Delaware Bay Ecosystem Technical Committee Report

January 24-25, 2011

The ASMFC Delaware Bay Ecosystem Technical Committee (DBETC) met on January 24 and 25, 2011 in Arlington, Virginia. Previously, the Horseshoe Crab Management Board felt that there were technical components to the harvest allocation method presented by John Sweka at the August 5, 2010 Board meeting, upon which they requested input from the DBETC prior to the development of a draft addendum. This report responds to the Board's request and summarizes the DBETC discussions regarding the allocation process and their technical judgments at the January 24-25, 2011 meeting of the committee, in addition to subsequent discussions via email and a webinar hosted on February 25, 2011.

Attendees

DBETC members and Invited Participants
Jeff Brust, Chair (NJ)
Greg Breese, Vice-Chair (USFWS)
Annette Scherer (USFWS)
Amanda Dey (NJ)
Kevin Kalasz (DE)
Stew Michels (DE)
Steve Doctor (MD)
Eric Hallerman (VA)
Alicia Nelson (VA)
Jean Woods (Shorebird AP-DE)
John Sweka (USFWS)
Sheila Eyler (USFWS)
Danielle Brzezinski (ASMFC)
Toni Kerns (ASMFC)
Robert Beal (ASMFC)

Public participants
Rick Robins (Horseshoe Crab AP-VA)
Larry Niles (ARM Subcommittee-NJ)
Caroline Kennedy (Defenders of Wildlife)
Jason Rylander (Defenders of Wildlife)

Introduction

Horseshoe crabs are linked ecologically with shorebirds in the Delaware Bay region, where many horseshoe crabs come ashore to breed and shorebirds stopover on their way to their breeding grounds. The need to successfully manage the horseshoe crab fishery to sustain both populations has driven the development of the Adaptive Resource Management (ARM) framework for management under the ASMFC. The ARM framework uses a double-loop process to allow for yearly and benchmark re-assessment based on model outputs and stock assessments. The model incorporates the population dynamics of both the horseshoe crabs and the red knots, a specific shorebird of international concern that is a candidate for listing under the Endangered Species Act.

Thresholds incorporated into the model structure the output of an optimized harvest, based on current conditions of the two populations. While providing novel management, the output of the ARM model is limited to a Regional Harvest Allocation only. That is, the optimized harvest is suggested for the entire Delaware Bay population of horseshoe crabs, from which it is assumed that Delaware, New Jersey, Maryland, and Virginia draw at least a portion of their yearly horseshoe crab harvest. The ARM model does not dictate the allocation of these crabs among the four states.

In order to determine a state-by-state allocation in an open and objective way, four factors or decisions need to be considered:

1) How much of each state's harvest is comprised of Delaware Bay-origin crabs?
2) On what basis should the total recommended harvest, output by the ARM model, be divided among the four states of Delaware, New Jersey, Maryland, and Virginia?
3) Should there be an overall harvest cap placed on Maryland and Virginia's harvest to protect non-Delaware Bay origin horseshoe crabs?
4) Should there be an allowable but minimal harvest of Delaware Bay origin horseshoe crabs for Maryland and Virginia if the ARM-recommended harvest option requires a moratorium on one or both genders?

This report provides background and recommendations, in the form of a slot, for Decision 1, based upon genetic data, tagging data, and expert opinion within the group. The DBETC agreed that Decision 2 is primarily a policy decision but offer some conceptual background on the implications for harvest management for several allocation options. The DBETC unanimously recommends that an overall harvest cap should be placed on Maryland and Virginia's harvest, given that no data currently exist indicating that harvest levels would be sustainable above their current levels. The DBETC recommends that the Board use the Addendum IV quota levels, which are currently in place, as the basis for the harvest cap levels. The DBETC agreed that it could not offer any input on Decision 4, as they believe it is solely a policy decision.

The DBETC hopes that this input will be valuable to the Board in going forward with the ARM framework for horseshoe crab management.

The problem

Under the ASMFC Fishery Management Plan, harvest is allocated on a state-by-state basis; however; the ARM framework, as designed, only recommends a regional (NJ, DE, MD, and VA combined) harvest. In order to translate this regional harvest into a state-by-state harvest, it is necessary to consider four factors and to decide how to incorporate these factors when calculating the state-by-state allocation. There are both technical and policy/value-based aspects to consider when incorporating these four factors. The DBETC convened a meeting to determine:

1) How much of each state's harvest (DE, NJ, MD, and VA) annually comes from Delaware Bay, based upon tagging and genetic data as well as expert opinion (λ, lambda);
2) What weighting method to allocate the Delaware Bay harvest quota among the four states;
3) Whether to place an overall cap on MD and VA harvest levels; and
4) Whether to institute an allowable Delaware Bay Stock Allowance (DBSA) harvest option for Maryland and Virginia, should the ARM model recommend a complete or female-only moratorium.

