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John Pappalardo, *Chairman* | Paul J. Howard, *Executive Director*

MEMORANDUM

DATE: **September 11, 2009**

TO: Scientific and Statistical Committee (SSC)

FROM: Richard Allen, Red Crab PDT Chair

SUBJECT: **Information and recommendations for determining ABC for red crab**

The Red Crab PDT met on September 8, 2009 and as a result of that meeting is forwarding the following information and recommendations SSC pertinent to setting an ABC for red crab.

1. The red crab industry disputes much of the information that was presented to the SSC at its August 11 meeting. The industry will provide its input to the SSC on September 16, as requested by Chairman Cadrin.

2. The PDT received information from PDT member Rick Wahle concerning the most appropriate spawner-recruit relationship for red crab. The Data Poor Stocks Working Group (DPSWG) concluded that Beverton-Holt recruitment dynamics are more likely for red crab because "there is no known biological mechanism that might result in maximum recruitment at intermediate spawning biomass levels." Rick cited a review of decapod spawner-recruit relationships that he published in 2003 to support his opinion that the applicability of Ricker dynamics should have been given more consideration by the DPSWG.

3. The PDT reviewed the recommendations of the DPSWG and concluded that the MSY estimates provided by the DPSWG were precautionary for the following reasons:

    a. The DPSWG relied primarily on the long-term average landings as the basis for its MSY estimates. (As explained below, the DCAC model was used in a way that caused it to simply calculate the average landings with variability added by the standard deviation of the depletion delta.) The PDT agreed with paragraph f) on page 195 of the Report of the DPSWG that: "historical catches may understate MSY to the extent that fishing mortality has been less than Fmsy during recent years." This is particularly true for red crab because the availability of markets controlled the landings. The impact of the zero landings in 1994 would bring the average catch down for reasons not associated with the status of the stock. The PDT was also advised by the industry that the recorded landings are lower than the actual landings. One vessel operator had higher landings than are recorded for 1995 and he knows that two additional boats were fishing red crab that year. Red crab boats were not required to have a federal permit prior to 2002 and no landings reports were required. For those boats that were submitting Vessel Trip Reports (VTRs) prior to 2002, there was no code specifically for red crab. It seems likely that some red crab landings may have been reported as unspecified crab and some simply weren't reported. Dealer reports were not required until 1995 at the earliest and possibly 2002 for red crab dealers located in Canada. For various reasons, the reported red crab landings that were used by the DPSWG to calculate mean annual landings and to estimate MSY were less than the actual landings. Under-reported landings also cause the results of the 2-point boundary model to underestimate the equilibrium catch.

b. The PDT discussed the assumption of a zero depletion delta that was used in running the DCAC model for red crabs as part of the DPSWG. Appendix 2 to the DPSWG Report explains the logic behind the DCAC model. The explanation implies that the depletion delta is calculated by subtracting the ending biomass from the beginning biomass, which in the case of red crab would entail subtracting the biomass from the 2003-5 survey from the comparable biomass from the 1974 survey. Table 3 in the DPSWG Report states that the 1974 survey data was used in running the DCAC model. The SSC was told repeatedly on August 11 that the models were run using the biomass estimates from the two surveys, one in 1974 and the other in 2003-5. As it turns out, however, the DCAC model was run with a zero depletion delta that was not calculated from the survey abundance data. PDT member Toni Chute is also the first author on the Red Crab section of the DPSWG Report. Toni explained that the zero depletion delta was a judgment call that was based on the modelers judgment concerning what the surveys were telling them, not on any mathematical calculation.

