2016 Chesapeake Bay Blue Crab Advisory Report

CBSAC Meeting Date: May 18, 2016
Report Final Draft: June 30, 2016

1. INTRODUCTION

1.1 Background: Science and Management

The Chesapeake Bay Stock Assessment Committee (CBSAC) combines the expertise of state representatives and scientists from the Chesapeake Bay region, as well as federal fisheries scientists from the National Marine Fisheries Service's Northeast and Southeast Fisheries Science Centers. This committee has met each year since 1997 to review the results of annual Chesapeake Bay blue crab surveys and harvest data, and to develop management advice for Chesapeake Bay jurisdictions: the state of Maryland, Commonwealth of Virginia, and the Potomac River Fisheries Commission (PRFC).

Three benchmark stock assessments of the Chesapeake Bay blue crab have been conducted since 1997. The most recent assessment was completed in 2011[1] with support from the Virginia Marine Resources Commission (VMRC), Maryland Department of Natural Resources (MD DNR), and the NOAA Chesapeake Bay Office (NCBO). The 2011 assessment recommended revision of the former overfishing reference point, which had been based on conserving a fraction of the maximum spawning potential (MSP), to one based on achieving the maximum sustainable yield (MSY; Table 1). The 2011 stock assessment recommended replacing the empirically-estimated overfished age 1+ (both sexes) abundance threshold and target with an MSY-based threshold and target based solely on the abundance of female age 1+ crabs.

Female-specific reference points were formally adopted by all three management jurisdictions in December 2011. Management of the blue crab stock is coordinated among the jurisdictions by the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team (SFGIT). Organized by the Chesapeake Bay Program and chaired by NCBO, the SFGIT is led by an Executive Committee of senior fisheries managers from the MD DNR, VMRC, PRFC, the Atlantic States Marine Fisheries Commission, and the District Department of the Environment.

CBSAC adopted the Baywide Winter Dredge Survey (WDS) as the primary indicator of blue crab population health in 2006 because it is the most comprehensive and statistically robust of the blue crab surveys conducted in the Bay[2]. The WDS measures the density of crabs (number per 1,000 square meters) at approximately 1,500 sites throughout the Bay. The measured densities of crabs are adjusted to account for the efficiency of the sampling gear and are expanded based on the area of Chesapeake Bay, providing an annual estimate of the number of over-wintering crabs by age and sex[2]. An estimate of the mortality during winter is also obtained from the survey results.

1.2 Background: Stock Status and Current Management Framework

Under the current framework, annual estimates of exploitation fraction are calculated as the annual harvest of female crabs in a given year (not including discards, bycatch, or unreported losses) divided by the total number of female crabs (age 0+) estimated in the population at the start of the season. As part of this calculation, the juvenile component of the total estimated number of crabs is scaled up by a factor of 2.5 so that the empirical estimate of exploitation uses the same assumption about juvenile susceptibility to the survey as the stock assessment that generated the reference points. Thus, the empirical estimates of exploitation rate can be compared with the assessment model derived target and threshold reference points. The 2016 exploitation fraction cannot be calculated until the completion of the 2016 fishery and is therefore listed as TBD (to be determined). Crab abundance is estimated from the WDS each year. The current framework recommends monitoring the abundance of female age-1+ crabs in comparison to female-specific abundance reference points. Management seeks to control the fishery such that the number of crabs in the population remains above the minimum set by the overfished (depleted) threshold. Ideally, the fishery should operate to meet target values and should never surpass the exploitation fraction threshold value and never go below the abundance threshold value (Table 1).

Table 1. Stock status based on reference points for age 0+ (exploitation fraction) and age 1+ (abundance) female crabs. Recent stock status levels that did not exceed threshold values are shown in green; whereas exploitation values or abundance estimates exceeding thresholds are shown in red.