Once these decisions are made and the ARM framework is fully implemented, the benefits will likely include:

- Management that is responsive to the current state of horseshoe crab and red knot populations
- Better ecological management of the fishery and the red knot and shorebird populations
- Improved understanding over time of the connections among the species, and
- Improved long-term management, anticipating more stable harvest levels

This report offers the DBETC's input, where appropriate, on the four decisions.

Decisions to be made in implementing ARM-based Management Harvest

Decision 1- Lambda (λ), Delaware Bay origin of Maryland and Virginia's catch

Delaware, New Jersey, Maryland, and Virginia all draw some portion of their yearly quota from Delaware Bay crabs. For Delaware and New Jersey, this level is assumed to be 100%; that is, all horseshoe crabs harvested by fishermen in Delaware and New Jersey come from the Delaware Bay population. Thus their lambda values, λ, would be set to one (1.0).

For Maryland and Virginia, the proportion of crabs is not as straight-forward to assess. To determine the origins of crabs around the mid-Atlantic region, the use of the U.S. Fish and Wildlife Service's (USFWS) tagging data and the genetic work done by Virginia Tech and collaborators at the U.S. Geological Survey- Biological Resources Division are sources of data to gain an understanding of the movements and thus the origins of horseshoe crabs.

The USFWS tagging program is the longest time series for horseshoe crab tagging data, having been in operation since 1999. The program experienced a large increase since 2008, when the number of released tags jumped nearly 3-fold in a single year. In addition, four new tagging programs began in 2009 on the Massachusetts coast, in the Raritan/Sandy Hook Bays area (New York/New Jersey), on the Georgia Coast and specifically near Wassaw Island, and finally in upper Chesapeake Bay. Through 2010, over 150,000 tags were released and over 17,000 tags recaptured. Sheila Eyler, who organizes the tagging program for the USFWS, presented the data and background at the DBETC meeting.

The tagging data indicated that low levels of Delaware Bay-origin horseshoe crabs are caught in Maryland and Virginia fisheries. The values ranged from around 10% to 20%, indicating that approximately 10-20% of the total Maryland or Virginia harvest originates from Delaware Bay. Although this analysis is based on empirical data, the DBETC was in consensus that these values were unexpectedly low. A discussion ensued regarding the data collection methodology, assumptions required for analyzing tagging data in general, and specific concerns for addressing the question at hand.

The greatest concerns were the location, timing, and effort expended in tagging and resighting crabs and how using different subsets of data would affect the results. For example, tagging and resighting only during spawning season provides only an indication of site fidelity among years. Conversely, tagging and resighting only during non-breeding periods is not useful since crabs from different breeding populations are mixed during non-breeding periods, thus providing no indication of the crabs' origins. Horseshoe crabs must be tagged when breeding, in order to give

some indication of the crabs' origins. Since neither tagging nor resighting is from the bait fishery, the data are not as useful to characterize the makeup of the harvest. Tagging data can provide more information as to crabs' origins, once sample sizes of crabs tagged while spawning and collected during non-spawning periods, or vice versa, are larger.

Since Maryland and Virginia harvest primarily during non-spawning months, tagging of crabs on spawning beaches (known origin) and recaptures from the commercial fishery (mixed population) would provide an indication of harvested crabs' spawning origins. However, a disproportionately large number of tags are applied in Delaware Bay, which would be expected to bias the results. In addition, reports of tagged crabs from the commercial fishery are very low. It is currently unknown as to whether the low reporting rate is due to low cooperation from the industry or a low catch rate of tagged crabs. In either case, the resulting sample size is too small to provide reliable estimates of harvested crabs' origins.

An alternate method that could provide meaningful results would be to use crabs tagged offshore during non-breeding periods (mixed population) and resightings from breeding periods (known origin). As noted before, however, the amount of effort expended in Delaware Bay is disproportionately higher than in Virginia and Maryland, presumably leading to higher numbers of resightings, and therefore skewed results. Further, the level of overall effort currently does not provide a large enough sample size at this time for this specific analysis.