The significance of the zero depletion delta is that the "windfall ratio" that is the heart of the DCAC model disappears when a zero delta is used. As explained in Appendix 2 of the DPSWG Report, "in the special case of no change in biomass, DELTA = 0, W/Y = 0 and Ysust is the historical average catch." The DCAC model simply calculates the average landings for the time period used (with some variability arising from the standard deviation associated with the zero delta). The DPSWG Report states that the DPSWG concluded that MSY ranges from 1700-1900 mt of males "based on congruence between average landings and results from the DCAC model." Whereas the DCAC model was used in a way that caused it to simply calculate the average landings, the congruence between the average landings and the results from the DCAC model is meaningless other than giving an air of scientific authority to a single estimator.

c. The Chairman of the PDT contacted Alec MacCall, who is cited in the report of the DPSWG wherever the DCAC model is mentioned. Alec wrote back that: "my inclination is to use the simplest interpretation of the surveys (i.e., subtract one from the other) as being the most likely to tell you something useful." The Chairman ran the DCAC model using the -0.2 delta for fishable males that is indicated by the survey abundances. DCAC model runs that use the actual biomass estimates for fishable males from the two surveys produce substantially higher estimates of sustainable yield (see revisited Table 3 from DPSWG Report and DCAC model inputs and outputs attached) than are indicated by the average landings or the 2-point boundary model. The PDT agreed that these model runs should be submitted to the SSC for their consideration.

d. None of the methods that were relied upon by the DPSWG result in estimates of MSY. Alec MacCall, the developer of the DCAC model, wrote in response to questions about the model that: "importantly, DCAC cannot estimate MSY. The DCAC value is usually (it is supposed to be) smaller than MSY, often in the range of 50% to 75% in my experience." (Alec subsequently provided more explanation and a spreadsheet example in which the DCAC result is 72% of MSY.) As indicated in Table 3 in the DPSWG Report, the long term sustainable catch, DCAC model, and 2-point boundary model produce estimates of either sustainable yield or equilibrium yield. None of these methods give any indication of the relationship between their estimates and MSY. In the absence of evidence to indicate that the stock had been reduced below Bmsy, or was at Bmsy, the estimates of sustainable yield from these methods would be expected to be less than MSY on the conservative side of the sustainable yield curve.

4. The PDT agreed to recommend to the SSC the following procedure for establishing the Overfishing Limit (OFL):

   a. The most recent biomass estimate for fishable males is 36,247 mt.

   b. Fmsy = (c) M, with c = 0.7 and M = 0.10. (Taken from the DPSWG explanation of Option 3 for Bmsy.)

   c. OFL = Fmsy * Bcurr = 0.07 * 36,247 = 2537 mt

   d. The PDT discussed the fact that a 30% buffer applied to the OFL calculated above would result in an ABC of 1776 mt, which almost exactly mimics the recorded long-term mean landings, which is the "catch limit" recommended by the DPSWG.

5. The PDT discussed the buffer between OFL and ABC that was recommended by the SSC at its August 11 meeting. There was a consensus among the PDT members that the 30% buffer may be more than is needed when all of the information is considered.

    a. The DPSWG noted that "based on the last stock assessment (NEFSC 2006a; 2006b), there is no evidence of serious problems in the red crab population (fishery induced mortality rates are $<0.1\ y^{-1}$) and recruitment was apparently occurring during 2003-2005. The DPSWG went on to point out the questions raised by the decline in the biomass of large males.

    b. The PDT noted that all of the relevant references regarding mating and fecundity had not been considered by the DPSWG as it relates to their concern about the reduction in biomass of large males. Similarly, the possibility that the reduction in large males could bring about an increase in the equilibrium stock size was not seriously considered in the report of the DPSWG. The PDT also noted research on small-mouth bass showing an increase in abundance of smaller animals as the population was fished intensively in an effort to reduce the population of an invasive species.[1] (Andre de Roos and colleagues have also conducted experiments that demonstrate the potential for increases in smaller size categories of fish when larger size categories are reduced by harvesting.[2])

    c. The 2003-2005 survey showed an increase in biomass for all crab categories except males over 114 mm after 35 years of fishing with recorded average annual landings of 1775 mt. Actual landings were likely higher.

    d. The PDT considered the 30% buffer to be arbitrary and possibly unnecessarily restrictive at the levels that were discussed at the August 11 SSC meeting.

    e. The PDT noted that the DPSWG recommended "a catch limit that mimics both recent and long term mean annual landings…" The PDT noted that "catch limit" is the final step in the process of setting OFL, ABC, and ACL.

