Atlantic States Marine Fisheries Commission

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Horseshoe Crab
Delaware Bay Ecosystem Technical Committee
Meeting Summary

Arlington, VA
September 24, 2013

Technical Committee Members: Greg Breese (chair, US FWS), Mike Millard (US FWS), Steve Doctor (MD DNR), Wendy Walsh (US FWS), Dave Smith (USGS), Jordan Zimmerman (DE FW), Eric Hallerman (phone, Virginia Tech)

ASMFC Staff: Marin Hawk

Public: John Sweka (US FWS), Derek Orner (phone, NOAA), Jim Lyons (US FWS)

The Delaware Bay Ecosystem Technical Committee (DBETC) met to review the Adaptive Resource Management (ARM) harvest output for the 2014 fishing year. The DBETC also reviewed horseshoe crab surveys. Usually, the DBETC also reviews shorebird surveys; however, the committee was not able to do so this year due to extenuating circumstances. Below is a summary of their discussions.

Calculation of Red Knot Threshold and ARM Harvest Output

Since the implementation of Addendum VII in 2012, the red knot threshold which is used in the ARM model has been 45,000 birds. This threshold was based upon aerial peak counts and ground counts when aerial counts were not able to meet objectives (such as bad weather) preventing them. However, it was recognized that peak counts do not capture the full population because they cannot take turnover into account. In 2011, new monitoring of the marked to unmarked ratio was implemented to address this issue. For 2014, the ARM Working Group (ARM WG) felt that there was enough data to begin using this mark-resight estimate. The ARM WG presented their recommendation for moving from ground and aerial counts to mark-unmarked ratio estimates of red knots, which involves adjusting the threshold to account for differences in the different methodologies. The DBETC discussed the best way to adjust the red knot threshold proportionately and decided to accept the recommendations of the WG, based upon 2012 and 2013 data, which results in a ratio of 1.82 and a threshold of 81,900 birds. The peak count from 2011 was deemed an outlier and discarded (Appendix A, Appendix B).

During these discussions, one member of the DBETC expressed concern that the peak count in 2012 was a ground count, while the peak count for 2013 was aerial, and suggested that it would be more desirable to be consistent and use either ground or aerial counts across the years in question. However, the only information available to the WG was what was presented, so this alternative could not be considered at this time. The DBETC decided to formally request all the ground and aerial count data for the years in question and have that available when the ARM model is re-evaluated in the future, .

Dr. Dave Smith (USGS), Chair of the ARM Subcommittee, presented the Subcommittee's recommendations on the ARM Framework harvest output (Appendix C). Based on the most recent data inputs and the new threshold for red knots, the ARM Framework selected Harvest Package 3 as the optimal harvest package, which allows harvest of 500,000 Delaware Bay male horseshoe crabs and zero female horseshoe crabs. Based on the allocation mechanism set up in Addendum VII to the Horseshoe Crab Fishery Management Plan, the following quotas would be set for the Delaware Bay states of New Jersey, Delaware, Maryland, and Virginia:

Table 1: Harvest recommendations based on harvest package three of the ARM model. Virginia quota refers to harvest east of the COLREGS line.

	Delaware Bay Origin HSC		Total State Quota	
State	**Male**	**Female**	**Male**	**Female**
Delaware	162,136	0	162,136	0
New Jersey	162,136	0	162,136	0
Maryland	141,112	0	255,980	0
Virginia	34,615	0	81,331	0

The DBETC accepted the ARM Subcommittee report and **recommends the Board accept Harvest Package #3, the optimal selected harvest package, for management of the 2014 horseshoe crab harvesting season**.

Review of Horseshoe Crab Surveys

The following reports were reviewed by the DBETC:

1) Virginia Tech Horseshoe Crab Trawl Survey Report
2) Delaware Bay Trawl Surveys (Delaware 16 - foot and 30 - foot) Report
3) New Jersey Surveys (Ocean Trawl, Delaware Bay Trawl, Surf Clam) Report
4) Delaware Bay Horseshoe Crab Spawning Survey Report
5) Maryland Horseshoe Crab Spawning Survey Report
6) Delaware Bay Horseshoe Crab Egg Survey Evaluation and Report
7) Delaware Bay and Atlantic flyway Red Knot Survey Report

The DBETC agreed that the surveys reflect little change in the status of horseshoe crabs in the Delaware Bay region (Table 2). The population has been stable since 2009. The DBETC also discussed the fact that due to the high variability of the surveys, it is difficult to discern any trends. In future stock assessments, the DBETC would like the stock assessment subcommittee (SAS) to investigate ways to deal with this high variability.