The consensus recommendation from the DBETC is that the current tagging analysis is not sufficient to accurately identify spawning origin in the commercial fishery. Since the analysis is based on empirical data, the DBETC decided to provide the results to the Board for their consideration, but recommends the results be interpreted as a lower limit on the proportion of Delaware Bay origin crabs in Maryland and Virginia harvests and not be used in the final allocation decision.

Genetics data also have the potential to provide insight into different populations of horseshoe crabs. By screening microsatellite DNA markers, researchers can estimate levels of genetic relatedness among different groups of crabs. Additionally, an "assignment" procedure can be used to examine the genetic composition of a harvest and to determine the most likely mix of source populations, from which that harvest was drawn. Dr. Eric Hallerman, who presented the data at the DBETC meeting, noted that low levels of genetically effective migration, or breeding across populations, can maintain genetic similarity. Thus, the estimates of lambda based on genetics data provide a more risk-averse situation.

The genetics data indicated that the horseshoe crabs from Cape Cod to Cape Hatteras comprise a genetically related stock, the Mid-Atlantic horseshoe crab stock, which in turn is comprised of smaller subunits. Within this geographic region, evidence indicated that the Delaware Bay subunit extends from Cape Cod, MA, to near Tom's Cove in Virginia, where it begins to mix with a separate and distinct Chesapeake Bay subunit. Dr. Hallerman noted that these results agreed well with tagging work reported by Shuster (1985) that also suggested genetic overlap of Delaware Bay and Chesapeake Bay stocks in the Tom's Cove region. The assignment test analysis used all spawning assemblages in the region as the baseline data, and then "assigned" proportions of the harvest in each fishery to any of the ten source populations in the region. An

overall lambda of 0.51 was estimated for the trawl fishery offshore of Maryland. An overall lambda of 0.35 was estimated for the two fisheries along the Atlantic coast of Virginia.

Based on these data, follow-up genetics work performed by Dr. Tim King, post-meeting email discussions, and the February 25, 2011 webinar, as well as the committee's expert opinion and experience with horseshoe crabs and the fishing industries, the DBETC recommends the following bracketed options:

Option 1: Highest Risk, based on tagging data

State	**Lambda, λ**
NJ	1.0
DE	1.0
MD	**0.13**
VA	**0.09**

As mentioned earlier, this option poses the highest risk to Delaware Bay origin horseshoe crabs should the estimates of lambda be incorrect. Results of this method are based on empirical tagging data, which is considered better than an ad hoc determination; however, the DBETC voiced major concerns that the basic assumptions for analyzing tagging data were violated, making the results of this analysis highly suspect. All members of the DBETC agreed that this option should not be used but rather serve as a lower boundary.
The DBETC does not recommend this option.

Option 2: Lowest risk, highest possible lambda values

State	**Lambda, λ**
NJ	1.0
DE	1.0
MD	**1.0**
VA	**1.0**

This option presents the upper boundary, as lambda values can be no higher than 1.0. By assuming a value of 1.0 for all four states, it is implied that all horseshoe crabs harvested by the four states orginate in the Delaware Bay region. Concurrently, it is implied that no crabs harvested in the defined area have originated elsewhere (defined area being Delaware, New Jersey, Maryland, and waters east of the COLREGS line for Virginia). This is the most risk-averse option, but the available genetics and tagging data, as well as expert opinion, support lambda values for Maryland and Virginia that are less than 1.0. It can also be noted that recent addenda have not addressed the origins of crabs within the harvests. There has generally been the assumption that some undefined proportion of the harvests originated from Delaware Bay, but not the full harvest.
The DBETC does not recommend this option.

Option 3: Medium risk, based on genetics data and expert opinion

State	Lambda, λ
NJ	1.0
DE	1.0
MD	**0.51**
VA	**0.35**

This option represents a medium-risk scenario compared to Options 1 and 2. The lambda values for Maryland and Virginia are based on genetics results, as well as expert opinion from the DBETC based on their work and knowledge of the horseshoe crab populations and the genetic tests. As this analysis uses genetic data, the term "of Delaware Bay origin" implies that these crabs are of the same genetic subunit originating in the Delaware Bay area. This interpretation is more conservative than the ARM-defined criteria of a Delaware Bay origin crab, as the ARM defines such a crab as being one that would spawn at least once inside the geographic Delaware Bay. The DBETC felt that, since the Delaware Bay population has only begun to show a slightly increasing trend, the use of this more conservative definition should be considered. In addition, the results are based on scientifically collected data and analysis, as well as being generally consistent with expert opinion of the DBETC members. As such, the DBETC makes a consensus recommendation that these lambda values, based on genetic data and analysis, be adopted by the Management Board.
The DBETC recommends this option.

