) is evaluated across alternative future states (good/bad recruitment, increasing/decreasing growth) for a series of alternative policy options. The rows of this table represent alternative future states, and the columns correspond to different harvest policies. Assuming all future scenarios are equally likely, then the performance and sensitivity of alternative harvest polices can be easily compared.

1.2.1 Overview of the simulation model

Running a single realization of the simulation model consists of several steps that can be broken down into two periods: (1) initializing the model from 1996:2011, (2) future projections from 2012:2026. Refer to Appendix B.2 for detailed information on step (1). Future projections in step (2) consist roughly 10 steps described by the following psuedo code:

1. Initialize future recruitment vector based on recruitment scenario

2. Project future weight at age based on growth scenario (done in calcGrowth)

3. Future selectivity continues to be a function of length (done in calcSelectivities)
4. Loop from nyr to nyr+nyr_proj
5. Calculate EBio at the start of the year (EBio = N * sel * wa)
6. Apportion EBio to management areas (l) based on 2011 apportionments
7. Calculate management area CEY as 0.215*$EBio_l$ or 0.16*$EBio_l$
8. Calculate the corresponding fishing rate ($f_{h,i,k}$)
9. Calculate Z and update total mortality.
10. Update numbers at age and return to 4) until end of projection years.

Future recruitment is actually initialized in the year 2007, as halibut are roughly 6 years of age before they recruit to the exploitable biomass based on the setline fishery selectivity. To approximate future growth for each sex, a von Bertalanffy growth model was fit to the IPHC survey mean length-at-age data collected between 1996 and 2011 (Figure 1.1 a,c).

Converting numbers-at-age to weight-at-age, the allometric relationship $w_j = al_j^b$ was used. The scaling and power parameters ($a = 9.321x10^{-6}$ and $b = 3.16$) were taken from Courcelles (2011) and assumed to be the same for females and males (Figure 1.1 b,d). Attempts were made to estimate the corresponding allometric parameters from the empirical survey length-at-age and commercial catch weight-at-age data; however, there was difficulty obtaining reasonable estimates from these two separate sources of information. Log-log plots of these data did not reveal a linear relationship between the log-length and log-weight (estimates of the exponent b were much less than 3 and there was a strong pattern in the residuals). In fact, the empirical weight-at-age data for males shrink from 14 pounds at age-6 to less than 14 pounds at ages 7-10. Therefore, all weight-at-age data in the simulation model are based on the allometric relationship from the Courcelles (2011) study.

Selectivity in the simulation model is the exact same length-based selectivity that is used in the IPHC assessment. The same piece-wise linear function that is used in the IPHC assessment model to convert mean length-at-age to age-based selectivity for the five different harvest categories is also used in this simulation model (Figure 1.2). Overall, males recruit to the various gears at much older ages due to slower growth of male halibut.

Simulated exploitable biomass each year is based on the sum of products between the numbers-at-age, weight-at-age, and selectivity-at-age in the commercial gear for both sexes combined. Apportionment of this coast-wide exploitable biomass to each of the statistical areas is based on the same apportionment scheme used by the IPHC staff in 2011. The constant exploitable yield ($CEY_{i,l}$) in year i for management area l was based on the application of area-specific harvest rate of 0.215 (areas 2A-3A) and 0.161 (areas 3B-4CDE).

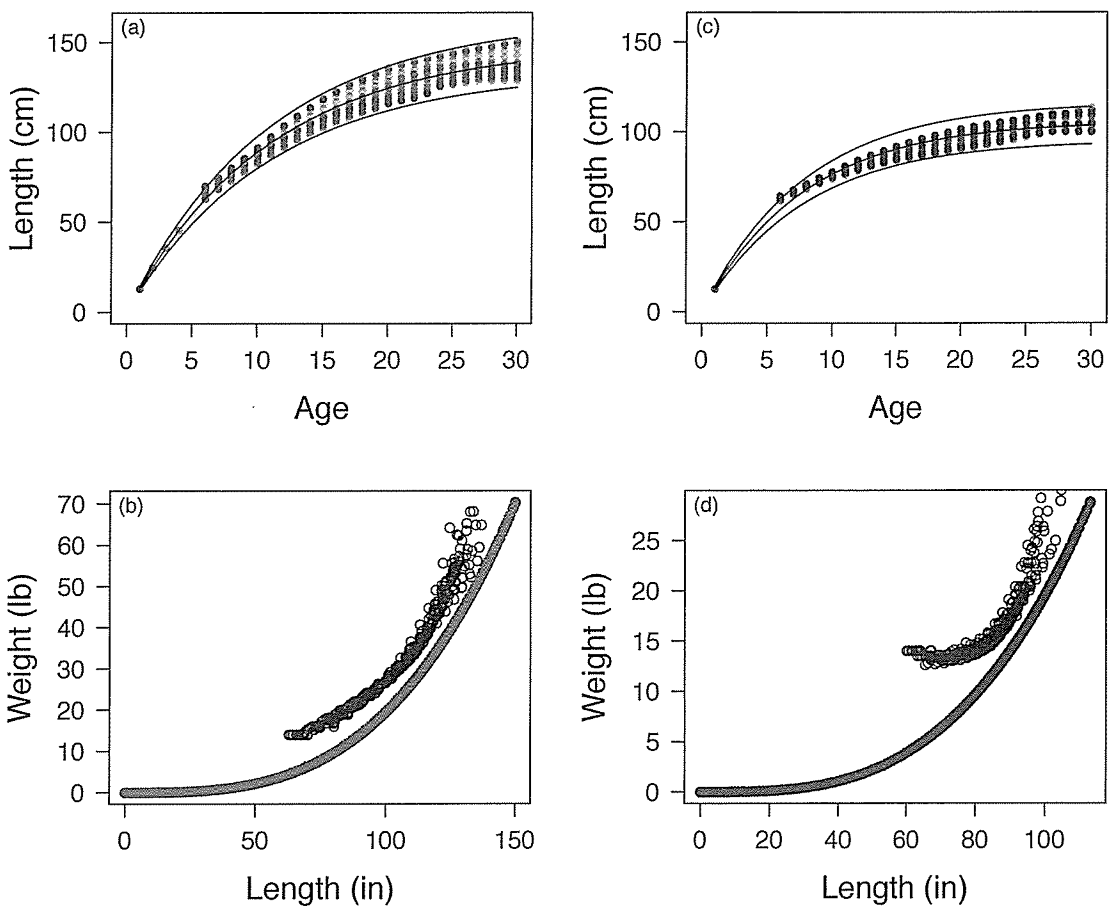

Figure 1.1: Observed mean length-at-age for female (a) and male (c) halibut in the IPHC research surveys between 1996 and 2011. Fitted lines are the von Bertalanffy growth model with the boundaries based on a 10% coefficient of variation in the asymptotic length. Estimated parameters for females are $L_\infty = 148.06$, $k = 0.0915$, and for males $L_\infty = 105.73$, $k = 0.1275$. Panels b (female) and d (male) show the length-weight relationship used in the model, along with the empirical catch weight-at-age data used in the IPHC assessment (open circles).

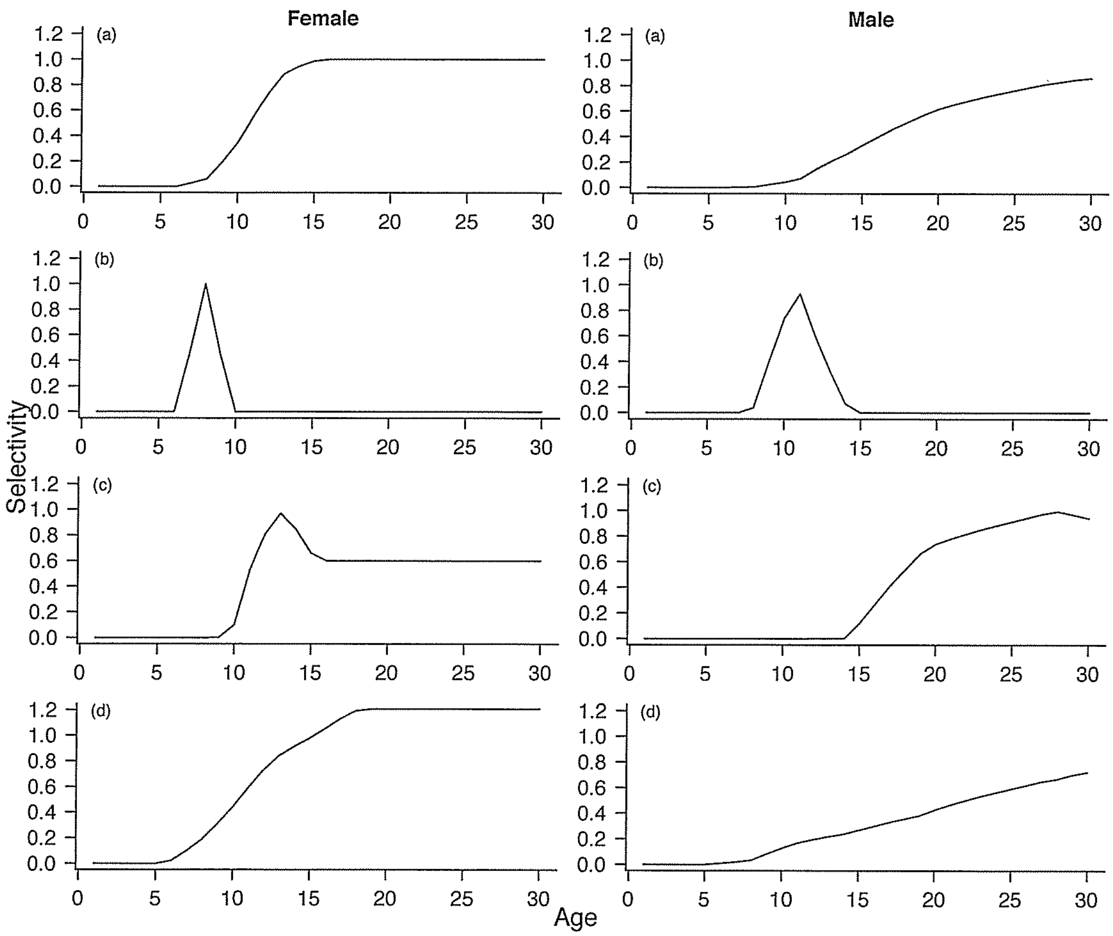

Figure 1.2: Age-based selectivity coefficients for female and male halibut for the setline fishery (a), U32 (b), O32 (c), the recreational and personal use fisheries (d).

1.2.2 Calculating setline fishery catch share

Annual allocations to the directed setline fishery in each of the areas are determined by first subtracting the expected bycatch/wastage from the area CEY. To simulate the same procedure for each statistical area, annual directed setline allocation was calculated as:

$$C_{i,k=1} = \text{CEY}_{i,l} - \sum_{k=2}^{k=5} C_{i,k},$$

where the catch allocations for gears other than the setline fishery ($k > 1$) are determined *a priori*. The rule differs slightly for area l=2B where 88% and 12% of the allocation is given to the commercial and recreational fisheries, respectively. A key component to the calculation of setline fishery catch share is that mandated reductions in bycatch levels are given entirely to the commercial fishery, with the exception of area 2B where the recreational fishery would also receive a corresponding increase.

1.2.3 Calculating area specific fishing mortality rates

A critical component of the simulation model is calculating the sex/age-specific fishing mortality rates from each of the major fisheries that target halibut or intercept them as bycatch. The IPHC uses two terms for the non-targeted mortality: (1) wastage, which is the catch of undersize fish, lost skates and loss at the rail of halibut in the directed fishery, and (2) bycatch, which is the interception of halibut in non-targeted fishery including groundfish trawl, longline, trap, and pelagic trawl.

The catch equation used in the IPHC assessment model and in this simulation model assumes that both natural mortality and fishing mortality occur simultaneously. This equation, also known as the Baranov catch equation, is given by:

$$C_{i,k} = \sum_h \sum_j \frac{N_{h,i,j} w_{h,i,j} f_{h,i,k} s_{h,i,j} (1 - \exp(-Z_{h,i,j}))}{Z_{h,i,j}}$$

In this simulation model, the annual fishing mortality rate ($f_{h,i,k}$) for gear k is solved for using an iterative method where it is assumed that the sex ratio of the catch is the same as the ratio of female:male vulnerable biomass. This approach differs from the approach used in the IPHC assessment, where annual fishing mortality rates for females are treated as latent variables, and the male fishing mortality rate is assumed to be proportional to the female fishing mortality rate. The latter method could not be used in the simulation model because it would require a catch allocation by sex.

For the directed setline fishery, the wastage component from this fishery is a combination of undersized fish and legal sized fish that are lost at the rail, or died. To simulate this process, a joint probability model was developed to account for the wastage of undersized fish only. The joint probability model is defined as:

$$v_{h,i,j,k} = s_{h,i,j,k}(r_{h,i,j,k} + (1 - r_{h,i,j,k})d_k),$$

Table 1.1: Summary calculations for model output

Exploitable Biomass	$EBio_i = \sum_h \sum_{j=6}^{j=30} N_{h,i,j} w_{h,i,j} \exp(\nu_{h,i,j,k=1})$	(T1.1)
Spawning Biomass	$SBio_i = \sum_{j=6}^{j=30} N_{h=1,i,j} w_{h=1,i,j} p_{h=1,j}$	(T1.2)
Commercial Wastage	$WBio_i = \sum_h \sum_j \frac{N_{h,i,j} w_{h,i,j} f_{h,i,k=1} s_{h,i,j,k=1}(1 - r_{h,i,j,k=1}) d_{k=1}(1 - \exp(-Z_{h,i,j}))}{Z_{h,i,j}}$	(T1.3)
Commercial Yield	$YBio_i = \sum_h \sum_j \frac{N_{h,i,j} w_{h,i,j} f_{h,i,k=1} s_{h,i,j,k=1} r_{h,i,j,k=1}(1 - \exp(-Z_{h,i,j}))}{Z_{h,i,j}}$	(T1.4)
Lost Yield	$LBio_i = YBio_i^{(f_{k=2,3}=0)} - YBio_i$	(T1.5)
Bycatch Yield	$BBio_i = \sum_h \sum_j \sum_{k=2}^{k=3} \frac{N_{h,i,j} w_{h,i,j} f_{h,i,k} s_{h,i,j,k} r_{h,i,j,k}(1 - \exp(-Z_{h,i,j}))}{Z_{h,i,j}}$	(T1.6)
Yield Loss Ratio	$YLR_i = \frac{LBio_i}{BBio_i}$	(T1.7)

where $v_{h,i,j,k}$ is the sex/age specific vulnerability to fishing from gear k in year i, $s_{h,i,j,k}$ is the probability of capturing a fish of age j, $r_{h,i,j,k}$ is the retention probability (i.e., the probability of being greater than the size limit for a given age), and d_k is the discard mortality rate associated with gear k. See section 2.2.1 for more details on the development of retention probability model.

1.2.4 Model outputs

Summary equations for the simulated model output are presented in Table 1.1. The simulated exploitable biomass ($EBio_i$) is the vulnerable biomass available to the commercial fishery (T1.1), where $k = 1$ denotes the selectivity for the commercial setline gear. Annual spawning stock biomass ($SBio_i$) is based on the female component only ($h = 1$) and the empirical weight-at-age data and the proportion mature $p_{h,j}$, (T1.2). Note that the exploitable biomass in the IPHC assessment is based on the empirical weight-at-age data from the commercial catches and ranges from ages 6:20 from 1996:2001, and ages 6:25 in 2001:2011 period. The commercial wastage in the simulation model is based only on the undersized fish that are discarded (T1.3), where $s_{h,i,j,k=1}$ is the commercial age-specific selectivity (a function of fish length), $r_{h,k,j,k=1}$ is age-specific retention probability, and $d_{k=1}$ is the discard mortality rate for the commercial fishery and is assumed to be 0.17 for this study. The commercial yield of legal sized fish is given by (T1.4).

To calculate the yield loss due to bycatch in non-directed fisheries, the simulation model was projected forward in time where the only source of fishing mortality is the directed fishery (including deaths from wastage), recreational, and personal use. To do this, bycatch allocations for the U32 and 032 fisheries were set to 0 and the corresponding fishing rates for these two gears are also determined to be 0 for all future projection years. This simulation run is denoted as $YBio_i^{(f_{k=2,3}=0)}$. The lost yield due to bycatch is the difference between the commercial yields with and without bycatch fishing mortality (T1.5). Note also, that with no bycatch fishing mortality, the annual allocation to the commercial fishery is the Constant Exploitable Yield ($\text{CEY}_{i,l}$) minus the recreational and personal use allocations:

$$C_{i,k=1} = \text{CEY}_{i,l} - \sum_{k=4}^{k=5} C_{i,k}.$$

In other words, in the scenario with no bycatch, the commercial fishery allocation increases by the amount normally set assigned for bycatch.

1.3 Simulation Scenarios

The simulations performed in this study are deterministic with a range of recruitment and growth options that roughly correspond to the ranges of observed growth and recruitment between 1996 and 2011. Ideally, future projections of this nature would include a stochastic component for recruitment based on a historical distribution of realized recruits and Monte Carlo procedures would be used to construct plausible ranges of future scenarios. This was not done in this simulation due to time limitations. As an alternative, the deterministic simulations were used to span a wide range of recruitment and growth hypotheses.

Three alternative future recruitment scenarios are explored, where future recruitment is based on the average recruitment estimated between 1996 and 2006 and $\pm 60\%$ average recruitment. These scenarios are denoted as poor, average, and good recruitment. The definition of recruitment in this simulation model is an age-1 halibut, so future recruitment was simulated by altering the number of age-1 fish starting in the year 2007. In this case, the first simulated cohort would enter the fishery in 2012 at age 6.

Two alternative scenarios were used to project future growth of halibut beyond 2011. To simulate alternative states of future growth a density-dependent relationship between cohort strength and the asymptotic length of males and females was developed. Growth varied by adjusting the asymptotic length of each cohort as a function of recruitment density. For example, if recruitment is roughly 2.7 times larger than the average recruitment, the the asymptotic length would decrease from 148 cm to 139 cm under density-dependent growth (Figure 1.3). The other alternative state was to assume that the 2011 mean length-at-age data from the setline survey was the new growth paradigm and remained constant well into the future.

A key component of the density-dependent growth model and the three alternative hypotheses about future recruitment is that it allows for growth to continue to decline under

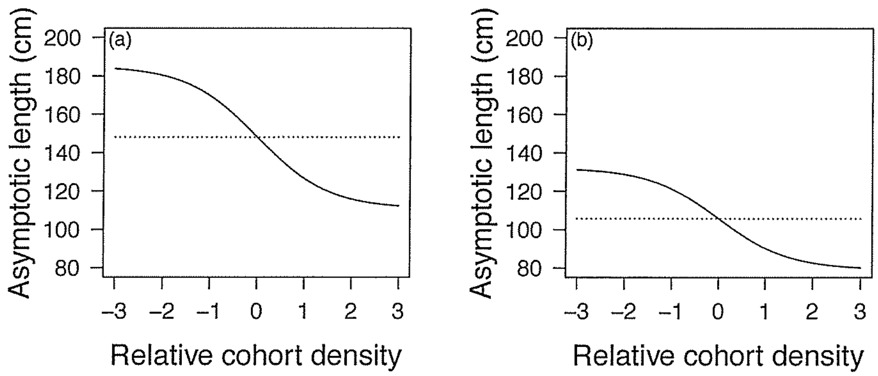

Figure 1.3: Relationship between asymptotic length $l_\infty^{(h)}$ for females (a) and males (b) and cohort density. Under density-dependent growth, $l_\infty^{(h)}$ decreases with increasing density (solid line) and density independent growth (dotted line).

scenarios with increasing recruitment. The opposite case occurs with below average recruitment; growth rates increase with low cohort densities.

1.4 Alternative policy options

Three alternative policies were explored to examine the impacts of bycatch adjustments in the non-directed fisheries. First a status quo policy was developed where the by catch levels observed in the 2011 fishery were held constant for all future simulation years (Table 1.2). The other two policies reduced the bycatch levels in the BSAI (areas 4ABCDE) or the GULF (3AB) to 50% of the 2011 levels, respectively.

For each of the alternative policies, the simulation model was run with a combination of poor, average, and good recruitment with density-independent and density dependent growth (a total of 6 model runs for each policy). Each of these alternative hypotheses were assumed to be equally plausible and a single score was developed to compare alternative policy options. For each of the model outputs (e.g., exploitable biomass, spawning biomass, yield, etc.) the average simulated value between the years 2020 and 2025 were arbitrarily selected for policy comparison.

1.5 Results

The initial numbers-at-age, age-1 recruits, fishing mortality rates and size selectivity parameters were all used to initialize this simulation model. Estimates of the sex/age-specific total mortality rates between this simulation model and the wobblesq model are nearly identical.

Table 1.2: The 2011 area apportionment, harvest rates, and observed landings for U32, O32, recreational (sport) and personal use. These catch levels were assumed constant into the future with the exception of area 2B, where 88% and 12% of the available CEY is allocated to the commercial and recreational fishery, respectively.

Area	Apportionment	Harvest Rate	Comm.	U32	O32	Sport	Personal
2A	0.024	0.215	-	0.040	0.110	0.398	0.025
2B	0.134	0.215	-	0.322	0.172	-	0.405
2C	0.105	0.215	-	0.192	0.219	1.313	0.425
3A	0.354	0.215	-	2.744	1.064	4.541	0.313
3B	0.158	0.161	-	1.507	0.437	0.025	0.023
4A	0.057	0.161	-	0.867	0.479	0.018	0.015
4B	0.055	0.161	-	0.288	0.329	0.000	0.001
4CDE	0.113	0.161	-	2.205	1.367	0.000	0.038

Trends in exploitable biomass between the two models differ due to at least two factors (Figure 1.4): age-smearing and differences in the weight-at-age data used to calculate exploitable biomass. In the IPHC assessment model, the annual calculation of exploitable biomass is based on the predicted numbers-at-age with aging error (smearing) times the empirical weight-at-age data from the commercial fishery. The simulation model does not use an age-misclassification matrix to smear the numbers at age, and the weight-at-age data is based on the allometric length-weight relationship and the empirical mean length-at-age data from the setline survey. The net results is that the predicted exploitable biomass in the simulation model is less than the predicted exploitable biomass from the IPHC assessment (Figure 1.4).

Figure 1.4 summarizes the results of the status quo scenario for the exploitable biomass, where 667 million pounds is the average predicted coastwide exploitable biomass over all three recruitment hypotheses with density-independent growth. This figure is the prototype that will be used to examine all response variables to simulated bycatch reductions.

The effect of increase recruitment density of each simulated cohort on growth rates is summarized in Figure 1.5. The asymptotic length of each cohort is a function of relative cohort density; with high densities the asymptotic length decreases. For example the an age-15 female halibut can weigh as little as 15.3lb. at high recruitment densities and as much as 42.8lb. at low recruitment density. Density-dependent growth has a large effect on the calculation of exploitable biomass, largely due to the increase in proportion of males that are now vulnerable to the fishing gear. Whereas, density-dependent growth is less important in the calculation of female spawning biomass, as females grow much faster and larger than males.

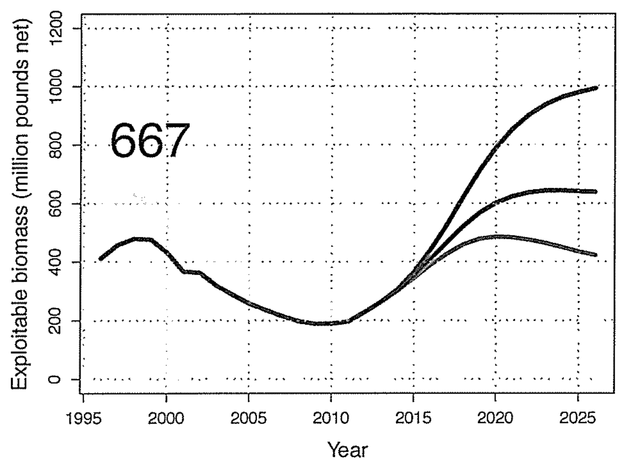

Figure 1.4: Example of simulation model output for the exploitable biomass under poor, average and good recruitment. The thick grey line is the exploitable biomass output from the IPHC wobblesq assessment conducted at the end of the 2011 fishing season.

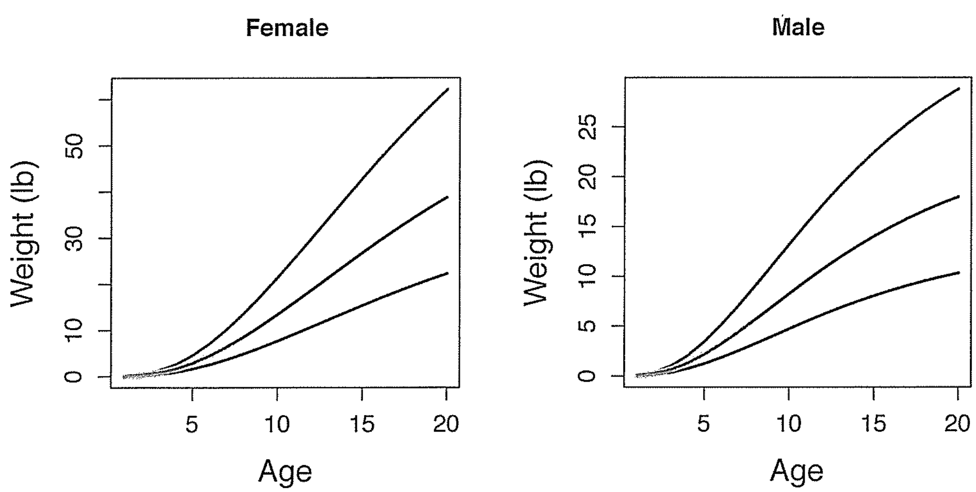

Figure 1.5: Simulated weight-at-age for halibut under low recruitment densities (red), average recruitment densities (black), and high recruitment densities (blue).

1.5.1 Effects of bycatch reduction on EBio

Overall, reducing bycatch in BSAI or the GULF by 50% has very little effect on the coastwide exploitable biomass. The average exploitable biomass between 2020 and 2025 ranged from 597 million lbs to 667 million lbs (Figure 1.6). Note that under the density-dependent growth scenario (bottom row of Figure 1.6), the biomass of the poor recruitment scenario is greater than the biomass of the good recruitment scenario. This difference in biomasss, in comparison to the density-independent growth scenario, demonstrates how slower growth under high recruitment density can have a significant impact on the exploitable biomass. Numerically, however, halibut abundance in numbers is much larger in the good recruitment scenario.

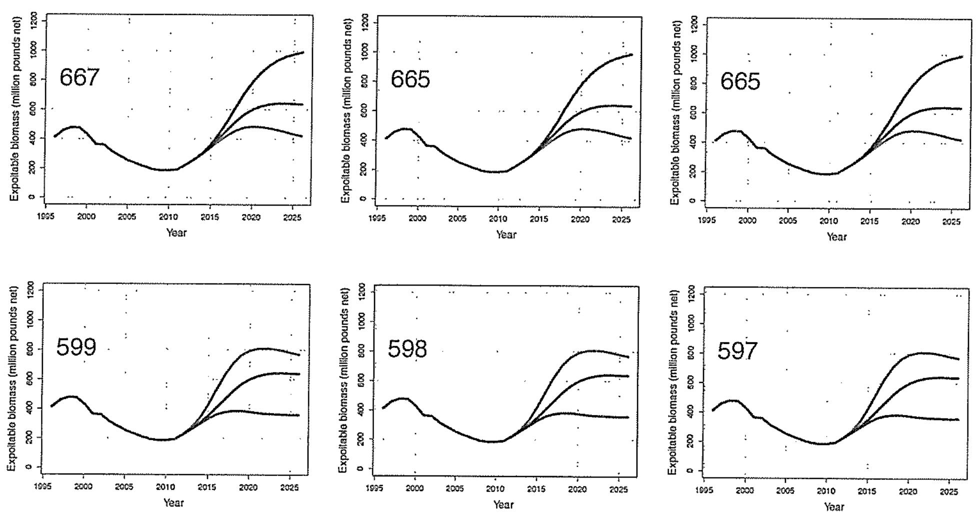

Figure 1.6: Simulated coastwide exploitable biomass under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for the Status Quo scenarios (left), 50% bycatch reduction in BSAI (middle), and 50% bycatch reduction in the GULF (right). Poor, average, and good recruitment scenarios denoted with, red, black and blue lines, respectively.

1.5.2 Effects of bycath reduction on Spawning biomass

Reducing bycatch in the BSAI and GULF fisheries also has little impact on the projected coastwide female spawning stock biomass (Figure 1.7). Projected female spawning biomass ranges between 472 million pounds to 506 million pounds under density-dependent and density-independent growth scenarios, respectively. The impacts of density-dependent growth on female spawning stock biomass is much less than the impacts on the exploitable biomass. This is largely due to the addition of faster growing males (at low density) in the calculation of exploitable biomass.