Control Rule	**Reference Points**			**Stock Status**					
	Period	**Target**	**Threshold**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Exploitation Fraction (age 0+ female crabs)	Current, Female-specific	25.5%	34% (max)	24%	10%	23%	17%	15%	**TBD**
Abundance (millions of age 1+ female crabs)	Current, Female-Specific	215	70 (min)	190	97	147	68.5	101	194

2. CONTROL RULES

2.1 Control Rule from 2011 Benchmark Assessment

The 2011 benchmark assessment recommended a control rule based on biological reference points for the female component of the population. The application of a control rule to management of the blue crab fisheries was first adopted by the Bi-State Blue Crab Advisory Committee in 2001[3]. The current female-specific targets and thresholds were developed using an MSY approach. U_{MSY} is defined as the level of fishing (expressed as the percentage of the population harvested) that achieves the largest average catch that can be sustained over time without risking stock collapse. Following precedent adopted by the New England and Mid-Atlantic Fishery Management Councils, the 2011 assessment recommended a target exploitation level that was associated with 75% of the value of U_{MSY} and a threshold exploitation level set equal to U_{MSY}. The female-specific, age-1+ abundance target and threshold were set accordingly at abundance levels associated with $N_{0.75*UMSY}$ (target) and 50% N_{MSY} (threshold).

2.2 Spawning-age Female Crabs: Reference Points

The 2011 benchmark assessment recommended a threshold abundance of 70 million female spawning-age (age 1+) crabs and a target abundance of 215 million female spawning-age crabs. Approximately 194 million female spawning-age crabs were estimated to be present in the Bay at the start of the 2016 crabbing season, a 92% increase from the 2015 estimate of 101 million spawning-age female crabs (Figure 1). The 2016 abundance of spawning-age female crabs is above the threshold, and about 10% below the target.

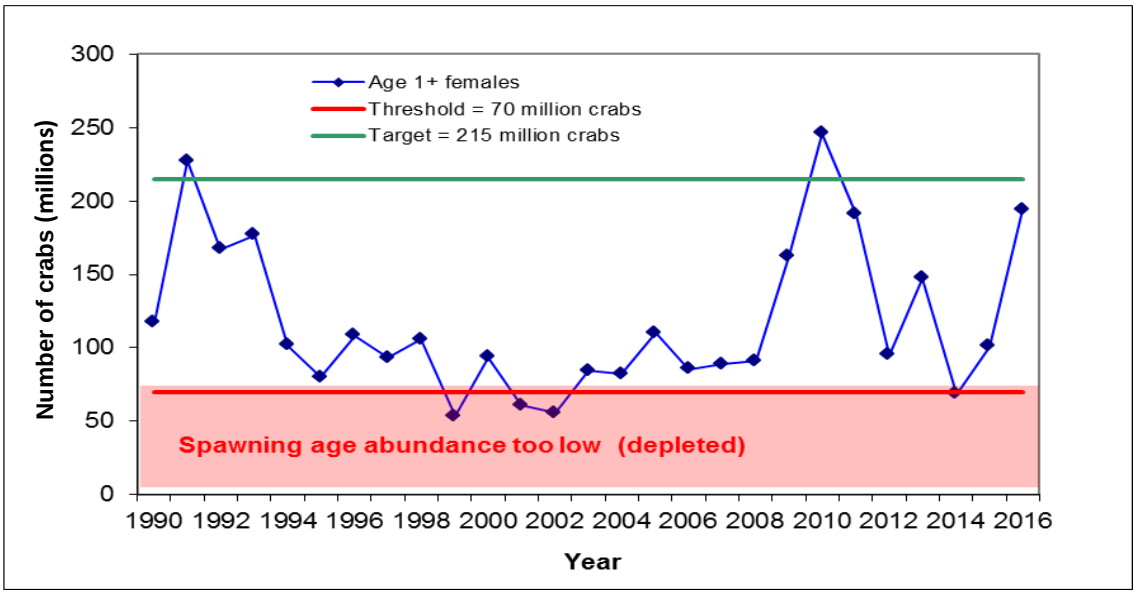

Figure 1. Winter dredge survey estimate of abundance of female blue crabs age one year and older (age 1+) 1990-2016 with female-specific reference points. These are female crabs measuring greater than 60 mm across the carapace and are considered the 'exploitable stock' that could spawn within this year.