Decision 2- W_i, Weighting system for state allocation of optimized harvest

Based on the optimized harvest level, a total Delaware Bay horseshoe crab harvest will be set. The weighting system used will determine how that harvest will be apportioned among the four states of Delaware, New Jersey, Maryland and Virginia. The DBETC agreed that this decision is primarily a policy decision, and thus up to the Board to decide, based upon their opinions as well input from the Advisory Panels and the public.

However, the DBETC felt that they could provide some context behind the different options available to the Board for deciding the weighting system for allocation. The DBETC felt that the weights could be based on three different options:

1) Historical, unregulated harvest levels:
   The Reference Period Landings (RPLs) represent the historic distribution of the catch, and presumably, also the historic distribution of the fishery.

State	Allocation weight, w_i
NJ	41.1%
DE	32.8%
MD	21.3%
VA	4.8%

2) Current management quotas:
These allocations mirror the current quotas set by Addendum IV, which include the Addendum III reductions for NJ, DE, and MD as well as the Addendum IV restriction for VA regarding harvest east of the COLREGS line. This option recognizes the current distribution of quota that is currently occurring, although those numbers are based on entire quota levels and not just Delaware Bay.

State	Allocation weight, w_i
NJ	32.4%
DE	32.4%
MD	28.2%
VA	7.0%

3) Current estimated abundance levels:
These levels are based on state-by-state estimates from the Virginia Tech trawl survey. This option has the advantages of being based on fishery-independent data and can be updated yearly pending survey results. It should be noted, however, that the survey design is not meant to be analyzed on a state-by-state basis, possibly introducing error into these estimates.

State	Allocation weight, w_i
NJ	28%
DE	47%
MD	18%
VA	7%

The DBETC does not make any recommendations on any of the above-mentioned allocation weight options.

Decision 3- Harvest cap for Maryland and Virginia

Placing a cap on the quota for Maryland and Virginia would prevent any further increases in their harvest should the ARM model output an optimized harvest level that, under the current allocation decision scheme, would allow for such an increase. The DBETC reviewed potential scenarios that could occur in the future, using different values of Lambda and harvest outputs. The results indicated that, without a cap and under certain assumptions, the harvest levels could rise to over one million total crabs for Maryland and Virginia in order to attain their quota of Delaware Bay origin crabs. The cap would serve as a precautionary measure against overharvest of non-Delaware bay populations of crabs.

The basis for the cap can include past effort and landing levels or caps from past management addenda. The DBETC considered caps that included RPL levels, Addenda I-IV, and average landings. The cap levels are indicated in **Table 1**. A cap based on the RPL or Addendum I levels would do little to limit harvest levels, except in extreme circumstances. Addenda III and

IV are similar, except that Addendum IV specifies the limit on Virginia harvest east of the COLREGS line. Average landings would provide the strictest cap.

Table 1. Proposed cap and resultant maximum quota levels for Maryland and Virginia

Cap Basis	MD quota	VA quota
RFPs	613,225	203,326
Add I	459,919	152,495
Add III	170,653	152,495
Add IV	170,653	60,998
Av Landings	160,746	21,280

The DBETC agreed that, without evidence of an increasing non-Delaware Bay population(s) that can support higher levels of harvest, a cap should be instituted. Considering that the Delaware Bay and southeast stocks are showing stable or increasing populations under current management measures, the **DBETC recommends a cap based on Addendum IV quota levels**. **The DBETC also recommends that the cap be considered an option that could be revisited in the future, pending new data**.

The DBETC would note, although not technical-based, feedback from audience members indicated that the industry had adapted itself to current harvest levels, and the stability from a harvest cap would likely be appreciated until data indicate further rebuilding of the stock.

Decision 4- Delaware Bay Stock Allowance (DBSA)

The DBETC noted that the Delaware Bay Stock Allowance (DBSA) decision is only relevant should the ARM model suggest a harvest package that has either a full or female-only moratorium AND should the Lambda values for Maryland and Virginia be set at some value less than 1.0. The current recommended ARM Harvest package, Package 3, contains a female-only moratorium, and thus the DBETC felt that this option should at least be discussed.