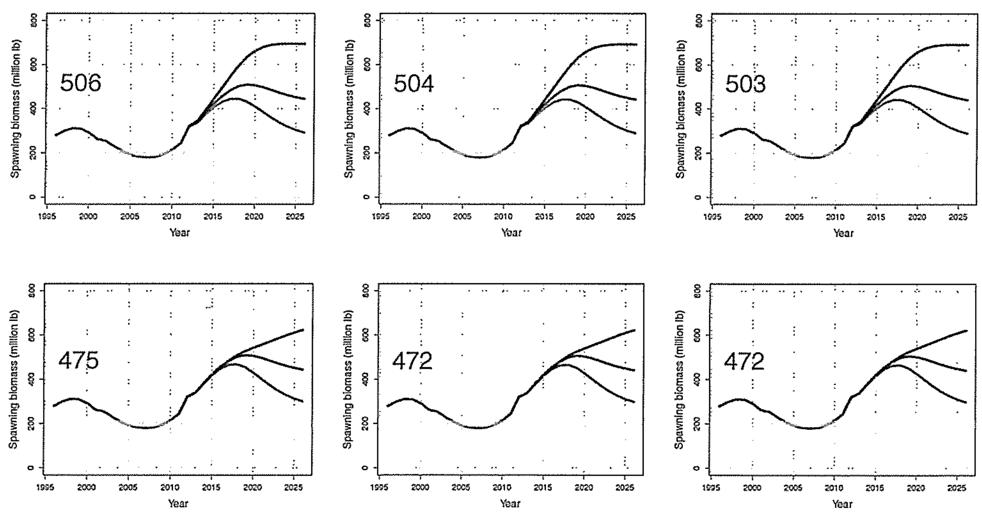

Figure 1.7: Simulated coastwide female spawning biomass under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for the Status Quo scenarios (left), 50% bycatch reduction in BSAI (middle), and 50% bycatch reduction in the GULF (right). Poor, average, and good recruitment scenarios denoted with, red, black and blue lines, respectively. The thick grey reference line corresponds to 30% of unfished spawning biomass.

1.5.3 Effects of bycatch reduction on commercial yield

The effects of reducing commercial bycatch in BSAI or the GULF by roughly 2.7 million pounds on the commercial yield is roughly a 2.5 million pound increase in the commercial catch (Figure 1.8). There is not a corresponding 1:1 increase in coastwide commercial yields with a reduction in bycatch in BSAI or the GULF management areas because the yield loss ratio (loss in commercial yield:bycatch) is less than 1 (Figure 1.9).

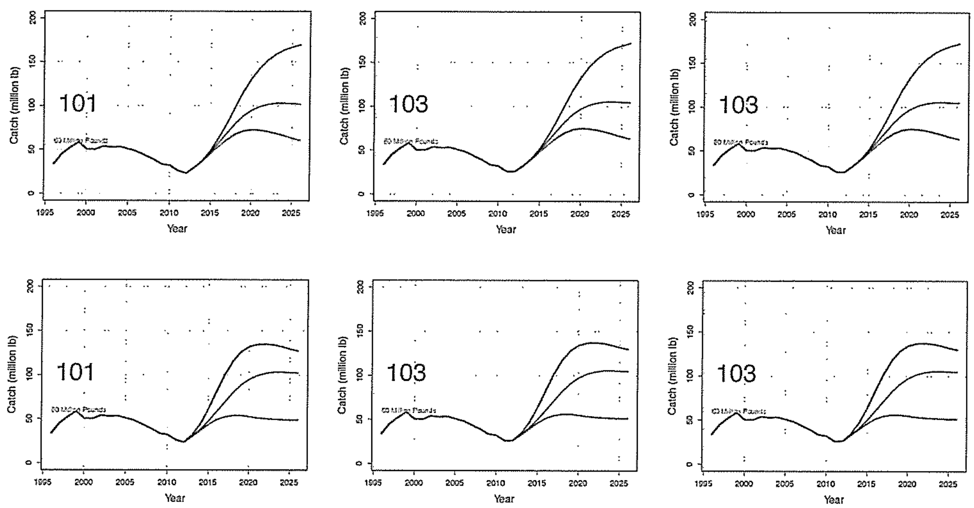

Figure 1.8: Simulated coastwide commercial yield under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for the Status Quo scenarios (left), 50% bycatch reduction in BSAI (middle), and 50% bycatch reduction in the GULF (right). Poor, average, and good recruitment scenarios denoted with, red, black and blue lines, respectively.

Trends in the yield loss ratios under constant growth assumptions are very similar due to stabilizing biomass-at-age in the simulated populations. However, under the density-dependent growth hypotheses trends in the yield loss ratios differ markedly. With reduced growth rates, the yield loss ratios are less than scenarios with increased growth rates. In short, there is some compensation in the yield associated with increased growth rates at low density. There is however, no substantial difference in the yield loss ratios with decreasing the bycatch rates in BSAI or the GULF regions (Figure 1.9).

1.5.4 Effects of bycatch reduction on commercial wastage

The modest increases in commercial yield associated with bycatch reduction in the non-targeted fisheries results in a corresponding increase in commercial waste. Waste increases from an average of 2.796 million pounds to 2.891 million pounds under the density independent growth hypotheses (Figure 1.10). Under the density-dependent growth hypothesis

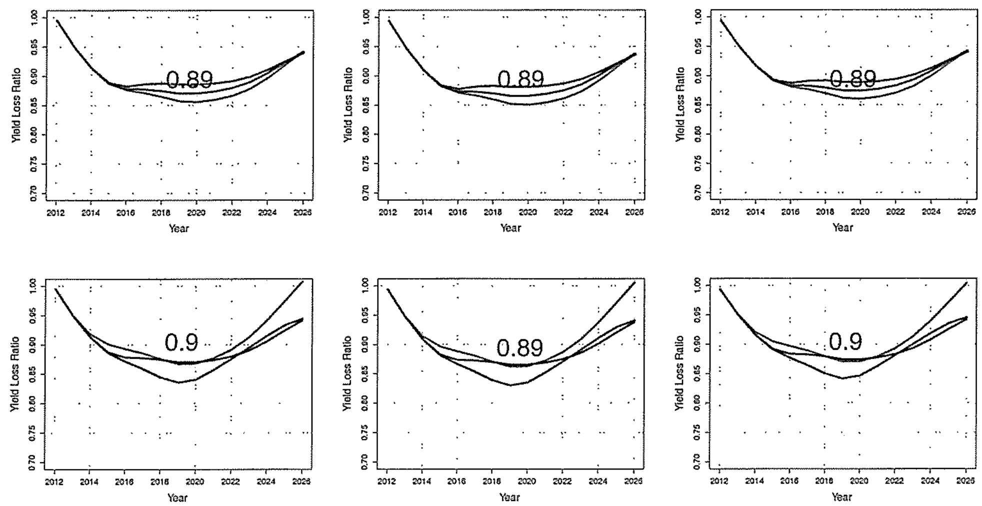

Figure 1.9: Simulated coastwide commercial yield loss ratios under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for the Status Quo scenarios (left), 50% bycatch reduction in BSAI (middle), and 50% bycatch reduction in the GULF (right). Poor, average, and good recruitment scenarios denoted with, red, black and blue lines, respectively.

wastage increases from 2.192 million pounds to 2.287 million pounds. At low recruitment densities, increasing growth rates actually result in reduced wastage under the current size limit of 32 inches (81.28 cm).

1.6 Discussion

The overarching objective of this study was to investigate the impacts of bycatch reduction in the BSAI and Gulf of Alaska on the halibut yields, exploitable biomass, spawing biomass and wastage in the directed commercial fishery. This was accomplished by using a sex/age-structured simulation model to account for future biomass and fishing mortality rates under alternative hypotheses about future recruitment and growth rates of halibut. The simulation model was, in part, parameterized using estimates of numbers-at-age and sex in the 1996, age-1 recruits from 1996–2006, empirical length-at-age data from the setline survey, a length-weight relationship from a recent study and fishing mortality rates from the directed fishery, O32, U32, recreational and personal use fishing fleets. All of these parameter inputs were taken from the most recent IPHC assessment of Pacific halibut (see Hare, 2012, wobblesq model). The simulation model did not perfectly replicate estimates of exploitable biomass in the IPHC assessment largely due to the differences in the average weight-at-age data.

The IPHC assessment model uses empirical weight-at-age data obtained from the commercial fishery catch. At ages 6-10 the mean weight-at-age data samples are largely biased

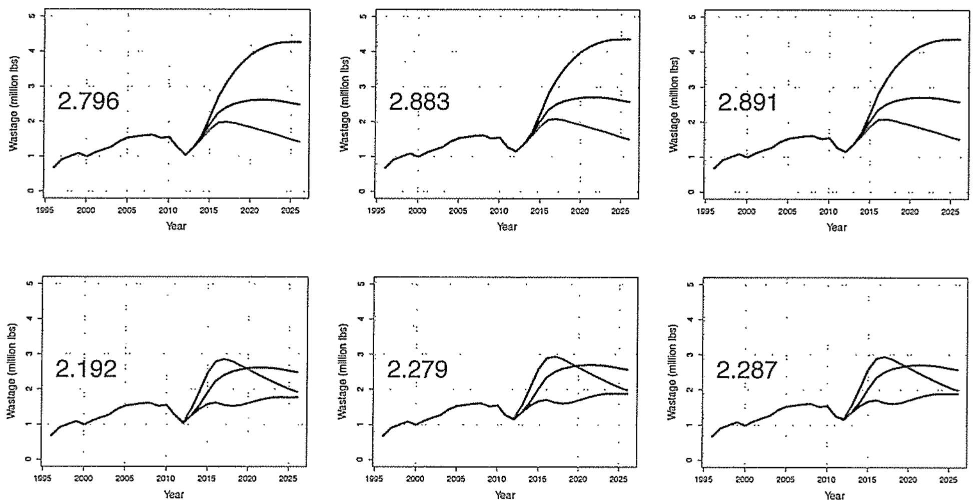

Figure 1.10: Simulated coastwide wastage from the commercial fishery under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for the Status Quo scenarios (left), 50% bycatch reduction in BSAI (middle), and 50% bycatch reduction in the GULF (right). Poor, average, and good recruitment scenarios denoted with, red, black and blue lines, respectively.

towards faster growing (larger) fish that are of legal size. For the purposes of simulating future biomass, it was not possible to come up with a simple procedure to replicate this size-selective process. In lieu, growth curves for female and male halibut were constructed from the empirical length-at-age data obtained in the setline survey between 1996–2011. Simulated weight-at-age data was then based on the allometric length-weight relationship developed by Courcelles (2011). The net result of using this growth curve is that simulated exploitable biomass between 1996-2011 was scaled downwards. The overall trends between the biomass simulated in this study and the IPHC assessment were nearly identical. This difference in projected biomass would change the overall scale of the simulated results, but would have very little influence on the relative changes in simulated exploitable biomass (and spawning biomass) over the two alternative management procedures that involve reducing the bycatch of non-targeted fisheries in the BSAI, or the Gulf of Alaska.

There are alternative approaches to modelling density-dependent growth. In the case adopted in this model, growth rates of individual cohorts are established at birth and are strictly a function of the density of that cohort relative to the average cohort density. The reason for adopting this approach, rather than a time-varying approach, is that it conveniently does not allow for individual fish to shrink in length. Unfortunately, this assumption does not allow for growth rates of individual cohorts to change in response to changing environmental conditions (if they were also modelled) or changes in the density of cohorts associated with fishing. For example, it may be plausible that growth rates of an individual cohort may increase over time as the density of halibut is reduced through natural and fishing mortality rates. Growth rate responses to changes in density have been observed in many experimental populations of rainbow trout in freshwater lakes (Post et al., 1999).

The results of the bycatch reductions in the BSAI and GOA regions do not appear to have much of an influence on the coastwide estimates of exploitable biomass and spawning biomass. The principle reason is that for every pound of reduced bycatch, there is a corresponding increase in the directed fishery. However, it appears that the directed fishery has more of an impact on the exploitable biomass than the bycatch fishery. This was demonstrated by the ratio of lost yield in the directed fishery per pound of bycatch taken by other fisheries. Or in other words, 10 pounds of bycatch removed is roughly equivalent to 9 pounds of yield lost to the commercial fishery.

Another important point about bycatch impacts on the halibut stocks lies in the small regional scale. In both this simulation model and the assessment model developed by the IPHC, there is no explicit or implicit spatial representation of the large-scale management areas. Unfortunately, it is not possible to examine how reducing bycath in area 4CDE, would affect the exploitable biomass, spawning biomass, wastage, etc. in the specific areas. Migration and movement of halibut between the management areas, and the lack of information about migration, is one of the primary reasons why the coastwide assessment model was adopted. It is possible that a reduction in bycatch in a specific area, may provide a local increase in exploitable biomass and impact catch rates in the directed fishery. But at this time data are insufficient to capture these small scale dynamics.

In summary, reducing halibut bycatch by 50% in the BSAI or GOA regions by 2.7 million pounds has no large impacts on the projected estimates of coastwide spawning biomass or exploitable biomass. Further, this reduction of 2.7 million pounds results in about a 2.5 million pound increase in the directed fishery; simulated yield loss ratios were less than 1.0 and are a function of the current age-structure in the population. The directed commercial fishery is by far the largest component of total mortality in the coastwide assessment model; information is lacking to determine the impacts of various fisheries at smaller spatial scales.

Part II

Effects of reduced minimum-size limits on yield, spawning biomass, and wastage.

Overarching objective: Investigate the short-term and long-term consequences of adopting a smaller (26 inch or 66 cm) size limit on halibut spawning biomass, exploitable biomass, yield, and wastage.

2.1 Introduction

Minimum size limits, or minimum weight limits, have been used in the commercial fishery since 1940. In 1940, a minimum weight limit of 5 lb was used, which at the time corresponded to a fish of roughly 66 cm in length (or 26 inches). In 1974 this minimum size limit was increased to 81.28cm or 32 inches in length. Reasons for adopting a minimum size limit (or MSL hereafter) include conservation of juvenile halibut and increases in yield per recruit. Female halibut grow much faster than male halibut and recruit to the legal size at a much younger age than males. The sex composition of the commercial catch is predominately females, and the age composition of landed males is much more uniform than the female fish (Hare, 2012).

Since at least 1996, the mean size-at-age of halibut in the setline survey has declined steadily over time. Halibut seem to be experiencing slow than recent historical average growth rates. Due to slower growth and a fixed 32 inch size limit, the age-at recruitment to the fishery should be shifting towards older females, and much older males. Under a fixed exploitation rate policy, if the size-selectivity of the fishing gear captures fish below the minimum size, then it would be expected that the individual fish of sub-legal size would be capture more frequently when growth is slow.

The term wastage in the commercial setline fishery traditionally refers to fish that are captured by the fishing gear but not landed because the gear is either lost (something that occurred frequently during the days of the derby fishery), the fish is lost at the rail and dies, or the fish is returned to the ocean and dies. In the directed commercial fishery, it is assumed that 16% of the sublegal fish that are returned to the ocean die due to delayed mortality. In the trawl fishery, discard mortality rates are assumed to be much higher (ca. 80-90%).

In 2011, an estimated 2.2 million pounds of halibut were treated as wastage. Assuming a modest value of $5 per pound for fish in the 26-32 inch size category, this roughly equates to $11 million dollars per year of halibut that are thrown overboard and assumed to have died. Assuming a 16% mortality rate, this would imply that roughly 13.75 million pounds were captured in the directed fishery and thrown overboard because they were of sublegal size. Clearly there is an added cost for halibut conservation through the use of extra fuel and handling time to catch a given quota of legal size (13.75 million pounds).

In this part of the report, a simulation model is used to evaluate the potential gains and losses of adopting a smaller size limit for the current directed fishery. First a joint probability model for capturing and retaining a halibut of legal size is developed. Followed by a series of simulations under alternative hypotheses about recruitment and future growth with the status quo size limit of 32 inches, a 29 inch size limit and a 26 inch size limit. A series of performance metrics including future yield, wastage and the value of the catch and wastage is computed to evaluate the potential gains in yield and value in the directed setline fishery.

2.2 Methods

Details of the simulation model are documented in Appendix B.2. In short, the simulation model is a sex- and age-structured population dynamics model were the initial 1996 age-structure and age-1 recruits from 1996-2006 is based on the IPHC assessment conducted by Hare (2012). Total mortality rates for the 1996-2011 period were based on the same values estimated in the IPHC assessment and historical and simulated weight-at-age data is based on the mean length-at-age data for males and females in the setline survey.

Future projections were based on poor, average, and good recruitment (defined as $\pm 60\%$ in average recruitment). Growth was modelled either as density-independent, or density-dependent where the asymptotic length of halibut would decrease with increasing cohort density, and vice versa. It was assumed that selectivity in the directed commercial fishery remained unchanged in all future simulations. Selectivity is a function of length, and therefore, with decreasing mean size-at-age the fishery would target older fish. The length-based selectivity function was based on the same piece-wise linear function where fish less than 60 cm have a selectivity of 0 and fish greater than 120 cm were fully vulnerable.

Additional model assumptions include a fixed natural mortality rate for each sex, the coefficient of variation in length-at-age is 0.1, the discard mortality rate in the directed fishery is 0.17 per year, and all future catches are based on the constand harvest rate policy (0.215, or 0.16 depending on area). Area specific biomass apportionment is based on the 2011 apportionment values, and discard rates for O32 and U32 fish are carried forward from the 2011 realized values. The price per pound is based on prices in Homer Alaska, 10-20lbs at \$6.75, 20-40lbs at \$7.35 and 40+lbs at \$7.50. An assumed price of \$5.00 per for fish in the length interval of 66cm to 81cm was adopted to calculate the value of the wastage or value of fish less than 81 cm. The definition of wastage for this simulation is the amount of fish (in lbs) that is caught but is less than the minimum size limit and is assumed to die.

2.2.1 Joint probability model for retention

The probability of capturing a fish in a given size interval x is a property of the selectivity of the fishing gear and the number of available fish in the size interval (x). This simulation model, and the IPHC assessment model, does not model the number of fish at length explicitly; rather, the accounting system is based on the numbers-at-age. The estimated selectivity function is based on length, and the probability of capturing a fish of a given age is approximated by the mean length-at-age in a given year. In the IPHC assessment model, a series of selectivity coefficients are estimated for the length intervals 60,70, ..., 120 and the probability of capturing a fish of a given age is a function of the mean length-at-age. With variable growth rates the probability of capturing a fish of a given age can change from year to year with changes in fish size. As fish grow slower, the age at recruitment to the fishery shift to an older age.

The probability of retaining a fish of a given age j is also a function of the mean length-at-age and the minimum size limit. Therefore the probability of capturing a fish of a given age and keeping it ($p(c_j)$) is a joint probability model that can be defined as follows:

$$p(c_j) = p(j) \cdot p(r_j),$$

where $p(j)$ is the probability of capturing a fish of age j, and $p(r_j)$ is the probability of retaining a fish of age j. The probability of capture $p(j)$ is the piece-wise linear interpolation of the mean length-at-age (length-based selectivity), and the probability that an individual age-j fish is greater than the minimum size limit is:

$$p(r_j) = \int_{l_j=\text{MSL}}^{l_j=\infty} \frac{1}{\sqrt{2\pi}\sigma_j} \exp\left[-\frac{(l_j - \text{MSL})^2}{2\sigma_j^2}\right] dl_j$$

where MSL is the minimum size limit, l_j is the mean length-at-age j, and σ_j is the standard deviation in the mean length-at-age. To approximate the above integral, a logistic function was used with a mean (50% probability of capture) corresponding to the MSL, and the standard deviation based on a CV of 0.1 for the mean length-at-age.

The probability of a fishing dying at a given age is then the probability of capturing a fish of a given age j times the probability of retention times the probability of discarding $(1 - p(r_j))$ the fish times the discard mortality rate:

$$p(h_j) = p(j)[p(r_j)(1 - p(r_j))d],$$

where d is the discard mortality rate.

2.2.2 Simulation scenarios

Three alternative size-limit policy options were explored, the status quo policy of 32 inch size limit, and a 29 and 26 inch size limit (Figure B.19). For each of the policy options, a total of 6 simulation runs were performed with poor, average, and good recruitment under two alternative hypotheses about future growth of halibut. These scenarios are summarized in the form of a graphical decision table where the rows of the table correspond to alternative growth models, and the columns correspond to alternative size limit policies.

Figure 2.11: Example of retention- and discard-at-age probabilities for a given growth curve over 32 inch (left) 29 inch (middle) and 26 inch (right) minimum size limit.

2.3 Results

2.3.1 Impacts of MSL on exploitable biomass

Decreasing the minimum size limit from 32 inches to 26 inches results in a 2 million pound increase in the average simulated exploitable biomass between the years 2020 and 2025 (Figure 2.12). Note that the exploitable biomass calculation is based on the product of the numbers-at-age, the weight-at-age, and the age-specific capture probabilities (commercial fishery selectivity). Under density-independent growth, exploitable biomass is highest for the good recruitment scenarios; whereas, under density-dependent growth larger exploitable biomass is expected due to growth compensation at low densities (note red & blue lines in Figure 2.12).

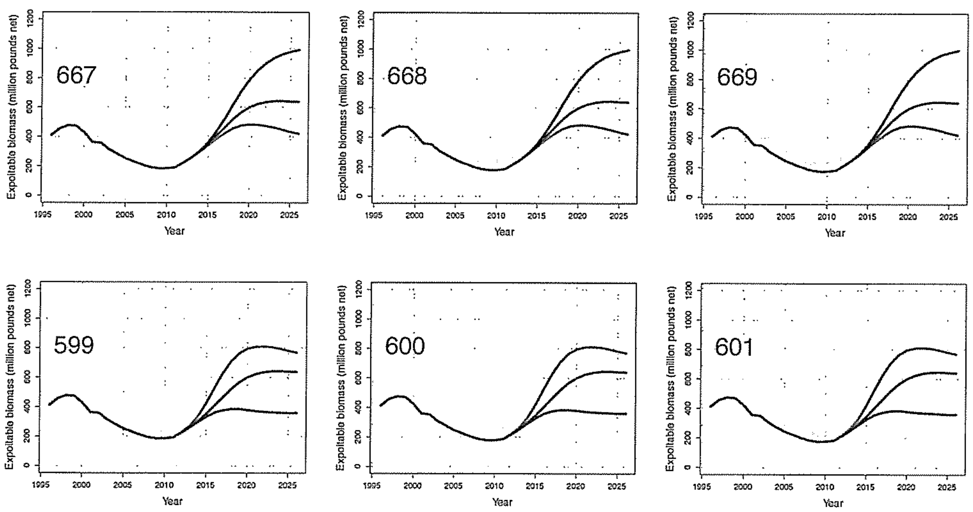

Figure 2.12: Effects of MSL on exploitable biomass under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for 32 inch (left), 29 inch (middle), and 26 inch (right) size limits. Poor, average, and good recruitment are denoted by red, black and blue lines, respectively. Value on each panel corresponds to 2020-2025 average over 3 recruitment hypotheses.

2.3.2 Impacts of MSL on commercial yield

A modest increase of 300,000 to 500,000 pounds in the average coastwide commercial yields (between the years 2020–2025) is projected with a decrease in the minimum size limit from 32 inches to 26 inches (Figure 2.13). This increase owes to the overall reduction in total mortality rates associated with commercial wastage. Note also that these results also assume that bycatch levels and removals by the recreational fishery and personal use, including subsistence harvest, remains at the 2011 levels.

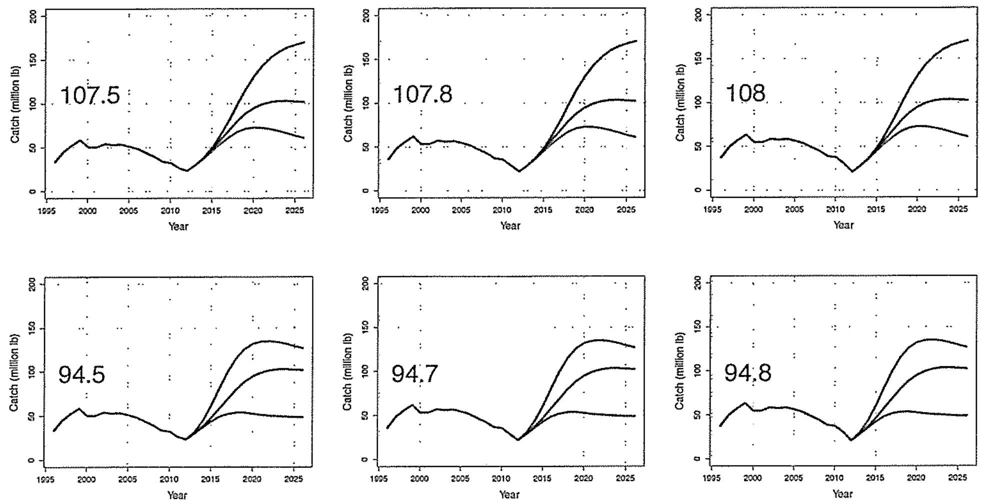

Figure 2.13: Effects of MSL on commercial yield under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for 32 inch (left), 29 inch (middle), and 26 inch (right) size limits. Poor, average, and good recruitment are denoted by red, black and blue lines, respectively. Value on each panel corresponds to 2020-2025 average over 3 recruitment hypotheses.

2.3.3 Impacts of MSL on commercial wastage

Substantial reductions in commercial wastage occur with a reduction in the minimum size limit. Under a 32 inch size limit, simulated wastage between 2020 and 20205 averaged 2.494 million pounds and this declined by nearly 90% to 0.26 million pounds under a 26 inch size limit (Figure 2.14). Reductions in wastage could also translate into reduced operation costs, as fewer fish have to be captured and discarded to make up the individual vessel quota. Between the years 2020–2025 and estimated 60% of the halibut captured in the commercial fishery (assuming a fixed length-based selectivity) are of sublegal size and discarded (Figure 2.15). Reducing the size limit from 32 inches to 29 or 26 inches would reduce this fraction to 30% and 10%, respectively. Reducing the size limit from 32 to 26 inches increases the overall retention probability from 40% to 90%.

2.3.4 Impacts of MSL on economic value

Decreasing the MLS to smaller sizes reduces the overall landed value of the commercial fishery because the composition of the catch contains a higher fraction of lower value 5-10 pound fish (assuming $5.00 per pound). The simulated projected landed value between 2020–2025 decreases from $684.7 million to $683 million (or $1.7 million) with a change in MLS of 32 inches to 26 inches (Figure 2.16).

Based on the allometric length-weight relationship a 26 inch halibut is roughly 5 pounds

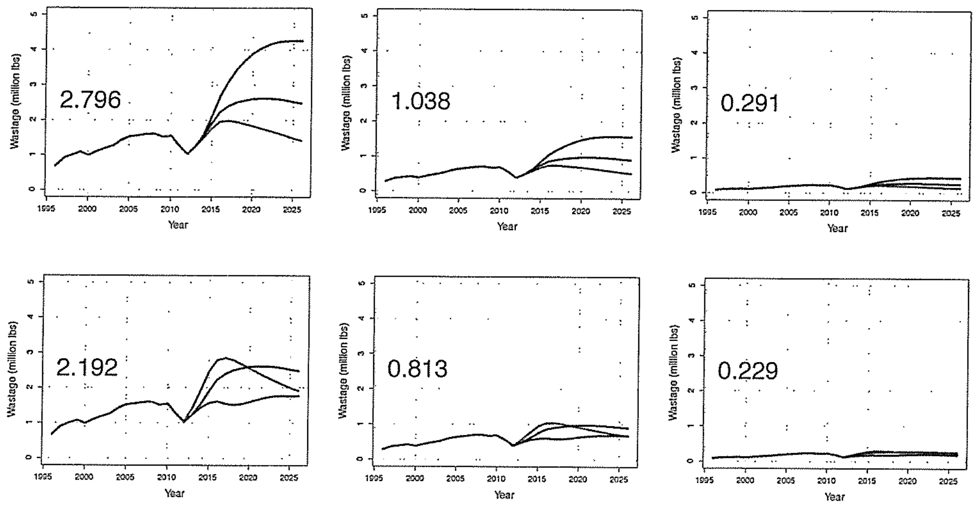

Figure 2.14: Effects of MSL on commercial wastage under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for 32 inch (left), 29 inch (middle), and 26 inch (right) size limits. Poor, average, and good recruitment are denoted by red, black and blue lines, respectively. Value on each panel corresponds to 2020-2025 average over 3 recruitment hypotheses.

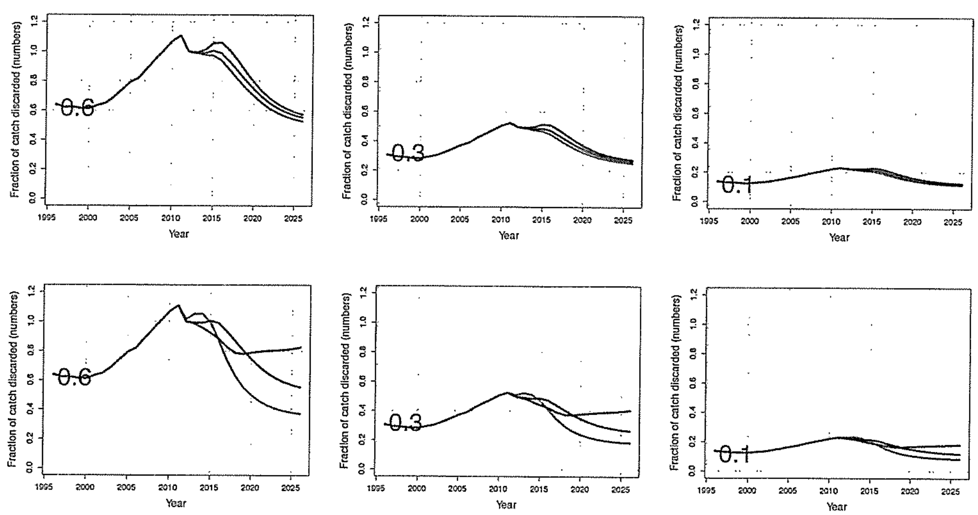

Figure 2.15: Fraction of captured fish discarded in the commercial fishery under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for 32 inch (left), 29 inch (middle), and 26 inch (right) size limits. Poor, average, and good recruitment are denoted by red, black and blue lines, respectively. Value on each panel corresponds to 2020-2025 average over 3 recruitment hypotheses.

net weight, and a 32 inch halibut is roughly 10 pounds net weight. Assuming a price of $5.00 per pound for halibut in the 5-10 pound range, the potential value of the sub-legal fish that are discarded and assumed to die (with 16% discard mortality rate) can be calculated. Under a 32 inch size limit the average value of the wastage is $15.5 million, and under a 26 inch size limit the value of the wastage is reduced by 90% to $1.55 million (Figure 2.17). Moreover, the value of this wastage is of dead fish that cannot be recovered in the future.

