New England Fishery Management Council
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C. M. "Rip" Cunningham, Jr., *Chairman* | Thomas A. Nies, *Executive Director*

MEMORANDUM

DATE: April 7, 2013
TO: Groundfish Oversight Committee
FROM: Groundfish Plan Development Team (PDT)
SUBJECT: **GOM Cod Status Determination Criteria**

1. The recent assessment of GOM cod (SARC 55) resulted in two assessment models, identified as the Base Case model and the Mramp model. The two models use a different assumption for natural mortality. The Base Case model uses M=0.2, and the Mramp model uses an increase in M from 0.2 to 0.4 during the time period 1989 to 2002. The SARC panel calculated the FMSY proxy based on F40% MSP and M=0.2. The panel recommended using the same overfishing reference point for projecting catches for both model formulations.

2. At the January 2013 Council meeting, the Council passed the motion shown below that tasks the PDT to provide information on the ABCs that would result from a different FMSY proxy (the PDT tasking is underlined).

> "The Council requests the NEFSC provide advice on the appropriate Gulf of Maine cod reference points for when natural mortality equals 0.40 <u>and task the PDT to provide the ABC that would result with F40% MSP and M=0.40</u>."

3. The PDT notes that the Council motion splits two issues that would be better addressed in concert. The task assigned to the PDT may appear, on the surface, to be relatively straightforward but the key question is what is the correct reference point for GOM cod when M=0.4. The argument was made at the Council that this projection was needed so that an "apples to apples" comparison could be made between the catches at F40% MSP with M=0.2 and M=0.4. *The real comparison that is important is between the catches at the appropriate F_{MSY} proxy for both assessment/projection scenarios*. If M has increased there may be other changes to stock dynamics that may influence the selection of an F_{MSY} proxy, and so a proxy based on 40%MSP may be appropriate for one model and not the other. For example, if M now equals 0.4, yield per recruit at F40% would be 80 percent lower than if M=0.2, and the age distribution of the stock will be more truncated (even in the absence of fishing mortality). That may mean the %MSP used as an FMSY proxy should differ between the two natural mortality assumptions. These same issues would apply to direct estimates of reference points. An argument can be made that when natural mortality doubles the response should not be to increase fishing mortality. If natural mortality increases then perhaps the stock's surplus production available for the fishery has decreased. This issue was not addressed by the SARC and is beyond the expertise of the PDT. This question was directed to the NEFSC. <u>*The PDT is concerned that providing catch estimates for the Mramp model with M=0.4 will be misinterpreted as implying that this is*</u>

an appropriate reference point and catch advice for this scenario. This has not been evaluated and the PDT emphasizes that this would be an incorrect interpretation of our response to the Council's tasking.

4. In addition to the question of what is the appropriate FMSY proxy if M=0.4, there are nuances that complicate providing these catches. For example, because the SARC did not consider a reference point based on M=0.4, it is not clear if the SARC guidance on projection inputs is valid for this approach. A key question is whether the Mramp recruitment stream is applicable if M=0.4 is used for the reference point. Many of the larger values from that stream are from periods when the model assumes that M=0.2, and some come from years when the SSB exceeded the SSB_{MSY}. Should these recruitment values be included in a projection for a stock that is below SSB_{MSY} and has a different M? If they are included, they will increase the catches at low stock sizes and may exacerbate the tendency of the projections to over-estimate stock growth. Some of these issues could be explored with sensitivity analyses.

5. Table 1 provides the catches that would result if the FMSY proxy was based on F40% MSP and M=0.4; the value for the FMSY proxy would be F=0.44, and 75% of this proxy would be 0.33. For comparison, this table also shows the catches using the SARC approved reference point (F40%, M=0.2) in both the Mramp model and the base case model. The largest difference is between the two Mramp model projections. The catches during this period at F40% and M=0.4 are about 400 to 600 mt larger than when the FMSY proxy assumes M=0.2.

6. It is one thing to choose a catch if one state of nature is identified that represents current conditions. In the current case we have two possible states and do not know which is correct. Any decision should carefully consider the implications of basing catch advice on an assessment model/reference point combination that is wrong – that it, it does not actually represent the true state of nature.

