draft working paper for peer review only

Deep sea red crab

2023 Management Track Assessment Report

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A data update for deep sea red crab (Chaceon quinquedens) occurs every four years during the specifications-setting process. The last data update occurred in 2019 when the specifications for fishing years 2020-2023 were set. The data updates do not result in a determination of the stock status as there are no biological reference points for red crab. Commercial fleet landings, incidental landings, estimated fleet LPUE, and port sampled length frequencies are compiled for this update. Data from observed red crab trips are also updated.

Table 1: Catch table for deep sea red crab. All weights are in (mt)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Data													
Commercial fleet landings	1,412	1,625	1,180	928	985	1,613	1,387	1,366	1,631	1,670	1,952	1,559	2,067
Incidental landings	2	1	0	0	0	0	1	0	2	1	4	3	5
Model Results													

Table 2

	2019	2023
Overfishing	Unknown	Unknown
Overfished	Unknown	Unknown

Special Comments:

- What are the most important sources of uncertainty in red crab data?
  Estimates of LPUE are made in two ways - per trap hauled and per day fished. The two estimates generally track each other well. In the case of per day fished, steam time is not considered which increases uncertainty. In the case of traps hauled, the number of traps per string noted in the VTR trip entry is not always the number of traps emptied per haul due to a number of causes normal for fishing, which increases uncertainty.
  Especially in a potentially food-limited environment, there also may be uncertainty in calculating LPUE in a baited trap fishery. If the pot is left to soak long enough, it can attract enough crabs to fill the pot and appear as if the population has not changed in density over time. The crabs must travel longer distances to reach the bait.
  There is very little uncertainly in landings due to the specialized fleet and processing needs.

- Does this assessment model have a retrospective pattern? If so, is the pattern minor, or major?
  N/A

- Based on this stock assessment, are population projections well determined or uncertain? If this stock is in a rebuilding plan, how do the projections compare to the rebuilding schedule?
  N/A

- Describe any changes that were made to the current stock assessment, beyond incorporating additional years of data and the effect these changes had on the assessment and stock status.
  N/A

- If the stock status has changed a lot since the previous assessment, explain why this occurred.
  N/A

- Provide qualitative statements describing the condition of the stock that relate to stock status.
  N/A

- Indicate what data or studies are currently lacking and which would be needed most to improve this stock assessment in the future.

  After implementation of the FMP in 2002, the red crab fishery was restricted to five full-access permits. The vessels fish cooperatively and over a wide area. The footprint of the fishery stretches from the Hague line to Virginia. The fishery is, by regulation, male-only. Landings include some females landed under an EFP during the years 2010 and 2011 but this did not continue. Red crabs are known to segregate loosely by sex and perhaps even size, with the smallest individuals being found further down the continental slope in deeper water. This is one aspect of the fishery that makes discarding highly variable, as the fishing vessels find areas where there is a high concentration of large males but there are always a certain number of females and undersized males which are discarded depending on where the pots are set.

  Red crab is considered a data-poor species. They live outside the range of NEFSC surveys (they are sometimes caught in the northern shrimp survey and non-random deep stations in the bottom trawl survey, but in very small numbers) so there is no fishery-independent index of abundance.

  Almost nothing is known about deep sea red crab growth and longevity, and methods of crustacean ageing are still in development and highly uncertain. There have been some studies on mating behavior of captive red crabs, but they do not live long in captivity so controlled growth studies have not been possible. A tagging sudy for growth was attempted in 2010 with poor results. Very few tagged crabs were ever recovered, for reasons unknown.

  There have been two surveys of the deep sea red crab resource in the past - one in 1974 (Wigley, Theroux and Murray, 1975) and another during the summers of 2003-2005 (Wahle et al. 2008). The first survey was undertaken soon after the fishery began and the second shortly after the deep sea red crab FMP was implemented in 2002. The methods used by the two surveys were the same, and the 2003-2005 survey attempted to replicate the survey gear used in 1974 as closely as possible. At some stations a benthic sled equipped with a camera and strobe light was towed along the bottom for 30-75 minutes, taking a picture every 10 seconds. The area of bottom illuminated in the images was estimated, and counting the red crabs visible in each image, then extrapolating that number out to the area of the survey resulted in an estimate of swept-area abundance. At other stations, a trawl net was deployed to determine red crab sex ratios, weights and length frequencies by sex. Mean weights were used to estimate swept-area biomass.