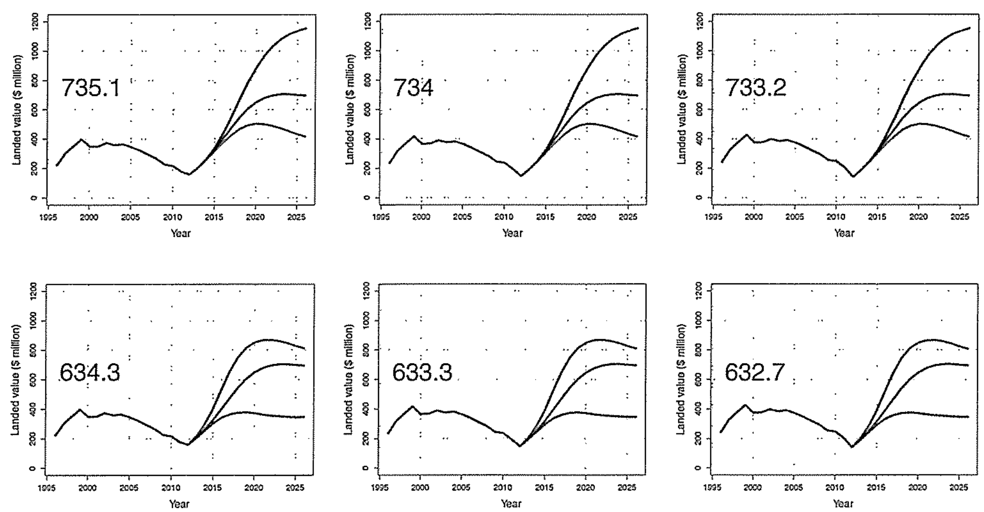

Figure 2.16: Landed value for the commercial fisher under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for 32 inch (left), 29 inch (middle), and 26 inch (right) size limits. Poor, average, and good recruitment are denoted by red, black and blue lines, respectively. Value on each panel corresponds to 2020-2025 average over 3 recruitment hypotheses.

Not all of the commercial fish that are captured die due to handling mortality; the estimated discard mortality rate for this fishery is 16%. The average simulated coastwide value of the commercial fish landed that are of sublegal size (assuming $5.00 per pound) under a 32 inch size limit is $91 million. Reducing the size limit to 29 and 26 inches reduces the value of sublegal fish captured to $33 and $9 million, respectively (Figure 2.18).

The practice of discarding sublegal size fish can be considered an added cost associated with handling time and lower capture probabilities of legal size fish due to competition for hooks. These cost can be significant and would increase or decrease with changes in size limits as shown in Figure 2.18. A proximate measure for fishing efficiency from an economic standpoint of view is can be defined as:

$$1 - \frac{\text{value of discards}}{\text{value of landings}}.$$

This term is a measure of the economic efficiency and under a 32 inch size limit this value is roughly 87% in comparison to 98.7% under a 26 inch size limit (Table 2.3). Another

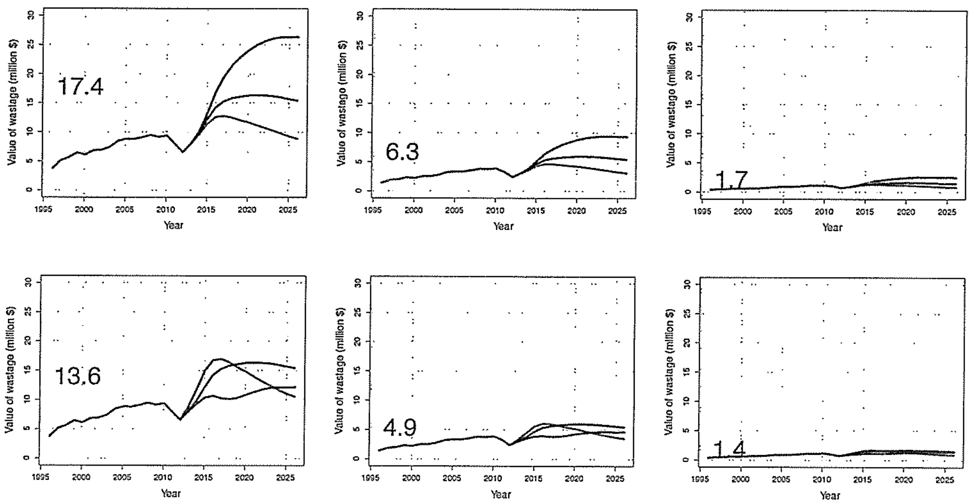

Figure 2.17: Value of commercial wastage under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for 32 inch (left), 29 inch (middle), and 26 inch (right) size limits. Poor, average, and good recruitment are denoted by red, black and blue lines, respectively. Value on each panel corresponds to 2020-2025 average over 3 recruitment hypotheses.

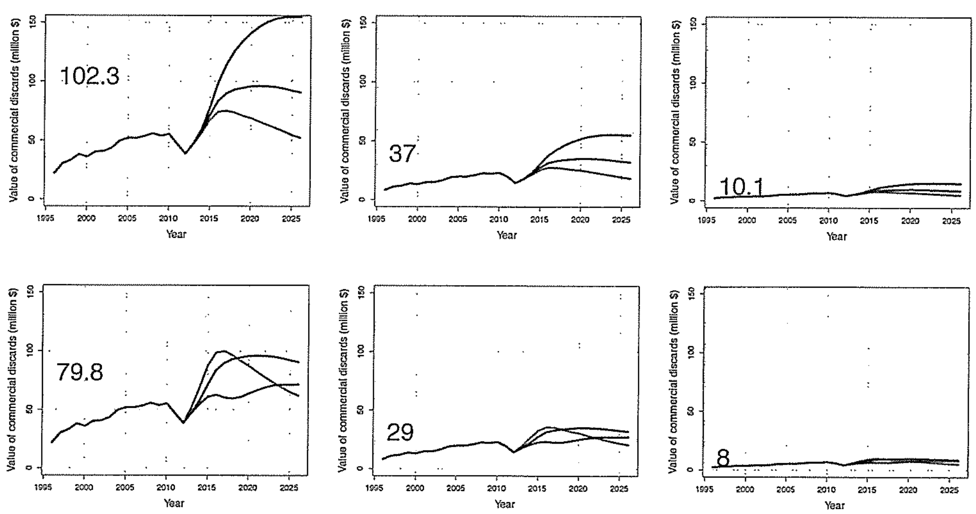

Figure 2.18: Value of all commercial sublegal size fish under the assumptions of density-independent growth (top row) and density-dependent growth (bottom row) for 32 inch (left), 29 inch (middle), and 26 inch (right) size limits. Poor, average, and good recruitment are denoted by red, black and blue lines, respectively. Value on each panel corresponds to 2020-2025 average over 3 recruitment hypotheses.

Table 2.3: Summary of simulated performance measures for three alternative size limit policies averaged over 3 recruitment levels and 2 alternative hypthoses about halibut growth.

Response (million lb)	32" MSL	29" MSL	26" MSL
EBio	633	634	635
Yield	101	101.25	101.4
Wastage	2.494	0.925	0.260
Response (million)			
Landed Value	$684.7	$683.6	$683
Waste Value[1]	$15.5	$5.6	$1.55
Discard Value[2]	$91	$33	$9
Efficiency	86.7%	95.2%	98.7%
Handling Efficiency	40%	66%	91%

proximate measure is the handling efficiency, or simply what fraction of the fish captured that are retained. Under a 32 inch size-limit the average simulated handling efficiency between 2020-2025 is 40%. In other words, 60 out of 100 captured halibut are below the minimum legal size and are discarded. Whereas, under a 26 inch size limit the handling efficiency increases to 91%, or 9 out of 100 captured halibut are below the minimum legal size (Table 2.3).

2.4 Discussion

Reducing the minimum size limit from 32 inches to 29 or 26 inches does not appear pose any substantial conservation risks. Simulated estimates of coastwide exploitable biomass actually increase with a reduction in the minimum size limit due to reduced overall total mortality rates associated with wastage in the directed commercial fishery. Female spawning biomass is also expected to increase with reductions in the minimum size limit. If the the discard mortality rate is greater than the assumed value, this increase in exploitable biomass could be even more substantial. This result seems counterintuitive, the general expectation would be a general decrease in spawning and exploitable biomass with decreasing size limits. Pine III et al. (2008) demonstrated that with increases in discard mortality rates (or a decrease in post-release survival rates), the overall spawning potential ratio (SPR) would decrease with with increasing size limits when fishing at rates equal to or greater than the maximum sustainable yield.

The overall landed value of the halibut fishery actually decreases slightly with a decrease in the minimum size limit. With a lower size limit the size composition of the catch contains a much higher fraction of low-value 5-10 pound fish. This result is also an artifact of the assumed $5.00 per pound price for 5-10 pound halibut. If this price is less, there would be even less of an economic incentive to lower the size limit. The real potential economic benefit of lowering the size limit is associated with operational costs; with a lower size limit, the time required to catch an individuals quota could be substantially reduced because the majority of fish landed would be retained, rather than discarded.

There may also be a potential benefit from reducing the size limit if intraspecific competition for food resources is one of the factors that is related to reduced halibut growth. Retention of smaller, more abundance halibut, could potentially improve halibut growth rates by lowering the overall halibut density and improving foraging conditions (Walters and Juanes, 1993; Walters and Martell, 2004). Unfortunately the density-dependent growth model used in this simulation study is not related to annual halibut density, so it could not be used to explore this hypothesis.

One of the major caveats in this study is that the assumed coastwide selectivity curve in the commercial fishery does not change in response to changes in the size limit. If in fact the commercial fishery selectivity did shift towards smaller sizes, then discarding of sublegal size fish would likely increase and lead to even more severe growth overfishing for this stock. However, it is clear that there are potential economic gains to be made by reducing the minimum size limit by reducing the time required to land the quota and the operational costs. To ensure selectivity does not change, an enforceable policy option might be to standardize fishing gear in the directed fishery. For example, limits on hook size, hook spacing, or other tactics could be out in place to prevent a massive shift in selectivity and increase the risk of growth over fishing. Alternatively, individual accountability for all mortality could be assigned to the individual quota holder. In this case, say 17% of the discarded halibut of sublegal size would count against the quota. The latter option would almost certainly create the appropriate behavioural incentives to shift away from small halibut, but would also require 100% observer coverage or electronic monitoring.

Lastly, even if the current minimum size limit of 32 inches is kept in place, then target fishing mortality rates need to be adjusted on an annual basis to ensure that the current fishing rate policy is commensurate with the spawning biomass reference points associated with changing growth rates. If alternative size limits were adopted, the target fishing mortality rate would almost certainly have to be reduced to ensure it is commensurate with the $SB_{30\%}$ and $SB_{20\%}$ spawning biomass reference points assuming constant growth. If, however, there is some persistent transition to lower or higher growth rates, then the corresponding absolute spawning biomass reference points would also decrease with lower growth rates, or increase with higher growth rates. If halibut growth rates increase, then fishing mortality reference points that correspond to $B_{30\%}$ would also increase, and vice-versa.

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Part III

Appendices

A.1 Input files for the Simulation Model

In this appendix, the input data, parameter controls and initial parameter values for the Halibut simulation model are given. Electronic copies of these files are available from a code repository hosted at: `http://code.google.com/p/iscam-project/source/browse/`. The source code is also available from the same repository under the Halibut branch. A history of the code development can be viewed here: `http://code.google.com/p/iscam-project/source/list?name=halibut`.

The following is the data file where, the # symbol to the left of any number denotes comment lines to document the data file.

```
## ------------------------------------------------------------------------ ##
## TEMPLATE DATA FILE FOR iSCAM                                             ##
## TIPS: -use '#' as comment character for the data file                    ##
##       -use '#' on all blank lines (windows compatible)                   ##
##                                                                          ##
##                                                                          ##
##                                                                          ##
## TEMPLATE is based on Flack Lake Trout (ADMB catage example)              ##
## ------------------------------------------------------------------------ ##
##
##
##
## ------------------------------------------------------------------------ ##
## MODEL DIMENSIONS                                                         ##
## ------------------------------------------------------------------------ ##
1996        # -first year of data           (syr)
2011        # -last year of data            (nyr)
1           # -age of youngest age class    (sage)
30          # -age of plus group            (nage)
40          # -minimum length               (slen)
140         # -maximum length               (nlen)
21          # -number of length bins        (nlbin)
5           # -number of gears              (ngear)
2           # -number of sexes              (nsex)
6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6   # vector of firstAge(j_sage)##
#20 20 20 20 20 20 25 25 25 25 25 25 25 25 25 25  # vector of plusAge (j_nage)##
25 25 25 25 25 25 25 25 25 25 25 25 25 25 25 25  # vector of plusAge (j_nage)##  Overwrote the wt_obs with a*pow(length-age,b)
# (j_nage)
##
## ------------------------------------------------------------------------ ##
## Allocation for each gear in (ngear), use 0 for survey gears.             ##
## Type of catch: an ivector based on legend below                          ##
##              1 = catch in weight                                         ##
##              2 = catch in numbers                                        ##
##              3 = catch in spawn (roe)                                    ##
## ------------------------------------------------------------------------ ##
1 0 0 0 0                                               ## ALLOCATION       ##
1 1 1 1 1                                               ## TYPE OF CATCH    ##
##                                                                          ##
## ------------------------------------------------------------------------ ##
## Age-schedule and population parameters                                   ##
## ------------------------------------------------------------------------ ##
##0.15 0.135474        # -natural mortality rate (m_fixed) TOBE DEPRECATED
##145 110             # -asymptotic length (linf)
##0.10 0.12            # -brody growth coefficient (k)
##-1.219753 -1.219753       # -theoretical age at zero length (to)
##6.921e-6 6.921e-6        # -scaler in length-weight allometry (a)
##3.24 3.24            # -power parameter in length-weight allometry (b)
##11.59 11.59           # -age at 50% maturity (approx with log(3.0)/k)
##1.776 1.776           # -std at 50% maturity (CV ~ 0.1)
##
## ------------------------------------------------------------------------ ##
## TIME SERIES DATA                                                         ##
## Observed catch (row dimensions syr:nyr) (col dimensions yr,1:ngear)      ##
## Units are in millions of pounds, net weight. From Hare 2012 RARA         ##
## Note that the setline includes IPHC research catch (assumed to have the  ##
## same selectivity).                                                       ##
## ------------------------------------------------------------------------ ##
## yrs   CatchWt  DiscardWt BycatchWt SportCatchWt PersUseWt
   1996  47.692   0.726     14.375     8.083       0.543
   1997  65.485   1.048     13.513     9.025       0.543
   1998  70.115   1.198     13.432     8.586       0.709
   1999  74.700   1.335     13.844     7.379       0.741
   2000  68.550   1.287     13.290     9.016       0.748
   2001  70.970   1.442     13.159     8.106       0.746
   2002  74.949   1.658     12.610     8.012       0.746
   2003  73.356   1.770     12.003     9.347       1.383
```

```
    2004  73.307   1.933      12.224     10.703       1.520
    2005  72.111   2.030      12.335     10.859       1.537
    2006  68.120   2.045      13.081     10.212       1.537
    2007  63.025   2.286      12.124     11.461       1.483
    2008  58.699   2.337      10.788     10.750       1.489
    2009  52.176   2.624      11.377      8.751       1.306
    2010  49.825   3.038      10.632      7.825       1.239
    2011  39.286   2.213       9.996      7.515       1.245
 ##
 ## ------------------------------------------------------------------------ ##
 ## ABUNDANCE INDICES -A RAGGED ARRAY: (1,nit,1,nit_nobs,1,5)                ##
 ## ------------------------------------------------------------------------ ##
 2               # Number of abundance series         int(nit)
 14  15          # Number of observations in series   ivector(nit_nobs(1,nit))
 2   2           # Survey type (see key below)        ivector(survey_type(1,nit))
 ## 1 = survey is proportional to vulnerable numbers
 ## 2 = survey is proportional to vulnerable biomass
 ## 3 = survey is proportional to spawning biomass (e.g., a spawn survey)
 ##
 ## survey_data (setline wpue)
 #iyr    it        gear  wt  survey timing
  1997   138        2    1   0.5
  1998   134        2    1   0.5
  1999   126        2    1   0.5
  2000   121        2    1   0.5
  2001   112        2    1   0.5
  2002   109        2    1   0.5
  2003    92        2    1   0.5
  2004    89        2    1   0.5
  2005    82        2    1   0.5
  2006    71        2    1   0.5
  2007    66        2    1   0.5
  2008    61        2    1   0.5
  2009    56        2    1   0.5
  2010    47        2    1   0.5
 ## commercial wpue (all areas)
 #1984 350          1    1   0.5
 #1985 395          1    1   0.5
 #1986 351          1    1   0.5
 #1987 345          1    1   0.5
 #1988 387          1    1   0.5
 #1989 376          1    1   0.5
 #1990 334          1    1   0.5
 #1991 333          1    1   0.5
 #1992 338          1    1   0.5
 #1993 399          1    1   0.5
 #1994 328          1    1   0.5
 #1995 351          1    1   0.5
  1996 415          1    1   0.5
  1997 423          1    1   0.5
  1998 429          1    1   0.5
  1999 398          1    1   0.5
  2000 416          1    1   0.5
  2001 382          1    1   0.5
  2002 379          1    1   0.5
  2003 346          1    1   0.5
  2004 338          1    1   0.5
  2005 314          1    1   0.5
  2006 283          1    1   0.5
  2007 268          1    1   0.5
  2008 249          1    1   0.5
  2009 237          1    1   0.5
  2010 222          1    1   0.5
 ##
 ## ------------------------------------------------------------------------ ##
 ## AGE COMPOSITION DATA (ROW YEAR, COL=AGE) Ragged object                   ##
 ## ------------------------------------------------------------------------ ##
 2           # Number of gears with age-comps int(na_gears)
 1   1       # Number of rows in the matrix   ivector(na_nobs)
 4   4       # Youngest age column            ivector(a_sage)
 26  26      # Oldest age column +group       ivector(a_nage)
 ## year gear age colums (numbers or proportions)
   2010 1     0.000000 0.000382 0.000446 0.004583 0.028833 0.060976 0.122207 0.167399 0.137356 0.081153 0.068296 0.057921
              0.048183 0.029915 0.024251 0.018522 0.021132 0.021195 0.024378 0.023869 0.013685 0.008147 0.037171
 ##
   2010 2     0.000071 0.002060 0.010582 0.035156 0.092401 0.107812 0.145952 0.165980 0.122798 0.060156 0.050710 0.044247
              0.033026 0.021449 0.014560 0.010724 0.010014 0.011932 0.011790 0.013210 0.009588 0.004616 0.021165
 ##
 ## ------------------------------------------------------------------------ ##
 ## EMPIRICAL WEIGHT-AT-AGE DATA                                             ##
 ## ------------------------------------------------------------------------ ##
 16          # Number of years of weight-at-age data int(n_wt_obs)
 21          # Number of columns in the weight at age data
 6           # age_min_wt
 #6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6           # sage_wt_obs
 #20 20 20 20 20 20 25 25 25 25 25 25 25 25 25 25           # nage_wt_obs (A plus group)
 ## year age columns (sage, nage) of weight at age data
```

```
## Catch-weight-at-age for females
1996 14 16.0 16.0 18.9 22.3 25.9 29.9 34.3 39.0 44.3 50.0 56.6 61.1 68.0 77.8 -99.0 -99.0 -99.0 -99.0 -99.0
1997 14 16.0 16.7 19.3 22.3 26.0 30.2 34.6 39.1 43.9 49.1 54.8 61.1 68.0 77.8 -99.0 -99.0 -99.0 -99.0 -99.0
1998 14 16.0 16.9 19.0 21.7 25.0 28.9 33.2 37.5 42.0 46.8 51.9 57.3 63.4 68.1 -99.0 -99.0 -99.0 -99.0 -99.0
1999 14 16.0 17.2 18.9 21.2 24.1 27.6 31.4 35.4 39.7 44.2 48.8 54.0 59.1 65.2 -99.0 -99.0 -99.0 -99.0 -99.0
2000 14 16.0 17.7 19.0 20.9 23.4 26.5 29.9 33.6 37.7 42.0 46.3 50.7 55.6 62.3 -99.0 -99.0 -99.0 -99.0 -99.0
2001 14 16.0 17.7 19.6 21.2 23.3 26.0 29.1 32.6 36.5 40.6 44.7 49.0 55.6 64.1 -99.0 -99.0 -99.0 -99.0 -99.0
2002 14 15.8 17.2 19.2 21.3 23.6 25.8 28.2 30.6 33.1 35.7 38.3 41.0 43.9 46.8  49.8  52.9  56.1  59.4  64.8
2003 14 15.8 17.8 19.8 21.9 24.0 26.2 28.5 30.8 33.2 35.6 38.0 40.7 43.4 46.2  49.1  52.1  55.1  58.5  64.8
2004 14 15.9 18.1 20.1 22.1 24.2 26.3 28.4 30.6 32.8 35.0 37.2 39.7 42.4 45.1  48.0  51.0  54.2  57.6  52.2
2005 14 16.0 18.1 20.1 22.1 24.1 26.1 28.1 30.2 32.2 34.1 36.2 38.5 41.1 43.8  46.7  49.8  53.2  56.7  58.9
2006 14 16.0 18.0 19.9 21.8 23.8 25.7 27.6 29.5 31.4 33.2 35.1 37.3 39.8 42.5  45.4  48.6  52.2  55.9  54.9
2007 14 15.7 17.6 19.4 21.3 23.2 25.0 26.9 28.8 30.6 32.3 34.2 36.3 38.9 41.5  44.5  47.4  51.2  55.0  49.6
2008 14 15.3 17.1 18.8 20.6 22.5 24.2 26.1 28.0 29.8 31.6 33.4 35.6 38.1 40.7  43.5  46.4  50.2  54.1  56.0
2009 14 14.8 16.4 18.1 19.8 21.6 23.4 25.3 27.2 29.2 31.0 33.0 35.2 37.6 40.2  42.9  45.7  49.3  53.2  62.4
2010 14 14.3 15.8 17.4 19.1 20.9 22.8 24.7 26.7 28.7 30.7 32.8 35.0 37.5 40.0  42.8  45.4  48.3  52.4  55.9
2011 14 14.3 15.3 16.9 18.6 20.4 22.3 24.4 26.4 28.5 30.7 32.9 35.2 37.6 40.0  42.8  45.5  48.4  51.5  49.4
## Catch-weight-at-age for males
1996 14 14.0 13.1 14.1 14.8 14.8 15.7 16.8 17.2 19.7 20.1 20.4 25.9 26.4 31.4 -99.0 -99.0 -99.0 -99.0 -99.0
1997 14 14.0 13.1 13.5 14.1 14.8 15.7 16.8 17.2 19.7 20.1 20.4 25.9 26.4 31.4 -99.0 -99.0 -99.0 -99.0 -99.0
1998 14 14.0 13.1 13.3 13.8 14.4 15.1 16.1 17.2 18.7 20.1 20.4 24.0 26.4 30.6 -99.0 -99.0 -99.0 -99.0 -99.0
1999 14 14.0 13.1 13.5 13.9 14.4 15.0 15.8 16.7 17.8 19.5 20.4 22.7 24.9 29.2 -99.0 -99.0 -99.0 -99.0 -99.0
2000 14 14.0 13.1 13.7 14.1 14.6 15.2 15.8 16.6 17.6 18.9 20.4 22.2 24.3 27.8 -99.0 -99.0 -99.0 -99.0 -99.0
2001 14 14.0 13.1 13.9 14.2 14.6 15.2 15.8 16.7 17.8 19.1 20.4 22.4 24.5 26.1 -99.0 -99.0 -99.0 -99.0 -99.0
2002 14 13.5 13.0 13.3 13.6 13.9 14.3 14.8 15.3 15.9 16.6 17.3 18.1 19.0 20.0  21.1  22.3  23.6  25.0  30.0
2003 14 13.5 13.3 13.5 13.8 14.1 14.4 14.7 15.1 15.6 16.2 16.8 17.5 18.4 19.3  20.4  21.5  22.7  24.1  28.9
2004 14 13.5 13.4 13.7 13.9 14.1 14.3 14.6 15.0 15.4 15.8 16.3 16.9 17.8 18.6  19.6  20.7  22.1  23.2  27.9
2005 14 13.5 13.6 13.7 13.9 14.1 14.3 14.4 14.8 15.1 15.5 15.9 16.5 17.2 18.1  19.0  20.2  21.5  22.7  26.9
2006 14 13.5 13.6 13.7 13.8 14.0 14.1 14.3 14.6 14.9 15.3 15.7 16.3 16.9 17.7  18.6  19.7  20.9  22.1  25.9
2007 14 13.5 13.5 13.6 13.7 13.8 13.9 14.1 14.3 14.6 15.0 15.4 16.0 16.5 17.3  18.3  19.2  20.3  21.5  24.8
2008 14 13.5 13.3 13.4 13.5 13.6 13.7 13.9 14.1 14.4 14.8 15.2 15.8 16.3 17.0  17.9  18.7  19.7  20.9  23.8
2009 14 13.5 13.1 13.1 13.2 13.4 13.5 13.7 13.9 14.2 14.6 15.0 15.5 16.1 16.7  17.5  18.3  19.2  20.3  22.8
2010 14 13.5 12.8 12.9 13.0 13.1 13.3 13.5 13.7 14.0 14.4 14.8 15.3 16.1 16.4  17.1  17.9  18.8  19.7  22.8
2011 14 13.5 12.6 12.7 12.8 13.0 13.1 13.3 13.6 13.9 14.2 14.5 15.3 16.1 16.1  16.8  17.5  18.3  19.7  22.8
##
## ------------------------------------------------------------------------- ##
## EMPIRICAL LENGTH-AT-AGE DATA                                               ##
## ------------------------------------------------------------------------- ##
16          # Number of years of length-at-age data int(n_lt_obs)
31          # Number of columns for the length-at-age data
1           # age_min_lt
## Mean length-at-age for female halibut (SurvLTrue_F)
1996   -99.0 -99.0 -99.0 -99.0 -99.0  69.9  74.6  80.0  85.5  91.4  97.6 103.7 109.0 113.8 118.5 122.6 126.4 129.4 132.5 135.4 137.6 139.3 141.0 142.4 143.8 145.2 146.6 1
1997   -99.0 -99.0 -99.0 -99.0 -99.0  69.9  74.6  80.0  85.5  91.4  97.6 103.7 109.0 113.8 118.5 122.6 126.4 129.4 132.5 135.4 137.6 139.3 141.0 142.4 143.8 145.2 146.6 1
1998   -99.0 -99.0 -99.0 -99.0 -99.0  70.0  74.4  79.4  84.8  90.7  97.2 103.5 108.8 113.5 118.1 121.9 125.5 128.3 131.1 133.8 135.8 137.7 139.5 141.0 142.5 144.0 145.4 1
1999   -99.0 -99.0 -99.0 -99.0 -99.0  70.0  74.2  78.8  83.9  89.7  96.1 102.3 107.5 111.9 116.2 119.9 123.2 125.9 128.6 131.2 133.2 135.0 136.8 138.3 139.8 141.2 142.7 1
2000   -99.0 -99.0 -99.0 -99.0 -99.0  70.0  74.0  78.4  83.2  88.5  94.3  99.9 104.8 109.0 113.2 116.7 120.0 122.8 125.4 128.1 130.1 131.8 133.5 134.9 136.3 137.7 139.1 1
2001   -99.0 -99.0 -99.0 -99.0 -99.0  70.0  74.0  78.0  82.4  87.2  92.2  97.2 101.6 105.7 109.7 113.2 116.5 119.2 122.0 124.6 126.6 128.3 129.9 131.2 132.5 133.8 135.2 1
2002   -99.0 -99.0 -99.0 -99.0 -99.0  69.8  74.8  80.4  85.0  89.4  93.6  97.7 101.6 105.4 109.1 112.7 116.2 119.6 123.0 126.3 129.4 132.4 135.4 136.1 136.9 137.6 138.4 1
2003   -99.0 -99.0 -99.0 -99.0 -99.0  69.8  74.8  79.7  84.4  88.9  93.2  97.2 101.0 104.8 108.3 111.6 114.7 117.8 120.8 123.9 126.7 129.5 132.2 133.4 134.7 136.0 137.3 1
2004   -99.0 -99.0 -99.0 -99.0 -99.0  68.8  73.9  79.0  83.9  88.5  92.9  97.1 101.0 104.7 108.0 111.0 113.8 116.5 119.2 121.9 124.5 127.1 129.5 131.2 132.8 134.5 136.2 1
2005   -99.0 -99.0 -99.0 -99.0 -99.0  67.7  73.0  78.2  83.2  88.0  92.5  96.9 100.9 104.5 107.7 110.5 113.0 115.4 117.9 120.3 122.7 125.3 127.1 129.8 131.6 133.3 135.1 1
2006   -99.0 -99.0 -99.0 -99.0 -99.0  66.7  72.0  77.3  82.4  87.3  91.9  96.5 100.7 104.4 107.6 110.3 112.6 114.9 117.2 119.4 121.4 123.5 125.0 128.6 130.4 132.2 134.0 1
2007   -99.0 -99.0 -99.0 -99.0 -99.0  65.7  71.1  76.3  81.5  86.3  90.9  95.4  99.6 103.3 106.6 109.4 112.0 114.3 116.4 118.4 120.2 121.8 123.3 127.5 129.3 131.1 132.9 1
2008   -99.0 -99.0 -99.0 -99.0 -99.0  64.7  70.1  75.3  80.4  85.2  89.8  94.2  98.3 102.0 105.4 108.3 111.0 113.3 115.3 117.2 118.8 120.3 121.6 126.4 128.2 130.0 131.8 1
2009   -99.0 -99.0 -99.0 -99.0 -99.0  63.8  69.2  74.3  79.3  84.1  88.7  93.0  97.1 100.9 104.2 107.2 109.8 112.1 114.1 115.9 117.5 118.9 121.6 125.8 127.4 129.0 130.7 1
2010   -99.0 -99.0 -99.0 -99.0 -99.0  62.9  68.3  73.4  78.4  83.1  87.6  91.9  96.0  99.7 103.0 106.0 108.7 111.1 113.1 115.9 117.5 118.9 121.6 125.5 126.8 128.2 129.6 1
2011   -99.0 -99.0 -99.0 -99.0 -99.0  62.9  68.3  72.6  77.6  82.3  86.8  91.0  95.0  98.7 102.0 105.0 107.7 110.1 113.1 115.9 117.5 118.9 121.6 125.2 126.3 127.4 128.5 1
## Mean length-at-age for male halibut (SurvLTrue_M)
1996   -99.0 -99.0 -99.0 -99.0 -99.0  63.3  67.0  70.4  74.0  77.4  80.7  84.0  86.8  89.3  91.7  93.8  95.9  97.7  99.5 101.3 102.7 103.9 105.1 106.1 107.1 108.1 109.1 1
1997   -99.0 -99.0 -99.0 -99.0 -99.0  63.3  67.0  70.4  74.0  77.4  80.7  84.0  86.8  89.3  91.7  93.8  95.9  97.7  99.5 101.3 102.7 103.9 105.1 106.1 107.1 108.1 109.1 1
1998   -99.0 -99.0 -99.0 -99.0 -99.0  63.6  67.2  70.7  74.1  77.3  80.5  83.5  86.1  88.3  90.4  92.4  94.3  96.0  97.8  99.7 101.3 102.9 104.6 105.9 107.3 108.6 109.9 1
1999   -99.0 -99.0 -99.0 -99.0 -99.0  63.6  67.2  71.0  74.3  77.3  80.2  83.0  85.4  87.6  89.8  91.7  93.6  95.3  97.1  98.9 100.3 101.5 102.7 103.7 104.7 105.6 106.6 1
2000   -99.0 -99.0 -99.0 -99.0 -99.0  63.8  67.3  70.9  74.0  77.0  79.7  82.4  84.8  86.9  89.1  91.0  92.9  94.7  96.4  98.1  99.3 100.1 100.9 101.5 102.0 102.6 103.2 1
2001   -99.0 -99.0 -99.0 -99.0 -99.0  63.8  67.3  70.0  73.1  76.0  78.7  81.4  83.7  85.8  87.9  89.7  91.6  93.3  95.1  97.0  98.3  99.3 100.2 101.0 101.8 102.5 103.3 1
2002   -99.0 -99.0 -99.0 -99.0 -99.0  64.2  67.5  71.0  73.8  76.4  78.7  80.9  82.9  84.9  86.8  88.5  90.2  92.0  93.8  95.6  97.5  99.4 101.4 103.1 104.8 106.6 108.3 1
2003   -99.0 -99.0 -99.0 -99.0 -99.0  64.2  67.5  70.5  73.3  75.8  78.2  80.2  82.1  83.9  85.7  87.3  88.8  90.4  92.1  93.8  95.6  97.4  99.5 101.9 104.6 107.2 109.8 1
2004   -99.0 -99.0 -99.0 -99.0 -99.0  63.7  67.0  70.1  72.9  75.5  77.9  79.9  81.7  83.6  85.2  86.6  87.9  89.3  90.9  92.5  94.2  95.9  97.6  99.3 100.8 102.2 103.7 1
2005   -99.0 -99.0 -99.0 -99.0 -99.0  63.2  66.6  69.7  72.6  75.3  77.7  79.7  81.6  83.4  84.9  86.2  87.4  88.7  90.1  91.6  93.1  94.7  96.3  97.4  98.2  99.0  99.8
2006   -99.0 -99.0 -99.0 -99.0 -99.0  62.7  66.0  69.3  72.2  74.9  77.3  79.5  81.4  83.2  84.7  85.9  87.0  88.3  89.5  90.9  92.4  93.8  95.5  97.7  99.8 101.9 104.0 1
2007   -99.0 -99.0 -99.0 -99.0 -99.0  62.1  65.5  68.7  71.6  74.3  76.7  78.9  80.9  82.7  84.2  85.5  86.6  87.9  89.1  90.5  91.7  93.0  94.6  96.3  97.9  99.5 101.1 1
2008   -99.0 -99.0 -99.0 -99.0 -99.0  61.5  64.8  68.0  70.9  73.6  76.0  78.2  80.2  82.1  83.7  85.0  86.3  87.6  88.8  90.1  91.3  92.4  93.8  95.4  97.0  98.6 100.2 1
2009   -99.0 -99.0 -99.0 -99.0 -99.0  60.8  64.1  67.2  70.1  72.7  75.2  77.4  79.4  81.3  83.0  84.5  85.9  87.3  88.5  89.8  90.9  91.9  93.0  94.5  96.1  97.7  99.3
2010   -99.0 -99.0 -99.0 -99.0 -99.0  60.1  63.4  66.4  69.2  71.9  74.3  76.5  78.6  80.5  82.3  83.9  85.4  86.8  88.1  89.3  90.3  91.9  92.3  93.8  95.2  96.5  97.9
2011   -99.0 -99.0 -99.0 -99.0 -99.0  60.1  63.4  65.6  68.4  71.0  73.4  75.7  77.7  79.7  81.5  83.1  84.6  86.1  87.4  88.6  89.7  91.9  92.3  93.2  94.2  95.2  96.2
##
## ------------------------------------------------------------------------- ##
## MARKER FOR END OF DATA FILE (eof)                                          ##
## ------------------------------------------------------------------------- ##
999
```

