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<b>TECHNICAL MEMORANDUM</b>
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DATE: December 18, 2013

TO: Bering Sea Crab Industry

FROM: Scott Goodman

SUBJECT: Potential changes in TAC related to smaller retained male sizes of *bairdi* Tanner crab

To interested parties:

This technical memo is provided to inform Bering Sea crab industry members that have asked for help understanding how potential changes in smaller size male *bairdi* retention could influence the calculations for TAC in the Eastern and Western Bering Sea Tanner crab districts. This document was prepared independently but is based on methods that were drawn from the current Alaska Department of Fish & Game (ADF&G) *bairdi* Tanner crab harvest strategy, results from the NMFS 2013 summer survey, and information from the current Eastern Bering Sea (EBS) Tanner crab stock assessment model. The summaries provided here reproduce the actual TACs and then proceed to calculate results from hypothetical scenarios with smaller retention targets for *bairdi* males. Results from the hypothetical scenarios have been reviewed by NMFS and ADF&G but do not represent either agency's endorsement or policy.

## **INTRODUCTION**

The management of EBS *bairdi* Tanner crab is done jointly between ADF&G and NMFS where a number of regulations, status levels, and data sources are considered and selected for use. Models, survey results and harvest strategy regulations are the key elements used to determine if a fishery will open and what the TAC will be. The NPFMC recently approved the Tanner crab stock assessment model and EBS Tanner crab moved from Tier 4 to Tier 3 status with some influence on management. NMFS summer survey data is a key component in the Tanner crab assessment and has shown a relatively stable trend of Tanner crab male abundance over the last few years during closed seasons, and an increase in abundance was evident in both Eastern *bairdi* Tanner (EBT) and Western *bairdi* Tanner (WBT) in the 2013 summer survey. Since the last open fishery, ADF&G adopted new regulations for the minimum retention size of male Tanner crab and also, approved new harvest strategy regulations. ADF&G and NMFS are aware of a mismatch between assessment and management for EBS Tanner crab in that the stock assessment model treats the stock as one stock and the fishery is managed as two stocks – east and west. This mismatch confounds the selection of some data for use and consequently, the ADF&G harvest strategy methods and TAC calculations rely on data drawn from both the survey directly and some information from the model.

Currently, the EBT and WBT crab seasons are both open for the first time in four years. At the Crab Plan Team in September 2013, the stock in both districts was determined to have likely reached the threshold to open the fishery for the current season. Before the official announcement of TAC later in October, there was an interest expressed by industry to consider the apparent potential of how retaining smaller size male Tanner crab would influence TAC. The summaries presented here have been revised twice to reflect a more accurate relationship between TAC and retained sizes of male *bairdi*. Methods shown below start with a description of tables showing the

actual TAC for both EBT and WBT, followed by the varying retained size scenarios.

## **METHODS**

A starting point to be certain the application of the harvest strategy was done correctly was to reproduce the EBT and WBT TACs that were announced by ADF&G. The ADF&G harvest strategy as applied to 2013 EBS Tanner crab was presented to the public in Seattle, on October 11, 2013 (D. Pengilly). Spreadsheets from several of the slides in that presentation were provided and these were modified to incorporate other aspects of the harvest strategy. The methods for computing the actual TACs were verified and reviewed, and different replicates were created in the same spreadsheet that applied the different retained sizes for male *bairdi*. The replicate tables were based on hypothetical shifts in the fishery selectivity curves – which corresponded to reduced retained male *bairdi* sizes. It was determined that shifts in selectivity would also correspond to new values of  $F_{OFL}$  (the fishing mortality associated with the Overfishing Level). The EBS Tanner crab stock assessment author provided the varying  $F_{OFL}$  values for each shifted curve and these were plugged in to give consistent results.

In brief, the spreadsheets contained the components of the harvest strategy that;

1. Reported the current mature male biomass status in relation to the long term average mature male biomass,
2. Calculated the catch biomass (at size\*) that results from fishing on the mature male biomass at the time of mating, discounted by fishery selectivity, at the full-selection fishing rate,
3. Calculated the biomass (at size\*) at the time of mating, discounted by fishery selectivity with no fishing mortality,
4. Computed the TAC, computed a maximum TAC to cap the computed result,
5. Apply a 50% reduction to the resulting TAC since no fishery was open one year prior.

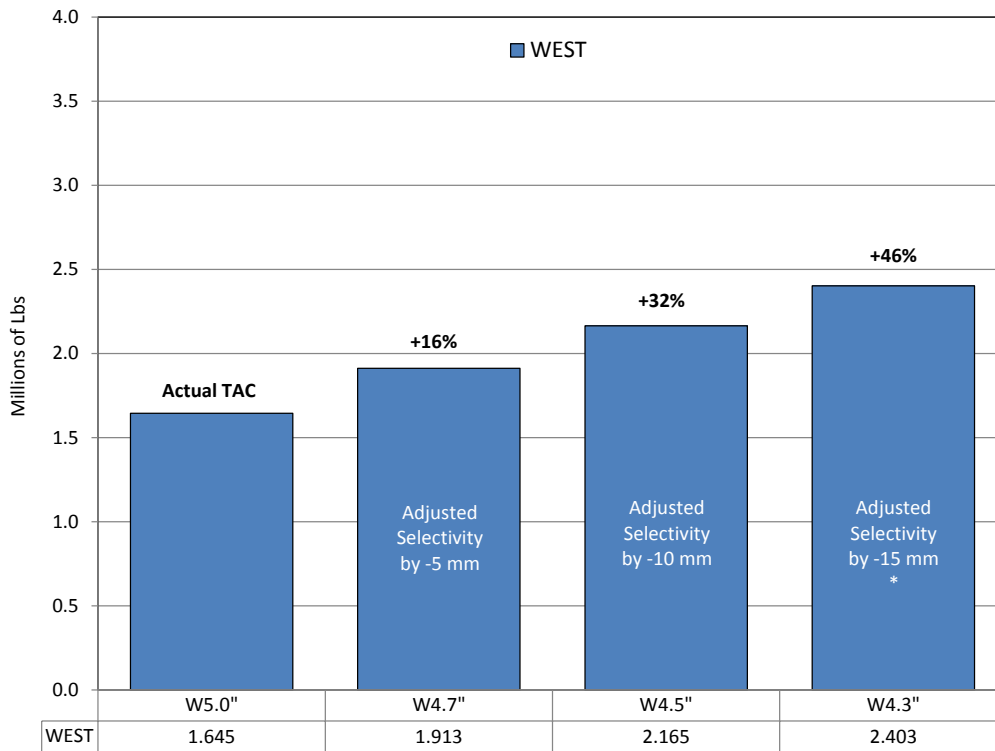
\*(at size) for EBT is 5.5" and for WBT is 5.0"