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[1] Zipkin, E. F., P. J. Sullivan, E. G. Cooch, C. E. Kraft, B. J. Shuter, and and BrianC. Weidel. "Overcompensatory Response of a Smallmouth Bass (Micropterus Dolomieu) Population to Harvest: Release From Competition?" *Can. J. Fish. Aquat. Sci.* 65 (2008): 2279-92.

[2] Schroder, A., L. Persson, and A. M. de Roos. "Culling Experiments Demonstrate Size-Class Specific Biomass Increases With Mortality." *Proc. Natl. Acad. of Science* 106, no. 8 (2009): 2671-76.

Table 1

Table 3 from DPWG Report Revisited

Method	Method or Model	Result	Estimate or range of estimates	Uses 1974 survey Information?	Equilibrium Estimator
1	Status quo MSY	MSY	2830 mt	Yes	No
2	Long term sustainable catch	Sustainable yield	1775 mt	No	Yes
5	DCAC model	Sustainable yield	1785-1862 mt*	Yes	Yes
5a	DCAC model	Sustainable yield	2019 - 2762 mt**	Yes	Yes
6	2-point boundary model	Equilibrium catch	1987-2044 mt**	Yes	Yes

* DCAC model did not use 1974 survey and was run with an assumed zero depletion delta. A zero depletion delta approximates the long term average catch as the model result.

** Model was run using the biomass estimates for fishable males from the two surveys.

	1974 Survey	2003-5 Survey	Depletion Delta
Fishable Biomass of Males	30302	36247	-0.20

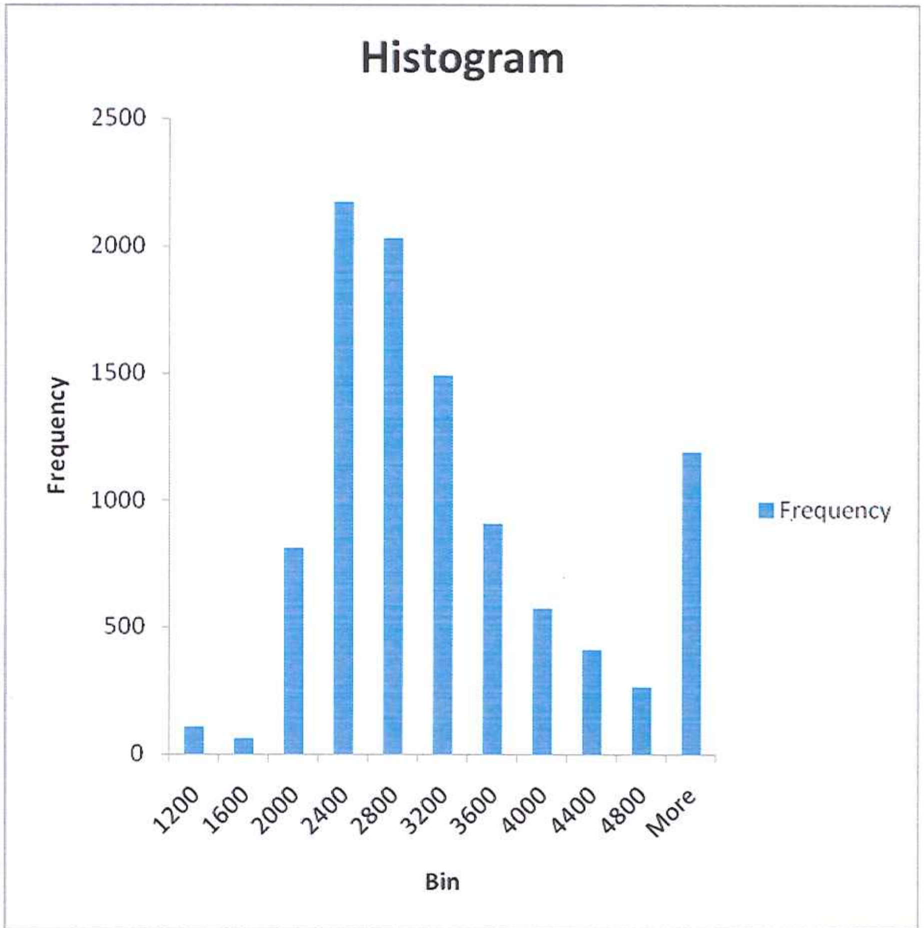


Table 2

Depletion Corrected Average Catch Model Version 1.1.1 (Calculation E

Warning - 104 Iterations Have Negative Values

Case Description: Minus pt2 dep delta m=05 sd 25 fmsy =08

Number of Years = 35
Random Number Seed = 29815167
Number of Iterations = 10000

		Value	STD Deviation
Sum of Catch	=	62132.0000	
Natural Mortality	=	0.0500	0.2500
FMSY to M	=	0.8000	0.0500
Depletion Delta	=	-0.2000	0.1000