The DBETC was unable to review the shorebird surveys. The DBETC will review those surveys in the future over a conference call.

Table 2: Reviewed horseshoe crab surveys.

Survey	Demographic	Gear Used
Virginia Tech Trawl – Coastal Area	Males Immature	Trawl
Virginia Tech Trawl – Coastal Area	Males Newly Mature	Trawl
Virginia Tech Trawl – Coastal Area	Males Mature	Trawl
Virginia Tech Trawl – Coastal Area	Females Immature	Trawl
Virginia Tech Trawl – Coastal Area	Females Newly Mature	Trawl
Virginia Tech Trawl – Coastal Area	Females Mature	Trawl
Delaware Bay Spawning Survey	Male	Beach
Delaware Bay Spawning Survey	Females	Beach
Delaware Bay 16-ft Trawl	Adults	16-ft Trawl
Delaware Bay 16-ft Trawl	Juveniles	16-ft Trawl
Delaware Bay 30-ft Trawl	All (April – July)	30-ft Trawl
Delaware Bay 30-ft Trawl	All (All months)	30-ft Trawl
Maryland Coastal Bays 16-ft Trawl	All	16-ft Trawl
NJ Surf Clam Dredge	Males	Surf Clam Dredge
NJ Surf Clam Dredge	Females	Surf Clam Dredge
NJ Surf Clam Dredge	Juveniles	Surf Clam Dredge
NJ Delaware Bay Trawl	Males	Trawl
NJ Delaware Bay Trawl	Females	Trawl
NJ Delaware Bay Trawl	Juveniles	Trawl
NJ Ocean Trawl - April	All	Trawl

Other Issues

The DBETC briefly discussed the absence of biomedical data in the stock assessment update. Due to policy, assessment updates cannot incorporate new data into the models. The DBETC would like this biomedical data to be incorporated into future benchmark assessments to ensure that an accurate portrayal of removals is occurring. The DBETC would also like the SAS to include the biomedical data in the regional trend analysis. However, confidentiality issues prevent this from occurring. The DBETC tasked the SAS with investigating options to incorporate biomedical data while avoiding any breaches in confidentiality.

Finally, the DBETC reviewed the recommendations for the DE Bay Egg Survey Working Group. The Working Group determined that the egg survey is not needed to inform management of horseshoe crabs for the following reasons:

1. Because of the long time to maturity and high natural mortality during the egg to hatching and early life stages, egg density is not predictive of future stock recruitment, which is especially true for egg density at the beach surface because those eggs will almost certainly not survive to hatching. Thus, egg density is not used to assess the horseshoe crab population.
2. Harvest recommendations using the ARM framework rely on annual estimates of abundance for red knot and horseshoe crab populations. Estimates of population abundance incorporate individuals that spawn throughout Delaware Bay. Ecological

uncertainty regarding the relationship between red knot weight gain and population growth is incorporated into the ARM framework. Thus, surface egg densities are not needed to inform harvest recommendations.

Due to the above reasons, the DBETC recommends that the egg survey be discontinued as a compliance element for the states of New Jersey and Delaware. The DBETC added a note that individual states might want to continue the egg survey (for example, NJ requires it as part of their State's regulations) and the TC is willing to provide guidance and expertise to help improve the survey to detect trends for their needs.

Appendix A

To: ARM Working Group
From: Jim Lyons
Re: Red Knot population estimate for 2013 and adjustments to Red Knot threshold in ARM framework
Date: 3 September 2013

Kevin Kalasz provided 2013 mark-resight data that were collected by field crews in Delaware and New Jersey. Fewer marked Red Knots were observed during resighting surveys than in previous years; in all 2,922 individually identifiable birds were detected, which is approximately 21-25% fewer individuals than were detected in 2011-2012. As in the 2011-2012 analysis, resighting data were converted to encounter histories with ten, 3-day sample periods. Similar to 2012, there was very little mark-resight data during the last survey period, 2-4 June. We used only the first nine sample periods in the analysis because only one marked bird was detected during the last sample period (see Appendix 1). Observers collected 429 scan samples of flocks over 26 days between 10 May and 5 June to estimate the proportion of the population with marks. The encounter histories and scan samples were analyzed in an integrated population model described in a previous report submitted to the Delaware Bay ARM Working Group.