The following text is the control file for the halibut simulation model

```
## ------------------------------------------------------------------------- ##
## CONTROL FILE TEMPLATE                                                      ##
```

```
## ------------------------------------------------------------------------ ##
##
##
## ------------------------------------------------------------------------ ##
## CONTROLS FOR LEADING PARAMETERS                                          ##
##  Prior descriptions:                                                     ##
##                      -0 uniform      (0,0)                               ##
##                      -1 normal       (p1=mu,p2=sig)                      ##
##                      -2 lognormal    (p1=log(mu),p2=sig)                 ##
##                      -3 beta         (p1=alpha,p2=beta)                  ##
##                      -4 gamma        (p1=alpha,p2=beta)                  ##
## ------------------------------------------------------------------------ ##
## npar
5
## ival         lb      ub      phz     prior   p1      p2      #parameter   ##
   16.8452      -5.0    15      1       0       -5.0    15      #log_ro      ##
   0.75         0.2     1.0     1       3       1.01    1.01    #steepness   ##
   17.93703     -5.0    15      1       0       -5.0    15      #log_avgrec  ##
   0.5          0.01    0.99    -3      3       1.01    1.01    #rho         ##
   0.8          0.01    5.0     -3      4       1.01    1.01    #vartheta    ##
## ------------------------------------------------------------------------ ##
##
## ------------------------------------------------------------------------ ##
## CONTROLS FOR SEX BASED PARAMETERS (nsex arrays, 9 rows, 7 cols)          ##
## ------------------------------------------------------------------------ ##
## FEMALE                                                                   ##
## ival         lb      ub      phz     prior   p1      p2      #parameter   ##
## ------------------------------------------------------------------------ ##
   15.18892     -5.0    15      1       0       -5.0    15      #log_recinit ##
   -1.89712     -3.0    2.0     -1      1       -1.74   0.1     #log_m_f     ##
   148.0627     0.0     200     -1      0       0.0     200     #linf        ##
   0.09154536   0.01    1.0     -1      0       0.01    1.0     #vonk        ##
   0            -2.0    0.0     -1      0       -2.0    0.0     #to          ##
   9.321e-6     0.0     1.0     -1      0       0.0     1.0     #a           ##
   3.16         2.0     3.5     -1      0       2.0     3.5     #b           ##
   11.59        0.0     30.     -1      0       0.0     30.     #ah          ##  11.49
   1.776        0.0     30.     -1      0       0.0     30.     #gh          ##  1.776
## ------------------------------------------------------------------------ ##
## MALE                                                                     ##
## ival         lb      ub      phz     prior   p1      p2      #parameter   ##
## ------------------------------------------------------------------------ ##
   15.34718     -5.0    15      1       0       -5.0    15      #log_recinit ##
   -1.99897     -3.0    2.0     -1      1       -1.74   0.1     #log_m_f     ##
   105.7311     0.0     200     -1      0       0.0     200     #linf        ##
   0.1275141    0.01    1.0     -1      0       0.01    1.0     #vonk        ##
   0            -2.0    0.0     -1      0       -2.0    0.0     #to          ##
   9.321e-6     0.0     1.0     -1      0       0.0     1.0     #a           ##
   3.16         2.0     3.5     -1      0       2.0     3.5     #b           ##
   11.49        0.0     30.     -1      0       0.0     30.     #ah          ##
   1.776        0.0     30.     -1      0       0.0     30.     #gh          ##
## ------------------------------------------------------------------------ ##

##
##
## ------------------------------------------------------------------------ ##
## SELECTIVITY PARAMETERS Columns for gear                                  ##
## OPTIONS FOR SELECTIVITY (isel_type):                                     ##
##      1) logistic selectivity parameters                                  ##
##      2) selectivity coefficients                                         ##
##      3) a constant cubic spline with age-nodes                           ##
##      4) a time varying cubic spline with age-nodes                       ##
##      5) a time varying bicubic spline with age & year nodes.             ##
##      6) fixed logistic (set isel_type=6, and estimation phase to -1)     ##
##      7) logistic function of body weight.                                ##
##      8) logistic with weight deviations (3 parameters)                   ##
##      11) logistic selectivity with 2 parameters based on mean length     ##
##      12) length-based selectivity coefficients with spline interpolation ##
##      sig=0.05 0.10 0.15 0.20 0.30 0.40 0.50 `                            ##
##      wt =200. 50.0 22.2 12.5 5.56 3.12 2.00                              ##
## ------------------------------------------------------------------------ ##
##CatchWt  DiscardWt BycatchWt SportCatchWt PersUseWt
  13    13    13    13    13                # -selectivity type ivector(isel_type) for gear
  97.13 97.13 97.13 97.13 97.133            # -Age/length at 50% selectivity (logistic)
  6     6     6     6     6                 # -STD at 50% selectivity (logistic)
  8     8     13    8     8                 # -No. of age/length nodes for each gear (0=ignore)
  0     0     0     0     0                 # -No. of year nodes for 2d spline(0=ignore)
  -2    -2    -2    -2    -2                # -Phase of estimation (-1 for fixed)
  2     2     2     2     2                 # -Penalty wt for 2nd differences w=1/(2*sig^2)
  3     3     3     3     3                 # -Penalty wt for dome-shaped w=1/(2*sig^2)
  81.28 0     0     0     0                 # -Size limit (cm) 81.28 for halibut or 26in (66.04cm) 73.66
  0.16  0     0     0     0.16              # -Discard mortality rate
## ------------------------------------------------------------------------ ##
##
##
##
## ------------------------------------------------------------------------ ##
## PRIORS FOR SURVEY Q                                                      ##
```

```
## Prior type:                                                              ##
## 0 - uninformative prior                                        ##
## 1 - normal prior density for log(q)                            ##
## 2 - random walk in q                                           ##
## ------------------------------------------------------------------------ ##
2 # -number of surveys (nits)
0 2    # -prior type (see legend above)
0 0    # -prior log(mean)
0 0.01    # -prior sd
## ------------------------------------------------------------------------ ##
##

## ------------------------------------------------------------------------ ##
## OTHER MISCELANEOUS CONTROLS                                              ##
## ------------------------------------------------------------------------ ##
0           # 1  -verbose ADMB output (0=off, 1=on)
1           # 2  -recruitment model (1=beverton-holt, 2=ricker)
0.100       # 3  -std in observed catches in first phase.
0.0707      # 4  -std in observed catches in last phase.
0           # 5  -Assume unfished in first year (0=FALSE, 1=TRUE)
0.00        # 6  -Minimum proportion to consider in age-proportions for dmvlogistic
0.20        # 7  -Mean fishing mortality for regularizing the estimates of Ft
0.01        # 8  -std in mean fishing mortality in first phase
2.00        # 9  -std in mean fishing mortality in last phase
-3          # 10 -phase for estimating m_deviations (use -1 to turn off mdevs)
0.1         # 11 -std in deviations for natural mortality
12          # 12 -number of estimated nodes for deviations in natural mortality
0.50        # 13 -fraction of total mortality that takes place prior to spawning
1           # 14 -switch for age-composition likelihood (1=dmvlogistic,2=dmultinom)
#81.28       # 15 -Size limit (cm) for retention (logistic with 10% CV)
#0.17        # 16 -Base discard mortality rate (age-size independent)
##
## ------------------------------------------------------------------------ ##
## MARKER FOR END OF CONTROL FILE (eofc)
## ------------------------------------------------------------------------ ##
999


# Number of parameters = 285  Objective function value = 3667.07  Maximum gradient component = 0.00000
# theta[1]:  #log_Ro
15.9
# theta[2]:  #steepness
0.750000000000
# theta[3]:  #log_Rbar
17.93703
# theta[4]:
8.00000000000
# theta[5]:
8.00000000000
# female parameters
15.18892
-1.89712
148.0627
0.09154536
-1.2197
9.321e-6 # a
3.16     # b
11.49
1.776
# male parameters
15.34718
-1.99897
105.7311
0.1275141
-1.2197
9.321e-6 #a
3.16     #b
11.49
1.776
# sel_par[1]:
1.63176e-09 3.25739e-09 0.0603022 0.300891 0.630344 0.913893 1 1
2.17169e-09 0.00396878 0.0567109 0.281436 0.585461 0.835614 1 1
# sel_par[2]:
0 0 1 0 0 0 0 0
0 0 1 0 0 0 0 0
# sel_par[3]:
0 0 0 0.001 0.7 1 0.6 0.6 0.6 0.6 0.6 0.6 0.6
0 0 0 0.001 0.7 1 0.6 0.6 0.6 0.6 0.6 0.6 0.6
# sel_par[4]:
0 0.0227976 0.18854 0.407238 0.654921 0.863483 1 1.20589
0 0.0266741 0.161269 0.242839 0.389576 0.673042 1 1.32696
# sel_par[5]:
0 0.0227976 0.18854 0.407238 0.654921 0.863483 1 1.20589
0 0.0266741 0.161269 0.242839 0.389576 0.673042 1 1.32696
# log_ft_pars:
-2.307296 -2.102751 -1.992090 -1.862461 -1.899322 -1.716355 -1.625466 -1.513355 -1.371879 -1.288079 -1.249249 -1.231001 -1.238392 -1.346766 -1.390905 -1.644806 -5.748506
-4.799907 -4.634285 -4.611588 -4.579337 -4.419579 -4.378035 -4.474458 -4.495733 -4.572945 -4.468456 -4.353657 -4.712525 -3.815718 -3.875378 -3.873048 -3.822219 -3.823495
```

```
-3.932297 -3.962359 -3.955437 -4.088814 -4.268712 -4.289695 -4.398994 -4.485602 -4.264599 -4.234448 -4.299606 -4.406967 -4.092137 -4.031404 -4.020839 -3.750274 -3.499536
-3.230384 -3.425503 -3.556316 -3.642721 -6.964999 -7.045085 -6.793632 -6.705370 -6.581514 -6.417055 -6.394806 -5.661074 -5.451366 -5.342769 -5.280884 -5.253524 -5.207165
# FMX(sex-based multiplier for ft)
1 0.925001
1 1
1 1
1 1.99269
1 1.99269
# init_log_rec_devs (females):
1.593029 0.8881916 0.9450568 1.074646 1.176216 1.339384 1.890281 2.337506 1.494435 1.052563 1.215801 1.293796 0.7483233
0.3074295 0.6185686 0.5827836 0.1066623 0.8227823 -1.411234 -1.510765 -1.610295 -1.709829 -1.80936 -1.908888 -2.008424
-2.107953 -2.207485 -2.307016 -0.8962065
# init_log_rec_devs (males):
 1.349134 0.678651 0.7432793 0.8673499 0.9717188 1.159698 1.68465 2.125607 1.344155 0.9419811 1.146674 1.295268 0.8127713
0.4089091 0.7391368 0.7059838 0.2194272 0.9217337 -1.331316 -1.423383 -1.515451 -1.607518 -1.699585 -1.791651 -1.883719
-1.975785 -2.067851 -2.15992 -0.6599482
# log_rec_devs:
 -0.39744428 -0.68985032 -0.72321874 -0.18832470 0.21952123 0.10200122 -0.01069562 0.26045469 0.19992632 0.32715933
0.60199112 0.04974662 0.04974662 0.04974662 0.04974662 0.04974662 0.04974662
# log_m_nodes:
 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000
 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000
 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000 0.0000000000
```

B.2 Model Description

The following detailed documentation is a description of the simulation model used to generate model output in this report. The description is broken down into three subsections: 1) simulation model input, 2) state dynamics, and 3) model outputs. A series of tables along with a detailed written description is used to document the model. The tables of equations are meant to represent the logical progression of using input data to initialize the population model, simulating dynamical responses to alternative policies and deriving model outputs.

To summarize the following subsections that describe the model in detail, the following pseudocode represents the general order of operations (implemented as specific functions within the computer code).

Pseudocode:

1. Read simulation model inputs, (biological data, fishery data and model parameters).
2. Initialize model parameters (initial age-structure, annual recruitment, etc).
3. Calculate length-based selectivities for each gear type for each sex.
4. Partition fishing mortality to each fishing sector.
5. Calculate age-specific total mortality rate for each year where the probability of capture and discard is a function of selectivity and size limits.
6. Calculate numbers-at-age each year based on annual values of Z.
7. Compute model outputs and performance measures.

The underlying model design is and age-structured population model with an annual time step. The population model has two periods: (1) a historical period in which the population model is initialized with numbers-at-age in the first year, and annual recruitments for each year up to the present, and (2) a projection period where the numbers-at-age are simulated

15 years into the future under alternative scenarios and harvest policy options. Information for the initialization of the population model is based on the most recent stock assessment for Pacific Halibut (Hare, 2012). At each time step in the model, total age/sex-specific mortality rates are computed as a sum of natural and fishing mortalities from each of the directed and non-directed fisheries.

The detailed analytical description of the simulation model that follows is arranged in a series of tables of equations that are intended to provide a concise description, as well as, provide the logical order of operations in which the code is executed. A list of parameter symbols, the units, and description is provided in Table A-1. The source code for this simulation model can also be obtained from a code.google repository at `http://code.google.com/p/iscam-project/`.

Permitted bycatch mortality in BSAI groundfish fisheries in 2012 are 900 mt for the fixed gear and 3,525 mt for the trawl gear. The accounting system for trawl by catch is that 80% of the net halibut weight landed is assumed to die, and in the case of the pollock fishery a 90% discard mortality is assumed.

B.2.1 Simulation model input

Input data for the simulation model was provided by Steve Hare from the IPHC in the form of the report file from the assessment model presented at the 2012 annual meeting (Hare, 2012). The input data for the simulation model, along with the control file and initial parameter value can be found in appendix A.1. The following list is a summary description of the model inputs that are required to run the simulation model.

List of model input:

1. Model dimensions (i.e., years, number of gears, number of age-classes).
2. Historical catch data and fishing mortality rates for 5 gear types.
3. Annual recruitment from 1996 to present.
4. Initial numbers-at-age (2-30) by sex.
5. Selectivity parameters (length-based selectivity).
6. Size limit, target harvest rate, & other policy related parameters (e.g., SUFD).

The model dimensions are consistent with the IPHC assessment model where the model starts in 1996 and is conditioned on the assessment data through 2011, the number of ages ranges from 1–30, and the fisheries are broken down into five distinct components:

1. the setline fishery (including the IPHC research catch),
2. the sublegal discards (including U32 wastage and U32 bycatch),
3. the fully recruited by catch (O32 wastage and bycatch),

4. the recreational sport fishery, and
5. and the personal use (subsistence fishery).

Each of these 'gears' have there own length-based selectivity coefficients and fishing mortality rates that are based on the most recent assessment model output. The historical catch data for each of these gears are also given in the input data, but are not used to calculate total mortality rates in anyway.

Table A-1: List of symbols, units and description of variables for the simulation model.

Symbol	Units	Description
h	-	index for sex
i	-	index for year
j	-	index for age
k	-	index for gear
l	-	index for length
Input Parameters		
R_0	millions	unfished recruitment
h	-	steepness of the stock-recruitment relationship
M_h	yr^{-1}	instantaneous natural mortality rate by sex (0.15 female, 0.135 male).
$\bar{R}$	millions	average recruitment
$\ddot{R}$	millions	initial recruitment
ω_i	-	annual recruitment deviation in year i (assume 50:50 sex ratio at age-1)
$\ddot{\omega}_{h,j}$	-	initial recruitment deviation for sex h and age j
Dynamic Variables		
$F_{h,i,k}$	yr^{-1}	Fishing mortality rate by sex h in year i, for gear k
$s_{h,l,k}$	-	log selectivity for sex h, length l for gear k
$\nu_{h,i,j,k}$	-	log selectivity for sex h, year i, age j in gear k
$Z_{h,i,j}$	yr^{-1}	Age-specific total mortality rate for sex h in year i
$N_{h,i,j}$	millions	numbers of halibut of sex h, in year i, at age j
SB_i	million pounds	Female spawning biomass in year i

B.2.2 Analytical description

Initial states (i=1996:2011)

The simulation model is initialized using the model estimates of numbers-at-age and annual recruitment produced by the IPHC 2011 halibut stock assessment (Hare, 2012). Two parameter vectors, Θ and Φ are used to categorize population parameters as sex independent and dependent, respectively. Components of these two vectors are defined in (T2.1) and (T2.2), where R_0 and h define the unfished age-1 recruits and steepness of the stock recruitment relationship. Note that these terms (R_0, h) are not of interest in this simulation model, because we do not use a stock recruitment relationship to simulate future recruitment. The average recruitment $\bar{R}$ and annual deviations ω_i are used to initialize age-1 recruits from 1996 to 2011 (T2.7), where these values were obtained from the IPHC assessment report file. The sex-specific parameters Φ consists of the initial average recruitment $\ddot{R}_h$ and cohort specific deviations $\ddot{\omega}_j$ which makes up the initial numbers at age in 1996 (T2.7). Sex-specific natural mortality M_h rates were set at 0.15 and 0.135 for females and males, respectively. The annual fishing mortality rates $f_{h,i,k}$ (on a log scale) for sex, year, and gear were taken from the IPHC assessment along with the selectivity coefficients $s_{h,l,k}$ (also on a log scale) for sex, length, and gear. Age-specific selectivities for each gear, year, and sex $(\nu_{h,i,j})$ were based on a piece-wise liner interpolation (T2.4) of the length-based selectivity coefficients $S_{h,i,k}$ and the mean length-at-age $l_{h,i,j}$ in the annual IPHC setline survey (T2.3). In (T2.4) the $l^{(0)}$ and $l^{(1)}$ terms correspond to the length intervals on either side of the current $l_{h,i,j}$ values (Note that this function is equivalent to the `approx` function implemented in the R-scripting (R Development Core Team, 2009) language). Annual sex- age-specific fishing mortality rates are based on (T2.5) for each gear k, and the total mortality is the sum of natural and fishing mortalities (T2.6).

The numbers-at-age by sex are initialized using (T2.7) and are updated using (T2.8) and (T2.9) for the plus group. Female spawning biomass each year is calculated as the product of the number of females surviving half the Z in a given year, the proportion mature-at-age, and the observed average catch weight-at-age $w_{h,i,j}$ in a given year. Prior to 2001, aging data ranged from age-6 to age-20, and post 2001 break and burn methods were used to age halibut upto age-25, where 25 is the new plus group. This calculation (T2.10) of spawning biomass differs slightly from the IPHC code, where the numbers-at-age each year are smeared by an aging error matrix, and the average weight at age from the survey was used. The predicted catch in year i for gear k is given by (T2.11), which is the sum over the catch-at-age by sex.

Joint probability model for fishing & discard mortality

For the future simulations $(i \geq 2012)$, the directed setline fishery for halibut is based on the probability of capturing a fish of age j times the probability of retaining a fish of age j. This joint probability is represented by the age-selectivity of the fishing gear (which is a length-based function) and variation in growth of male and female halibut. The age-based selectivity is based on (T2.4). The probability of retaining a fish of age j is the based on the probability of an age j fish being larger than the size limit. This integral was approximated using a logistic function of the mean length-at-age and assuming a coefficient of variation of 0.1 in length-at-age such that the standard deviation in length-at-age σ_j increases as a linear function of length:

$$p(r)_j = \frac{1}{1 + \exp(-(l_j - \text{MSL})/\sigma_j)}$$

Table A-2: Analytical description of the sex-based age-structured model used for simulation projections.

Model parameters

$$\Theta = \{R_0, h, \bar{R}, \omega_i\} \quad (T2.1)$$

$$\Phi = \{\ddot{R}_h, \ddot{\omega}_{h,j}, M_h, f_{h,i,k}, s_{h,l,k}, a_{50}, \gamma_{50}\} \quad (T2.2)$$

Input data

$$C_{i,k}, l_{h,i,j}, w_{h,i,j} \quad (T2.3)$$

Initialize state variables

$$\nu_{h,i,j} = s_{h,l}^{(0)} + \frac{(l_{h,i,j} - l^{(0)})s_{h,l}^{(1)} - (l_{h,i,j} - l^{(0)})s_{h,l}^{(0)}}{l^{(1)} - l^{(0)}}, \quad \text{where} \quad l^{(0)} \le l_{h,i,j} \le l^{(1)} \quad (T2.4)$$

$$F_{h,i,j,k} = \exp(f_{h,i,k} + \nu_{h,i,j,k}) \quad (T2.5)$$

$$Z_{h,i,j} = M_h + \sum_k F_{h,i,j,k} \quad (T2.6)$$

Numbers at age

$$N_{h,i,j} = \begin{cases} \ddot{R}_h \exp(\ddot{\omega}_{h,j} - M_h(j-1)), & \text{for } 2 < j < 30 \\ 0.5R_h \exp(\omega_i), \quad \text{for } 1996 < i < 2026 \end{cases} \quad (T2.7)$$

$$N_{h,i+1,j+1} = N_{h,i,j} \exp(-Z_{h,i,j}), \quad \text{for } 1 < j < 30 \quad (T2.8)$$

$$N_{h,i+1,j} = N_{h,i,j-1} + N_{h,i,j} \exp(-Z_{h,i,j}), \quad \text{for } j = 30 \quad (T2.9)$$

Model outputs

$$SB_i = \sum_{j=6}^{j=30} N_{h,i,j} \exp(-0.5Z_{h,i,j}) p_{h,j} w_{h,i,j}, \quad \text{where } h = 1 \quad (T2.10)$$

$$C_{i,k} = \sum_h \sum_j \frac{N_{h,i,j} w_{h,i,j} f_{h,i,k} s_{h,i,j}(1 - \exp(-Z_{h,i,j}))}{Z_{h,i,j}} \quad (T2.11)$$

$$EB_i = \sum_h \sum_{j=6}^{j=30} N_{h,i,j} w_{h,i,j} \exp(\nu_{h,i,j,k=1}) \quad (T2.12)$$

$$YBio_i = \sum_h \sum_j \frac{N_{h,i,j} w_{h,i,j} f_{h,i,k=1} s_{h,i,j,k=1} r_{h,i,j,k=1}(1 - \exp(-Z_{h,i,j}))}{Z_{h,i,j}} \quad (T2.13)$$

$$WBio_i = \sum_h \sum_j \frac{N_{h,i,j} w_{h,i,j} f_{h,i,k=1} s_{h,i,j,k=1}(1 - r_{h,i,j,k=1}) d_{k=1}(1 - \exp(-Z_{h,i,j}))}{Z_{h,i,j}} \quad (T2.14)$$

$$LBio_i = YBio_i^{(f_{k=2,3}=0)} - YBio_i \quad (T2.15)$$

$$BBio_i = \sum_h \sum_j \sum_{k=2}^{k=3} \frac{N_{h,i,j} w_{h,i,j} f_{h,i,k} s_{h,i,j,k} r_{h,i,j,k}(1 - \exp(-Z_{h,i,j}))}{Z_{h,i,j}} \quad (T2.16)$$

$$YLR_i = \frac{LBio_i}{BBio_i} \quad (T2.17)$$

The probability of discarding a fish of age j is defined as $1 - p(r)_j$. Figure B.19 shows how retention and discarding probabilities vary with age with a 32 inch size limit in place. Note that when the mean length-at-age gets smaller, this retention probability shifts to the right (older ages) and fish recruit to the fishing gear later in life.