This option, if chosen, would still allow Maryland and Virginia to harvest some Delaware-Bay origin horseshoe crabs that are under a moratorium (e.g. females under Harvest Package 3) at a defined minimal level. The option recognizes that at least some portion of the Maryland and Virginia harvest is composed of non-Delaware Bay origin crabs. Without this option, any sort of a moratorium on Delaware Bay origin crabs would impose a similar moratorium on Maryland and Virginia's harvests of non-Delaware Bay origin crabs

Two options discussed included 1% or 5% of a two-year average of coastwide horseshoe crab harvest. This total value would then be split proportionally among the two states. **Table 2** presents an example of Maryland and Virginia allowable harvests of Delaware Bay origin females under Harvest Package 3, which is the currently recommended package.

Table 2. DBSA percentage and the resulting Maryland and Virginia female quotas of Delaware Bay origin female crabs under Harvest Option 3, based on an average of coastwide 2008-09 landings.

DBSA percentage	MD quota	VA quota
1%	2,236	1,307
5%	11,179	6,537

The DBETC also considered basing the DBSA percentage based on the catches of just the four Delaware Bay states discussed, Delaware, New Jersey, Maryland, and Virginia (Table 3). Note that these estimated DBSA quota levels include New Jersey's complete moratorium, which began in 2007. Again, the quotas shown in **Table 3** reflect those female quotas available under Harvest Package 3.

Table 3. DBSA percentage and the resulting Maryland and Virginia female quotas based on an average of Delaware Bay (NJ, DE, MD, VA) 2008-09 landings, including New Jersey's moratorium.

DBSA percentage	MD quota	VA quota
1%	1,246	728
5%	6,223	3,645

This allowance would permit continued harvest by Maryland and Virginia under a complete or female-only moratorium, recognizing the following two statements:

- A certain, small number of Delaware Bay-origin crabs may still be caught by Maryland and Virginia
- Maryland and Virginia catch crabs that are not of Delaware-Bay origin.

Should a DBSA not be allowed and the ARM model dictates a complete or female-only moratorium, that moratorium will be implemented for all four Delaware Bay states (NJ, DE, MD, VA). For example, currently Harvest Package 3 was selected as the optimized harvest level by the ARM model. This package includes a female moratorium. Under the DBSA, a number of female crabs up to the DBSA level would be factored into the harvest quotas for Maryland and Virginia. These Delaware Bay-female crabs would be allowed to be caught, as well as a certain number of presumed non-Delaware Bay-origin female crabs. In contrast, no DBSA would mean that none of the landings from New Jersey, Delaware, Maryland or Virginia could include female horseshoe crabs.

The DBETC felt that this decision was purely policy-based and does not offer any technical recommendations.

Conclusions

The ARM Framework does not provide state-by-state allocations. In order to convert the ARM Regional Allocations to state-by-state allocations in a transparent and scientifically-sound way,

the DBETC recommends use of the spreadsheet model, originally presented to the Board by John Sweka at the August 2010 meeting. This model calculates the state-by-state allocation, factoring in four different decisions. The DBETC discussed all of these at their January 24-25, 2011 meeting in Arlington, Virginia, through email, and during the February 25, 2011 webinar, and reached the following recommendations for the Board to consider:

1) *Lambda, λ*
   The **DBETC recommends Option 3**, with lambda values set at 0.35 for Virginia and 0.51 for Maryland, based on genetics and tagging data as well as expert opinion. In addition, the **DBETC recommends against Options 1 and 2**, as they do not reflect what is currently known about the stock movements based on genetics and tagging data, and expert experience.

2) *Allocation weights, w_i*
   The **DBETC does not make any recommendations,** but provides three alternatives for consideration by the Management Board.

3) *Harvest cap for Maryland and Virginia*
   The **DBETC recommends using Addendum IV quota levels** for the harvest cap, based on current stock population and recovery trends.

4) *Delaware Bay Stock Allowance (DBSA)*
   The **DBETC does not make any recommendations**.

Appendix A

At its March 23, 2011 Horseshoe Crab Management Board meeting, the Board requested that additional options be included for the Delaware Bay Stock Allowance for consideration by the Horseshoe Crab and Shorebird Advisory Panels. These options included 10% and current quota levels. All projections are based on Harvest Package 3 from the ARM model. For Maryland current quota levels are based on Maryland's rules of a required 2:1, male:female ratio, and the level of Delaware Bay harvest of females necessary to achieve the normal quota harvest of females in its totality (56,885 females). For Virginia current quota levels are based on the Interstate Fishery Management Plan requirement that there be a 2:1, male:female ratio and no more than 40% of the crabs come from east of the COLREGS line. It is this harvest quota level of females (20,333 female crabs) that is used to calculate the DBSA percentage to achieve current quota levels.