In general, stopover population dynamics in 2013 were similar to prior years in that the population peaked during 22-24 May as it did in 2011 and 2012 (Fig. 1). A small number of birds were present in early May and most had departed by the end of May. The peak abundance was greater in 2013 than in prior years (Table 1). The 2013 population peaked during 22-24 May at 29,810 birds compared to 25,390 (2011) and 28,970 (2012) in prior years. One aerial survey was conducted in 2013. On 28 May 2013 observers for the aerial survey detected 25,596 Red Knots in the study area (Table 1).

Overall stopover population size, accounting for population turnover, was slightly greater in 2013 than prior years. An estimated 48,955 (95% BCI, [39,119–63,130]) Red Knots used Delaware Bay in 2013 (Table 2). In 2013, the estimate for overall proportion with marks was 0.092 (95% BCI, 0.073 – 0.115), which was slightly lower than in prior years.

At our last meeting, we decided to use the 2013 data if available, and estimates from 2011-2012, to adjust the Red Knot threshold in the ARM decision-making framework. The threshold was originally set during the development of the ARM framework in reference to historical data from aerial surveys of Red Knots in Delaware Bay. Before declines in Red Knot abundance in Delaware Bay, peak counts using aerial surveys suggested that the bay supported approximately 90,000 Red Knots in some years. This reference value (90,000) does not account for the proportion of birds that are not detected during aerial surveys, and it does not account for population turnover during migration, but at the time of these counts and at the time of the ARM development, 90,000 was considered a historic reference point for Red Knot stopover population size in Delaware Bay.

The threshold in the ARM framework was set at 45,000 Red Knots based on the reasoning that if and when the bay supported half as many knots as the historic population size, there is value in considering the potential for some level of female crab harvest. At times when the Red Knot population is below the threshold, there is no potential value in female crab harvest.

As we move from aerial surveys to mark-resight methods for population monitoring, we decided it is appropriate to adjust the Red Knot threshold upward because mark-resight methods account for both imperfect detection during surveys and population turnover, aspects of survey data for open populations that are not addressed by the conventional aerial surveys conducted in Delaware Bay. We also decided that the Red Knot threshold should be adjusted upward to a degree determined by the ratio of mark-resight estimates to aerial survey indices.

Table 1 provides a comparison of mark-resight estimates and peak aerial or ground counts for 2011-2013. The overall ratio of peak mark-resight estimate and peak counts was 1.14. Note that the aerial survey in 2011 may be a low outlier and may be an anomalous value because the observer became ill with motion sickness during the aerial survey. Note also that the aerial count on 28 May 2013 was greater than the mark-resight estimate for this sampling period (but within the 95% credible interval). The 95% credible interval for this is sampling period, 28-30 May, was wide because resighting probability was relatively low in 2013 in general and at the end of the season in particular (Appendix 1). Nevertheless, using the ratio of 1.14 would result in an adjustment of the threshold from 45,000 to 51,300.

Table 2 provides a comparison of total stopover population size (i.e., accounting for population turnover) and the same aerial survey data for 2011-2013. The overall ratio of total stopover population and peak counts was 2.14, with the same considerations for the 2011 aerial survey as a low outlier. Using Table 2 and a ratio of 2.14, the 45,000 threshold would be adjusted to 96,300.

To date we have considered only the approach of Table 1 (ratio of peak, time-specific estimates). We did this because the aerial survey provides a time-specific estimate and we considered a time-specific mark-resight estimate the most appropriate comparison. It may be appropriate to discuss using the approach of Table 2 (total stopover population estimate) because the historic reference points were considered an index to total stopover population size, lack of adjustment for imperfect detection and turnover notwithstanding. Using the approach of Table 2, we would be adjusting the threshold based on corrections for both detection bias and population turnover.

