Comments on Data Poor Working Group (DPWG) Report for Red Crab

Submitted to the Red Crab PDT
Rick Wahle, Bigelow Laboratory for Ocean Sciences
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General Comments

The DPWG report (NEFSC 2009) is a response to the limited information available to evaluate the impact and sustainability of harvesting red crab. It describes new approaches to evaluate whether recent fishing effort is sustainable and whether there is evidence that the evident depletion of large males is having an impact on population reproductive performance. In the specific comments below I question certain assumptions associated with the analyses and offer additional relevant information. The working group perhaps could have taken more advantage of published literature and available survey data. In fairness, the working group may not have been aware that the data on egg-bearing females were available from the 2003-05 survey. The report identifies important data gaps for red crab and recommends research to address these deficiencies. Research recommendations resulting from the DPWG align with those identified in the 2006 Stock Assessment (NEFSC 2006).

Specific Comments

Main Report

p. 185, 188, 191: The report mentions the potential bias in density estimates only during the 2003-05 survey, but not for the 1974 survey (Wigley 1975). Related text in the recent stock assessment (NEFSC 2006) reads as follows:

> *"Crabs occurred with significantly greater frequency in the background (79% of the time) than the foreground sub-areas (34% of the time; $\chi 2$ contingency analysis: $\chi 2 = 49.06$, $df = 1$, $p < 0.0001$). This result suggests crabs may have been avoiding the oncoming sled, and that the resultant density estimates may be too low.*
>
> *It is possible that population estimates from the 1974 survey would be subject to the same bias, although perhaps to a lesser extent given the larger area photographed. However, it is also possible that the larger area sampled in the 1974 photographs (31.8 m^2 versus 6.6 m^2 in 2003-2005) might cause smaller red crabs to escape detection at the margins, and in turn, result in underestimates of abundance."*

The working group seems to dismiss the 1974 survey as being less accurate than the more recent one, whereas both surveys have their inherent biases. It is my understanding that since the 2006 stock assessment, NEFSC staff has found the original films from the 1974 survey, so it now may be possible to evaluate biases.

p. 188, para. 1 and p. 193, last para: *"Bmsy = ½ Bo is reasonable if the underying spawner recruit relationship is a Ricker curve. However, Bmsy< ½ Bo if the underlying spawner recruit relationship is a Beverton-Holt curve. Beverton-Holt 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."* While it is true the recruitment dynamics for red crab species are poorly understood, there is literature on a number of better-studied crab taxa suggesting that Ricker (dome shaped), not Beverton-Holt (asymptotic) stock-recruitment dynamics tend to prevail. These taxa include snow

crab, Dungeness crab, blue crab, and green crab (see Table 1 in Wahle 2003, attached). For these crabs, cannibalism is the density-dependent mechanism operating at high density (Wahle 2003, Table 4).

p. 188, para 3: *"The total biomass for male red crabs during 2003-2005 (56k mt) exceeds the estimate for 1974 (32k mt) despite consistent fishing, indicating that the estimate for 1974 is a poor estimate of Bo."* It is dangerous to dismiss the 1974 survey simply because the biomass of males doesn't meet a simple-minded expectation that the abundance of males must be lower after a period of harvesting. Any number of factors could have caused the population to be larger in 2003 than in 1974. Given that female abundance more than tripled since 1974 (NEFSC 2006, Wahle et al. 2008), in the absence of harvesting we might have expected a similar increase in males. It seems reasonable to expect a more modest increase in males considering the impact of harvesting, and we cannot simply rule out the possibility an increase occurred.

Appendix 1: Red crab size composition analysis

The exercise seems a rather indirect way of projecting an impact of harvesting males on reproductive performance. A more direct measure of female reproductive output would be to compare egg production over the period. Although the depletion of large males gives reason for concern, the abundance of egg bearing female appears to have been higher in the more recent survey. By several measures (Table 1a in the DPWG Report; and Wahle et al. 2008), female abundance was considerably higher during 2003-05 than in the mid-1970s. Meanwhile, the proportion of egg-bearing females does not appear to have changed: Fig. 1 (below) compares the size composition of egg-bearing females in 1974-1976 (from Haefner 1977) to that in 2003-05 (from Wahle unpublished). A more thorough investigation of female reproductive performance relative to geographical differences in male abundance and sex ratio is one of the objectives of an industry-scientist proposal recently submitted to the Saltonstall-Kennedy Program.

p. 204, para. 1: *"…we assume that males must be at least 25% larger than females to mate successfully…."* Specific data are very limited to a total of 14 observations of mating red crab pairs. During camera surveys of 2003-2005 we observed 11 mating pairs in which the males averaged 51% larger than the females, ranging from 18-72% (Wahle unpublished). Elner (1987) observed three mating pairs of *C. quinquedens* in captivity in which males were 10.2, 15.1, and 20.6 % larger than the females. These females were later found to contain sperm masses. Therefore, it may be more accurate to say that males must be at least 10% larger than females to successfully mate.

p. 204, Direct Analysis.. para. 1: *"Females are assumed to mature at 70 mm and males at 90 mm."* Estimates of female size at maturity are based on the smallest females observed to be ovigerous (Haefner 1977, Wahle unpublished). Male red crabs are physiologically mature at around 40 mm, but probably are not functionally mature until they can embrace a mature female. Given Elner's (1987) observations of a male only 10% larger than his mate, indexing male functional maturity above 90 mm may be overly conservative.

p. 204, 2nd to last sentence: *"In order to maintain a similar level of fertilization the average male in 2003-2005 must mate with 2.33 times the number of females that it did in 1974."* This is pretty speculative. See comments above and Fig. 1.