Table AI-a. DBSA percentage and the resulting Maryland and Virginia female quotas of Delaware Bay origin female crabs, as well as total female quotas, under Harvest Option 3, based on an average of coastwide 2009-10 landings. Assumptions include Lambda for Maryland = 0.51 and for Virginia = 0.35, weight allocation based on RPLs, and a total harvest cap based on Addendum IV levels.

DBSA percentage	MD DE Bay females	MD Total females	VA DE Bay females	VA Total females
1%	2,751	5,395	626	1,789
5%	13,756	26,973	3,130	8,943
10%	27,513	53,946	6,260	17,887
Current quota (12%)	33,015	64,735	7,512	21,464

Table AI-b. DBSA percentage and the resulting Maryland and Virginia female quotas of Delaware Bay origin female crabs, as well as total female quotas, under Harvest Option 3, based on an average of coastwide 2009-10 landings. Assumptions include Lambda for Maryland = 0.51 and for Virginia = 0.35, weight allocation based on Addendum IV quota allocations, and a total harvest cap based on Addendum IV levels.

DBSA percentage	MD DE Bay females	MD Total females	VA DE Bay females	VA Total females
1%	2,712	5,318	665	1,901
5%	13,560	26,589	3,326	9,504
10%	27,120	53,177	6,653	19,008
Current quota (11%)	29,832	58,495	7,318	20,908

Table AI-c. DBSA percentage and the resulting Maryland and Virginia female quotas of Delaware Bay origin female crabs, as well as total female quotas, under Harvest Option 3, based on an average of coastwide 2009-10 landings. Assumptions include Lambda for Maryland = 0.51 and for Virginia = 0.35, weight allocation based on Virginia Tech Trawl Survey estimated abundances, and a total harvest cap based on Addendum IV levels.

DBSA percentage	MD DE Bay females	MD Total females	VA DE Bay females	VA Total females
1%	2,432	4,768	946	2,702
5%	12,158	23,840	4,728	13,509
10%	24,317	47,649	9,456	27,018
Current quota (11%)	29,180	57,215	11,348	32,422

The following tables are based on a DBSA percentage of just the Delaware Bay states' harvest from 2009-10. These calculations include the New Jersey moratorium as well as Virginia's total harvest (west and east of the COLREGS line).

Table AI-d. DBSA percentage and the resulting Maryland and Virginia female quotas of Delaware Bay origin female crabs, as well as total female quotas, under Harvest Option 3, based on an average of the Delaware Bay (DE, NJ, MD, VA) 2009-10 landings. Assumptions include Lambda for Maryland = 0.51 and for Virginia = 0.35, weight allocation based on RPLs, and a total harvest cap based on Addendum IV levels.

DBSA percentage	MD DE Bay females	MD Total females	VA DE Bay females	VA Total females
1%	1,662	3,258	378	1,080
5%	8,309	16,292	1,891	5,402
10%	16,618	32,584	3,781	10,804
Current quota (19%)	31,574	61,909	7,184	20,527

Table AI-e. DBSA percentage and the resulting Maryland and Virginia female quotas of Delaware Bay origin female crabs, as well as total female quotas, under Harvest Option 3, based on an average of the Delaware Bay (DE, NJ, MD, VA) 2009-10 landings. Assumptions include Lambda for Maryland = 0.51 and for Virginia = 0.35, weight allocation based on Addendum IV quota levels, and a total harvest cap based on Addendum IV levels.

DBSA percentage	MD DE Bay females	MD Total females	VA DE Bay females	VA Total females
1%	1,638	3,212	402	1,148
5%	8,190	16,060	2,009	5,740
10%	16,381	32,119	4,018	11,481
Current quota (18%)	29,485	57,814	7,233	20,665

Table AI-f. DBSA percentage and the resulting Maryland and Virginia female quotas of Delaware Bay origin female crabs, as well as total female quotas, under Harvest Option 3, based on an average of the Delaware Bay (DE, NJ, MD, VA) 2009-10 landings. Assumptions include Lambda for Maryland = 0.51 and for Virginia = 0.35, weight allocation based on Virginia Tech Trawl Survey estimated abundances, and a total harvest cap based on Addendum IV levels.

DBSA percentage	MD DE Bay females	MD Total females	VA DE Bay females	VA Total females
1%	1,469	2,880	571	1,632
5%	7,344	14,399	2,856	8,160
10%	14,687	28,798	5,712	16,319
Current quota (20%)	29,374	57,597	11,423	32,638