Finally, perhaps we should consider not using the 2011 aerial survey data as this count may be problematic. Using the approach of Table 2, without the 2011 data, provides a ratio of 1.82 and a concomitant threshold adjustment to 81,900.

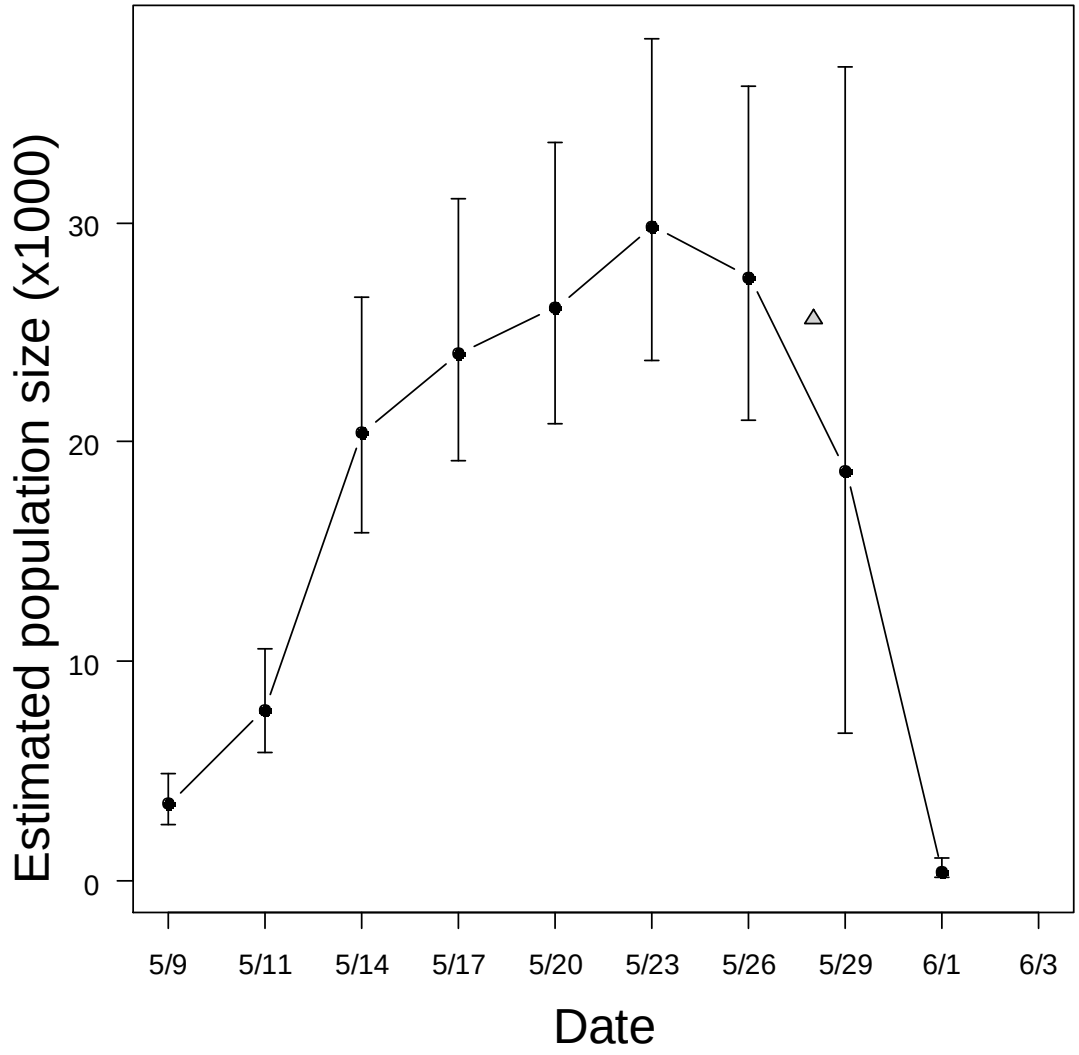

Figure 1. Stopover population dynamics in 2013. x-axis is three-day mark-recapture sampling periods. Filled triangle is aerial count of 25,596 birds on 28 May 2013. The peak of time-specific mark-resight estimates was 29,810 birds (95% BCI: 23,710–38,381) which occurred during 22-24 May 2013, about 5 days before the lone aerial survey for 2013. Total stopover population size, accounting for population turnover, was 48,955 birds (39,119–63,130).