7. Table 2 shows the consequences for fishing mortality and SSB if the ABC/catch is based on one model assumption and a different model is correct. In this table, the model used to set catch advice is identified in the first column, and the projected effects on F and SSB are shown for the two models in the other columns. The lower catch stream from the base case/M=0.2 model results in faster rebuilding in the short term (2013-2015) regardless of the true state of nature. The tradeoff is a loss of 1,593 mt of potential yield over the three year period.

8. Table 3 shows the consequences of choosing the wrong basis for the reference point on yield per recruit. The comparisons are shown at 75% FMSY since this is the target fishing mortality rate in the default ABC control rule. If base case/M=0.2 represents the true state of nature, using F=0.33 as the target mortality rate reduces SSB/R by 48 percent while increasing YPR only 21 percent. If Mramp/0.4 represents the true state of nature, using 0.135 as the target fishing mortality rate reduces YPR by 35 percent and increases SSB/R by 46 percent.

9. Figure 2 shows the consequences of using the wrong mortality target on the age distribution of the stock. Again, the target mortality rate used is 75% FMSY. The catches used as inputs to the projection are derived from the base case/M=0.2 model and the Mramp/M=0.4 model. Both catch streams are input into each model's projections. The projected age distribution is for three different time periods: 2015, 2020, and 2025. The differences in the age distribution in 2015 are minor, but in the early years results in fewer old fish. The results change direction by

2025. This is because the base case/m=0.2 model would project higher catches than the Mramp/M=0.4 model after 2017.

10. The two possible states of nature have different short and long-term impacts on the stock. The base case model, with a reference point based on 40% MSP and M=0.2, over the long-term results in a higher SSBMSY and higher MSY than is the case with the Mramp model with a reference point based on 40% MSP and M=0.4. In the short term, basing catches on this model would rebuild slightly more quickly than would be the case if catches are based on the Mramp model. This is true regardless of the true state of nature. After 3-4 years, however, the Mramp model produces lower catches and if the true state of nature is unknown, this means these catches would lead to larger stock sizes.

Table 1 – GOM cod ABC at 75% of FMSY under two models and two M assumptions used when caclcualting the reference point

	Base Case M=0.2 F=0.135`		Mramp M=0.4 F=0.33	
Year	**ABC (mt)**	**SSB (000 mt)**	**ABC(mt)**	**SSB (000 mt)**
2012	3,767	8.995	3,767	7.711
2013	1,249	9.403	1,873	6.688
2014	1,503	12.139	1,907	7.789
2015	2,030	16.868	2,595	10.604

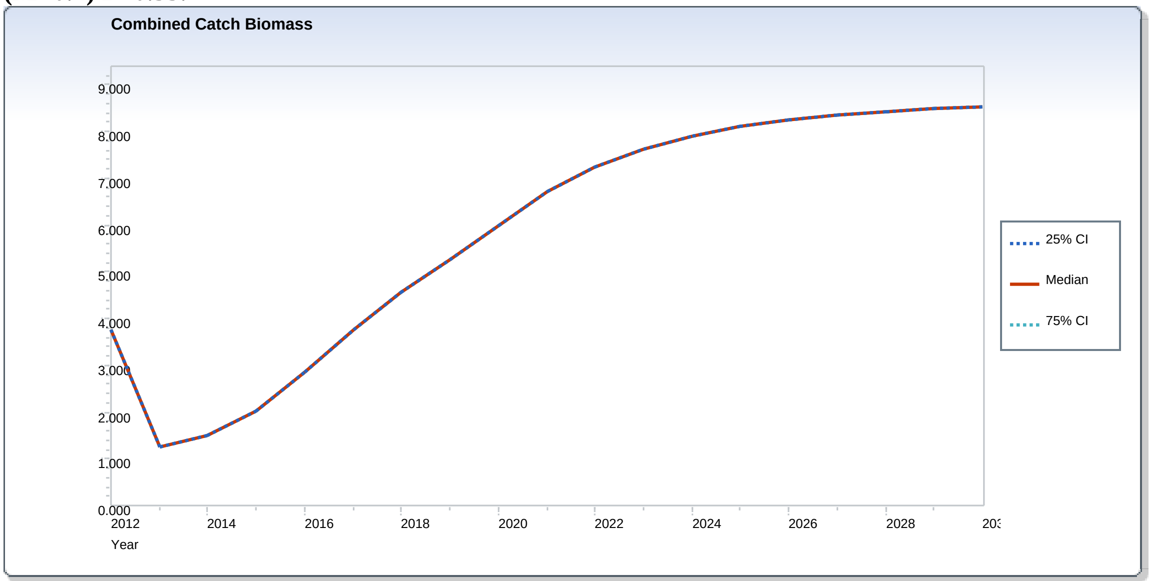
Table 2 – Consequence table for different catches and different GOM cod assessment models. The catches in the top half of the table are based on 75% of FMSY using an FMSY proxy calculated with M=0.2 and the Base Case model. The bottom half of the table use catches based on an FMSY proxy calculated with M=0.4 and the Mramp model.