The hypotheticals were completed by applying a shifted 2009/10 fishery selectivity curve (last open fishery and the one used in the 2013 harvest strategy) by 5 mm, 10 mm and 15 mm to the left – to simulate the effect of retaining progressively smaller target sizes – and reporting the results. The changes in the  $F_{OFL}$  (decreasing) values for shifted selectivity curves were included in the calculation to account for the changing fishing pressure.

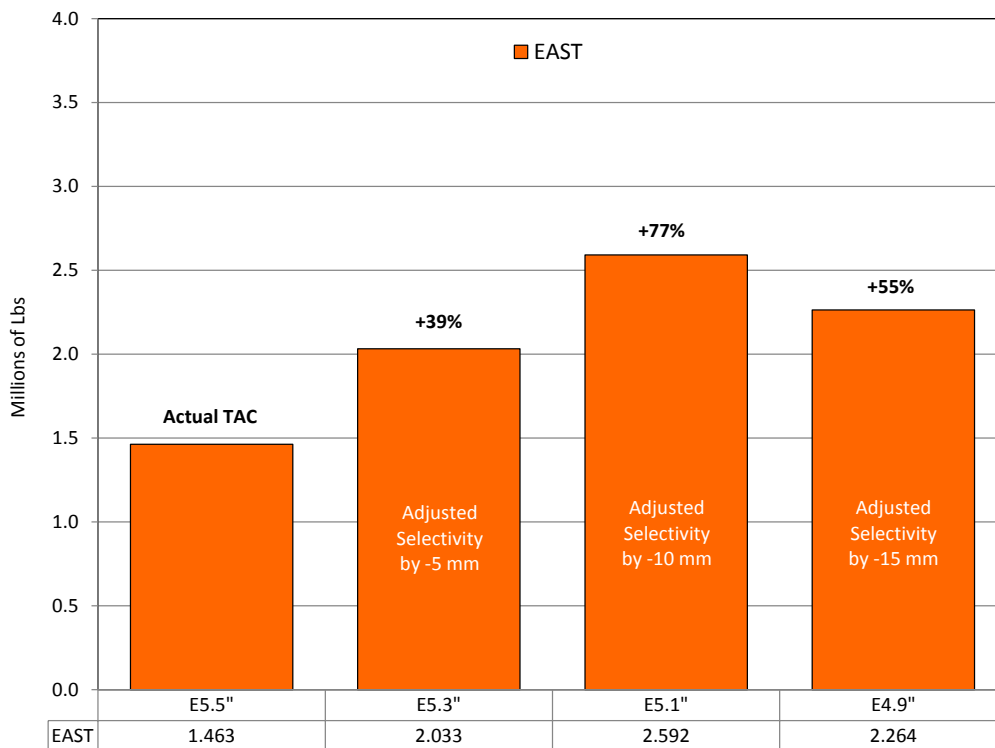
## **RESULTS**

The final results showed that the effects of smaller retained male *bairdi* crab in the EBT and WBT fisheries will have a smaller than anticipated influence on TAC calculations than first thought (+16% to +77%). The commensurate changes in  $F_{OFL}$  dampen the available biomass as the selectivity curves shift left – and in one scenario show a reduction of the TAC compared to the scenario with selectivity shifted 5 mm larger (EBT, 15 mm shift). Overall, the results prove that TAC is sensitive to small changes in the fishery selectivity curve – to the retention at size actually seen in the fishery – and there may be worthwhile incentives to consider the retention of smaller size male *bairdi* toward the legal limits. The summary below includes the resulting TAC amounts for EBT and WBT that were actual, and for hypothetical smaller retention size scenarios.

The results are reported for each district separately as the summary tables were discrete per east and west. Scenarios with size change splits less than 5 mm intervals were not able to be completed, therefore the requested scenarios differ in retained sizes slightly from those presented here – but mixed preferences can be matched up to gauge the effect of combining different size scenarios per district.



\* The scenario shifting retention by 15 mm in the West goes below the legal retained size by 0.10", this was included in the scenarios as the size categories of biomass and fishery selectivity values did not allow for a smaller size scale split than 5 mm.



## **DISCUSSION**

The initial review of smaller size retention of male *bairdi* in a given year suggested that changes in TAC could be very significant. Initial estimates were based on Tier 4 methods (no selectivity discounting) and compared actual TAC total for EBT and WBT of slightly over 3 million lbs to hypothetical TACs ranging from about 10-12 million lbs for both districts together. Regardless of direct use of survey data, the Tier 3 status of the stock required that selectivity needed to be applied as a discounting factor. A second revision lowered the scenario results (4-8 million lbs) but was determined to be inaccurate as it assumed a static  $F_{OFL}$  value of 0.73. Once the lower  $F_{OFL}$  values were considered, the resulting scenarios decreased further. The full details from the results tables per scenario are attached.

The shifts in hypothetical selectivity were plotted with the actual 2009/10 fishery selectivity curves – and overlain with a biomass size frequency distribution, that showed the split in the biomass that was included for TAC consideration. These curves show strong shifts from the 2009/10 actuals but are more similar to prior fishery (before 2009/10) actual fishery selectivity curves (see attached). The outcomes that may be most important to consider will be to review what the actual retained selectivity curves look like from this season's fishery – which would likely be applied to the process of computing TAC for the next season.