Table 1. Peak (time-specific) population estimate using mark-resight methods compared to peak count using aerial or ground methods. Neither peak mark-resight estimate nor peak count accounts for population turnover during migration. Ratio is mark-resight/peak count.

Year	Peak mark-resight	95% BCI Peak mark-resight	Peak count (aerial or ground)	Ratio
2011	25,390[1]	(23,480–27,430)	12,804 (A)[2]	1.98

2012	28,970[1]	(27,020–31,040)	25,458 (G)[3]	1.14
2013	18,675[4]	(6,735–37,090)	25,596 (A)[5]	0.73
Total	73,035		63,858	1.14

(A) Aerial count
(G) Ground count
[1] 22-24 May
[2] 23 May
[3] 24 May
[4] 28-30 May, past the peak of time-specific mark-resight estimates for 2013 (see Fig. 1)
[5] 28 May

Table 2. Stopover (total) population estimate using mark-resight methods compared to peak count using aerial or ground methods. Mark-resight estimate of stopover population accounts for population turnover during migration; peak count does not account for turnover. Ratio is mark-resight/peak count.

Year	Stopover population (mark-resight)	95% BCI Stopover population (mark-resight)	Peak count (aerial or ground)	Ratio	Red Knot Threshold
2011	43,570[1]	(40,880–46,570)	12,804 (A)[2]	3.40	-
2012	44,100[1]	(41,860–46,790)	25,458 (G)[3]	1.73	-
2013	48,955[1]	(39,119–63,130)	25,596 (A)[4]	1.91	-
Total 2011-2013	136,625		63,858	2.14	96,300
Total 2012-2013	93,055		51,054	1.82	81,900

(A) Aerial count
(G) Ground count
[1] estimate for entire season, including population turnover
[2] 23 May
[3] 24 May
[4] 28 May

Appendix 1. m-arrary summary of 2013 mark-resight data

		Next resighted as sample									
Sample	Resighted	2	3	4	5	6	7	8	9	10	NR[a]
1	144	63	11	10	17	7	5	2	0	0	29
2	322		87	79	39	24	7	5	0	0	81
3	459			139	80	29	15	9	0	0	187
4	790				329	77	49	21	0	0	314
5	1105					347	124	49	0	0	585
6	942						235	65	1	0	641
7	736							110	0	1	625
8	447								1	0	446
9	9									0	9

[a] NR never resighted

Appendix B

Recommendations for improved estimates of red knot stopover population size and associated calibration of red knot threshold

Updated report to the Delaware Bay Ecosystem Technical Committee by the ARM Subcommittee

September 2013

In August 2012, the ARM subcommittee recommended transitioning to a mark-resight methodology for future estimates of red knot abundance in the ARM framework and calibrating the red knot threshold within the ARM framework to maintain proportionality. (Recall that the red knot threshold is part of the utility function that is maximized in the ARM framework, and the threshold assigns value to harvest of female horseshoe crabs – if red knot population is below the threshold in a given year then there is no value assigned to harvesting females in that year.) The ARM subcommittee has met to finalize the threshold calibration, and this memo summarizes the final recommendations.

The ARM subcommittee reviewed mark-resight estimates of red knot stopover population for 2011-2013 based on analyses conducted by Jim Lyons (see Jim's accompanying memo on these estimates). After review of those analyses, the ARM subcommittee's recommendation is to use the ratio of the stopover population estimate to the peak aerial/ground count as the basis for calibrating the threshold (cf Table 2 in Jim's memo). The ARM subcommittee makes this recommendation because 1) the stopover population estimate is the best estimate for the red knot state variable in the ARM framework, 2) the annual peak counts were used previously as the red knot state variable in the ARM framework, 3) the red knot threshold was based originally on historic peak counts, and thus 4) the ratio between stopover population and peak counts will maintain proportionality between population estimates and the threshold.