  After the second survey, it was possible to see the effect the fishery had on red crab population structure. As would be expected, the number of large male crabs was reduced. However, the number of smaller males and females appeared to have increased. After the results of the second survey were presented at the Northeast Data Poor Stocks Working Group in 2008 (citation below), the potential for sperm limitation in the red crab population caused concern. It was noted in the mating studies and seen in the benthic sled images that male red crabs needed to be about 50% larger than the females to be able to mate, since the male carries the female underneath his body during the process. If the larger males were being removed from the population, there was concern that the largest females with the highest repoductive potential would not be able to find mates and recruitment would diminish.

  There have been efforts to estimate MSY for red crab, most recently also at the Northeast Data Poor Working Group meeting. The group tried several models and methods at the time, and reviewed estimates that had taken place in the past. Specifically the models were the depletion-corrected average catch (DCAC) model and the two-point boundary model. The DCAC model works from the idea that for a new fishery, in calculating average catch for an estimate of sustainable yield, the windfall at the start of a fishery will represent a certain number of units of sustainable yield and increase n beyond the actual number of years of fishing, with that increase being based on an estimate of natural mortality. The two-point boundary model estimates the average recruitment needed to sustain the catch time series based on mature biomass at two points in time defined as the initial and final survey values, then estimates equilibrium catch based on recruitment, final biomass and survival. At the end of the day there was not one widely accepted value due to many factors, and the group *determined there was substantial uncertainty in any potential BRP estimates that came out of the workshop based on current information about the stock. Survey-based BRPs were also relying on assumptions that the population was stationary and the fishing area did not extend beyond the surveyed area.*

In terms of other effects of the fishery on the population, the percent mortality for discarded crabs is unknown. Crabs apparently survive being brought to the surface and returned to the bottom still contained at a high percentage, but method of discard (dropping vs. sliding) can increase mortality (Tallack 2007). Little is known about the survival of crabs discarded from a vessel that must descend down through hundreds of meters of water without protection after handling.

Since the FMP was put in place, the information originally avaiable to assess the sustainability of the fishery has been total landings and port sampled carapace widths from which estimates of LPUE could be made and the size of landed crabs could be monitored. Estimates of LPUE used as a proxy for abundance can be uncertain in a pot fishery (see above). There are also economic and/or market factors that may affect culling patterns, fishing effort, location and catch for red crab. The fishery is market-driven and annual variations in landings reflect this.

In recent years (2016+) observer coverage of the red crab fishery has increased substantially and the data observed trips provide have allowed us to look at other aspects of red crab biology and the fishery. Since we never had information about undersized males that were discarded at sea, their numbers and length frequencies recorded by observers give us some information about recruitment. Since we never had information about females as they were all discarded at sea, their length frequencies and reproductive status (egg) data recorded by observers give us some information about the potential for sperm limitation. Most of the egg observations have been presence/absence but there have been some observers who stage the eggs, which determines if they are viable - important to note on the larger females especially where sperm limitation is a concern. The measurements of females, which have not had the same level of fishery removals as the males, have provided evidence that the crabs caught at the southern end of the fishery footprint reach greater maximum sizes than those caught in the more northern regions. Anecdotally, the red crabs found in the Gulf of Maine are the smallest, so there is likely a latitudinal size gradient.

Based on this information and previous recommendations, questions for research are listed below. They include the recommendations from the 2008 Northeast Data-poor Stocks Working Group report, past assessments, Tallack (2007) and Wahle et al. (2008).

What is the lifespan of a red crab?

How often do red crabs molt, and what is the percent increase in body size after a molt? Do red crabs, especially females, have a terminal molt? Molt frequency of females would be especially important too, as they mate during the molt period.

Do red crabs store sperm and if so for how long? Although some crabs are known to store sperm from a single mating to produce several clutches of eggs, it is unclear whether red crabs have this ability.

What percent of females with eggs are carrying viable eggs? Unmated females may produce clutches of unfertilized eggs.

How long do red crabs incubate their eggs? This would be useful to know in conjunction with molt frequency and sperm storage capability as it could relate to how many clutches of eggs a female could have in an intermolt period.

How many eggs are carried in a clutch and how does this vary by the size of the crab? Are there patterns that might indicate sperm storage?

Can we gather additional information on the relative sizes of mating pairs and any possible effects on reproductive potential? Could simulation modeling be used to explore the response of population sex ratios and size ratios to different fishing patterns? Is there a way to evaluate the importance of large male red crabs in reproduction considering the size distribution of females?

How can we design a successful tagging study to explore red crab growth rates, fishing mortality rates and molt frequencies in situ?

Are there any new, innovative ageing methods that might work for red crab?

What is the main food source for red crabs? Are they cannibalistic?

How much and when do red crabs move about their range? Is there a seasonal migration of one or both sexes?