Importantly, the results presented here are only based on applying the assessment process steps and harvest strategy steps within one year. No consideration has been included here regarding changes in yield over time that may result from actual shifts downward in retained male sizes. Further, results presented have not addressed any economic consideration that may result from harvesting and processing smaller sized Tanner crab.

## **ATTACHMENTS**

TAC calculation sheets

Fishery selectivity curves plotted with size frequency biomass

**ACTUAL TAC, 2009/10 Selectivity, FOFL = 0.73**

This is the TAC summary calculations that match the numbers and methods presented by D. Pengilly for the 2013/14 bairdi fishery. The male size bins below are 5mm with the exception of the first size bin included in the summary (138-139) which was done to match up with the current harvest strategy calculations of  $C_{E,MSY}$  and  $C_{E,0}$  at 5.5".

Computing  $C_{E,MSY}$

Male Size Group	A @ Survey Biomass	B +0.625 yr (M=0.25) Biomass	C Fishery Selectivity	D (1-exp(-Fofl)) (Fofl = 0.73)	MSY catch = B*C*D
110-114	18,867,463	16,138,196	0.0000	0.51809101	0
115-119	25,342,764	21,676,815	0.0000	0.51809101	0
120-124	21,203,440	18,136,264	0.0000	0.51809101	0
125-129	10,888,706	9,313,604	0.0000	0.51809101	25
130-134	6,462,579	5,527,737	0.0012	0.51809101	3,493
<b>138-139</b>	<b>1,349,980</b>	<b>1,154,699</b>	<b>0.1752</b>	<b>0.51809101</b>	<b>104,837</b>
140-144	3,772,891	3,227,125	0.6265	0.51809101	1,047,473
145-149	2,743,235	2,346,413	0.7142	0.51809101	868,248
150-154	1,780,744	1,523,151	0.7799	0.51809101	615,444
155-159	442,832	378,774	0.8394	0.51809101	164,729
160-164	663,814	567,790	0.8937	0.51809101	262,888
165-169	230,086	196,803	0.9380	0.51809101	95,642
170-174	87,139	74,534	0.9693	0.51809101	37,431
175-179	0	0	0.9888	0.51809101	0
180-184	124,292	106,313	1.0000	0.51809101	55,080
185+	0	0	1.0000	0.51809101	0
<b>Total</b>	<b>11,195,013</b>	<b>9,575,602</b>	<b>-</b>	<b>-</b>	<b>3,251,771</b>

Computing  $C_{E,0}$

Male Size Group	A @ Survey Biomass	B +0.625 yr (M=0.25) Biomass	C Fishery Selectivity	Biomass w/o fishing discounted by fishery selectivity (B*C)
110-114	18,867,463	16,138,196	0.0000	0
115-119	25,342,764	21,676,815	0.0000	0
120-124	21,203,440	18,136,264	0.0000	0
125-129	10,888,706	9,313,604	0.0000	48
130-134	6,462,579	5,527,737	0.0012	6,743
<b>138-139</b>	<b>1,349,980</b>	<b>1,154,699</b>	<b>0.1752</b>	<b>202,352</b>
140-144	3,772,891	3,227,125	0.6265	2,021,794
145-149	2,743,230	2,346,409	0.7142	1,675,857
150-154	1,780,741	1,523,148	0.7799	1,187,905
155-159	442,831	378,773	0.8394	317,953
160-164	663,813	567,789	0.8937	507,415
165-169	230,085	196,803	0.9380	184,604
170-174	87,139	74,534	0.9693	72,248
175-179	0	0	0.9888	0
180-184	124,292	106,312	1.0000	106,312
185+	0	0	1.0000	0
<b>Total</b>	<b>11,195,001</b>	<b>9,575,592</b>	<b>-</b>	<b>6,276,439</b>

	fixed factor 1	$B_E / B_{E,AVG}$ factor 2	$C_{E,MSY}$ factor 3	TAC product
TAC	0.9	1.0	3.252	2.927
	$\leq 50\% C_{E,0}$ factor 1	$C_{E,0}$ factor 2		MAX TAC product
MAX TAC	0.5	6.276		3.138
	50% TAC no fish $Y_{-1}$ factor 1	TAC factor 2		FINAL TAC product
FINAL TAC	0.5	2.927		1.463



**Selectivity 5 mm Adjusted, FOFL = 0.5788**

This is the TAC summary calculations that differ from actuals by adding the male crab biomass in the 135-139 mm size category and adjusting the selectivity curve applied values by 5 mm (curve shifted to left). This change accounts for about a 39% increase in the FINAL TAC calculation.

Computing  $C_{E,MSY}$

Male Size Group	A @ Survey Biomass	B +0.625 yr (M=0.25) Biomass	C Fishery Selectivity	D (1-exp(-F <sub>off</sub> )) (F <sub>off</sub> = 0.5788)	MSY catch = B*C*D
110-114	18,867,463	16,138,196	0.0000	0.439429352	0
115-119	25,342,764	21,676,815	0.0000	0.439429352	0
120-124	21,203,440	18,136,264	0.0000	0.439429352	41
125-129	10,888,706	9,313,604	0.0012	0.439429352	4,992
130-134	6,462,579	5,527,737	0.1752	0.439429352	425,672
135-139	4,961,139	4,243,487	0.6265	0.439429352	1,168,242
140-144	3,772,891	3,227,125	0.7142	0.439429352	1,012,833
145-149	2,743,235	2,346,413	0.7799	0.439429352	804,143
150-154	1,780,744	1,523,151	0.8394	0.439429352	561,844
155-159	442,832	378,774	0.8937	0.439429352	148,746
160-164	663,814	567,790	0.9380	0.439429352	234,038
165-169	230,086	196,803	0.9693	0.439429352	83,829
170-174	87,139	74,534	0.9888	0.439429352	32,387
175-179	0	0	1.0000	0.439429352	0
180-184	124,292	106,313	1.0000	0.439429352	46,717
185+	0	0	1.0000	0.439429352	0
<b>Total</b>	<b>21,268,751</b>	<b>18,192,127</b>	<b>-</b>	<b>-</b>	<b>4,518,451</b>