			State of Nature									
			Base M=0.2					**Mramp M=0.4**				
Act as if state of nature is:	Year	Catch	F	SSB	Prob. F> FMSY	Prob. SSB< SSBMSY (27372)		F	SSB	Prob. F> FMSY	Prob SSB< ½ SSBMSY (7785)	
M=0.2	2012	3767	0.459	8.995	1	1		0.576	7.711	0.842	0.53	
	2013	1249	0.135	9.403	0.197	1		0.211	6.834	0.025	0.67	
	2014	1503	0.135	12.139	0.19	1		0.235	8.432	0.026	0.38	
	2015	2030	0.135	16.868	0.149	0.98		0.231	11.428	0.002	0.04	
M=0.4	2012	3767	0.459	8.995	1.00	1.00		0.576	7.711	0.84	0.53	
	2013	1873	0.209	9.268	0.70	1.00		0.33	6.688	0.21	0.70	
	2014	1907	0.184	11.485	0.53	1.00		0.33	7.789	0.20	0.50	
	2015	2595	0.188	15.759	0.57	0.99		0.33	10.604	0.13	0.10	

Table 3 – Yield per recruit analyses for two GOM cod assessment models and values for natural mortality

Model	M	F	YPR	Total Stock B/R	SSB/R	% MSP	Mean age	Mean generation
Base	0.2	0	0.0	22.4	20.3		5.5	7.5
Base	0.2	0.135	1.3	11.6	9.8	48.2	3.9	5.5
Base	0.2	0.330	1.5	6.8	5.1	25.2	3.2	4.5
Mramp	0.4	0	0.0	5.2	4.0		3.0	4.7
Mramp	0.4	0.135	0.3	3.8	2.7	67.7	2.7	4.1
Mramp	0.4	0.330	0.5	2.9	1.9	46.5	2.4	3.7

Figure 1 – Catch streams used in projections. Top stream is base case (M=0.2), F=0.135. Bottom is Mramp (M=0.4) F=0.33.