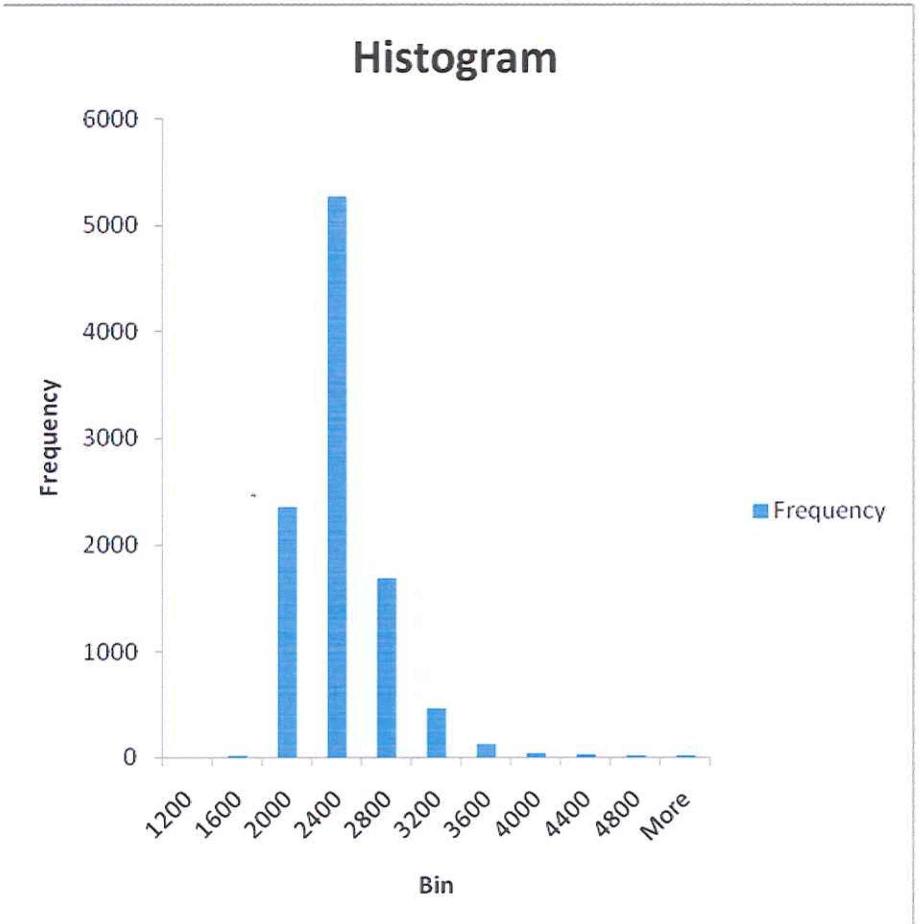
Uncorrected Avg. Catch = 1775.200000

Average DCAC = 3441.107193
Median DCAC = 2761.493856

1% - 99% CI = -4028.609061 - 17833.631206
5% - 95% CI = 1862.373515 - 7177.449308
10% - 90% CI = 2007.831882 - 5154.875708
20% - 80% CI = 2210.387052 - 3898.547968

Minimum = -2763319.357482 - Maximum = 2308486.228268

Table 3



Depletion Corrected Average Catch Model Version 1.1.1 (Calculation Engine)

Warning - 1 Iterations Have Negative Values

Case Description: Minus pt2 dep delta sd 1 m=1sd 25 fmsy =08 sd05

Number of Years = 35
Random Number Seed = 29815167
Number of Iterations = 10000

		Value	STD Deviation
Sum of Catch	=	62132.0000	
Natural Mortality	=	0.1000	0.2500
FMSY to M	=	0.8000	0.0500
Depletion Delta	=	-0.2000	0.1000