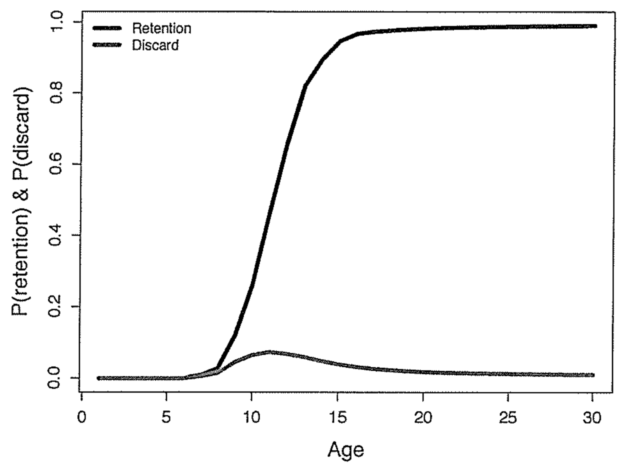


Figure B.19: Probability of retention and discarding a halibut with a 32 inch size limit in place.

In the more recent stock assessment models, the age/sex/size composition of the commercial landings are estimated externally to the model. These data were not available to be used in this analysis. For the 1996 to 2011 period, fishing mortality rates were taken from the IPHC assessment model. For the projection period ($i > 2011$), fishing mortality rates were based on the projected catches for each of the five gears (commercial, U32, O32, recreational, personal). Sex-specific fishing mortality rates were determined using a numerical procedure to solve the Baranov catch equation (T2.11). An initial guess for the sex-specific fishing rate $f_{h,i,k}$ for gear k in year i, followed by the use of Newtons' root finding method to find the appropriate values of $f_{h,i,k}$ such that the sum of the predicted female and male catches for each gear was equivalent to the catch allocated to that gear.

B.2.3 Model outputs

Simulation model outputs of interest for this study are:

1. Exploitable biomass, EBio defined by (T2.12).

2. Female spawning biomass, SBio defined by (T2.10).

3. Commercial Yield, YBio defined by (T2.13).

4. Wastage from the commercial fishery, WBio defined by (T2.14).
5. Lost yield due to bycatch from non-directed fisheries, LBio defined by (T2.15).
6. Bycatch from non-directed fisheries, BBio defined by (T2.16).
7. The yield loss ratio, YLR defined by (T2.17).

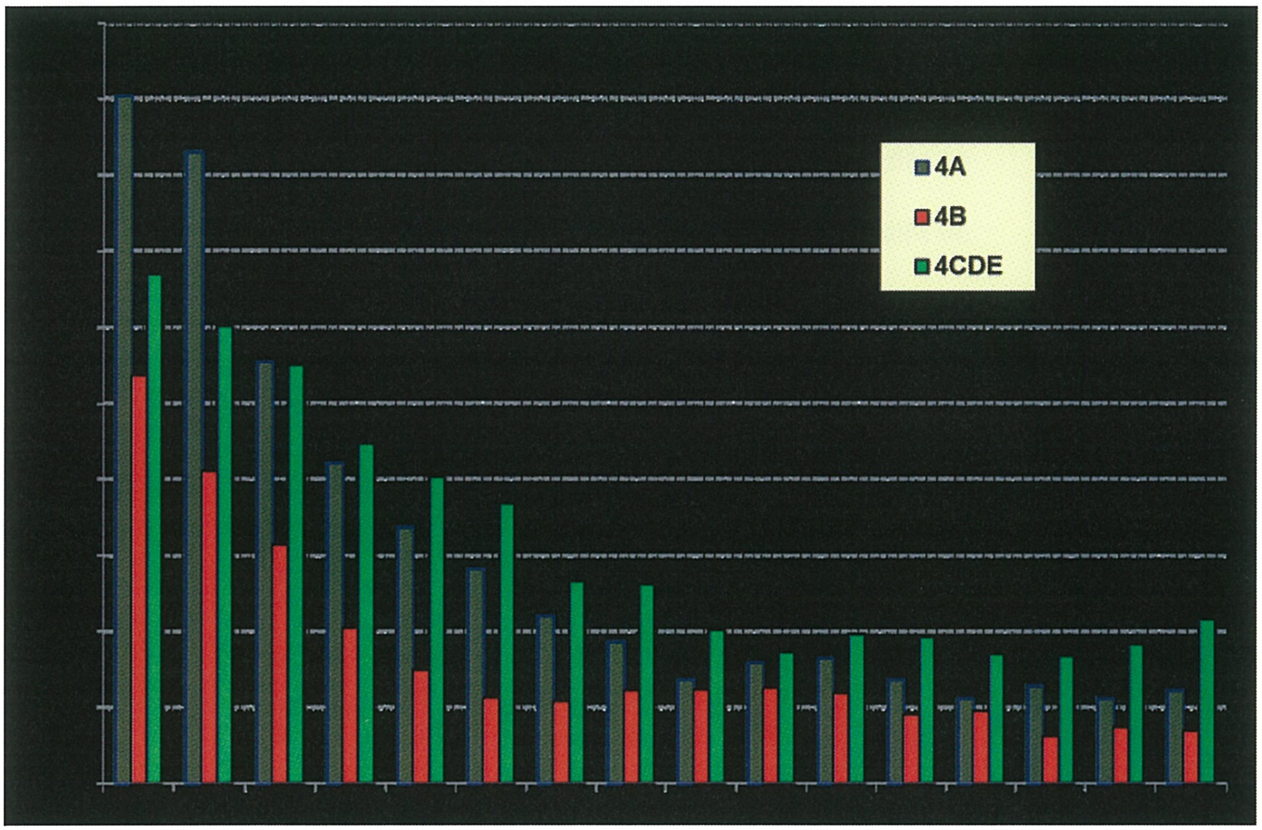
Note that in order to calculate the lost yield (T2.15), the model was run as if there were no bycatch of halibut in other fisheries, and all of the available CEY for each area was allocated to the commercial gear. The lost yield is the difference between the yield obtained with no bycatch and the yield obtained with bycatch allotments in place.

C2 Arne Fuglvog

NPFMC PUBLIC TESTIMONY

Thank you Mr. Chairman. My name is Arne Fuglvog and I am testifying on the behalf of Iquique US. Iquique owns and operates four vessels in the Amendment 80 sector.

I think generally staff did a good job of incorporating most of the suggestions the Council made to provide additional information on the status of halibut and halibut management. There are a few areas I would like to highlight and a few additional things I would like to comment on.



I appreciate staff adding all the new tables and figures to the analysis. I would like to highlight figure 3-4 on page 54. Unfortunately, ALL the figures and tables in the document that show biomass estimates are hind cast in 2015, after the model corrections, and do not show the biomass estimates from the annual stock assessment that the IPHC used to set the catch limits. It is **misleading** because it doesn't show the declines in biomass estimate that led to the lower catch limit recommendations and shows a different trend then was occurring.

For example, in figure 3-4, the annual EBio for area 4 estimates dropped by almost 50%, from 2011-2014, but the hind cast Ebio estimates show a different trend. The analysis notes the change in assessment in 2012 to correct for the retrospective bias, but it says that subsequently, estimates of stock size decreased by 30%. But the actual exploitable biomass estimates actually dropped by quite a bit more during this time. The Area 4CDE Ebio estimate went from 35 M lbs. in 2011 to 18 M lbs. in 2014. Correspondingly, the catch limits were reduced by 64% during this same time period.

I will note that the IMS model did use corrected updated biomass estimates to determine the potential benefits to the directed halibut fishery.

AREA 4CDE

YEAR	$Biomass_1$	$Biomass_2$	%Diff	Blue Line	4CDE FCEY	Intensity($F_{xx\%}$)$_4$
2002	66 Mlbs	57 Mlbs	12%	4.45 Mlbs	4.45 Mlbs	34%
2003	74 Mlbs	52 Mlb	30%	4.45 Mlbs	4.45 Mlbs	30%
2004	47 Mlbs	44 Mlbs	6%	3.39 Mlbs	3.79 Mlbs	28%
2005	34 Mlbs	30 Mlbs	11%	3.99 Mlbs	3.99 Mlbs	26%
2006	37 Mlbs	30 Mlbs	19%	3.55 Mlbs	3.55 Mlbs	26%
2007	37 Mlbs	24 Mlbs	35%	3.65 Mlbs	4.10 Mlbs	25%
2008	31 Mlbs	21 Mlbs	32%	3.89 Mlbs	3.89 Mlbs	25%
2009	34 Mlbs	22 Mlbs	35%	2.93 Mlbs	3.46 Mlbs	26%
2010	36 Mlbs	20 Mlbs	46%	3.25 Mlbs	3.58 Mlbs	27%
2011	35 Mlbs	19 Mlbs	46%	3.72 Mlbs	3.72 Mlbs	31%
2012	26 Mlbs	17 Mlbs	35%	2.47 Mlbs	2.47 Mlbs	35%
2013	20 Mlbs	18 Mlbs	9%	1.93 Mlbs	1.93 Mlbs	38%
2014	18 Mlbs	18 Mlbs	0%	.64 Mlbs	1.29 Mlbs	43%
2015	19 Mlbs	19 Mlbs	0%	.52 Mlbs	1.29 Mlbs	43%

$Biomass_1$-Expoitable Biomass estimate from annual reports (2002-2014).
$Biomass_2$–Exploitable Biomass estimate from 2014 assessment (retrospective analysis)
% Diff- the amount the annual biomass overestimated the biomass compared to the retrospective analysis.
Blue Line-the staff recommended area harvest limit
FCEY- the final harvest limit after IPHC commissioners adjust
Intensity- $F_{35}$is over fishing and $F_{40}$is equivalent to ABC

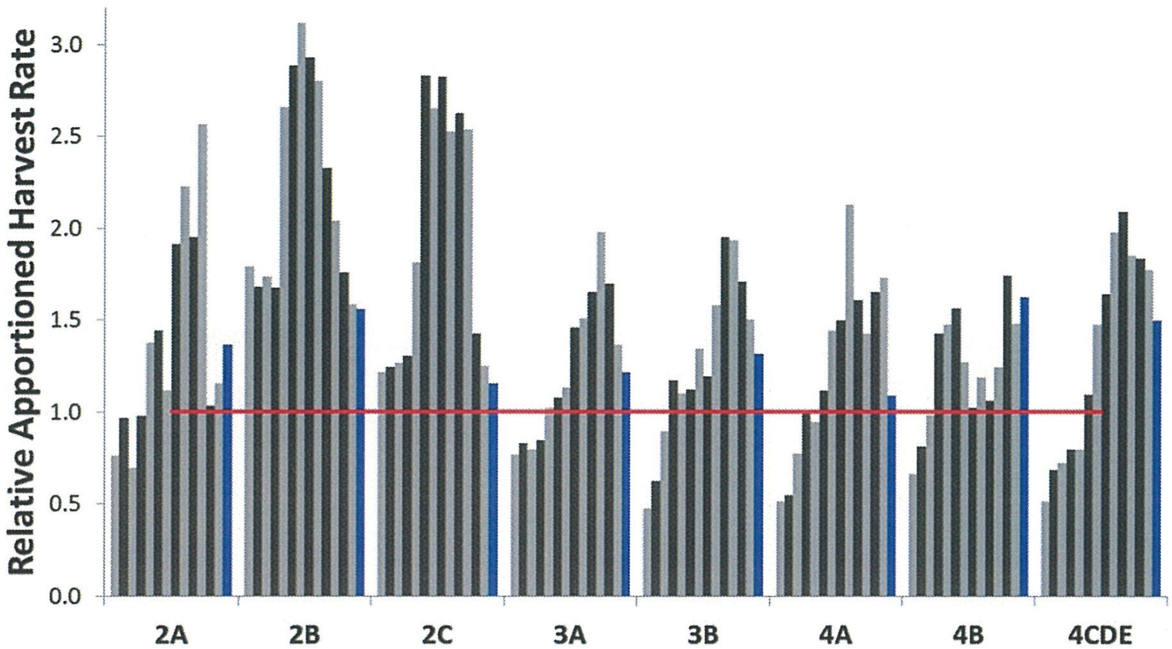
Even before the model corrections, the legal size portion of the stock was on the decline in the Bering Sea. Between 1999-2011, the Area 4C and 4D survey and fishery WPUE dropped over 70%, as did the Exploitable Biomass estimate. Interestingly, the FCEY for area 4CDE only went down 16% during this time period. It was only after the model correction in 2012 that the FCEY began to catch up with the biomass, survey and fishery catch rate declines.

I also want to highlight Table 3-1 on page 53 which shows the magnitude of coastwise realized harvest rates, which were up to 60% above target levels in some years. As the table shows, the coastwise exploitation rates were above 40% for 13 straight years and above 35% for 10.

Year	Spawning biomass	Fishing intensity (*FXX%*)	Exploitable biomass
1996	584.6	49%	779.2
1997	605.7	43%	809.6
1998	591.8	42%	762.7
1999	567.1	40%	746.8
2000	529.5	40%	688.3
2001	483.9	38%	603.0
2002	434.5	34%	532.2
2003	382.6	30%	460.5
2004	339.5	28%	403.6
2005	299.5	26%	352.6
2006	266.7	26%	307.9
2007	241.5	25%	266.9
2008	224.4	25%	236.3
2009	204.6	26%	203.9
2010	197.8	27%	186.4
2011	195.3	31%	175.6
2012	197.2	35%	169.2
2013	203.9	38%	168.8
2014	208.5	43%	169.7
2015	215.1	NA	180.6

Table 1. Median population (Mlb) and fishing intensity estimates (based on median Spawning Potential Ratio) (From the 2015 IPHC Annual Meeting handout)

This is also well illustrated on page 61 in figure 3-10. You can see that for area 4CDE, the realized harvest rates were substantially higher than target for a decade, sometimes double.



Migration/tag studies

I would like to briefly discuss section 3.1.1.2 Distribution and Migration on pages 56 and 57 of the analysis and Table ES-4 in the executive summary.

I have noticed that many of the written comments have repeated the statement from the analysis that 70-90 percent of juvenile halibut tagged in the BSAI end up in the Gulf of Alaska. Unfortunately, not many of the comments have focused on the qualifying statement,

"At present, it is not possible to correct for the spatial distribution of fishing effort in these data, which may lead to an overestimate of movement to areas like the Gulf of Alaska, with more fishing activity and therefore a higher rate of tag recoveries".

If you read the IPHC paper that reviewed the historical tagging data, you will find another statement that clarifies use of the tagging data,

"We conclude that a combination of low recovery rates from the most representative releases, unrepresentativeness of releases with higher recovery rates, and the lack of consistent simultaneous tagging programs in the Gulf likely preclude the estimations of reliable, unbiased

migration rates from the Bering Sea into the Gulf of Alaska from these data". Webster. 2014. Trawl Tag releases of small halibut in the Bering Sea

I believe it is safe to say that there is a general eastward migration of halibut. Beyond that, I think it is very difficult to say much more including the two charts in figure 3-8. The first is 17 tag recoveries and the second is 8. It seems very difficult to draw any definitive conclusions about migration rates from the Bering Sea into other areas.

I appreciate that the SSC requested that the Analysis look at downstream effects of U26 halibut bycatch mortality. And I appreciate the work that Markus and the IPHC did to put Table ES-4 together and review it. It provides an estimate of U26 PSC savings from BSAI halibut bycatch. We have heard a lot of testimony about the downstream effects and I think it is important to quantify them and put those into perspective.

Table ES-4 Comparison of Halibut Fishery Yield Impacts from U26 PSC Savings in the BSAI, in Areas External to the BSAI (Gulf of Alaska, British Columbia, Pacific Coast)

	From Option 1 A80-CPs		From Option 2 BSAI TLA		From Option 3 LGL-CPs		Option 6 CDQ Fisheries	
PSC Limit Cut Percent	Annual Average Harvest from U26 Savings from 2019 to 2023 (1,000's n.w. lb)	10-Year Sum of Future Discounted Present Value of Wholesale Revenue (2013 $millions)	Annual Average Harvest from U26 Savings from 2019 to 2023 (1,000's n.w. lb)	10-Year Sum of Future Discounted Present Value of Wholesale Revenue (2013 $millions)	Annual Average Harvest from U26 Savings from 2019 to 2023 (1,000's n.w. lb)	10-Year Sum of Future Discounted Present Value of Wholesale Revenue (2013 $millions)	Annual Average Harvest from U26 Savings from 2019 to 2023 (1,000's n.w. lb)	10-Year Sum of Future Discounted Present Value of Wholesale Revenue (2013 $millions)
-10%	8 to 12	$0.34 to $0.50	4 to 5	$0.13 to $0.18	These suboptions are not expected to produce material impacts		These suboptions are not expected to produce material impacts	
-20%	38 to 43	$1.60 to $1.79	7 to 11	$0.30 to $0.44				
-30%	83 to 86	$3.48 to $3.64	12 to 19	$0.52 to $0.82	2 to 5	$0.10 to $0.18		
-35%	106 to 112	$4.47 to $4.72	16 to 26	$0.64 to $1.09	5 to 7	$0.23 to $0.33	0 to 0	$0.02 to $0.01
-40%	129 to 133	$5.44 to $5.59	19 to 32	$0.81 to $1.37	10 to 13	$0.42 to $0.56	1 to 2	$0.07 to $0.07
-45%	153 to 156	$6.44 to $6.54	24 to 42	$0.99 to $1.75	17 to 20	$0.70 to $0.84	4 to 4	$0.17 to $0.16
-50%	176 to 179	$7.38 to $7.53	29 to 50	$1.21 to $2.11	23 to 26	$0.98 to $1.09	6 to 6	$0.27 to $0.26

Note: The first yield increases from U26 PSC Savings that accrue as a result of PSC limit reductions are not realized until 2019. For this reason average annual harvests are estimated over the last five years only. Also note that when numbers are shown as a range, they represent estimates from two Scenarios—Scenario A is a relatively "low impact" scenario and Scenario B is a relatively "high impact" scenario.

%Reduction	Coastwise lbs.	annual revenue	# fishermen	lbs. per fishermen
20%	54,000	$223,000	2400	22 lbs
30%	110,000	$464,000	2400	44 lbs
40%	180,000	$759,000	2400	73 lbs
50%	261,000	$1,099,000	2400	107 lbs

%Reduction	2C lbs.	Annual revenue	#fishermen	lbs. per fishermen
20%	8100	$33,450	1003	8 lbs
30%	16,500	$69,600	1003	16 lbs
40%	27,000	$113,850	1003	27 lbs
50%	39,150	$164,850	1003	39 lbs

So, starting in 2019, the first year that benefits would accrue, we can calculate that at the extreme end of the range of options- (a 50% reduction)the **maximum** benefit that the other IPHC areas would get (not including Area 4) would be 261,000 net lbs which is less than 1% of the 2013 coastwide FCEY, this would generate approximately $1.1 million in wholesale revenues annually to the coastwise halibut fishery. At a 20% reduction in halibut PSC mortality limit, the other IPHC areas would see 54,000 net lbs which is less than .2% of the 2013 coastwide FCEY, with wholesale revenues of approximately $220,000.00. And incidentally, would equal

If we calculate the benefit to area 2C (which has 15% of the coastwise biomass) a 50% reduction would yield 39,000 lbs and a 20% reduction in BSAI halibut PSC mortality would yield 8100 lbs. worth approximately $33,000. Yes, 8100 lbs a year. If you were to divide that equally for every halibut IFQ holder in area 2C, you would provide each of the 1003 IFQ holders 8 lbs a year worth $32 dollars.

These numbers are the downstream impacts of a reduction in U26 bycatch in the Bering Sea and Aleutian Islands. We have heard repeated testimony that halibut bycatch in the Bering Sea is causing dramatic impacts to the other IPHC areas. I am not sure what data people are using to make this statement and I don't know how you could draw that conclusion from the Council document.

O32/U32 to O26/U26 IPHC POLICY CHANGE

I want to briefly mention another issue that was not in the analysis, but is having a substantial impact on the catch limits in 4CDE. Treatment of bycatch mortality in IPHC management has changed over time. I don't to go into detail about all the changes, but I want to highlight the most resent modification. Beginning in 1997, setline yield was reduced for every pound of O32 bycatch and wastage, but not for U32 bycatch and wastage, which were factored into the optimum harvest rate calculation.

In 2009, the IPHC was getting pushed to change their existing method to an O26/U26 policy in which halibut bycatch mortality over 26 inches would directly come out of the TCEY in the area the bycatch occurred, while U26 would be factored into the optimum harvest rate as U32 currently was.

In the 2010 RARA IPHC staff wrote, *"For nearly 15 years, bycatch and wastage removals of halibut under 32 inches in size have not been deducted from TCEY, but rather were accounted for in determining a target harvest rate. While staff felt this methodology was appropriate and sufficiently precautionary, there has been increasing dissatisfaction among some constituency with such accounting."*

There was also a brief discussion at the IPHC 2009 Bycatch Workshop on the potential impacts to directed halibut yields by changing this policy and deducting O26 bycatch directly from the CEY calculation. IPHC staff commented *that "the result would be that wastage and 1-2M pounds of bycatch would be moved to the CEY calculation. This could have major effects on directed halibut yield in some regulatory areas."*

In spite of these concerns and knowing the potential impacts on some regulatory areas, the IPHC adopting a new policy to include halibut U32/O26 in the other removals category which would be deducted from the Total CEY in the area where the mortality occurred. In order to potentially mitigate the impacts they also increased target harvest rates from 20 to 21.5% in all of area 2 and Area 3A and from 15 to 16.125% in Area 3B, and all of Area 4.

The immediate result of the new policy was a deduction of an additional 400,000 pounds out of the area 4CDE TCEY in 2010. While the IPHC staff anticipated that the increased deduction for bycatch mortality would be offset by the increase in target harvest rates that was not the result. The impact of this policy change has been much more pronounced as the biomass estimates have been reduced. With the biomass estimate now half of what it was when the policy was adopted, the impacts of deducting O26 bycatch from the area TCEY is much greater.

The reason this is important is that the impacts of this policy change have significantly contributed to the low TCEY in area 4CDE. This was not unforeseen or unanticipated and when you combine the effect of this decision with all the effects of IPHC management on the exploitable biomass, and the reduced size at age, where fish that used to recruit to the directed fishery at age 12 are not reaching legal size until age 12 or 13, and you get a perfect storm that is the primary reason that the 4CDE catch limits are so low.

HALIBUT TOTAL ABUNDANCE and NMFS TRAWL SURVEY

We have had lots of testimony questioning the utility of the trawl survey as an abundance of halibut. Rather than give you my opinion, I will just give you the opinion of the Halibut Commission. The IPHC concluded, after comparing BS setline survey station data to trawl survey data that the trawl survey provided an adequate accounting of halibut biomass in the Bering Sea (Clark and Hare 2007). The Bering Sea trawl survey is also used to construct an density index for the IPHC stock assessment. The absence of setline surveys data for much of the BS requires the IPHC to use other data to determine exploitable biomass estimates and they do that to construct a WPUE density index for O32 fish.

We also heard that using the NMFS trawl survey to reference biomass was a head fake and that 1 and 2 year old fish are not a good indicator of halibut biomass. The NMFS trawl survey doesn't even detect 1 and 2 year old fish. Eight year old fish make up the largest contributors of the age sample and the trawl survey and the majority of halibut in the survey are between the ages of 5 and 10.

RECRUITMENT

We have also heard about the missing 2004-2006 year classes. I disagree that they are missing. If you look at Figure 3 from my testimony, you will see that the 2004 and 5 year classes are what are making up the majority of the trawl survey total biomass. The total biomass is the highest ever in the last 5 years. Those fish are the 2004 and 2005 year classes which are now 9 and 10 years old. The problem is that they are not of legal size. If you look at the trawl survey results you will see that the 2004 and 2005 year classes are still sublegal. They are somewhere between 70 and 80 cm (80 is legal size) but halibut are growing so slowly, that instead of reaching legal size at age 8 or 9, like they were twenty years ago, they are now reaching legal size at about age 12. So, the 2004 and 2005 year classes will not be legal size until 2016 or 2017. These year classes track through the Gulf of Alaska as well in the setline survey and NMFS GOA trawl survey where they make up the largest contributors.

CONCLUSION

Perspective- it is an incredibly useful word right now. We have to put this issue into perspective. I realize that we have some deeply held beliefs and those are not going to change with data, but we need to take a look at the data.

- Last year halibut bycatch mortality was 1 million fish. That is a lot of halibut. But the NMFS trawl survey estimated the abundance at 63 million halibut. That is 1.5%.
- Halibut bycatch was a little over 5 million pounds, half of what it was in 1992. But the NMFS trawl surveys for the BS and AI showed total abundance of over 400 million lbs. That is 1.2%
- Halibut bycatch rates of .62 for the A80 fleet. That is half of what it was two decades ago and means that 99.4% of the catch is groundfish. That is certainly very close to the edge of practicability.

You have a very difficult task in front of you. I liken it to a finish carpenter who needs a ball peen hammer to do a job but the only thing he is given is a sledge hammer. That is unfortunate.

Thank you.

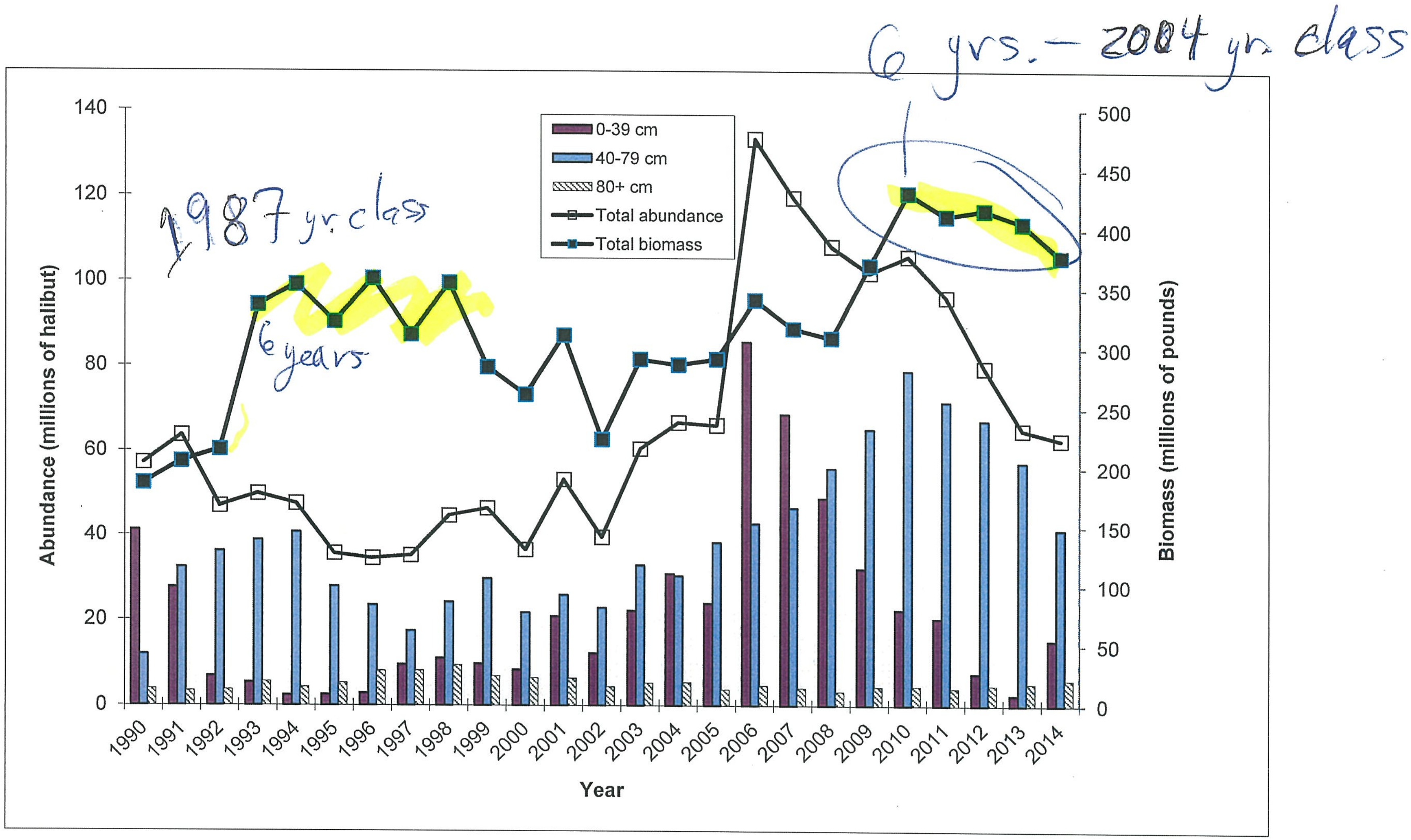


Figure 3. Estimated abundance of Pacific halibut by length category and total biomass as estimated by the NMFS Bering Sea trawl survey from 1990-2014, using swept-area estimates.

Table 1. Pacific halibut length (cm) and age (years) composition information from sampled fish for the 2013 NMFS Bering Sea trawl survey standard grid.