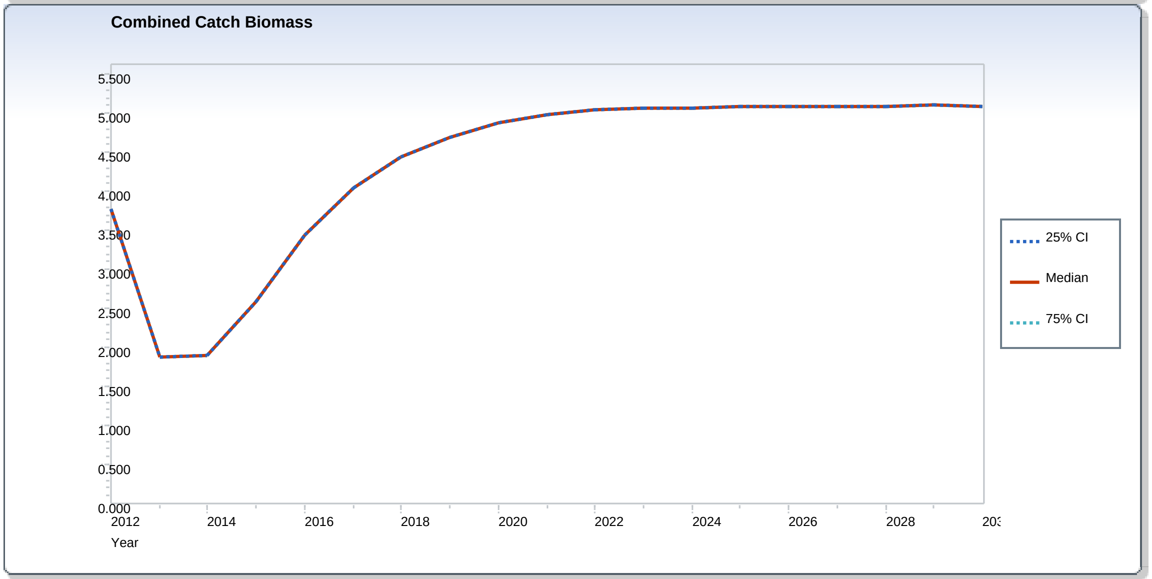


Figure 2 – Projected age distribution for GOM cod under two catch streams and two "true" states of nature

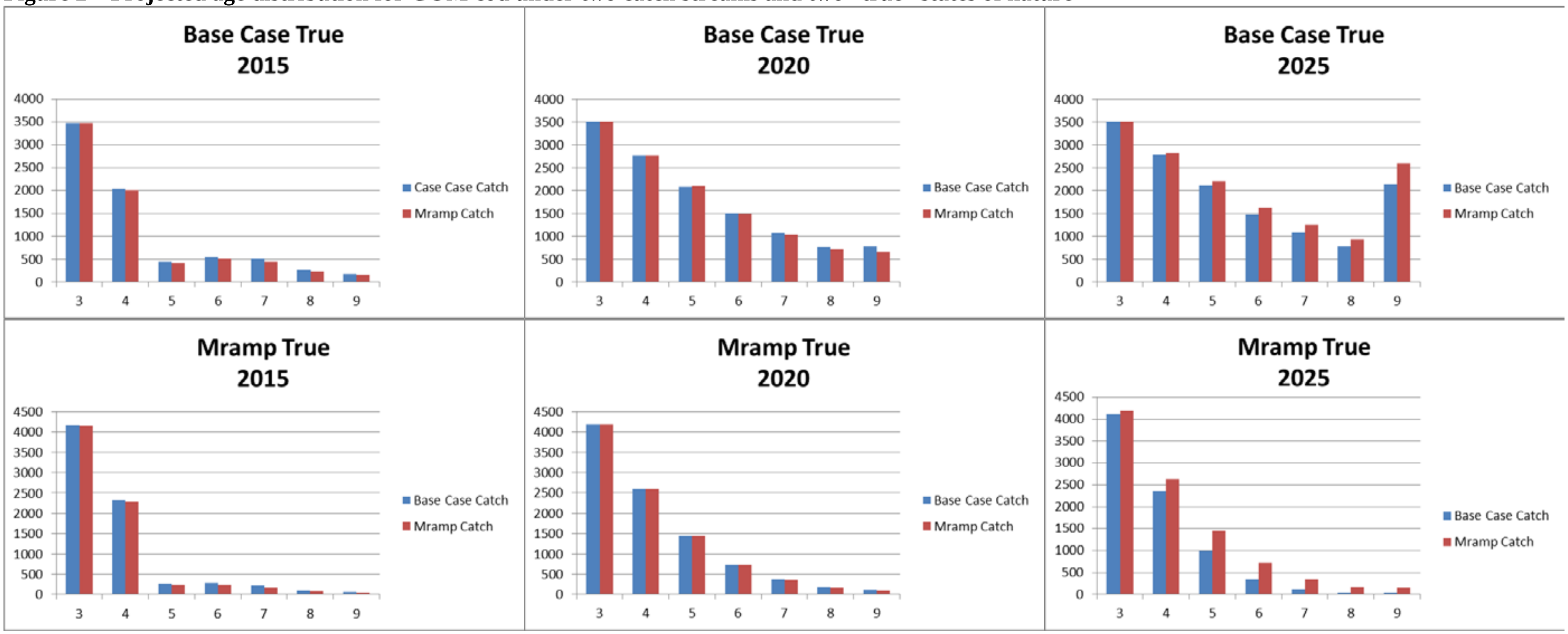


Figure 3 – Difference in numbers at age at three different times. A negative value means the numbers at age are smaller if catches are based on the Mramp (M=0.4) model.