Can we improve estimates of total discard mortality by considering seasonality, predation and displacement?

Could gear design studies help reduce discard and increase efficiency in the red crab fishery?

Could soak time studies help reduce uncertainty in LPUE as an estimate of abundance?

Traditional reference points for the deep sea red crab stock are difficult to estimate due to lack of basic information. Are there non-traditional reference points that could be used to determine stock status? Could BRPs based on size and sex ratios be useful due to the importance of preventing sperm limitation? It would require regular surveying.

How do economic factors alter the distribution and interpretation of fishing effort for the red crab fishery?

Can we collect biological data from a large number of red crabs over a wide area, crabs that have not been selected by a commercial trap (say, with a trawl) and are therefore more representative of the population at large? What questions could that help us answer - percentage of females with eggs, sperm storage, percentage in different shell conditions and states of molting, degree of segregation of the population by sex and size?

Would regular surveys of the red crab population provide useful information on the continuing effects of the fishery and the current population structure? What methods could be used? Can we get a better understanding of the habitat-abundance relationship for allocation of effort for any potential survey?

- Are there other important issues?
  None.

References:

Wigley, Roland L., Roger B. Theroux and Harriett E. Murray, 1975. Deep-sea red crab, *Geryon quinquedens*, survey off northeastern United States. Marine Fisheries Review 37:8, 1-21. 1975

Wahle, Richard A., Charlene E. Bergeron, Antonie S. Chute, Larry D. Jacobson, and Yong Chen, 2008. The Northwest Atlantic deep-sea red crab (*Chaceon quinquedens*) before and after the onset of harvesting. ICES Journal of Marine Science 65:862-872.

Tallack, S.M.L, 2007. Escape ring selectivity, bycatch and discard survivability in the New England fishery for deep-water red crab, (*Chaceon quinquedens*). ICES Journal of Marine Science 64:1579-1586.

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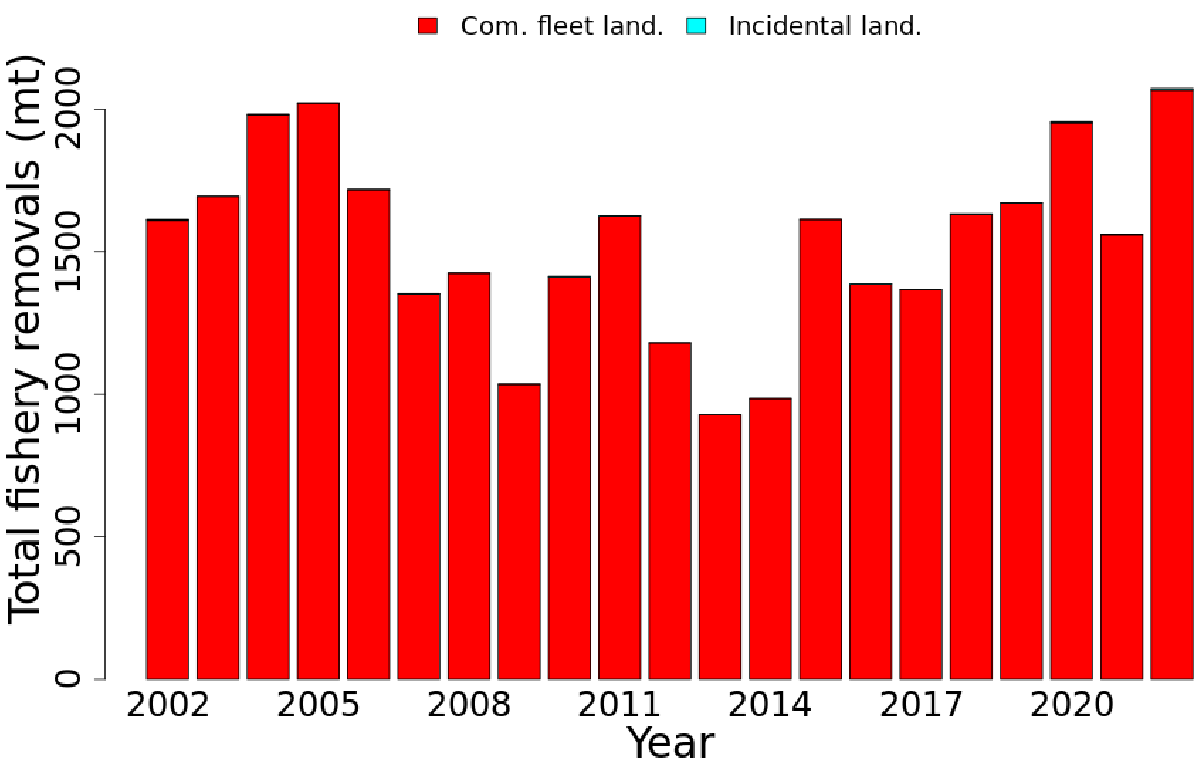

Figure 1: Total annual (calendar year) landings of deep sea red crab since the FMP was implemented and the fleet was limited to five permits. Incidental landings are so small they are not visible in this plot.