Age	Mean fork length (cm)	Std. dev. of fork length	Fish aged	Year class
2	n/a	-	0	2011
3	30.1	2.70	29	2010
4	41.9	3.58	59	2009
5	49.4	4.12	198	2008
6	52.8	4.08	52	2007
7	57.2	5.45	136	2006
8	61.2	6.95	217	2005
9	66.4	8.05	135	2004
10	70.2	7.95	107	2003
11	76.5	9.55	36	2002
12	81.1	12.68	14	2001
13	80.0	11.31	2	2000
14	n/a	-	0	1999
15+	96.5	13.16	13	1998 & earlier
Average	**58.8**	**12.80**	**998**	

C-2: BSAI PSC Limits

NPFMC, June 2015

BSAI CP H&L sector began voluntary efforts to reduce halibut bycatch beginning in 1992.

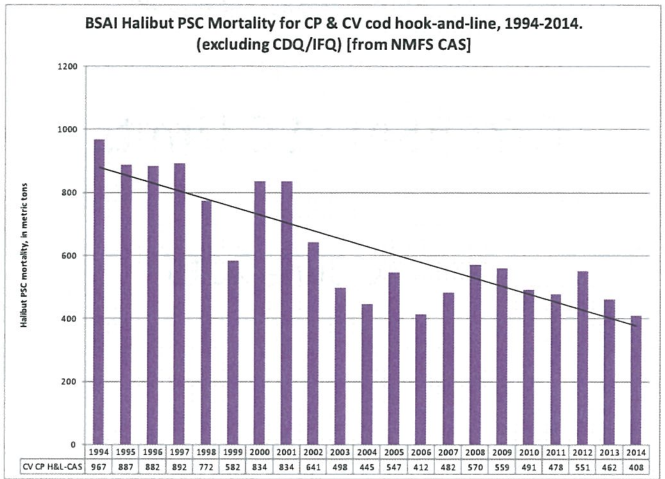
From 1994 to 2014:

- Halibut mortality has been reduced **-58%.**
- Discard mortality rate has been reduced **-47%**
- Encounter rate has been reduced **– 41%**

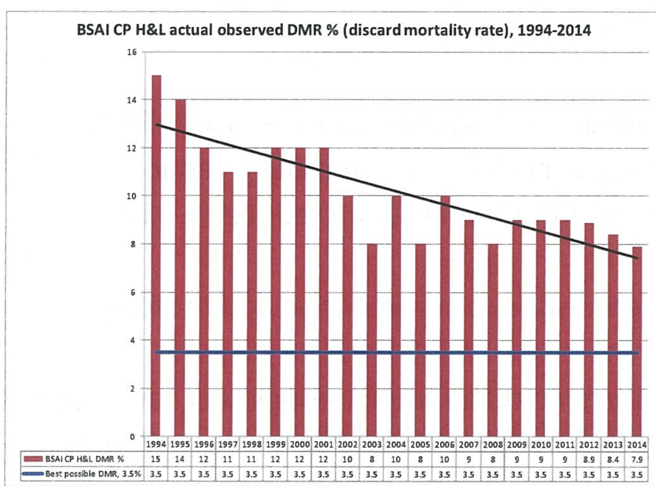
The analysis is comprehensive and thorough.

Supports what the freezer-longliners have been doing for halibut bycatch reduction has been working.

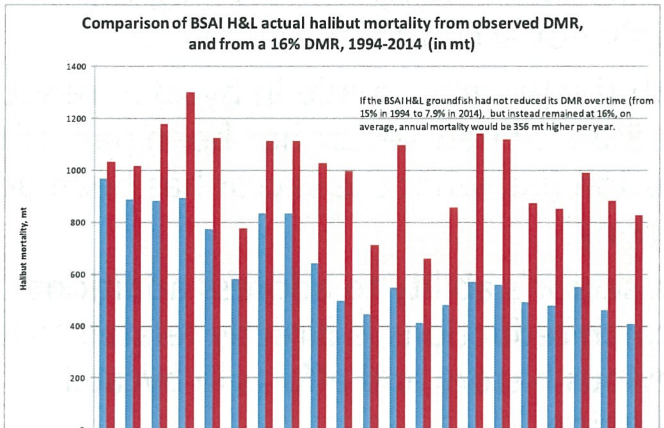
The groundfish H&L sector has reduced BSAI halibut mortality by -58% from 1994 to 2014.



The actual) DMR (discard mortality rate) has been reduced -47% (1994 to 2014) from 15% to 7.9%.



If the CP H&L sector had not reduced its DMR over time, average annual mortality would be +356 mt higher per year (or about twice the mortality in recent years)

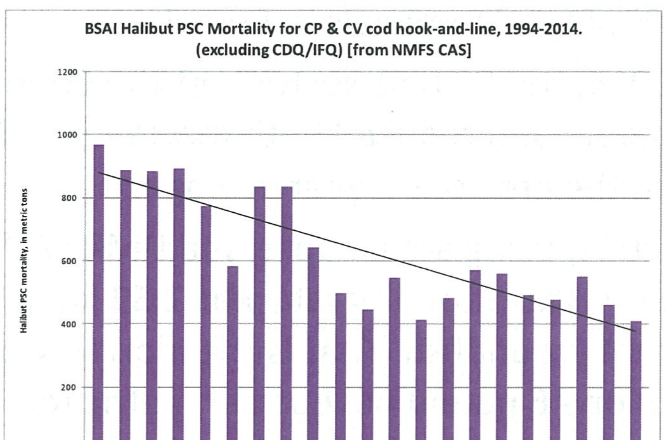


	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CV CP H&L-CAS	967	887	882	892	772	582	834	834	641	498	445	547	412	482	570	559	491	478	551	462	408
IPHC 16% DMR	1031	1014	1176	1297	1123	776	1112	1112	1026	996	712	1094	659	857	1140	1118	873	850	991	880	826

- In 2014, the CP H&L sector accounted for **11%** of BSAI total halibut bycatch mortality and **6.5%** of total removals in Area 4.
- In 2014, the CP H&L sector met the Council mandate and reduced both mortality and rate from the previous 5 year average.
- In 2014, using actual observed DMR (**7.9%**), the CP H&L mortality rate was **2.53 kg** halibut per mt groundfish. That is the mortality of less than one 6 pound halibut per metric ton of groundfish (2204 lbs)

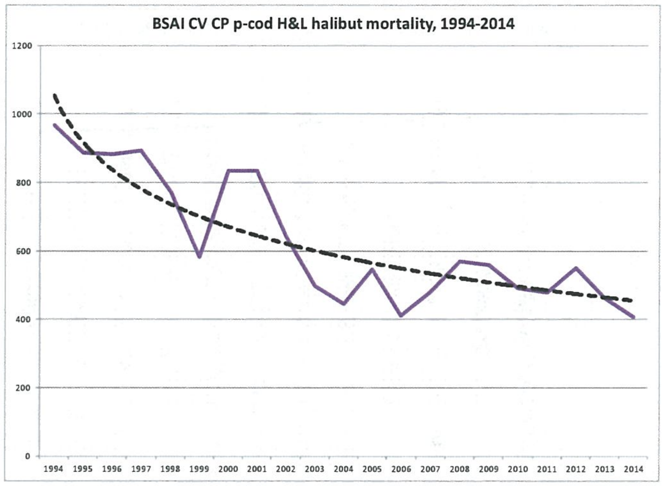
- The assumption that bycatch reductions can only be achieved by constraining cap levels is simply not accurate for this sector.
- With the progress made in bycatch reduction, the BSAI CP H&L sector has been part of the solution (i.e. what the sector has been doing is working).
- The sector's ability to address additional bycatch reductions is directly related to its previous history and efforts in bycatch reduction.

1994-2014 with linear trend

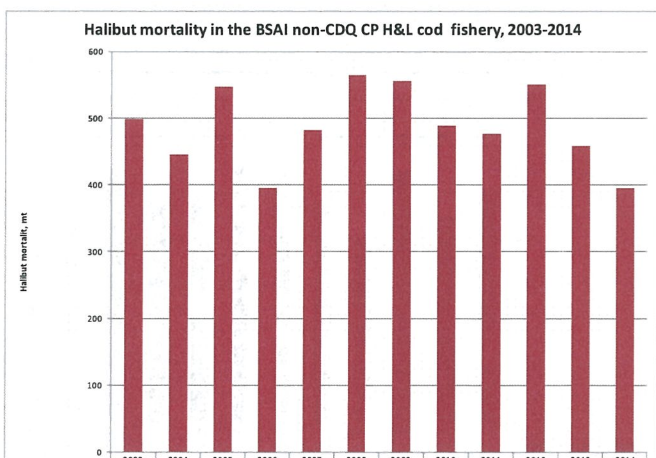


	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CV CP H&L-CAS	967	887	882	892	772	582	834	834	641	498	445	547	412	482	570	559	491	478	551	462	408

Reductions in bycatch are not linear: Initial efforts will result in larger reductions but additional incremental reductions will be of smaller magnitude (and at higher costs)

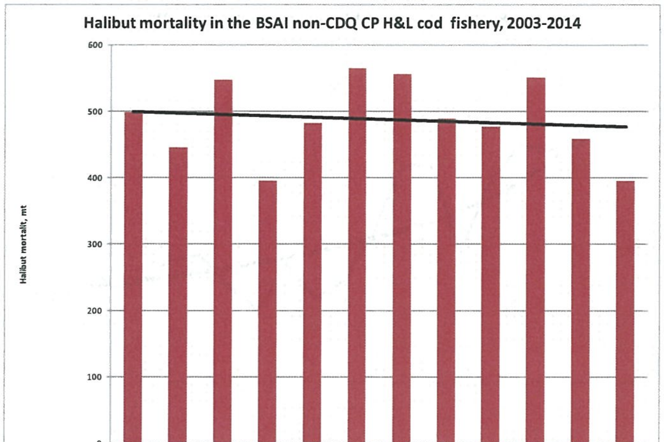


CP H&L mortality 2003-2014: The sector's ability to address additional reductions is directly linked to previous reduction efforts (where you are on the curve).



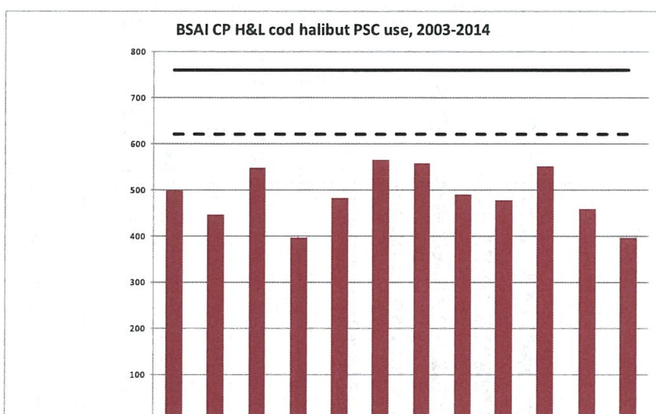
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CP H&L cod mortality	498	445	547	395	482	564	556	489	477	550	458	395

Variability in 2003-2014 PSC use (from changes in A/B apportionment; coop formation; p-cod TACs, halibut biomass distribution). Downward trend is flattening out.



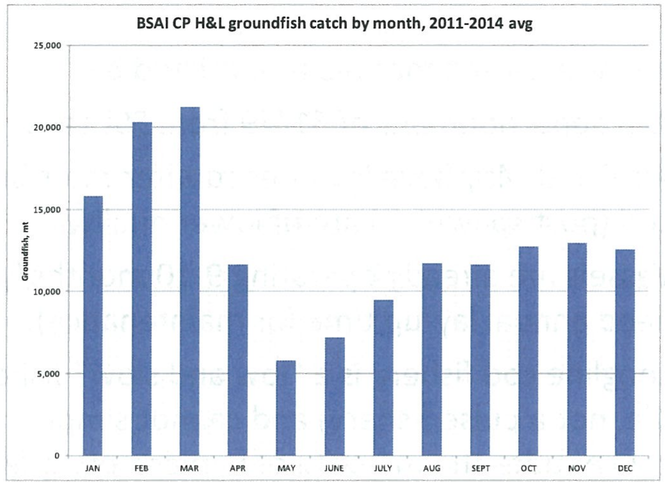
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CP H&L cod mortality	498	445	547	395	482	564	556	489	477	550	458	395

CP H&L PSC mortality use in 2003-2014 with current cap (and 10% buffer)

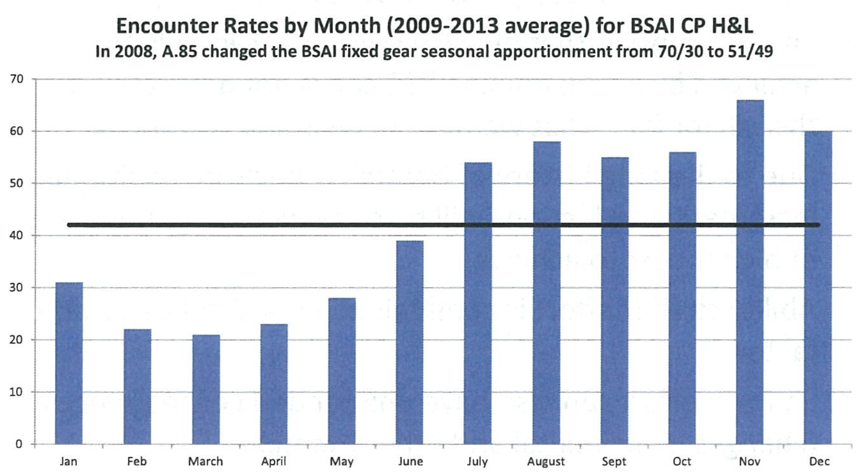


	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CP H&L cod mortality	498	445	547	395	482	564	556	489	477	550	458	395
Current cap	760	760	760	760	760	760	760	760	760	760	760	760
10% buffer from high use	620	620	620	620	620	620	620	620	620	620	620	620

The CP H&L sector fishes late into the B season and must maintain a PSC buffer well into Dec. (i.e. imperfect knowledge). Revised caps could be constraining at 90% of cap level.



Ability to shift effort to other months is limited by SSL A/B split and other factors (i.e. cod quality, low and slow nature of the fishery)



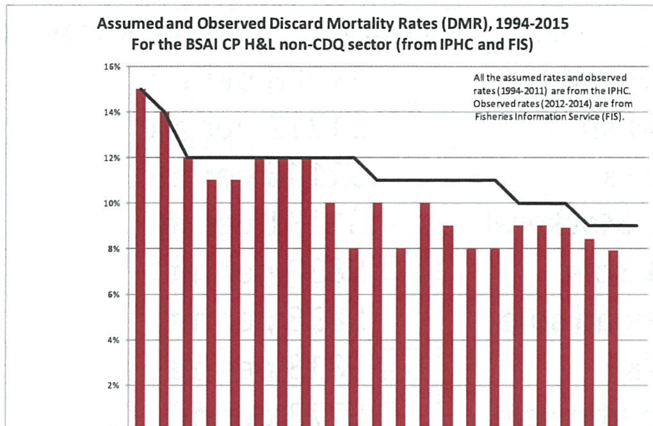
Scenario A and B assume that effort can be shifted into months and areas with lower encounter rates.

Movement between months is restricted by:

- A/B apportionment of 51/49 from SSL regs
- April and May have lower encounter rates but p-cod (post spawning) are of lower quality.
- Vessels are already operating 9-10 months/yr (and need annual lay-up time for maintenance).
- Longline cod fishery is a "low and slow" fishery; (i.e. not a pulse fishery) and cannot simply concentrate the majority of harvest into a few months or a few discrete areas.

- **SUMMARY**
- Sector has continually improved performance (and did not operate to merely stay below the cap level).
- The assumption that bycatch reduction can only be achieved by a constraining PSC cap is not accurate for this sector (i.e. what we have been doing is working).
- Due to the long history of bycatch reduction, additional incremental reductions will be of smaller magnitude and of higher cost to achieve.
- Ability to shift effort is constrained by A/B split and other factors.
- Shifts in effort can also have unintended consequences (changes in incidental and other bycatch)

CP H&L sector is the only sector whose actual DMR has always been below the assumed DMR. (p. 70)



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
Actual observed rate	15%	14%	12%	11%	11%	12%	12%	12%	10%	8%	10%	8%	10%	9%	8%	8%	9%	9%	8.9%	8.4%	7.9%	
Assumed rate	15%	14%	12%	12%	12%	12%	12%	12%	12%	12%	11%	11%	11%	11%	11%	11%	10%	10%	10%	9%	9%	9%

DMR revisions: IPHC re-evaluating discard mortality rates for all H&L fisheries

- This could have a large impact on the estimation of bycatch in the H&L groundfish fisheries
- *"Even a small change in the percentage mortality associated with a category has the potential to make a big change in the estimated total PSC mortality attributed to this sector."* p. 70-71
- This revision could also have a large impact on the calculation of wastage in the directed halibut fishery.

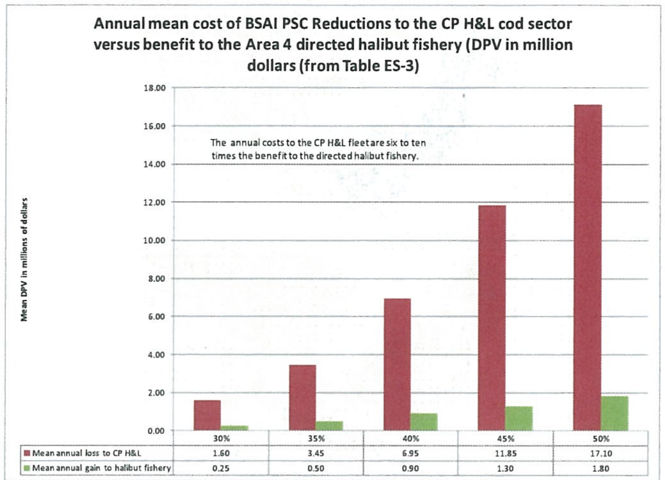
Longline p-cod has the highest wholesale value per mt of groundfish of all BSAI targets (2007-2013 avg, p. 129)

- Longline cod **$3560 per mt (2.72 X trawl cod)**
- Trawl cod $1308 per mt
- Rockfish $1212 per mt
- Pollock $1146 per mt
- Atka Mackerel $1131 per mt
- Rock sole $839 per mt
- Flathead sole $838 per mt
- ATF/KF $813 per mt
- Yellowfin sole $773 per mt

Wholesale value per mt halibut PSC

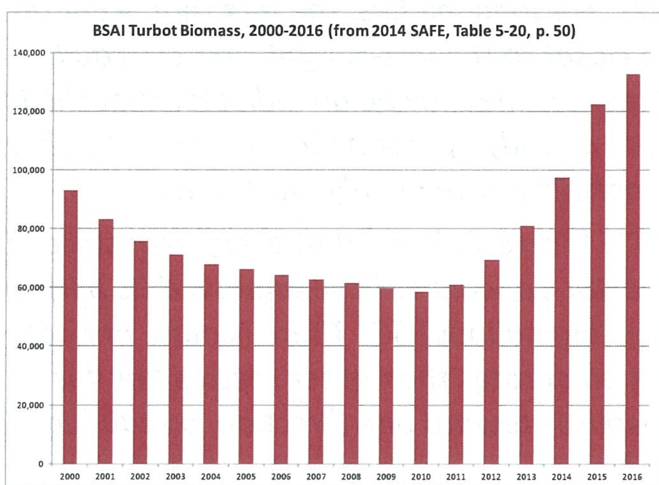
- Pollock $4,170 K - 5,050 K per mt
- Atka Mackerel $820 K per mt
- H&L turbot $400 K per mt
- **H&L cod** **$316 K – 460 per mt**
- Trawl cod $250 per mt
- Yellowfin sole $150 – 160 per mt
- ATF/KF $90 K per mt

Cost to benefit ratios range from 6:1 to 10:1

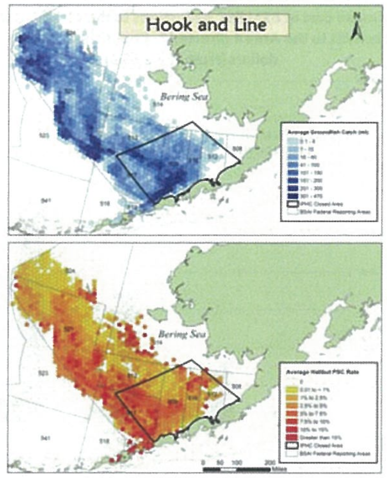


	30%	35%	40%	45%	50%
Mean annual loss to CP H&L	1.60	3.45	6.95	11.85	17.10
Mean annual gain to halibut fishery	0.25	0.50	0.90	1.30	1.80

BSAI Turbot biomass, 2000-2016



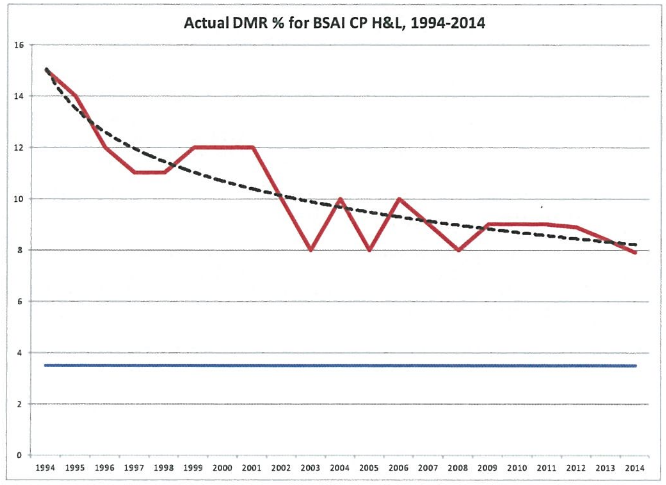
Longline is the most spatially dispersed fishery in the BSAI; there are limitations on the ability to shift effort. FLC will continue to work with Sea-State and FIS to identify "hot spots" by rate (kg halibut per mt groundfish).



C-2 BSAI PSC Analysis

- *(p. 27) "For longline CPs, the fact that Scenario A and B are closer to the last-caught-first-cut catch progression line may be an indicator that the longline CPs are already operating in a manner that keeps PSC mortality at relatively low levels."*
- *(p. 441) "Table 7 shows that every year since 2008, this sector appears to have improved its performance in avoiding halibut PSC...There is more annual variation of rates than other sectors but it is consistently toward one direction, a reduction in rates."*

Again, the trend is not linear and further reductions in DMR will be of smaller magnitude and more difficult to achieve (as the DMR moves increasingly closer to 3.5% - perfect score)



C2 Chad See

Freezer Longline Coalition

Appendix: FLC Halibut Bycatch Monitoring and Reduction Program

Reducing halibut mortality has been a priority in the CP H&L fleet for over twenty years and has become institutionalized as a standard operating procedure in vessel management in the fleet. The monitoring and reporting program has been highly successful in motivating vessels to take pro-active action to reduce halibut encounter rates and discard mortality rates (DMRs).

From 1994-2014, halibut mortality has been reduced -58%, the DMR rate has been reduced -47%, and the encounter rate has been reduced -41%. In short, what the FLC and CP H&L fleet has been doing to reduce halibut bycatch mortality, has been working.

While information about methodologies for bycatch reduction have been formally and informally exchanged within the fleet, at the individual boat level the captains and managers use various combinations of approaches. The variety in approaches is due to factors such as the unique configuration of each vessel and each company's fishing strategy. Examples of the factors regarding encounter rate include: area fished, soak time, hook-spacing, length of set, depth, and night or day setting. Examples of the factors regarding DMR include: avoidance of sand flea areas, soak time, and employment of various careful release in hook removal techniques.

The BSAI freezer-longline sector began efforts in 1992 to monitor and reduce halibut bycatch. At the individual boat level, managers were informed of recent-past and current halibut encounter rates and their boat(s)' relative standing as far as bycatch rates. A significant component is that vessel performance within the fleet is not anonymous.

Also in 1992, Fisheries Information Services (FIS) developed a detailed spatial and seasonal analysis of longline halibut bycatch (funded by a Saltonstall-Kennedy grant and based on observer data). This report was made available to the fleet and has been updated and revised in 2007 and 2015.

Chronology

1991: Implementation of halibut PSC limits for BSAI groundfish trawl, longline, and pot fisheries.

1992: NPLA (North Pacific Longline Association) contracts with FIS (Fisheries Information Service) to monitor halibut encounter rates and discard mortality rates for the CP H&L fleet in the BSAI and GOA. Initially, the vessels faxed the observer deck sheets (with encounter rates) to FIS. In order to obtain observed DMRs, FIS had to file FOIA (Freedom of Information Act) requests for raw data sheets.

1993: CP H&L sector voluntarily implements "careful release program" designed to improve handling practices of halibut and reduce discard mortality (see poster).

1994: Weekly reports are expanded to include individual vessel encounter and DMR information by set (by then available as part of downloadable observer database).

1995: NMFS begins posting vessel specific PSC rates for all observed vessels. FIS begins providing weekly rate estimates compiled from observer data and NMFS reports.

1998: Weekly seabird report initiated; summary includes takes by boat (coded) and rank. In 2011, report changed to takes by boat name and rank.

2010: FLC voluntary coop established. FLC membership agreement includes specific language on the management of PSC catch by members, including stiff penalties for exceeding limits on PSC catch established by the cooperative. Membership agreement specifically states that the forfeiture amount for each metric ton or part thereof by which a Member's halibut PSC harvest exceeds such Member's corresponding BSAI halibut PSC share shall be an amount calculated by multiplying the then-current P-cod Base Value by 100. For some perspective, the forfeiture amount for a Member exceeding their P-cod share is only three times (vs. 100) the P-cod Base Value.

2010: FLC quota manager hired to monitor harvest rates of P-cod and PSC allocations to freezer longline sector. FLC begins practice of holding back from members 50 mt of halibut PSC allocated by NMFS to sector in Fall each year to help conserve resource. Halibut only released to members at end of year if needed.

2010: FLC contracts with Sea-State, which provide access to regularly updated catch data produced on targeted and bycatch species, including halibut.

2010: FLC vessels become voluntarily 100% observed in both the GOA and BSAI. Members were required to accept observer coverage on their vessels as a component of membership in the FLCC.

2011: FLC begins hosting an annual informational symposium for officers and crew on fishery management actions at Council and other developments impacting their operations including reports on halibut DMR from FIS. FLC members train all crew on careful release practices for handling PSC species to enable them to return to the sea minimally affected by their encounter with our boats.

2012: FLC observer coverage modified to be 100% plus the addition of flow scales (or two observers). All but one vessel installed flow scales (and that vessel carries two observers).

2014: FLC establishes an internal Halibut Bycatch Committee. Committee is the most active FLC committee, with seven meetings in the past year. Committee members also correspond regularly by email and phone to review bycatch reduction efforts by fleet and consider additional FLC actions.

Individual FIS reports:

- Fleet: Weekly BSAI report to the fleet on cod catch and halibut bycatch with vessels ranked by encounter rate (not anonymous, see attached).
- Fleet: Weekly GOA report (as above).
- Fleet: Weekly seabird report (not anonymous).
- Fleet: Weekly (and year-to-date) actual observed aggregated DMR for the fleet: by BSAI, GOA, CDQ, and target.
- Company: Weekly report of individual vessel by sampled set of halibut release condition for each set. FIS determines if any high rates are anomalies, data issues, or represents a trend. Companies are alerted if a trend is developing that needs to be corrected.

Weekly FIS report to fleet on BSAI cod catch and halibut bycatch

Fisheries Information Services

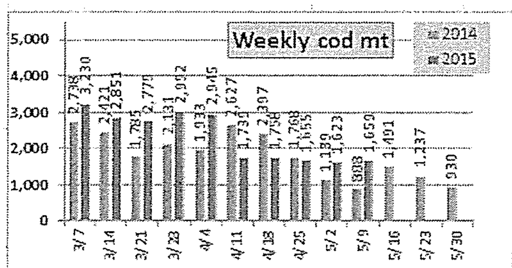
Phone 541-602-1609 E-mail Janet.Smoker10@gmail.com

To: PARTICIPANT, FLC MONITORING PROGRAM
Fm: Janet Smoker, *FIS*
DATE: May 15, 2015

Note: Below is total mortality

BSAI Halibut seas. cap: cumul. catch as of 5/15.
H&L CPs: 105 mt of 455 mt cap (2014 comp. 159 mt)
H&L CVs: 1.4 mt of 10 mt cap (2014 comp. 4.7 mt)

Graphs below are for H&L CP cod (not incl. CDQ).



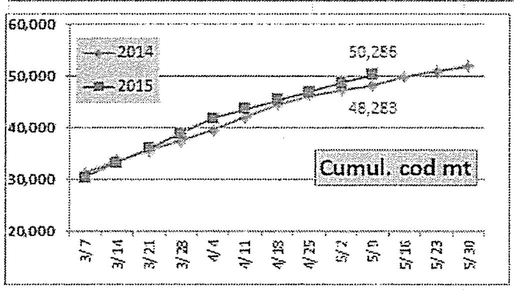


Table below shows H&L, week 5/09. Incl. CDQ.
C= confidential. Numbers in red are my estimates.

FA	SECT	GF mt	HLBT kg	RATE	HMORT
513	CP	842	27,156	32	2.4
517	CP	C	3,057	32	0.3
518	CP	C	581	50	0.1
519	CP	C	285	31	0.0
521	CP	1,334	12,428	9	1.1
BSAI	CP	2,293	43,507	19	3.9

Note: Above is encounter rate & total mortality by NMFS area.