Computing  $C_{E,0}$

Male Size Group	A @ Survey Biomass	B +0.625 yr (M=0.25) Biomass	C Fishery Selectivity	Biomass w/o fishing discounted by fishery selectivity (B*C)
110-114	18,867,463	16,138,196	0.0000	0
115-119	25,342,764	21,676,815	0.0000	0
120-124	21,203,440	18,136,264	0.0000	93
125-129	10,888,706	9,313,604	0.0012	11,360
130-134	6,462,579	5,527,737	0.1752	968,692
135-139	4,961,139	4,243,487	0.6265	2,658,544
140-144	3,772,891	3,227,125	0.7142	2,304,883
145-149	2,743,235	2,346,409	0.7799	1,829,967
150-154	1,780,741	1,523,148	0.8394	1,278,575
155-159	442,831	378,773	0.8937	338,498
160-164	663,813	567,789	0.9380	532,594
165-169	230,085	196,803	0.9693	190,767
170-174	87,139	74,534	0.9888	73,702
175-179	0	0	1.0000	0
180-184	124,292	106,312	1.0000	106,312
185+	0	0	1.0000	0
<b>Total</b>	<b>21,268,739</b>	<b>18,192,116</b>	<b>-</b>	<b>10,282,534</b>

	fixed factor 1	$B_E / B_{E,AVG}$ factor 2	$C_{E,MSY}$ factor 3	TAC product
TAC	0.9	1.0	4.518	4.067
	$\leq 50\% C_{E,0}$ factor 1	$C_{E,0}$ factor 2		MAX TAC product
MAX TAC	0.5	10.283		5.141
	50% TAC no fish $Y_{-1}$ factor 1	TAC factor 2		FINAL TAC product
FINAL TAC	0.5	4.067		2.033

**Selectivity 10 mm Adjusted, FOFL = 0.4742**

This is the TAC summary calculations that differ from actuals by adding the male crab biomass in the 135-139 mm size category and adjusting the selectivity curve applied values by 10 mm (curve shifted to left). This change accounts for about a 77% increase in the FINAL TAC calculation.

Computing  $C_{E,MSY}$

Male Size Group	A @ Survey Biomass	B +0.625 yr (M=0.25) Biomass	C Fishery Selectivity	D (1-exp(-Fofl)) (Fofl = 0.4742)	MSY catch = B*C*D
110-114	18,867,463	16,138,196	0.0000	0.377617236	0
115-119	25,342,764	21,676,815	0.0000	0.377617236	42
120-124	21,203,440	18,136,264	0.0012	0.377617236	8,354
125-129	10,888,706	9,313,604	0.1752	0.377617236	616,322
130-134	6,462,579	5,527,737	0.6265	0.377617236	1,307,736
135-139	4,961,139	4,243,487	0.7142	0.377617236	1,144,479
140-144	3,772,891	3,227,125	0.7799	0.377617236	950,401
145-149	2,743,235	2,346,413	0.8394	0.377617236	743,773
150-154	1,780,744	1,523,151	0.8937	0.377617236	514,010
155-159	442,832	378,774	0.9380	0.377617236	134,166
160-164	663,814	567,790	0.9693	0.377617236	207,831
165-169	230,086	196,803	0.9888	0.377617236	73,487
170-174	87,139	74,534	1.0000	0.377617236	28,145
175-179	0	0	1.0000	0.377617236	0
180-184	124,292	106,313	1.0000	0.377617236	40,146
185+	0	0	1.0000	0.377617236	0
<b>Total</b>	<b>32,157,457</b>	<b>27,505,730</b>	<b>-</b>	<b>-</b>	<b>5,760,497</b>

Computing  $C_{E,0}$

Male Size Group	A @ Survey Biomass	B +0.625 yr (M=0.25) Biomass	C Fishery Selectivity	Biomass w/o fishing discounted by fishery selectivity (B*C)
110-114	18,867,463	16,138,196	0.0000	0
115-119	25,342,764	21,676,815	0.0000	112
120-124	21,203,440	18,136,264	0.0012	22,122
125-129	10,888,706	9,313,604	0.1752	1,632,135
130-134	6,462,579	5,527,737	0.6265	3,463,127
135-139	4,961,139	4,243,487	0.7142	3,030,792
140-144	3,772,891	3,227,125	0.7799	2,516,838
145-149	2,743,235	2,346,409	0.8394	1,969,644
150-154	1,780,741	1,523,148	0.8937	1,361,190
155-159	442,831	378,773	0.9380	355,295
160-164	663,813	567,789	0.9693	550,375
165-169	230,085	196,803	0.9888	194,606
170-174	87,139	74,534	1.0000	74,534
175-179	0	0	1.0000	0
180-184	124,292	106,312	1.0000	106,312
185+	0	0	1.0000	0
<b>Total</b>	<b>32,157,445</b>	<b>27,505,720</b>	<b>-</b>	<b>15,254,847</b>

	fixed factor 1	$B_E / B_{E,AVG}$ factor 2	$C_{E,MSY}$ factor 3	TAC product
TAC	0.9	1.0	5.760	5.184
	$\leq 50\% C_{E,0}$ factor 1	$C_{E,0}$ factor 2		MAX TAC product
MAX TAC	0.5	15.255		7.627
	50% TAC no fish $Y_{-1}$ factor 1	TAC factor 2		FINAL TAC product
FINAL TAC	0.5	5.184		2.592

**Selectivity 15 mm Adjusted, FOFL = 0.3995**

This is the TAC summary calculations that differ from actuals by adding the male crab biomass in the 135-139 mm size category and adjusting the selectivity curve applied values by 15 mm (curve shifted to left). This change accounts for about a 54% increase in the FINAL TAC calculation, and is less than the calculated TAC for the 10 mm adjustment.