An additional issue that the ARM subcommittee considered was whether to include the aerial survey data from 2011 in the calibration. The aerial counts in 2011 are thought to be biased unusually low due to observer illness during the flight (Kevin Kalasz, personal communication). Although the ARM subcommittee's position is to avoid removing a data point unless it is clearly an outlier, the consensus was that those who knew the data the best, i.e., Kevin Kalasz and Jim Lyons, consider 2011 problematic and thus it would be reasonable to exclude that data point. Jim Lyons' memo presents calibrations for the threshold with and without 2011 so that the DBETC can discuss and consider this issue further.

In summary, the ARM subcommittee recommends use of mark-resight methodology for estimates of red knot abundance in the ARM framework. To maintain proportionality within the ARM framework, the red knot threshold should be calibrated using the ratio between mark-resight stopover population estimates and peak aerial/ground counts. Also, the aerial survey data from 2011 should be excluded because it is an outlier. The red knot threshold would increase from 45,000 to 81,900 as a result of these recommendations. As a reference, in 2013 the peak count was 25,596 and stopover population estimate was 48,955 (95% BCI: 39,119 to 63,130).

Appendix C

Horseshoe Crab Harvest Recommendations Based on Adaptive Resource Management (ARM) Framework and Most Recent Monitoring Data

Report to the Delaware Bay Ecosystem Technical Committee by the ARM Subcommittee

September 2013

This report summarizes annual harvest recommendations. Detailed background on the ARM framework and data sources can be found in previous technical reports[i].

Objective statement
Manage harvest of horseshoe crabs in the Delaware Bay to maximize harvest but also to maintain ecosystem integrity and provide adequate stopover habitat for migrating shorebirds.

Alternative harvest packages
These harvest packages were compared to determine which will best meet the above objective given the most recent monitoring data. Harvest is of adult horseshoe crabs of Delaware Bay origin.

Harvest package	Male harvest (×1,000)	Female harvest (×1,000)
1	0	0
2	250	0
3	500	0
4	280	140
5	420	210

Population models
Population dynamics models that link horseshoe crabs and red knots were used to predict the effect of harvest packages. Three variations in the models represent the amount and type of dependence between horseshoe crabs and red knots. Stochastic dynamic programming was used to create a decision matrix to identify the optimal harvest package given the most recent monitoring data.

Monitoring data
Sources of data were VT trawl survey for horseshoe crab abundance[ii] and mark-resight estimate for red knot abundance[iii].

Horseshoe crab abundance (millions)			Red knot abundance (×1,000)	
Year	Male	Female	Year	Male and female
2012 (Fall)	10.7	4.5	2013 (Spring)	48.96

Harvest recommendations
Decision matrix was optimized incorporating recommendations on red knot stopover population estimates and associated calibration of red knot threshold[4].

Recommended harvest package	Male harvest (×1,000)	Female harvest (×1,000)
3	500	0

Quota of horseshoe crab harvest for Delaware Bay region states. Allocation of allowable harvest under ARM package 3 (500K males, 0 females) was conducted in accordance with management board approved methodology in *Addendum VII to the Interstate Fishery Management Plan for Horseshoe Crabs*. Note: Maryland and Virginia total quota refer to that east of the COLREGS line.

	Delaware Bay Origin HSC Quota		**Total Quota**	
State	**Male**	**Female**	**Male**	**Female**
Delaware	162,136	0	162,136	0
New Jersey	162,136	0	162,136	0
Maryland	141,112	0	255,980	0
Virginia	34,615	0	81,331	0

References

[i] McGowan, C. P., D. R. Smith, J. D. Nichols, J. Martin, J. A. Sweka, J. E. Lyons, L. J. Niles, K. Kalasz, R. Wong, J. Brust, M. Davis. 2009. A framework for the adaptive management of horseshoe crab harvests in the Delaware Bay constrained by Red Knot conservation. Report to the Atlantic States Marine Fisheries Commission Horseshoe Crab Technical Committee.

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ASMFC 2009. Terms of Reference and Advisory Report to the Horseshoe Crab Stock Assessment Peer Review. Stock Assessment Report No. 09-02.

[ii] Dave Smith's June 12 2013 Memo

[iii] Jim Lyons' 2013 estimate in the 26 August Memo

[4] ARM's recommendations for improved estimates of red knot stopover population size and associated calibration of red knot threshold