2.3 Female Exploitation Fraction: Reference Points

The percentage of all female crabs (ages 0+) removed by fishing (exploitation fraction) in 2015 was approximately 15%. This exploitation fraction is below the target of 25.5% and the threshold of 34% for the eighth consecutive year since female-specific management measures were implemented in 2008 (Figure 2).

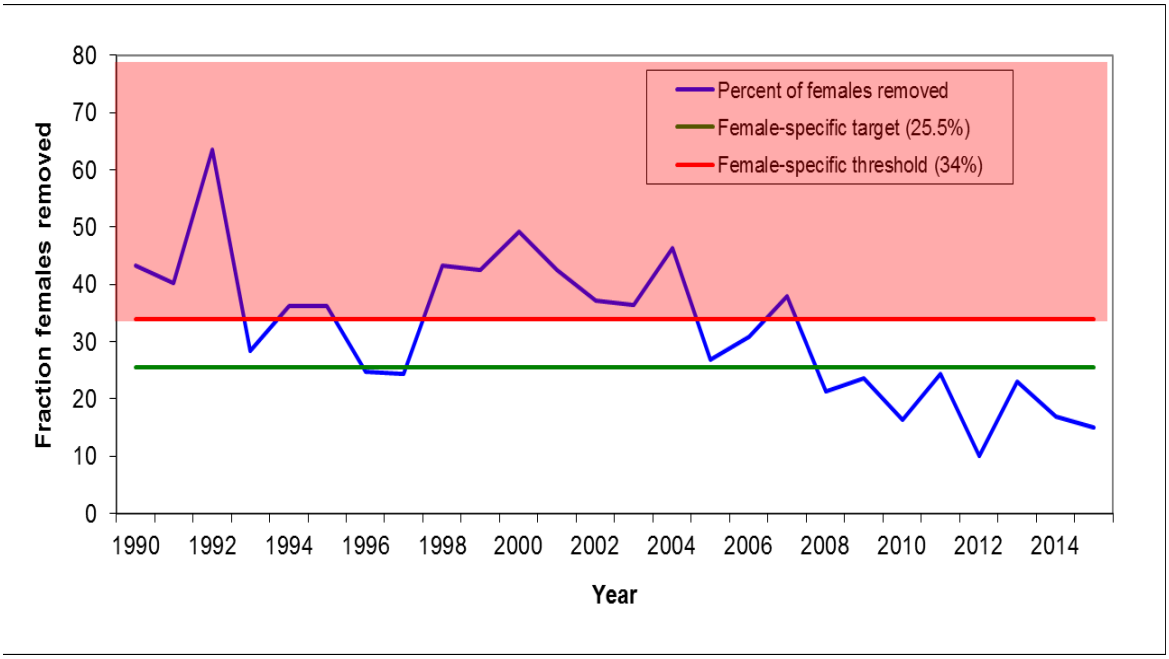

Figure 2. The percentage of all female blue crabs removed from the population each year by fishing relative to the female-specific target (25.5%) and threshold (34%) exploitation rates, 1990 through 2015. Exploitation rate (% removed) is the number of female crabs harvested within a year divided by the female population (age 0 and age 1+) estimated by the WDS at the beginning of the year.

2.4 Control Rule Visualization

Figure 3 shows the status of the blue crab stock for each year relative to both the female age 1+ abundance (N) reference points and female age 0+ exploitation (U) reference points (explained in sections 2.2 and 2.3). The red areas show where the threshold for female abundance and/or the threshold for female exploitation fraction are exceeded. The intersection of the green lines shows where both the abundance and exploitation fraction targets would be reached.