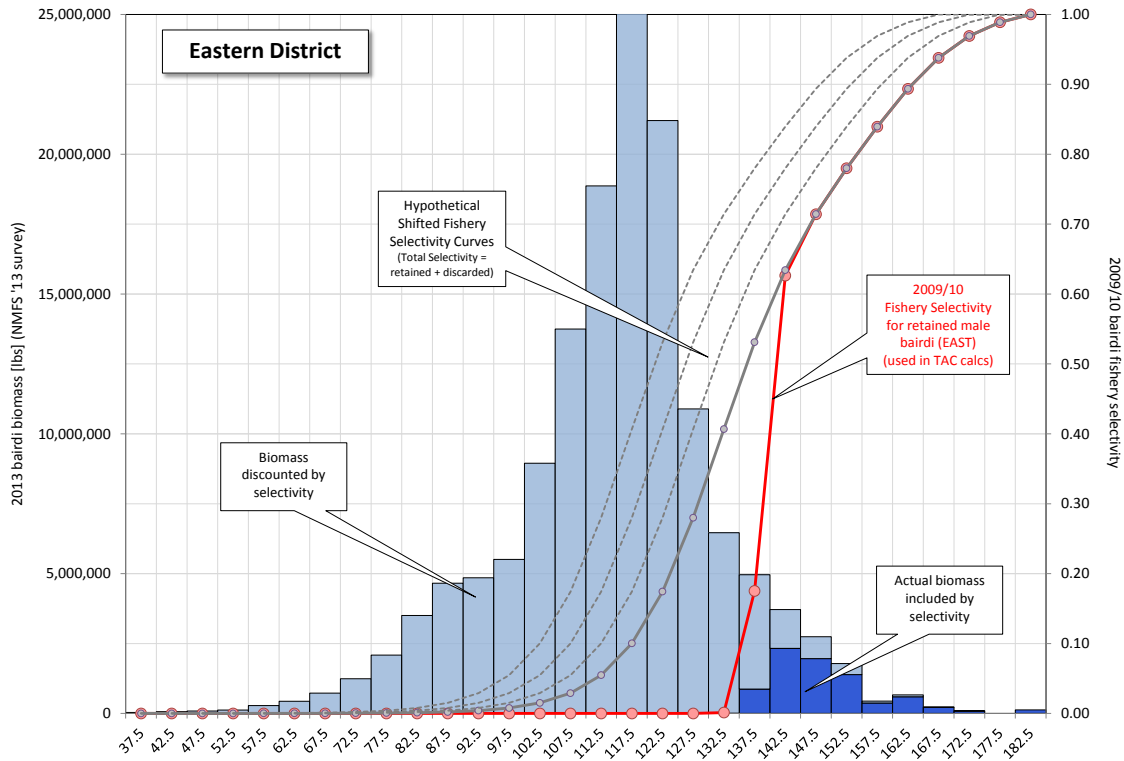
Computing  $C_{E,MSY}$

Male Size Group	A @ Survey Biomass	B +0.625 yr (M=0.25) Biomass	C Fishery Selectivity	D (1-exp(-F <sub>0fl</sub> )) (F <sub>0fl</sub> = 0.3995)	MSY catch = B*C*D
110-114	18,867,463	16,138,196	0.0000	0.32934471	0
115-119	25,342,764	21,676,815	0.0000	0.32934471	37
120-124	21,203,440	18,136,264	0.0012	0.32934471	7,286
125-129	10,888,706	9,313,604	0.1752	0.32934471	537,535
130-134	6,462,579	5,527,737	0.6265	0.32934471	1,140,563
135-139	4,961,139	4,243,487	0.7142	0.32934471	998,175
140-144	3,772,891	3,227,125	0.7799	0.32934471	828,907
145-149	2,743,235	2,346,413	0.8394	0.32934471	648,693
150-154	1,780,744	1,523,151	0.8937	0.32934471	448,302
155-159	442,832	378,774	0.9380	0.32934471	117,015
160-164	663,814	567,790	0.9693	0.32934471	181,263
165-169	230,086	196,803	0.9888	0.32934471	64,093
170-174	87,139	74,534	1.0000	0.32934471	24,547
175-179	0	0	1.0000	0.32934471	0
180-184	124,292	106,313	1.0000	0.32934471	35,014
185+	0	0	1.0000	0.32934471	0
<b>Total</b>	<b>53,360,897</b>	<b>45,641,994</b>	<b>-</b>	<b>-</b>	<b>5,031,392</b>

Computing  $C_{E,0}$

Male Size Group	A @ Survey Biomass	B +0.625 yr (M=0.25) Biomass	C Fishery Selectivity	Biomass w/o fishing discounted by fishery selectivity (B*C)
110-114	18,867,463	16,138,196	0.0000	0
115-119	25,342,764	21,676,815	0.0000	112
120-124	21,203,440	18,136,264	0.0012	22,122
125-129	10,888,706	9,313,604	0.1752	1,632,135
130-134	6,462,579	5,527,737	0.6265	3,463,127
135-139	4,961,139	4,243,487	0.7142	3,030,792
140-144	3,772,891	3,227,125	0.7799	2,516,838
145-149	2,743,230	2,346,409	0.8394	1,969,644
150-154	1,780,741	1,523,148	0.8937	1,361,190
155-159	442,831	378,773	0.9380	355,295
160-164	663,813	567,789	0.9693	550,375
165-169	230,085	196,803	0.9888	194,606
170-174	87,139	74,534	1.0000	74,534
175-179	0	0	1.0000	0
180-184	124,292	106,312	1.0000	106,312
185+	0	0	1.0000	0
<b>Total</b>	<b>53,360,885</b>	<b>45,641,983</b>	<b>-</b>	<b>15,276,969</b>

	fixed factor 1	$B_E / B_{E,AVG}$ factor 2	$C_{E,MSY}$ factor 3	TAC product
TAC	0.9	1.0	5.031	4.528
	$\leq 50\% C_{E,0}$ factor 1	$C_{E,0}$ factor 2		MAX TAC product
MAX TAC	0.5	15.277		7.638
	50% TAC no fish $Y_{-1}$ factor 1	TAC factor 2		FINAL TAC product
FINAL TAC	0.5	4.528		2.264



Note: The frequency distribution above is Eastern District NMFS survey total male *bairdi* biomass. The light blue and dark blue bars are the total survey biomass at each size category split by the 2009/10 retention curve at that size (i.e. the light blue bars represent the proportion of the survey biomass that is not retained and the dark blue bars represent the proportion of the survey biomass that is retained).