Uncorrected Avg. Catch = 1775.200000

Average DCAC = 2193.877073
Median DCAC = 2168.012150

1% - 99% CI = 1711.938690 - 3567.040166
5% - 95% CI = 1833.489094 - 2907.854635
10% - 90% CI = 1896.721951 - 2668.770194
20% - 80% CI = 1975.836868 - 2454.328912
Minimum = -507732.466462 - Maximum = 9221.308928

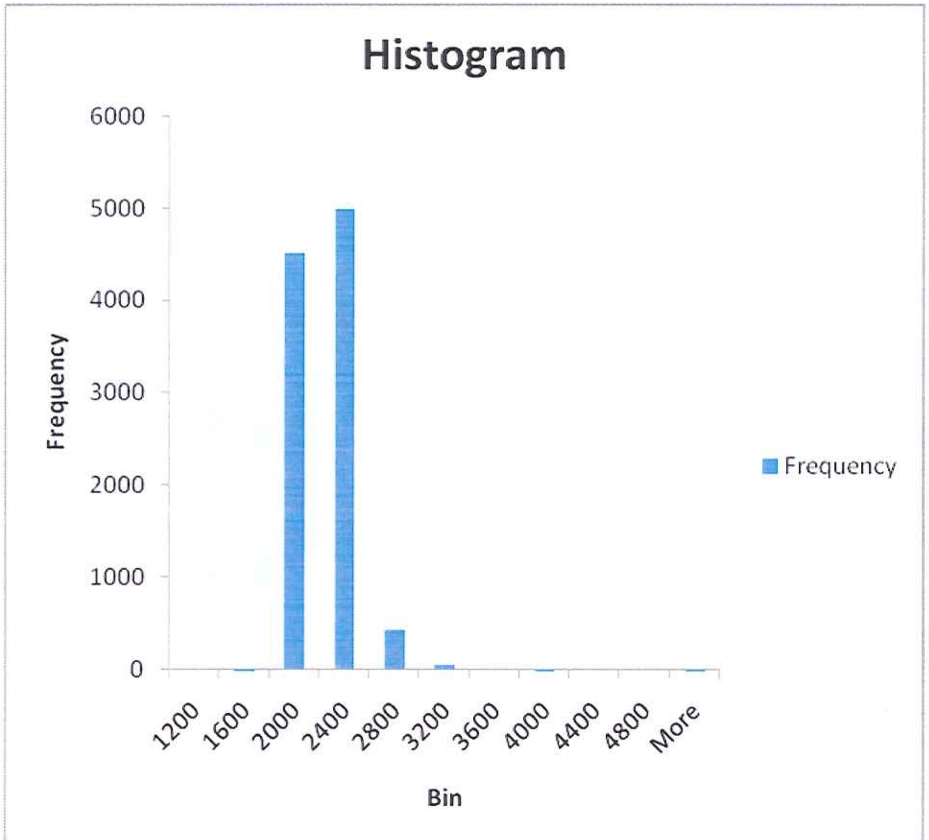


Table 4

Depletion Corrected Average Catch Model Version 1.1.1 (Calculation Eng

Case Description: Minus pt2 dep delta sd 1 m=15 sd 25 fmsy =08 sd05

Number of Years = 35
Random Number Seed = 29815167
Number of Iterations = 10000

		Value	STD Deviation
Sum of Catch	=	62132.0000	
Natural Mortality	=	0.1500	0.2500
FMSY to M	=	0.8000	0.0500
Depletion Delta	=	-0.2000	0.1000

Uncorrected Avg. Catch = 1775.200000

Average DCAC = 2050.983893
Median DCAC = 2019.131231

1% - 99% CI = 1732.879967 - 2669.029912
5% - 95% CI = 1813.670053 - 2398.034004
10% - 90% CI = 1854.408904 - 2285.355647
20% - 80% CI = 1904.156225 - 2176.858981

Minimum = 1593.860647 - Maximum = 5363.102346