Depletion-Adjusted Average Catch Model

p. 206, line 1: *"We replace the value of 0.5 with a value of 0.4 as a better approximation of common stock-recruitment relationships."* On what basis? See comments above on S-R relationships for other crab taxa.

p. 206, para. 2: Justification for the use of the parameter c is vague, and mostly based on west coast groundfish.

p. 206, para. 4:*"The windfall is based on the reduction in abundance from the beginning of the catch time series to the end."* Is there evidence such a windfall occurred?

References

Haefner, J., P. A. 1977. Reproductive biology of the female deep-sea red crab, *Geryon quinquedens*, from the Chesapeake Bight. Fishery Bulletin 75(1):91-102.

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Wahle, R.A. 2003. Revealing the stock-recruitment relationship in lobsters and crabs: Is experimental ecology the key? *Fish. Res.* 65: 3-32.

Wahle, R.A., C.E. Bergeron, A. Chute, Y. Chen, L. Jacobson. 2008. Northwest Atlantic deep-sea red crab before and after the onset of harvesting. *ICES J. Mar. Sci.65:* doi:10.1093/icesjms/fsn058

Wigley, R. L., R. B. Theroux, and H. E. Murray. 1975. Deep-Sea red crab, *Geryon quinquedens*, survey off northeastern United States. Marine Fisheries Review 37:1-21.

A.

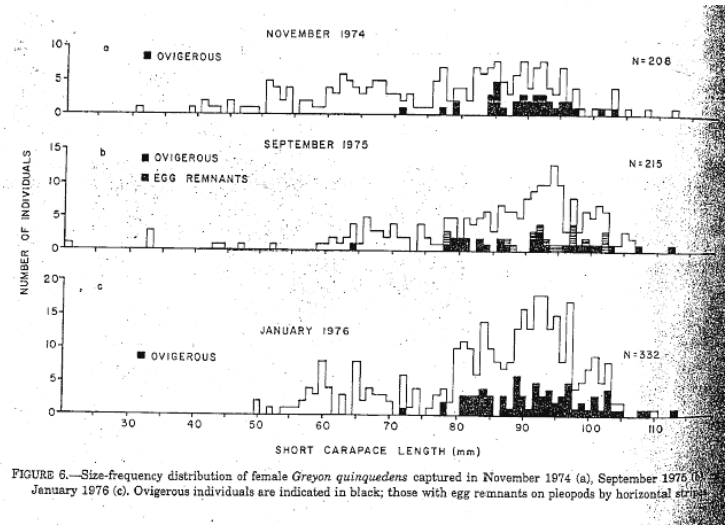

FIGURE 6.—Size-frequency distribution of female *Geryon quinquedens* captured in November 1974 (a), September 1975 (b), and January 1976 (c). Ovigerous individuals are indicated in black; those with egg remnants on pleopods by horizontal stripes.

B.

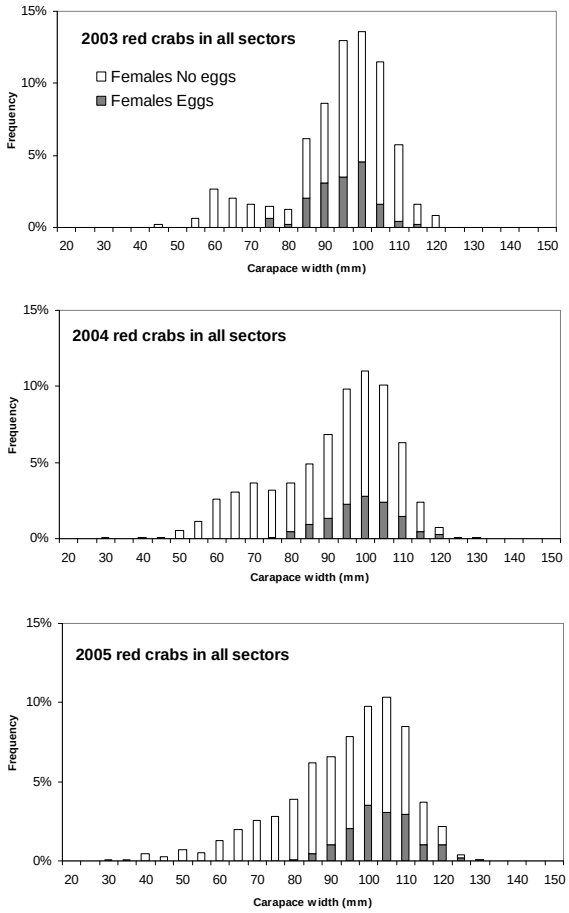

Figure 1. Size distribution of ovigerous and non-ovigerous female red crabs from otter trawl surveys conducted in (a) 1974-1976 near Norfolk Canyon (excerpted from Haefner 1977) and (b) in 2003-2005 from the New England and mid-Atlantic shelf-break (Wahle unpublished).