**ACTUAL TAC, 2009/10 Selectivity, FOFL = 0.73**

This is the TAC summary calculations that match the numbers and methods presented by D. Pengilly for the 2013/14 bairdi fishery.

Computing  $C_{w,MSY}$

	A	B	C	D	
	@ Survey	+0.625 yr (M=0.25)	Fishery	(1-exp(-Fofl))	MSY catch =
Size Group	Male total Biomass	Biomass	Selectivity (Fofl = 0.73)	B*C*D	
110-114	5,987,866	5,121,693	0.0000	0.518091	0
115-119	5,894,944	5,042,213	0.0000	0.518091	13
120-124	5,365,224	4,589,119	0.0012	0.518091	2,900
125-129	5,217,597	4,462,847	0.1752	0.518091	405,188
130-134	3,876,648	3,315,872	0.4067	0.518091	698,613
135-139	2,400,570	2,053,316	0.5310	0.518091	564,862
140-144	2,459,377	2,103,616	0.6343	0.518091	691,265
145-149	1,324,087	1,132,552	0.7143	0.518091	419,112
150-154	970,814	830,381	0.7799	0.518091	335,524
155-159	492,969	421,659	0.8394	0.518091	183,380
160-164	1,301,724	1,113,424	0.8937	0.518091	515,517
165-169	244,701	209,304	0.9380	0.518091	101,717
170-174	92,830	79,402	0.9693	0.518091	39,876
175-179	0	0	0.9888	0.518091	0
180+	0	0	1.0000	0.518091	0
<b>Total</b>	<b>18,381,316</b>	<b>15,722,373</b>	<b>-</b>	<b>-</b>	<b>3,955,053</b>

Computing  $C_{w,0}$

	A	B	C	Biomass w/o fishing	
	@ Survey	+0.625 yr (M=0.25)	Fishery	discounted by	
Size Group	Male total Biomass	Biomass	Selectivity	fishery selectivity (B*C)	
110-114	5,987,866	5,121,693	0.0000	0.0000	0
115-119	5,894,944	5,042,213	0.0000	0.0000	26
120-124	5,365,224	4,589,119	0.0012	0.0012	5,598
125-129	5,217,597	4,462,847	0.1752	0.1752	782,078
130-134	3,876,648	3,315,872	0.4067	0.4067	1,348,436
135-139	2,400,570	2,053,316	0.5310	0.5310	1,090,276
140-144	2,459,377	2,103,616	0.6343	0.6343	1,334,254
145-149	1,324,087	1,132,552	0.7143	0.7143	808,955
150-154	970,814	830,381	0.7799	0.7799	647,615
155-159	492,969	421,659	0.8394	0.8394	353,953
160-164	1,301,724	1,113,424	0.8937	0.8937	995,032
165-169	244,701	209,304	0.9380	0.9380	196,330
170-174	92,830	79,402	0.9693	0.9693	76,966
175-179	0	0	0.9888	0.9888	0
180+	0	0	1.0000	1.0000	0
<b>Total</b>	<b>18,381,316</b>	<b>15,722,373</b>	<b>-</b>	<b>-</b>	<b>7,633,896</b>

	fixed	$B_w / B_{w,AVG}$	$C_{E,MSY}$	TAC
	factor 1	factor 2	factor 3	product
TAC	0.9	0.92	3.955	3.290
	$\leq 50\% C_{E,0}$	$C_{w,0}$		MAX TAC
	factor 1	factor 2		product
MAX TAC	0.5	7.634		3.817
	50% TAC	TAC		FINAL TAC
	no fish $Y_{-1}$			product
	factor 1	factor 2		
FINAL TAC	0.5	3.290		1.645

**Selectivity 5 mm Adjusted, FOFL = 0.5788**

This is the TAC summary calculations that differ from actuals by adjusting the selectivity curve applied values by 5 mm (curve shifted to left). This change accounts for about a 16% increase in the FINAL TAC calculation.

Computing  $C_{W,MSY}$

	A	B	C	D	
	@ Survey	+0.625 yr (M=0.25)	Fishery	(1-exp(-Fofl))	MSY catch =
Size Group	Male total Biomass	Biomass	Selectivity (Folf = 0.5788)		B*C*D
110-114	5,987,866	5,121,693	0.0000	0.439429352	12
115-119	5,894,944	5,042,213	0.0012	0.439429352	2,703
120-124	5,365,224	4,589,119	0.1752	0.439429352	353,392
125-129	5,217,597	4,462,847	0.4067	0.439429352	797,505
130-134	3,876,648	3,315,872	0.5310	0.439429352	773,691
135-139	2,400,570	2,053,316	0.6343	0.439429352	572,291
140-144	2,459,377	2,103,616	0.7143	0.439429352	660,270
145-149	1,324,087	1,132,552	0.7799	0.439429352	388,138
150-154	970,814	830,381	0.8394	0.439429352	306,302
155-159	492,969	421,659	0.8937	0.439429352	165,587
160-164	1,301,724	1,113,424	0.9380	0.439429352	458,943
165-169	244,701	209,304	0.9693	0.439429352	89,153
170-174	92,830	79,402	0.9888	0.439429352	34,502
175-179	0	0	1.0000	0.439429352	0
180+	0	0	1.0000	0.439429352	0
<b>Total</b>	<b>23,746,540</b>	<b>20,311,492</b>	-	-	<b>4,599,776</b>