Please do not distribute outside FLC participants

Halibut rates on H&L boats; Cod target
Week ending 5/09. Includes CDQ.

BOAT	RATE	RANK
BRISTOL LEADER	0.5	1
NORTHERN LEADER	2.2	2
ALASKAN LEADER	5.1	3
BLUE PACIFIC	6.7	4
PROWLER	10.2	5
BEAUTY BAY	14.1	6
DEEP PACIFIC	20.3	7
COURAGEOUS	22.8	8
BERING PROWLER	22.9	9
ALASKAN LADY	24.7	10
U S LIBERATOR	24.9	11
BLUE ATTU	28.8	12
BLUE BALLARD	35.5	13
SIBERIAN SEA	50.5	14

Note: Above is encounter rate (kg/MT) by vessel and rank (not mortality rate)

BSAI catch by gear through 5/09. Includes CDQ.

SPECIES	H&L	NPT	POT	PTR	TOTAL
PCOD	50,126	47,993	20,002	3,847	131,968
PLCK	2,550	20,388	19	502,791	525,748
TR FF	648	88,128	55	4,093	92,924
GTRB	4	100	0	25	130
AMCK	6	21,869	1	61	21,937
SR/RE	17	34	0	2	53
OTH RK	91	5,804	2	184	6,081
SABL	99	12	0	0	111
SKATE	9,381	1,038	0	555	10,974
SHARK	16	2	0	10	28
SCLP	923	959	100	138	2,120
OCTP	25	6	109	5	145
SQID	0	29	0	54	83
TOTAL	73,886	186,362	20,288	511,766	792,302

Blue King Crab BSAI H&L CP
from car250_psc_crab
Total through 5/09: 22

WED	AREA	BKC#
3/7	513	7
4/18	513	6
5/02	513	9

NPLA Careful Release Program Placard (from 1993)

DON'T DESTROY YOUR LIVELIHOOD!

Help Keep Halibut Bycatch Alive

DO:

- Try to RELEASE the halibut before it is brought on board.
- UNHOOK the halibut by pulling on the hook with a gaff using a twisting motion, or--if that doesn't work--cut the gangion.
- ASK someone to show you if you don't know how.
- STOP THE HAULER if you can't release the halibut before it reaches the crucifier.
- RETURN halibut to the water as quickly as possible. Don't let valuable fish pile up in a checker.
- KEEP tagged halibut for an observer to examine.
- COOPERATE with observers. When instructed, allow an observer to sample the halibut bycatch.

DON'T:

- Gaff halibut anywhere in the head or body.
- Run halibut through a crucifier. This kills twice as many fish.
- Unhook halibut by horning or slamming the fish against the side of the boat.

The North Pacific Longline Association is dedicated to the protection of our fishery resources and the livelihood of those who fish for a living. Too many halibut deaths can shut down our fishery. Do your part: Help keep halibut bycatch alive.

The future of the North Pacific longline fishery is in your hands.

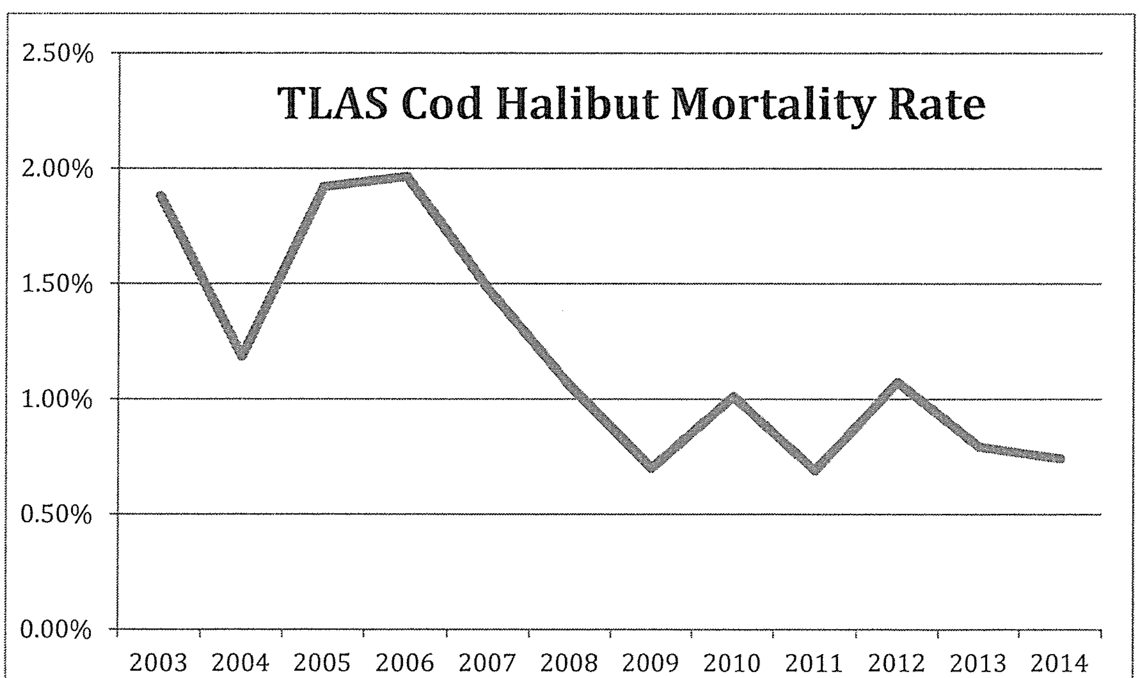
North Pacific Longline Association
4209 21st Avenue West, Suite 300
Seattle, WA 98199

C2 Jeff Lack

My name is Jeff Lackey and I manage the F/V Seeker cod catcher vessel that has participated in that fishery every year since 1988 as a member of the Akutan Catcher Vessel Association coop. The Seeker's investment in the fishery by its longtime fisherman owner is significant, as is the crew's dependence on the fishery. Tax revenue, both directly from the vessel and through economic activity generated by the processor, is significant for the state of Alaska.

There are five main points to make about the cod catcher vessels:

1) **Any PSC cut to the TLAS sector will be amplified** to the cod cv's because the Pollock set aside of 250 is not likely to be reduced; A 15% cut to TLAS translates into a 21% cut to cod CV's and a 30% cut to TLAS translates into a 42% cut to cod CV's.
2) **The cod CV's already had a near 50% halibut PSC reduction** less than a decade ago, down from 875 to 453mt; and cod catcher vessels reduced their halibut mortality by half from pre-2008 #'s to post 2008 #'s
3) **Cod CV's made many changes to achieve these results**, and well-managed AFA coops require large cod end mesh sizes, strict prohibition on night fishing, and 100% excluder use. Communication between vessels and the coop manager tracking halibut catch was higher than ever in 2015, and we had a fleet halibut stand down at one point.
4) **The analysis had insufficient cod CV data**; Cod CV data was lumped in with all TLAS sector, and data only went back to 2008 in order to compare apples to apples, but that data set missed the cod CV PSC limit reduction and drastic mortality reductions. Also, a failed AP motion to impose a bigger cut to TLAS than to Hook and Line sector was justified by H&L having better mortality improvements than TLAS, but the opposite is true when all the data is analyzed (AP did not have full data at that time).
5) **Cod CV Sector does not historically fish up to the PSC cap**. With dozens of vessels, individual accountability in the coop structure, and a seasonal fishery short on PSC transfer opportunities, the cod CV sector has not historically fished up to the PSC cap, and the dynamics that cause this result are not changing.



halibut and further the goals and objectives of the Pacific Fishery Management Council (PFMC) and the North Pacific Fishery Management Council (NPFMC).

DATES: The IPHC's 2015 annual management measures are effective March 13, 2015. The 2015 management measures are effective until superseded.

ADDRESSES: Additional requests for information regarding this action may be obtained by contacting the International Pacific Halibut Commission, 2320 W. Commodore Way Suite 300, Seattle, WA 98199–1287; or Sustainable Fisheries Division, NMFS Alaska Region, P.O. Box 21668, Juneau, AK 99802, Attn: Ellen Sebastian, Records Officer; or Sustainable Fisheries Division, NMFS West Coast Region, 7600 Sand Point Way NE., Seattle, WA 98115. This final rule also is accessible via the Internet at the Federal eRulemaking portal at *http://www.regulations.gov.*

FOR FURTHER INFORMATION CONTACT: For waters off Alaska, Glenn Merrill or Julie Scheurer, 907–586–7228; or, for waters off the U.S. West Coast, Sarah Williams, 206–526–4646.

SUPPLEMENTARY INFORMATION:

Background

The IPHC has recommended regulations which would govern the Pacific halibut fishery in 2015, pursuant to the Convention between Canada and the United States for the Preservation of the Halibut Fishery of the North Pacific Ocean and Bering Sea (Convention), signed at Ottawa, Ontario, on March 2, 1953, as amended by a Protocol Amending the Convention (signed at Washington, DC, on March 29, 1979).

As provided by the Northern Pacific Halibut Act of 1982 (Halibut Act) at 16 U.S.C. 773b, the Secretary of State, with the concurrence of the Secretary of Commerce, may accept or reject, on behalf of the United States, regulations recommended by the IPHC in accordance with the Convention (Halibut Act, Sections 773–773k). The Secretary of State of the United States, with the concurrence of the Secretary of Commerce, accepted the 2015 IPHC regulations as provided by the Halibut Act at 16 U.S.C. 773–773k.

The Halibut Act provides the Secretary of Commerce with the authority and general responsibility to carry out the requirements of the Convention and the Halibut Act. The Regional Fishery Management Councils may develop, and the Secretary of Commerce may implement, regulations governing harvesting privileges among U.S. fishermen in U.S. waters that are in addition to, and not in conflict with, approved IPHC regulations. The NPFMC has exercised this authority most notably in developing halibut management programs for three fisheries that harvest halibut in Alaska: the subsistence, sport, and commercial fisheries.

Subsistence and sport halibut fishery regulations are codified at 50 CFR part 300. Commercial halibut fisheries in Alaska are subject to the Individual Fishing Quota (IFQ) Program and Community Development Quota (CDQ) Program (50 CFR part 679), and the area-specific catch sharing plans.

The IPHC apportions catch limits for the Pacific halibut fishery among regulatory areas (Figure 1): Area 2A (Oregon, Washington, and California), Area 2B (British Columbia), Area 2C (Southeast Alaska), Area 3A (Central Gulf of Alaska), Area 3B (Western Gulf of Alaska), and Area 4 (subdivided into 5 areas, 4A–4E, in the Bering Sea and Aleutian Islands of Western Alaska).

The NPFMC implemented a catch sharing plan (CSP) among commercial IFQ and CDQ halibut fisheries in IPHC Areas 4C, 4D and 4E (Area 4, Western Alaska) through rulemaking, and the Secretary of State approved the plan on March 20, 1996 (61 FR 11337). The Area 4 CSP regulations were codified at 50 CFR 300.65, and were amended on March 17, 1998 (63 FR 13000). New annual regulations pertaining to the Area 4 CSP also may be implemented through IPHC action, subject to acceptance by the Secretary of State.

The NPFMC recommended and NMFS implemented through rulemaking a CSP for guided sport (charter) and commercial IFQ halibut fisheries in IPHC Area 2C and Area 3A on January 13, 2014 (78 FR 75844, December 12, 2013). The Area 2C and 3A CSP regulations are codified at 50 CFR 300.65. The CSP defines an annual process for allocating halibut between the commercial and charter fisheries so that each sector's allocation varies in proportion to halibut abundance; specifies a public process for setting annual management measures; and authorizes limited annual leases of commercial IFQ for use in the charter fishery as guided angler fish (GAF).

The IPHC held its annual meeting in Vancouver, British Columbia, January 26–30, 2015, and recommended a number of changes to the previous IPHC regulations (79 FR 13906, March 12, 2014). The Secretary of State accepted the annual management measures, including the following changes to the previous IPHC regulations for 2015:

1. New halibut catch limits in all regulatory areas in Section 11;
2. New commercial halibut fishery opening and closing dates in Section 8;
3. New management measures for Area 2C and Area 3A guided sport fisheries in Section 28, and in Figure 3 and Figure 4; and
4. Addition of California Division of Fish and Wildlife to the list of officers authorized to enforce these regulations in Section 3.

Pursuant to regulations at 50 CFR 300.62, the 2015 IPHC annual management measures are published in the **Federal Register** to provide notice of their immediate regulatory effectiveness and to inform persons subject to the regulations of their restrictions and requirements. Because NMFS publishes the regulations applicable to the entire Convention area, these regulations include some provisions relating to and affecting Canadian fishing and fisheries. NMFS could implement more restrictive regulations for the sport fishery for halibut or components of it; therefore, anglers are advised to check the current Federal or IPHC regulations prior to fishing.

Catch Limits

The IPHC recommended to the governments of Canada and the United States catch limits for 2015 totaling 29,223,000 lb (13,255 mt). The IPHC recommended area-specific catch limits for 2015 that were higher than 2014 in most of its management areas except Area 3B, where catch limits were reduced, and Areas 4B and 4CDE where catch limits remained at the same level as in 2014. The IPHC is responding to stock challenges with a risk-based precautionary approach and a review of the current harvest policy to ensure the best possible advice. A description of the process the IPHC used to set these catch limits follows.

As in 2012 and 2013, the 2014 stock assessment was based on an ensemble of models incorporating the uncertainty within each model as well as the uncertainty among models. This approach provides a stronger basis for risk assessment of specific management measures that may be recommended by the IPHC. There were two new additions to this year's ensemble of models: The use of long and short time-series models treating Areas As Fleets (AAF). The two AAF models considered this year assess the halibut population as a coastwide stock, while allowing for region-specific variations in the selectivity and catchability in the treatment of survey and fishery information. The AAF approach is a commonly applied stock assessment method for dealing with populations showing evidence of spatial structure, but without explicitly modeling different recruitment distribution and migration rates among areas. Spatially explicit approaches are currently being developed for future evaluation; however, there is no comprehensive information available on juvenile distribution and movement. For 2014, the stock assessment ensemble included short and long time-series models based on both the coastwide and the AAF approaches. This combination of models included uncertainty in natural mortality rates, environmental effects on recruitment, and uncertainty in other model parameters.

The assessment indicates that the Pacific halibut stock declined continuously from the late 1990s to around 2010. That trend is estimated to have been a result of decreasing size at age as well as smaller recruitments than those observed through the 1980s and 1990s. In recent years, the estimated female spawning biomass appears to have stabilized near 200 million pounds. Overall, the ensemble models project a stable halibut biomass in the next 3 years at current harvest rates. The AAF models project a slight increase in halibut biomass in the next 3 years at current harvest rates.

As in 2014, and as part of an ongoing effort to provide Commissioners with greater flexibility when selecting catch limits, in January 2015 IPHC staff provided a decision table that estimates the consequences to stock and fishery status and trends from different levels of harvest. This decision table more fully accommodates uncertainty in the stock status and allowed the Commissioners to weigh the risk and benefits of management choices as they set the annual catch limits. After considering harvest advice for 2015 from its scientific staff, Canadian and U.S. harvesters and processors, and other fishery agencies, the IPHC recommended catch limits for 2015 to the U.S. and Canadian governments (see Table 1 below).

The IPHC recommended higher catch limits than 2014 for Areas 2A, 2B, and 2C because the stock assessment survey and fishery weight per unit effort (WPUE) estimates indicate a stable and upward trend in exploitable biomass in these areas. The IPHC recommended the higher catch limits in Areas 2A, 2B, and 2C than would result from the application of the IPHC's adopted harvest policy. The IPHC made these catch limit recommendations after considering the low risk of an adverse impact on the halibut stock from the recommended catch limits in Areas 2A, 2B, and 2C, and the favorable survey and fishery trends in these areas.

The IPHC recommended a more precautionary approach to their catch limit recommendations for Areas 3A and 3B relative to Areas 2A, 2B, and 2C. The IPHC recommended catch limits that were consistent with the IPHCs adopted harvest policy in Areas 3A and 3B. The IPHC noted that the catch limit recommendations in Areas 3A and 3B are precautionary and catch limits greater than the adopted harvest policy were not warranted given downward trends in exploitable biomass and WPUE in these areas. The catch limit in Area 3A increased slightly relative to 2014 due to increased biomass estimates in Area 3A. The catch limit in Area 3B decreased slightly relative to 2014 due to decreased biomass estimates in Area 3B.

The IPHC recommended a catch limit for Area 4A that was higher than the 2014 limit. The IPHC-recommended catch limit in Area 4A is consistent with the IPHC's adopted harvest policy in this area. The IPHC did not recommend a catch limit amount in Area 4A greater than its adopted harvest policy in this area because the stock trends in this area are uncertain and a more precautionary approach to management is appropriate. Specifically, the survey trends in Area 4A show an increased biomass, but the commercial WPUE decreased in 2014.

The IPHC recommended a catch limit for Area 4B that was the same as that adopted in 2014. The IPHC recommended a catch limit in Area 4B that is slightly higher than that which would result from application of its adopted harvest policy in Area 4B. The IPHC made this catch limit recommendation after considering the low risk of an adverse impact on the halibut stock from the recommended catch limit in Area 4B, and the after considering the adverse socioeconomic impact that could result from a catch limit that was lower than that provided in 2014.

Similarly, the IPHC recommended a catch limit for Areas 4CDE that is the same as that adopted in 2014. The IPHC recommended a catch limit in Areas 4CDE that is higher than that which would result from application of its adopted harvest policy in Areas 4CDE. The IPHC made this catch limit recommendation after considering the low risk of an adverse impact on the halibut stock from the recommended catch limit in Areas 4CDE, and the after considering the adverse socioeconomic impact that could result from a catch limit that was lower than that provided in 2014. The IPHC also noted that overall stock trends in Area 4CDE from the fishery survey show an increasing biomass. The IPHC also considered ongoing efforts by the North Pacific groundfish fleet to reduce the amount of halibut mortality from bycatch, particularly in Areas 4CDE, during 2014 and 2015. The IPHC noted that reduced bycatch mortality in 2015 is likely to provide additional harvest opportunities for the commercial fishery in the future. Overall, the IPHC's catch limit recommendations for 2015 are projected to result in a stable or slightly increasing halibut stock in the future.

TABLE 1—PERCENT CHANGE IN CATCH LIMITS FROM 2014 TO 2015 BY IPHC REGULATORY AREA

Regulatory Area	2015 IPHC Recommended catch limit (lb)	2014 Catch limit (lb)	Percent change from 2014
2A[1]	970,000	960,000	1.0
2B[2]	7,038,000	6,850,000	2.7
2C[3]	4,650,000	4,160,000	11.8
3A[3]	10,100,000	9,430,000	7.1
3B	2,650,000	2,840,000	−6.7
4A	1,390,000	850,000	63.5
4B	1,140,000	1,140,000	0
4CDE	1,285,000	1,285,000	0
Coastwide	29,223,000	27,515,000	6.2

[1] Area 2A catch limit includes sport, commercial, and tribal catch limits.
[2] Area 2B catch limit includes sport and commercial catch limits.
[3] Shown is the combined commercial and charter allocation under the Area 2C and Area 3A CSP. This value includes allocations to the charter sector, and an amount for commercial wastage. The commercial catch limits after deducting wastage are 3,679,000 lb in Area 2C and 7,790,000 lb in Area 3A.

Agenda Item C-2
Mike Hyde
American Seafoods Company
June 1, 2015

C2 Mike Hyde
E-Copy

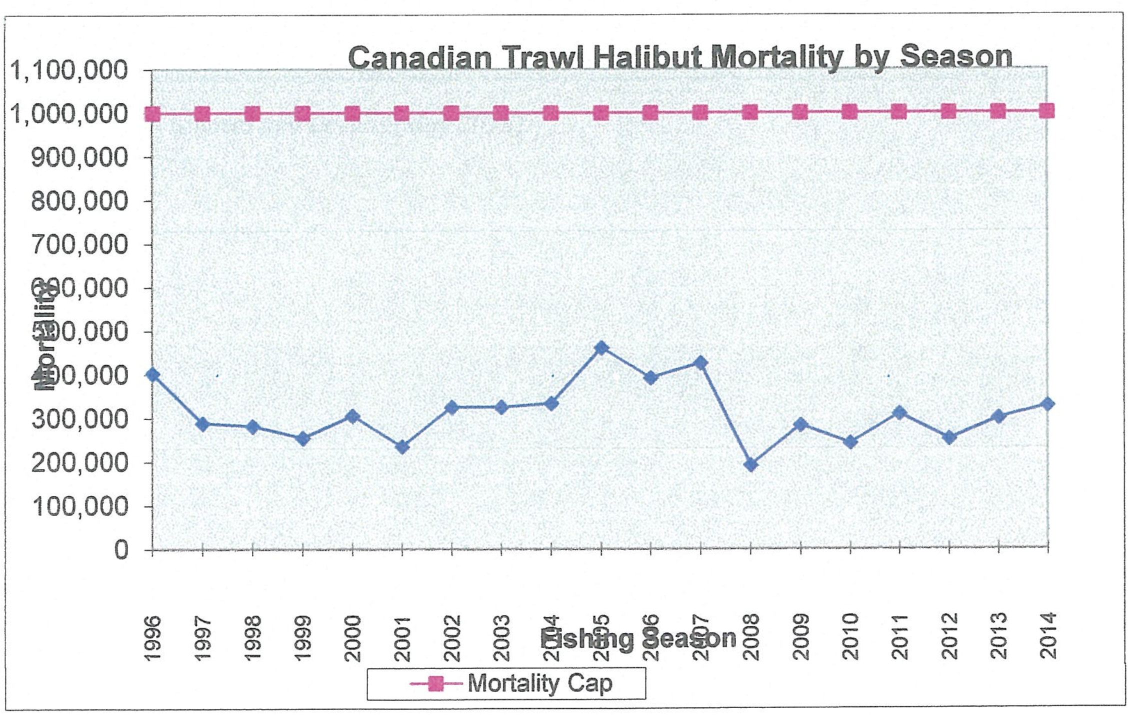
"Practicable" and the Myth of the Canadian Miracle

The Magnuson-Stevens Fishery Conservation and Management Act requires that all fishery management plans and implementing regulations be consistent with ten national standards. Several of the national standards establish guidelines that <u>shall</u> be met. For those standards, there is no limitation on the mandate that the guideline "shall" be met. For example, under national standard one, management measures shall prevent overfishing while achieving the optimum yield from each fishery. On the other hand, several of the national standards provide that management measures shall achieve the objective only "<u>to the extent practicable</u>". For example, national standard 8 states that management measures shall "<u>to the extent practicable</u>, minimize adverse economic impacts on such communities". National standard 9 states that management measures "shall, <u>to the extent practicable</u>, (A) minimize bycatch...". Therefore, in analyzing potential reductions in halibut bycatch caps, a critical determination for each fishery is what is "practicable".

In public testimony on the halibut bycatch reduction issue, severalcommenters have stated that the Canadian trawl fleet has achieved substantial reductions in halibut bycatch and that these achievements set a standard for similar reductions in U.S. Bering Sea trawl bycatch. In the context of the Magnuson-Stevens Act national standards, the argument is essentially that the Canadian bycatch performance has demonstrated what is "practicable" in considering halibut bycatch reduction in other groundfish trawl fisheries. This paper looks at these claims and compares bycatch performance in the Canadian bottom trawl groundfish fisheries against the performance of the U.S. Bering Sea bottom trawl fisheries. The conclusion is that the Canadian bycatch rate has remained relatively unchanged since 1996, has an "encounter" rate (halibut brought aboard the vessel compared to total catch) more than double the Bering Sea rate, has a bycatch rate that is similar to the U.S. rate only as a result of using an approximate 31% discard mortality rate for trawl caught halibut versus the 83% discard mortality rate currently assigned to the Bering Sea yellowfin sole fishery and has a hard cap on halibut bycatch that allows bycatch at more than double the rate allowed under current Bering Sea caps.

1. Canadian Halibut Bycatch Mortality

The following figure shows the annual bycatch mortality in the Canadian trawl fisheries. Annual bycatch has ranged from a high of 402,014 lbs. in 1996 to a low of 190,705 lbs. in 2008. The bycatch mortality for 2014, the most recent year for which data is available was 327,091 lbs., the sixth highest bycatch total since 1996 (see also Table 1 for specific figures).



2. Canadian Total Bycatch and Discard Mortality Rates

Table 1, below, provides information on total Canadian halibut bycatch and the associated discard mortality rates since 1996. Changes in total annual halibut catch generally track the annual mortality because the assumed discard mortality rate in the Canadian bottom trawl fishery has remained relatively constant at between 30% and 34% from 1996 - 2014. The year 2014 is representative of the entire time series. Total bottom trawl catch was 55,217,366 lbs. (approximately 5% of U.S. Bering Sea catch). The total halibut brought onboard (the "bycatch total") was 991,593 lbs. After applying a discard mortality rate of 32.99%, the total halibut mortality was 327,091 lbs. which results in a halibut bycatch mortality rate compared to groundfish landed of 0.059%

Table 1

Year	Bottom Trawl lbs	Total Halibut (lbs)	Halibut Mortality (lbs)	Halibut Mortality Rates	Halibut Bycatch Rates	Halibut Encounter rates
1996	63,765,398	1,360,237	402,014	*29.6%*	*0.63%*	*2.13%*
1997	57,637,893	966,939	288,407	*29.8%*	*0.50%*	*1.68%*
1998	61,476,003	880,374	281,650	*32.0%*	*0.46%*	*1.43%*
1999	61,923,775	836,908	254,227	*30.4%*	*0.41%*	*1.35%*
2000	66,957,035	1,048,499	304,698	*29.1%*	*0.46%*	*1.57%*
2001	71,472,176	785,082	234,060	*29.8%*	*0.33%*	*1.10%*
2002	68,969,024	1,070,516	324,062	*30.3%*	*0.47%*	*1.55%*
2003	72,490,933	1,093,100	323,917	*29.6%*	*0.45%*	*1.51%*
2004	70,617,913	1,090,530	333,244	*30.6%*	*0.47%*	*1.54%*
2005	93,024,817	1,446,673	460,155	*31.8%*	*0.49%*	*1.56%*
2006	67,318,214	1,228,255	391,349	*31.9%*	*0.58%*	*1.82%*
2007	52,910,518	1,415,729	425,140	*30.0%*	*0.80%*	*2.68%*
2008	45,511,030	587,831	190,705	*32.4%*	*0.42%*	*1.29%*
2009	48,680,239	833,591	283,186	*34.0%*	*0.58%*	*1.71%*
2010	47,430,710	809,945	241,543	*29.8%*	*0.51%*	*1.71%*
2011	57,320,385	903,146	309,099	*34.2%*	*0.54%*	*1.58%*
2012	51,785,041	845,719	251,563	*29.7%*	*0.49%*	*1.63%*
2013	58,196,161	881,129	299,431	*34.0%*	*0.51%*	*1.51%*
2014	55,217,366	991,593	327,091	*33.0%*	*0.59%*	*1.80%*

Source: Canada Department of Fisheries and Oceans (May 2015)

3. Bering Sea Halibut Bycatch Rates

Bycatch rates in Table 2 are calculated as the ratio of halibut mortality to groundfish catch. The following tables are based on annual bottom trawl catch and exclude catch from the pelagic pollock fishery in the Bering Sea.

Table 2

BSAI Non-Pelagic Catch and Halibut Mortality 2003-2014

Year	Non-Pelagic Trawl (mt)	Halibut Mortality (mt	Halibut Mortality Rates
2003	326,257	3,512	*1.08%*
2004	366,240	3,313	*0.90%*
2005	352,194	3,443	*0.98%*
2006	357,454	3,342	*0.93%*
2007	392,928	3,249	*0.83%*
2008	418,346	2,549	*0.61%*
2009	382,746	2,475	*0.65%*
2010	412,212	2,608	*0.63%*
2011	441,146	2,291	*0.52%*
2012	456,901	2,760	*0.60%*
2013	471,384	2,868	*0.61%*
2014	463,055	2,872	*0.62%*

Source: SeaState (May 2015)

4. U.S. v. Canada Halibut Bycatch Rates – Comparison

Comparing the tables for U.S. and Canadian bycatch rates, the average bycatch rate in the Canadian bottom trawl fishery from 2008-2014 is 0.5%. The average bycatch rate in the U.S. Bering Sea bottom trawl fishery for the same period 2008-2014 is 0.6%, essentially identical. However, during the same period, the Canadian rate of halibut brought onboard relative to total groundfish caught was more than double the U.S. rate while the discard mortality rate applied by the Canadians was less than half of the discard mortality rate applied to the bottom trawl fisheries in the Bering Sea.

Year	Canada	US Bering Sea
2008	0.42%	0.61%
2009	0.58%	0.65%
2010	0.51%	0.63%
2011	0.54%	0.52%
2012	0.49%	0.60%
2013	0.51%	0.61%
2014	0.59%	0.62%

5. Conclusion

In summary, the public testimony arguing that the halibut bycatch performance of the Canadian bottom trawl fleet is evidence that greater bycatch reductions are practicable in the U.S. Bering Sea fleet is not supported by the facts. The Canadian bycatch mortality rate is essentially identical to the U.S. Bering Sea rate. The Canadian encounter rate is more than double the U.S. Bering Sea rate. The difference in total mortality is a function of using a lower discard mortality rate in Canada and a bottom trawl groundfish catch that is only 1/20th of the U.S. bottom trawl catch. If any conclusion can be reached by reviewing the Canadian fishery, it is that there is an inherent bycatch rate in both of these fisheries and that further bycatch reductions are not practicable.