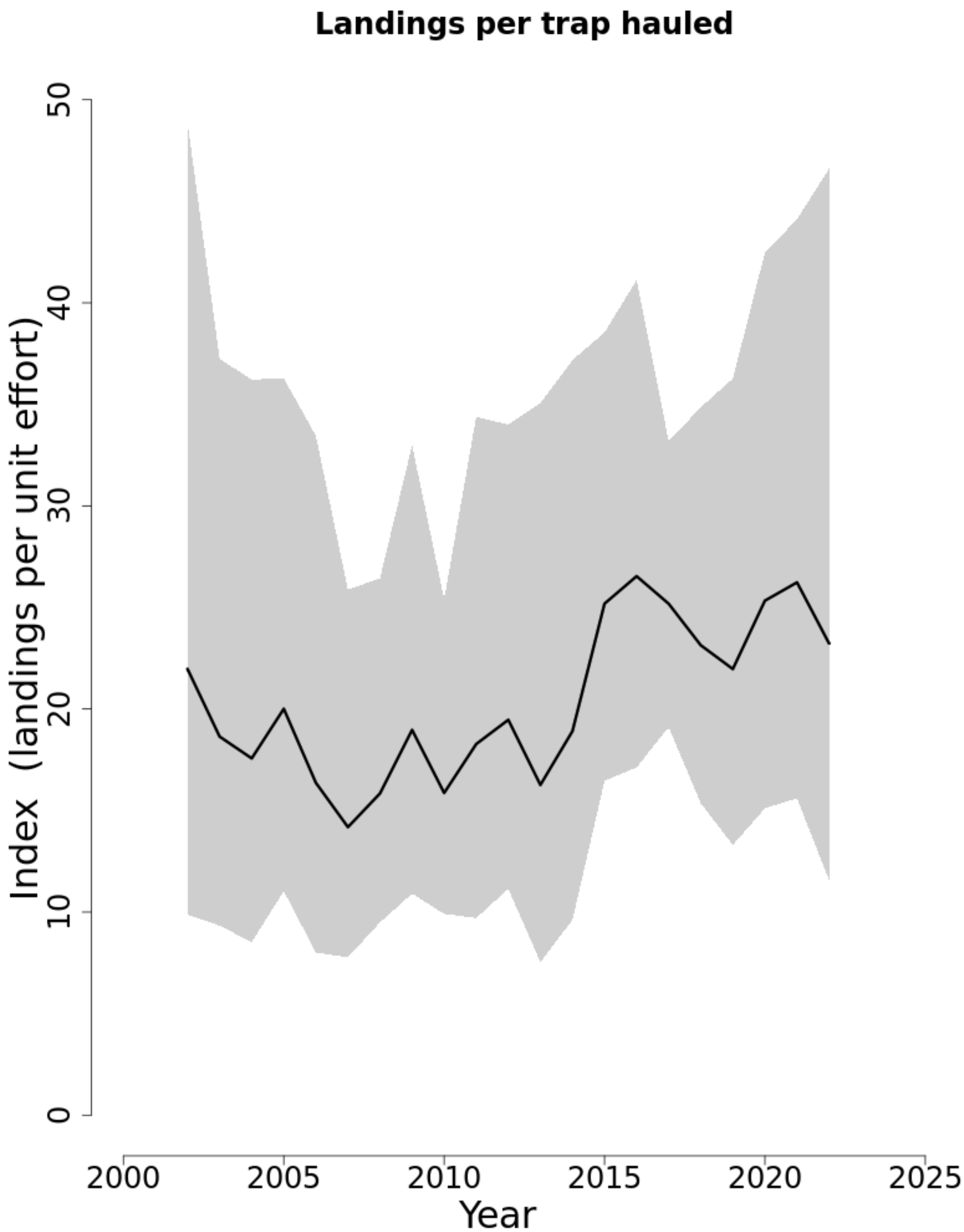

Figure 2: Estimated mean annual LPUE for the deep sea red crab fleet in units of landings per trap hauled. Trips with less than 1000 pounds of catch were excluded, and one vessel that fished shorter trips from 2016 to 2020 was excluded.