Computing  $C_{W,0}$

	A	B	C	Biomass w/o fishing
	@ Survey	+0.625 yr (M=0.25)	Fishery	discounted by
Size Group	Male total Biomass	Biomass	Selectivity	fishery selectivity (B*C)
110-114	5,987,866	5,121,693	0.0000	26
115-119	5,894,944	5,042,213	0.0012	6,150
120-124	5,365,224	4,589,119	0.1752	804,206
125-129	5,217,597	4,462,847	0.4067	1,814,866
130-134	3,876,648	3,315,872	0.5310	1,760,672
135-139	2,400,570	2,053,316	0.6343	1,302,351
140-144	2,459,377	2,103,616	0.7143	1,502,563
145-149	1,324,087	1,132,552	0.7799	883,278
150-154	970,814	830,381	0.8394	697,046
155-159	492,969	421,659	0.8937	376,823
160-164	1,301,724	1,113,424	0.9380	1,044,407
165-169	244,701	209,304	0.9693	202,885
170-174	92,830	79,402	0.9888	78,515
175-179	0	0	1.0000	0
180+	0	0	1.0000	0
<b>Total</b>	<b>23,746,540</b>	<b>20,311,492</b>	-	<b>10,467,612</b>

	fixed	$B_W / B_{W,AVG}$	$C_{E,MSY}$	TAC
	factor 1	factor 2	factor 3	product
TAC	0.9	0.92	4.600	3.826
	$\leq 50\% C_{E,0}$	$C_{W,0}$		MAX TAC
	factor 1	factor 2		product
MAX TAC	0.5	10.468		5.234
	50% TAC	TAC		FINAL TAC
	no fish $Y_{-1}$			product
	factor 1	factor 2		
FINAL TAC	0.5	3.826		1.913

**Selectivity 10 mm Adjusted, FOFL = 0.4742**

This is the TAC summary calculations that differ from actuals by adjusting the selectivity curve applied values by 10 mm (curve shifted to left). This change accounts for about a 32% increase in the FINAL TAC calculation.

Computing  $C_{W,MSY}$

	A	B	C	D	
	@ Survey	+0.625 yr (M=0.25)	Fishery	(1-exp(-F <sub>ofl</sub> ))	MSY catch =
Size Group Male total	Biomass	Biomass	Selectivity (F <sub>ofl</sub> = 0.4742)		B*C*D
110-114	5,987,866	5,121,693	0.0012	0.377617236	2,359
115-119	5,894,944	5,042,213	0.1752	0.377617236	333,665
120-124	5,365,224	4,589,119	0.4067	0.377617236	704,715
125-129	5,217,597	4,462,847	0.5310	0.377617236	894,838
130-134	3,876,648	3,315,872	0.6343	0.377617236	794,185
135-139	2,400,570	2,053,316	0.7143	0.377617236	553,826
140-144	2,459,377	2,103,616	0.7799	0.377617236	619,524
145-149	1,324,087	1,132,552	0.8394	0.377617236	359,000
150-154	970,814	830,381	0.8937	0.377617236	280,224
155-159	492,969	421,659	0.9380	0.377617236	149,356
160-164	1,301,724	1,113,424	0.9693	0.377617236	407,553
165-169	244,701	209,304	0.9888	0.377617236	78,155
170-174	92,830	79,402	1.0000	0.377617236	29,983
175-179	0	0	1.0000	0.377617236	0
180+	0	0	1.0000	0.377617236	0
<b>Total</b>	<b>29,641,485</b>	<b>25,353,705</b>	-	-	<b>5,205,025</b>

Computing  $C_{W,0}$

	A	B	C	Biomass w/o fishing
	@ Survey	+0.625 yr (M=0.25)	Fishery	discounted by
Size Group Male total	Biomass	Biomass	Selectivity	fishery selectivity (B*C)
110-114	5,987,866	5,121,693	0.0012	6,247
115-119	5,894,944	5,042,213	0.1752	883,608
120-124	5,365,224	4,589,119	0.4067	1,866,216
125-129	5,217,597	4,462,847	0.5310	2,369,696
130-134	3,876,648	3,315,872	0.6343	2,103,148
135-139	2,400,570	2,053,316	0.7143	1,466,635
140-144	2,459,377	2,103,616	0.7799	1,640,613
145-149	1,324,087	1,132,552	0.8394	950,697
150-154	970,814	830,381	0.8937	742,086
155-159	492,969	421,659	0.9380	395,522
160-164	1,301,724	1,113,424	0.9693	1,079,275
165-169	244,701	209,304	0.9888	206,968
170-174	92,830	79,402	1.0000	79,402
175-179	0	0	1.0000	0
180+	0	0	1.0000	0
<b>Total</b>	<b>29,641,485</b>	<b>25,353,705</b>	-	<b>13,783,864</b>

	fixed	$B_W / B_{W,AVG}$	$C_{E,MSY}$	TAC
	factor 1	factor 2	factor 3	product
TAC	0.9	0.92	5.205	4.330
	$\leq 50\% C_{E,0}$	$C_{W,0}$		MAX TAC
	factor 1	factor 2		product
MAX TAC	0.5	13.784		6.892
	50% TAC	TAC		FINAL TAC
	no fish $Y_{-1}$			product
	factor 1	factor 2		
FINAL TAC	0.5	4.330		2.165

**Selectivity 15 mm Adjusted, FOFL = 0.3995**

This is the TAC summary calculations that differ from actuals by adjusting the selectivity curve applied values by 15 mm (curve shifted to left). This change accounts for about a 46% increase in the FINAL TAC calculation.