C2 Mike Hyde
E-COPY

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May 19, 2015

Dan Hull, Chairman
North Pacific Fishery Management Council
19300 Villages Scenic Pkwy
Anchorage, AK 99516

RE: Public Comment - Agenda Item C-2 Halibut PSC

Dear Mr. Hull:

The purpose of this letter is to outline, on behalf of the Bering Sea/Aleutian Islands trawl groundfish industry, the legal issues and limitations associated with implementing bycatch reduction actions pursuant to National Standard 9 of the Magnuson-Stevens Fishery Conservation and Management Act ("MSA"), 16 U.S.C. §1851(a)9. As set forth in further detail below, the MSA's ten National Standards include an implicit prioritization that the North Pacific Fishery Management Council ("Council") and the National Marine Fisheries Service ("NMFS") should take into account when applying the standards to a fishery management plan ("FMP"). In addition, National Standard 9 expressly includes the phrase "to the extent practicable," which is intended to limit the extent to which bycatch limits are imposed in FMPs.

a. Balancing the National Standards

The MSA sets forth ten National Standards for fishery conservation and management. 16 U.S.C. §1851(a). It is the duty of the Council and NMFS to ensure that FMPs and their associated regulations are consistent with these National Standards. *Id.* While the standards are designed to achieve certain goals, these goals may at times be in conflict. The tension among the standards therefore necessarily requires that certain goals be sacrificed to some extent to meet the others. *National Coalition for Marine Conservation v. Evans*, 231 F.Supp.2d 119, 132 (D.D.C. 2002). Indeed, "Congress, while aware of the potential conflicts among the [MSA's] provisions, nevertheless 'required [NMFS] to exercise discretion and judgment in balancing among the conflicting national standards…." *Id.* at 141 (quoting *Alliance Against IFQs v. Brown*, 84 F.3d 343, 350 (9th Cir. 1996)).

However, in finding the appropriate balance among the different National Standards, it must be recognized that Congress awarded some National Standards a higher priority than others. The objectives of certain National Standards, including National Standard 9, are to be

achieved "to the extent practicable." In contrast, other National Standards are stated as an imperative. National Standard 1 provides that FMPs "shall" prevent overfishing and achieve optimum yield. National Standard 2 provides that FMPs "shall" be based on the best scientific information available. National Standard 4 provides that FMPs "shall not" be discriminatory. National Standard 6 requires that FMPs "shall" allow for variation among and contingencies in fisheries. The requirements of these National Standards are not modified by the "to the extent practicable" clause Congress inserted into National Standards 8, 9, and 10. In short, when Congress created the National Standards, it did so using words that gave some standards a higher priority than others.

Courts have also recognized the prioritization that necessarily arises when applying the National Standards. In *Recreational Fishing Alliance v. Evans,* 172 F.Supp.2d 35, 46 (D.D.C. 2001), the court considered the requirements of the "to the extent practicable" requirement in National Standard 8 stating: "While economic effects must be taken into account, such effects were not meant to trump the real purpose of the [MSA], which is to preserve and protect United States fisheries. NMFS must minimize adverse impacts on fishing communities only 'to the extent practicable.'" *See also A.M.L. International, Inc. v. Daley*, 107 F.Supp.2d 90, 107 n.28 (D. Mass. 2000) ("economic considerations are not designed to trump conservation considerations in the process of developing fishery management plans") (citing 142 Cong. Rec. S10794, 10825 (September 18, 1996) (statement of Sen. Snowe)).

In short, the National Standards that are stated as a mandate should be given higher priority by the Council and NMFS than National Standards that are only to be applied "to the extent practicable." This means that National Standard 1 (FMPs "shall" prevent overfishing and achieve optimum yield) should be given higher priority than National Standard 9 (FMPs shall minimize bycatch "to the extent practicable"). While the MSA gives the Council broad authority to manage and conserve fisheries, *Ocean Conservancy v. Gutierrez*, 394 F.Supp.2d 147, 156 (D.D.C. 2005), *aff'd*, 488 F.3d 1020 (D.C. Cir. 2007), the ultimate goal of any FMP is to establish conservation and management measures that allow a fishery to produce its optimum yield – and each National Standard is to be implemented with that goal in mind.

b. "To The Extent Practicable" and National Standard 9

National Standard 9 provides:

> Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.

16 U.S.C. §1851(a)(9)."[1]

NMFS has promulgated guidelines interpreting National Standard 9 ("Guidelines"). The Guidelines state the Council "should assess the impacts of minimizing bycatch and bycatch mortality, as well as [the] consistency of the selected measure with other national standards and applicable laws." 50 C.F.R. §600.350(d)(2). The Guidelines then identify specific factors that should be considered in determining if a proposed bycatch reduction plan is practicable, including "negative impacts on affected stocks; incomes accruing to participants in directed fisheries in both the short and long term; incomes accruing to participants in fisheries that target the bycatch species; environmental consequences; non-market values of bycatch species, which include non-consumptive uses of bycatch species and existence values, as well as recreational values; and impacts on other marine organisms." 50 C.F.R. §600.350(d).

<u>Applicable Case Law</u>

Bearing these Guidelines in mind, courts interpreting the term "to the extent practicable" in National Standard 9 have held that the words mean exactly that. "NMFS is required to minimize bycatch only 'to the extent practicable ....'" *National Coalition for Marine Conservation v. Evans,* 231 F.Supp.2d at 137. In *Ocean Conservancy v. Gutierrez,* 394 F.Supp.2d at 159, the court was more direct noting: "Simply stated, National Standard 9 is not entitled to greater weight than any of these other Standards." Thus, the court concluded:

> [B]ecause bycatch could only be entirely avoided by eliminating *all* commercial activity in the fishery, National Standard 9 only made sense within the larger context of the Magnuson-Stevens Act if it was interpreted as requiring the NMFS to find the combination of regulations that would best meet the statute's various objectives.

Id. (citations omitted).

In *Conservation Law Foundation v. Evans,* 360 F.3d 21, 28 (1st Cir. 2004), the plaintiffs argued that the term "practicable" should be interpreted to mean "possible." The issue arose with respect to compliance with National Standard 9 and with section 303(a)(7), which requires that an FMP minimize adverse effects on essential fish habitat "to the extent practicable." *See* 16 U.S.C. §1853(a)(7). The court stated:

---

[1] A parallel provision is found in MSA section 303(a)(11), which provides that any FMP "shall ... include conservation and management measures that, to the extent practicable and in the following priority – (A) minimize bycatch; and (B) minimize the mortality of bycatch which cannot be avoided. 16 U.S.C. §1853(a)(11). Sections 301(a)(9) and 303(a)(11) are parallel provisions. Both sections were added to the MSA in 1996 by the Sustainable Fisheries Act, P.L. 104-297, and the legislative history makes it clear that National Standard 9 is applied through section 303 (a)(11). The term "to the extent practicable" in both provisions is to be given the same meaning. 142 Cong. Rec. H11437 (daily ed. Sept. 27, 1996).

> [T]he plaintiffs essentially call for an interpretation of the statute that equates "practicability" with "possibility," requiring NMFS to implement virtually any measure that addresses [essential fish habitat] and bycatch concerns so long as it is feasible. Although the distinction between the two may sometimes be fine, there is indeed a distinction. The closer one gets to the plaintiffs' interpretation, the less weighing and balancing is permitted. We think by using the term "practicable" Congress intended rather to allow for the application of agency expertise and discretion in determining how best to manage fishery resources.

360 F.3d at 28; *see also* 63 Fed. Reg. 24,212, 24,226 (May 1, 1998) (stating in the preamble to the Guidelines that "[f]or the purposes of this national standard, the term 'practicable' is not synonymous with the term 'possible,' because not all reductions that are possible are practicable").

Based on the "to the extent practicable" language, courts have placed limits on what is required by National Standard 9. In *National Coalition for Marine Conservation v. Evans,* conservation groups claimed that regulations governing the Atlantic highly migratory species fishery violated National Standard 9 by failing to adequately address billfish bycatch. 231 F.Supp.2d at 124. Plaintiffs sought gear and other restrictions that would effectively close the fishery to one gear type. *Id.* The agency's defense was that the FMP needed to minimize bycatch only "to the extent practicable" and that eliminating all fishing was not reasonable. *Id.* at 137. NMFS contended that it had analyzed various alternatives to "find the combination that would best meet the [MSA's] objectives of reducing bycatch while minimizing economic costs to the extent practicable." *Id.* The court upheld the FMP, concluding that to impose the bycatch reductions sought by plaintiffs, NMFS would have to eliminate all pelagic longline fishing – an unreasonable alternative not required by the MSA. *Id.*[2]

Similarly, in *Natural Resources Defense Council v. NMFS,* --- F.Supp.3d ---, 2014 WL 5148407, at *1 (D.D.C. Oct. 14, 2014), plaintiffs challenged an FMP amendment that lifted a ban on targeting six deep-water fish species believed to co-occur with overfished speckled hind and warsaw grouper. *Id.* In evaluating whether the amendment complied with National Standard 9, the court reasoned "that the NMFS must consider bycatch mortality in order to comply with National Standard Nine, but that the NMFS is not required to adopt every measure that could conceivably reduce bycatch." *Id.* at *23. After considering evidence that the ban was ineffective and unnecessary, the court upheld the amendment, concluding it was consistent with National Standard 9. *Id.; see also Blue Ocean Institute v. Gutierrez,* 585 F.Supp.2d 36, 47-48 (D.D.C.

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[2] Similarly, in the preamble to the Guidelines, NMFS noted that one commenter had argued National Standard 9 encourages, if not requires, the elimination of non-selective gear types. NMFS rejected this view stating: "[T]he legislative history [of National Standard 9] includes a floor statement by Congressman Young that 'it is not the intent of Congress that the [Council] ban a type of fishing gear or a type of fishing in order to comply with this standard.'" 63 Fed. Reg. at 24,224 (citing 142 Cong. Rec. H11437 (daily ed. Sept. 27, 1996)).

2008) (upholding an FMP bycatch reduction plan because it "struck the best balance between its competing duties to minimize bycatch" among multiple species).

Courts have also found that NMFS complied with National Standard 9, even though NMFS could have done more to reduce bycatch. In *Ocean Conservancy v. Gutierrez,* the court rejected the plaintiffs' arguments that National Standard 9 was to be given the top priority among the National Standards. Instead, the court noted that "[a]lthough the NMFS *might* have done more to reduce bycatch, '*more*' is not the standard that NMFS must follow." 394 F.Supp.2d at 159 (emphasis in original). In other words, if the Council and NMFS have rationally balanced the competing goals of the different National Standards, the fact that more might have done to reduce bycatch is not a fatal flaw in the FMP.

Moreover, it is imperative that, when applying National Standard 9, the Council and NMFS thoughtfully consider the evidence and reach a reasoned decision. In *Ocean Conservancy v. Gutierrez,* where compliance with National Standard 9 was a key issue, the court upheld the FMP only after concluding that "[NMFS] thoroughly reviewed the relevant scientific data on bycatch and consulted with participants in the fishery to determine whether the proposed regulations would be effective and practical." 394 F.Supp.2d at 159; *see also Little Bay Lobster Company, Inc. v. Evans,* 352 F.3d 462, 469-471 (1st Cir. 2003) (holding that the "to the extent practicable" language requires NMFS to make a good faith effort to consider comments and alternatives); *A.M.L. International, Inc. v. Daley,* 107 F.Supp.2d at 103 (stating that any decision in an FMP regarding bycatch "must be supported by analysis"). Similarly, in *Flaherty v. Bryson,* 850 F.Supp.2d 38, 43 n. 2 (D.D.C. 2012), NMFS adopted and implemented an amendment to the Atlantic herring FMP without ever once mentioning whether the affected conservation measures would reduce bycatch. *See id.* at 59 (noting that the record did "not reflect any examination or consideration" of whether the amendment reduced bycatch). Thus, the court held that NMFS's approval of the amendment violated the MSA. *Id.*; *see also Pacific Marine Conservation Council, Inc. v. Evans,* 200 F.Supp.2d 1194 (N.D. Cal. 2002) (NMFS was found to have violated National Standard 9 because it failed to explain why it had rejected a proposed bycatch reduction measure); *Conservation Law Foundation v. Evans,* 209 F.Supp.2d 1, 14 (D.D.C. 2001) (holding National Standard 9 was violated because there was "no record" of NMFS conducting any evaluation of whether the FMP complied with National Standard 9).

Economic Considerations

It is also entirely appropriate for the Council and NMFS to take into account economics in applying National Standard 9. Indeed, the preamble to the Final Rule promulgating the Guidelines provides guidance on this important issue. In the preamble, NMFS responded to a comment that economics cannot justify bycatch having a negative impact on the health of any stock in a multispecies fishery. NMFS stated it agreed with the commenter but then went on to say:

> The economic consequences of dealing with bycatch is one of the factors that determines the extent to which it is practicable to reduce bycatch or bycatch mortality in a particular fishery.

63 Fed. Reg. 24212, 24226 (May 1, 1998). NMFS' position is fully consistent with the legislative history of National Standard 9. Senator Breaux, a member of the Committee with jurisdiction over the MSA, stated during floor consideration of the legislation adding National Standard 9 to the MSA that preventing bycatch had to be done "without destroying the fishermen who are going after a targeted species." 142 Cong. Rec. S10818 (daily ed. Sept. 18, 1996). This position was echoed in comments by Congressman Young, Chairman of the Committee of jurisdiction in the House of Representatives, who stated during floor debate:

> "Practicable" requires an analysis of the cost of imposing a management action; the Congress does not intend ... to impose costs on fishermen and processors that cannot be reasonably met.

142 Cong. Rec. H11437 (daily ed. Sept. 27, 1996).

Consistent with this legislative and regulatory history, courts have accepted the importance of economic considerations in determining the appropriateness of a bycatch reduction plan. In *National Coalition for Marine Conservation v. Evans,* 231 F.Supp.2d at 137, the court found that NMFS' balancing of the MSA objectives of "reducing bycatch while minimizing economic costs to the extent practicable" was appropriate.

Other Statutes

Other statutes also offer guidance as to what the term "to the extent practicable" means in the context of National Standard 9. In this regard, it is important to recognize what Congress did not say. Congress did not say that the goals of National Standard 9 are to be met to the "maximum" extent practicable. Those more imperative words are used in other statutes, such as the Endangered Species Act, where the impacts of a permitted action on a protected species are to be minimized "to the maximum extent practicable." 16 U.S.C. §1539(a)(2)(B)(ii). Congress also did not say that the Council is to use "all" practicable means to achieve National Standard 9's objective. That imperative is used in statutes such as the National Environmental Policy Act, which requires that federal agencies use "all practicable means" to comply with certain requirements. 42 U.S.C. §4331(b). In the MSA, Congress used a lesser mandate, requiring only that the goal of National Standard 9 be met "to the extent practicable."

Courts have also opined on the limits that the term "practicable" places on regulatory actions in other statutory contexts. In *Utahns for Better Transp. v. U.S. Dep't of Transp.*, 305 F.3d 1152, 1163 (10th Cir. 2002), *as modified on reh'g*, 319 F.3d 1207 (10th Cir. 2003), the court considered the term "practicable" in the context of the Clean Water Act, which prohibits issuance of certain permits if "there is a practicable alternative which would have less adverse impact and does not have other significant adverse environmental consequences." *Id.* (citing 40

C.F.R. §230.12(a)(3)). The court explained that, as defined by regulations, the term "practicable" means "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes." *Id.* (citing 40 C.F.R. §230.10(a)(2)). After noting that "Merriam-Webster's Collegiate Dictionary defines infeasible as impracticable," the court upheld the Corps of Engineers' determination that an alternative was impracticable because it was "infeasible because of its high cost and high impact on existing development." *Id.; see also* 23 C.F.R. §650 .105(k) (defining "practicable alternatives" as "capable of being done within reasonable natural, social, or economic constraints").

Similarly, in *Vigil v. Leavitt*, 381 F.3d 826, 846 (9th Cir. 2004), the issue was a provision of the Clean Air Act requiring certain conditions to be met in order for a state (Arizona) to be given an extension of an air quality compliance deadline. The provision stated that the extension would be granted only "if attainment by the [deadline] ... would be impracticable." *Id.* The court interpreted the provision as requiring Arizona to show only that it had implemented "the best practicable measures—not every possible measure." *Id.; see also Train v. Natural Res. Def. Council, Inc.*, 421 U.S. 60 (1975) (noting that compliance with certain Clean Air Act requirements in less than three years could be impracticable, and thus not required).

c. Conclusion

In sum, the requirement to avoid bycatch "to the extent practicable" cannot be considered in a vacuum. *Blue Ocean Institute v. Gutierrez,* 585 F.Supp.2d at 48. Practicability must be evaluated in the unique factual context of each FMP, a context in which the goals of National Standard 9 are balanced against the goals of other National Standards, including standards that have a higher priority. National Standard 9 does not require the Council and NMFS to reduce all possible bycatch, but rather only to reduce bycatch "to the extent practicable." In doing so, it is appropriate for the Council and NMFS to take into account the impacts of any proposed limits, including whether the limits can be reasonably met and whether the limits represent the best balance between competing interests.

We would be happy to discuss any of the issues addressed in this letter with the Council at your convenience.

Sincerely,

George J. Mannina, Jr.

Ashley J. Remillard

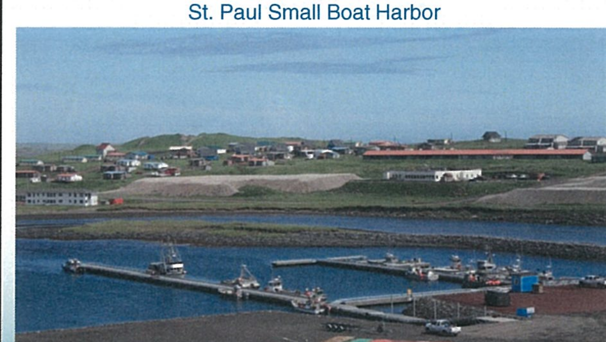
GJM/jm

St. Paul Fishermen – in 2001

St. Paul Small Boat Harbor Constructed in 2010

Blessing of the new Small Boat Harbor 2011
Cost $20 Million

St. Paul Small Boat Harbor



Artistic rendering of CBSFA Boat Shop & Tribal Ship Supply
Construction to begin in 2016
Joint-venture project between the Tribe and CBSFA

My Crew – Water Safety Training with AMSEA
Dustin – 15 Years, Matt – 10 Years, Shaun 12 Years

Nice Set – F/V Bay Rose

F/V Bay Rose Crew

My 12 year old son

My kids baiting halibut gear/Daughter Bessie and cousin Roman going to get gear from boat

My 8 year old daughter, 15 year old daughter and 15 year old niece baiting

Melovidov Family – 3 generations of fishermen

F/V Aleut Crusader – Myron Jr., Henry, Myron, Sean, and Ray

F/V Niqax baiters, Phillip's daughter Vivian in Center

F/V Niqax crew – Marvin, Chucky, Shane

F/V Niqax offloading – summer 2014

Phillip and I – Back in the day!

F/V Rena Gal and factory longliner Bristol Leader
St. Paul Harbor

Niqax, Wind Dancer & Tolstoi preparing to offload

Simeon Swetzof - F/V Windancer

Subsistence halibut fishermen

BSAI Halibut PSC Limits By Sector, in metric tons

Sector	Current PSC Limit	Percentage Reduction	New PSC Limit	2014 Use	% Change from 2014 Use	Average Use (2008-2013)	% Change from Average Use	Bycatch Savings (2014 Use - New PSC Limit)
BSAI TLA	875	41.2%	515	717	-28%	700	-26%	185
Amendment 80	2325	41.2%	1,368	2,106	-35%	2,037	-33%	668
Longline Pacific cod CVs	15	41.2%	9	7	26%	3	231%	-
Longline Pacific cod CPs	760	41.2%	447	412	9%	521	-14%	74
CDQ	393	41.2%	231	244	-5%	210	10%	-
Other non-trawl	58	41.2%	34	1	3313%	5	606%	-
Total	4,426	-41.2%	2,605	3,487	-25.3%	3,475	-25.0%	927

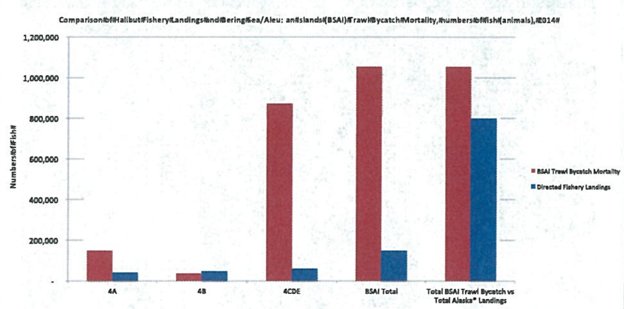
IPHC Area	Net Weight Savings in Area		O26 Net Weight Savings in Area	
	%	lb	%	lb
4A	15%	226,540	57%	129,075
4B	7%	102,734	87%	89,563
4C	36%	558,915	64%	355,894
4D	36%	558,915	64%	355,894
4E	6%	86,002	64%	54,763
Total		1,533,104		985,189

Bycatch Savings		
in MT	in round lbs.	in net lbs.
927	2,044,138	1,533,104

2015 BSAI Blue Line FCEY	2,640,000
Change to BSAI FCEY (O26 Savings)	985,189
Estimated BSAI FCEY (Blue Line + O26 Savings)	**3,625,189**

547,914 U26 Savings

2015 4CDE Blue Line FCEY	520,000
Change to 4CDE FCEY (O26 Savings)	766,551
Estimated Area 4CDE FCEY (2015 Blue Line + O26 Savings)	**1,286,551**



Sources:
Stewart. Personal Communication via email, March 23, 2015
NMFS. 2015. Halibut Mortality Estimate. January 8, 2015.
Forsberg, J.E. 2015. Age distribution of the commercial halibut catch for 2014. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2014: 83.
Stewart, I.J. 2015. Overview of data sources for the Pacific halibut stock assessment and related analyses. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2014:107.

26

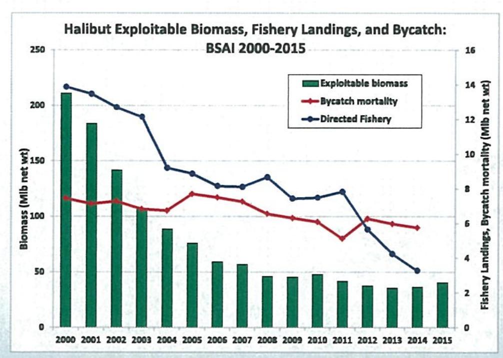
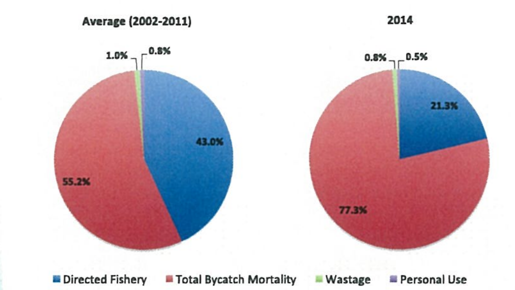


Figure 7. Halibut exploitable biomass, fishery landings, and bycatch mortality for the BSAI region, 2000-2015.

Leaman et al. 2015. Considerations Concerning Bycatch Control and Abundance based Prohibited Species Catch Limits for Pacific Halibut in the Bering Sea/Aleutian Islands. Int. Pac. Halibut Comm.

Comparison of Total Halibut Removals in Area 4CDE



- 2002-2011 is the 10-yr period of time prior to sharp reductions in directed fishery catch limits
- The distribution of removals has changed significantly since 2011
- Bycatch mortality now comprises the bulk of the removals in Area 4CDE

Sources: IPHC. 2015. Total and Fishery CEY and removals by Areas, 1995-2014 Retrieved from http://www.iphc.int/meetings/2015am/bb/02_06_TotalandFisheryCEYandRemovals.pdf
IPHC. 2015. IPHC Annual Meeting Handout: 240

~~[scribble]~~
Robert Savage
P. 6 # 5

A prudent man could not except as practicable to drop the halibut fishery in 4cde from 3.7 million lbs. to 550,000 lbs. in order to facilitate the flathead and arrowtooth fishery, nither is endangering the livelyhoods of American fisherman to improve the diets of Chinese consumers.

Coastal communitys, protected by the

magneson/stevens act have been divestated by dragger bi-catch. Native user groups are the first group to axcess halibut by virtue of the trust responsibility at the end of the fir seal fishery. Dramatic reallocation of halibut from the directed fishery to bi-catch has brought the Alaskan way of life to a stand still.

Bi-catchers own not one pound of halibut, but contend that their bi-catch comes first, it's the other way around. The 80 fleet, interlopers in a limited entry fishery, speck of the impact on their new comer investers and crews; they have buildt their lives on the backs of American halibut stake holders. Just remember that castles

made of sand drift into the sea eventualy.

Mark fena is right “drag coop’s have no chair at the ICHP meetings because they don’t have halibut quota to fish, until they can work that out, they need to stay tied to the boards. If they want to fish halibut they need to buy quota to do so, I want 1.5 million for mine.

Unlimited bi-catch is left over policy from the days that n.o.o.a was trying to encourage drag boat investment after fleets were kicked out of the donut hole; now that the drag fleet is 3 times overcalitalized, delivering fish for 50 cents a pound, it,s up to this body to cut back the drag fleet by any means necessary.

100% video coverage belongs on board all bottom and midwater fleets. Everyone knows that these sectors are responsible for bi-catching halibut and salmon stocks, let's stop kidding ourselves,it's time to cut psc's to the quick and make bi-catch percentages equal to directed fishery reductions.

The Japanese fishery complex has plans to make drag fish the only ground fish on the table, it's the market they are after, they have been successful up to now, if this body does not drop bi-catch by 50 %, the 4cde fishery will be gone.

Shore based processors, local businesses and coastal communitys infrastructures

have deteriorated in the last 12 years of my involvement.

With halibut futures being shoved over the side, bi-catch is replacing local economys with high seas tramper deliverys, benefiting the few at the expense of the Alaskan way of life.

Recruitment is the issue, not only for the halibut resource, but also for next

generations of western Alaskan native villages and coastal communitys. If wanton waste can be eliminated, so can the social problems of the native villages. Depression can be combated with a vibrant halibut fishery, to retain the hunter/fisher culture of Alaska's first user group.

Robert w Savage

4c fisherman

Paul Olson D.6 #6

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Magnuson-Steven Act Context: History of Halibut bycatch

- In 1976, Congress enacted the Magnuson-Stevens Act to conserve U.S. fishery resources and particularly to protect them from the foreign groundfish fleets.
- Overall coastwide halibut PSC again rose to alarming levels by the early 1990s.
- In 1996, Congress amended the Magnuson-Stevens Act in order to require that councils reduce the amount of bycatch in every fishery. The bycatch minimization requirements set forth in National Standard 9 explicitly targeted the Bering Sea trawl fisheries.
- The pre-SFA BSAI trawl limit has cumulatively been reduced by roughly 8% through Amendment 21 (2000) and Amendment 80 over the past 20 years.

National Standard 9

- Economic impacts are just "one of the factors that determine the extent to which it is practicable to reduce bycatch ... in a particular fishery."
- The determination of whether a measure "minimizes bycatch or bycatch mortality to the extent practicable" involves consideration of multiple factors - population effects for the bycatch species, changes in the economic, social or cultural value of fishing activities and nonconsumptive uses of fishery resources, and social effects. The NS-9 guidelines require Councils to adhere to the precautionary approach when faced with uncertainty regarding these factors. The precautionary approach provides that "[t]he absence of scientific information should not be used as a reason for postponing or failing to take measures to conserve ... non-target species and their environment."
- Relevant biological criteria include "population effects" under the NS-9 guidelines, and consideration of changes in halibut biomass and stock condition and potential impacts on halibut stocks and fisheries under the FMP. The NS-9 guidelines identify a particular concern about bycatch of juvenile fish.
- The NS-9 guidelines contemplate an "optimum level" population threshold for the halibut resource, and contemplate limiting bycatch well below a threshold at which there is a risk of precipitating or contributing to a decline.

National Standards 4 and 8

- National Standards 4 and 8 reflect the conservation goals of the Magnuson-Stevens Act. The MSA defines conservation broadly:

  The term "conservation and management" refers to all of the rules, regulations, conditions, methods and other measures which (A) are required to rebuild, restore, or maintain, and which are useful in *rebuilding, restoring, or maintaining*, any fishery resource and the marine environment; and (B) which are designed to assure that—

  (i) A supply of food and other products may be taken, and that recreational benefits may be obtained, on a continuing basis;

  (ii) Irreversible or long-term adverse effects on fishery resources and the marine environment are avoided; and

  (iii) There will be a multiplicity of options available with respect to future uses of these resources.

- NS 4 requires that measures be "[r]easonably calculated to promote conservation."
- NS 8 requires that Councils consider the importance of fishery resources to fishing communities "within the contexts of the conservation requirements of the Magnuson-Stevens Act" and thus measures "must not compromise the achievement of conservation requirements and goals of the FMP."
- When there are two alternatives that achieve similar conservation goals, the alternative that provides for sustained participation of communities and minimizes adverse economic impacts is preferred.
- NS 8's requirement that conservation and management measures take into account the sustained participation and adverse economic impacts to fishing communities "implies the maintenance of continued access to fishery resources in general by the community."
- The NS-8 guidelines explain "any particular management measure may economically benefit some communities while adversely affecting others."
- Sustained participation means continued access to the resource, within the constraints of the condition of the resource".
- A "fishing community" is one "that is substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet *social* and economic needs."