Computing  $C_{W,MSY}$

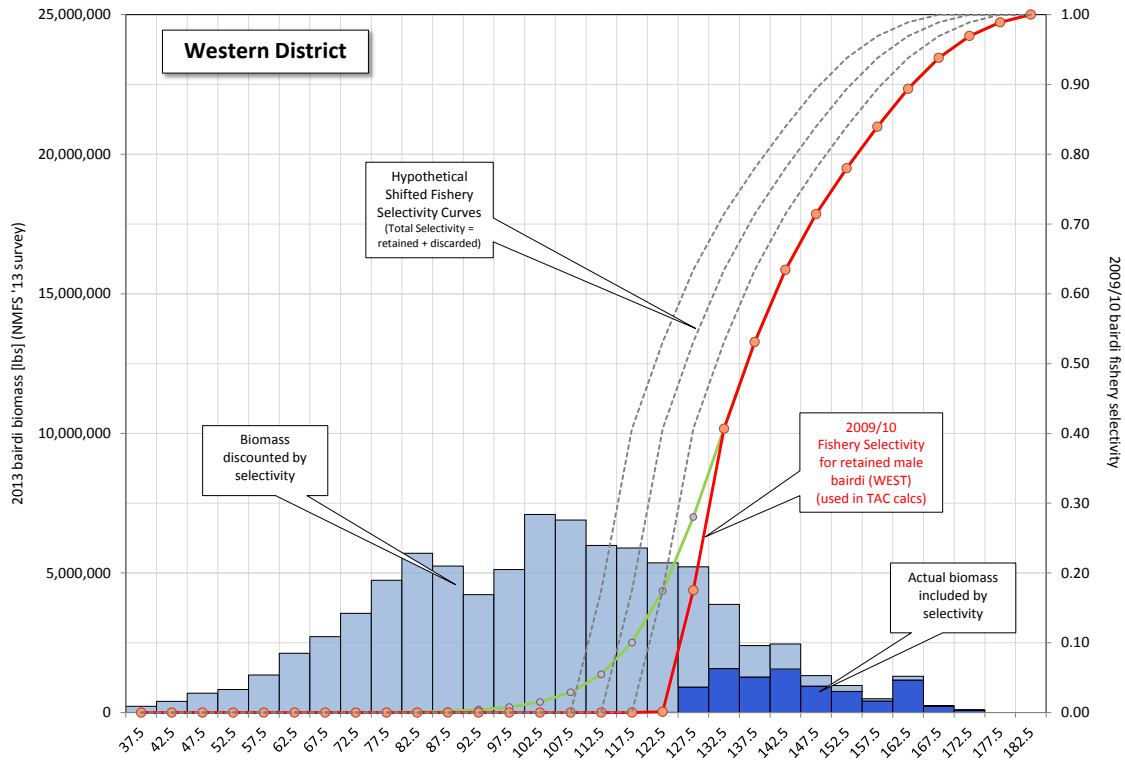
	A	B	C	D	
	@ Survey	+0.625 yr (M=0.25)	Fishery	(1-exp(-Fofl))	MSY catch =
Size Group	Male total Biomass	Biomass	Selectivity (Folf = 0.3995)		B*C*D
110-114	5,987,866	5,121,693	0.1752	0.32934471	295,599
115-119	5,894,944	5,042,213	0.4067	0.32934471	675,312
120-124	5,365,224	4,589,119	0.5310	0.32934471	802,529
125-129	5,217,597	4,462,847	0.6343	0.32934471	932,255
130-134	3,876,648	3,315,872	0.7143	0.32934471	780,036
135-139	2,400,570	2,053,316	0.7799	0.32934471	527,407
140-144	2,459,377	2,103,616	0.8394	0.32934471	581,569
145-149	1,324,087	1,132,552	0.8937	0.32934471	333,339
150-154	970,814	830,381	0.9380	0.32934471	256,530
155-159	492,969	421,659	0.9693	0.32934471	134,612
160-164	1,301,724	1,113,424	0.9888	0.32934471	362,608
165-169	244,701	209,304	1.0000	0.32934471	68,933
170-174	92,830	79,402	1.0000	0.32934471	26,150
175-179	0	0	1.0000	0.32934471	0
180+	0	0	1.0000	0.32934471	0
<b>Total</b>	<b>35,629,350</b>	<b>30,475,398</b>	<b>-</b>	<b>-</b>	<b>5,776,878</b>

Computing  $C_{W,0}$

	A	B	C	Biomass w/o fishing
	@ Survey	+0.625 yr (M=0.25)	Fishery	discounted by
Size Group	Male total Biomass	Biomass	Selectivity	fishery selectivity (B*C)
110-114	5,987,866	5,121,693	0.1752	897,536
115-119	5,894,944	5,042,213	0.4067	2,050,471
120-124	5,365,224	4,589,119	0.5310	2,436,744
125-129	5,217,597	4,462,847	0.6343	2,830,637
130-134	3,876,648	3,315,872	0.7143	2,368,448
135-139	2,400,570	2,053,316	0.7799	1,601,383
140-144	2,459,377	2,103,616	0.8394	1,765,837
145-149	1,324,087	1,132,552	0.8937	1,012,127
150-154	970,814	830,381	0.9380	778,909
155-159	492,969	421,659	0.9693	408,727
160-164	1,301,724	1,113,424	0.9888	1,100,999
165-169	244,701	209,304	1.0000	209,304
170-174	92,830	79,402	1.0000	79,402
175-179	0	0	1.0000	0
180+	0	0	1.0000	0
<b>Total</b>	<b>35,629,350</b>	<b>30,475,398</b>	<b>-</b>	<b>17,540,523</b>

	fixed factor 1	$B_W / B_{W,AVG}$ factor 2	$C_{E,MSY}$ factor 3	TAC product
TAC	0.9	0.92	5.777	4.806
	$\leq 50\% C_{E,0}$ factor 1	$C_{W,0}$ factor 2		MAX TAC product
MAX TAC	0.5	17.541		8.770
	50% TAC no fish $Y_{-1}$ factor 1	TAC factor 2		FINAL TAC product
FINAL TAC	0.5	4.806		2.403





Note: The frequency distribution above is Western District NMFS survey total male *bairdi* biomass. The light blue and dark blue bars are the total survey biomass at each size category split by the 2009/10 retention curve at that size (i.e. the light blue bars represent the proportion of the survey biomass that is not retained and the dark blue bars represent the proportion of the survey biomass that is retained).