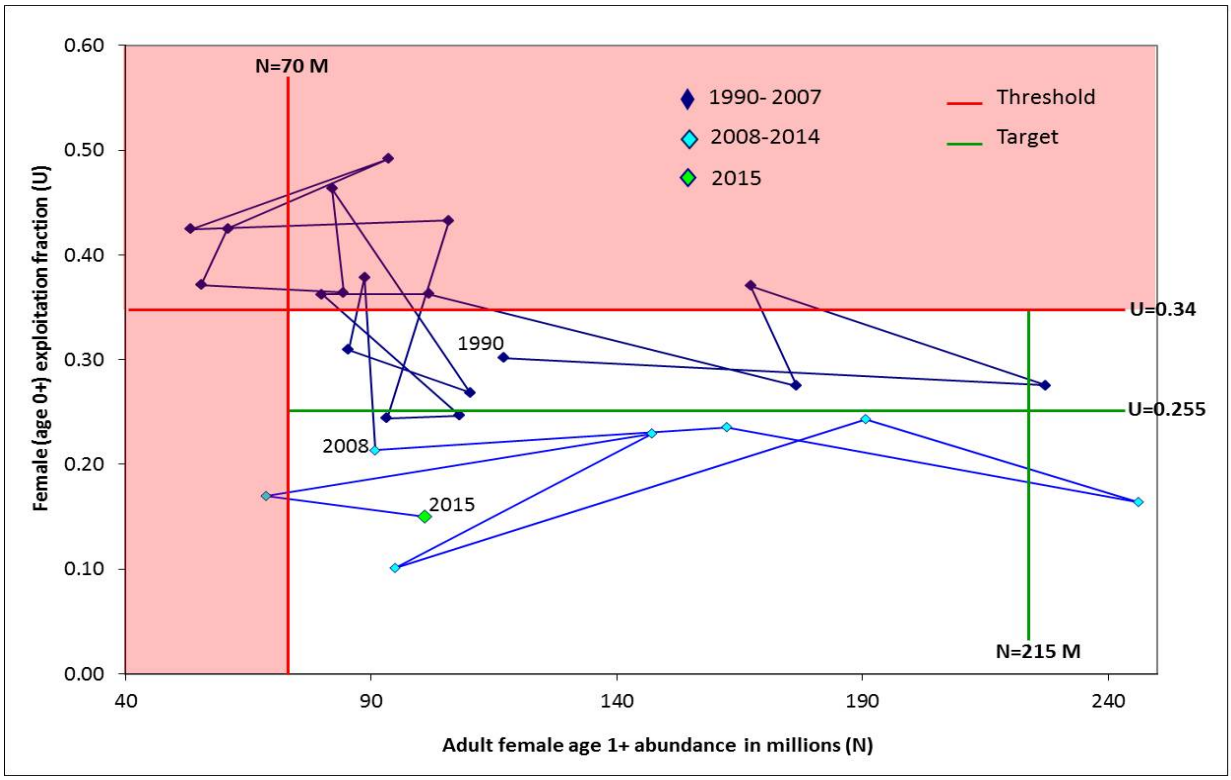

Figure 3. The female-specific control rule for the Chesapeake Bay blue crab fishery prior to and after implementation of initial female-specific management measures in 2008. The current female-specific management framework was formally adopted in 2011. In 2015, adult female abundance (N) was below the 215 million target, while the female exploitation rate (U) was below the 25.5% target. In 2016, age 1+ female abundance was 194 million crabs. 2016 data will be added at the completion of the 2016 fishery.

---

3. POPULATION SIZE (ABUNDANCE)

3.1 All Crabs (both sexes, all ages)

The total abundance of all crabs (males and females of all ages) increased by 35% from 411 million crabs in 2015 to 553 million crabs in 2016 (Figure 4). This level continues an increasing trend seen since 2014, but is still below peaks seen in 2012 and the early 1990s.

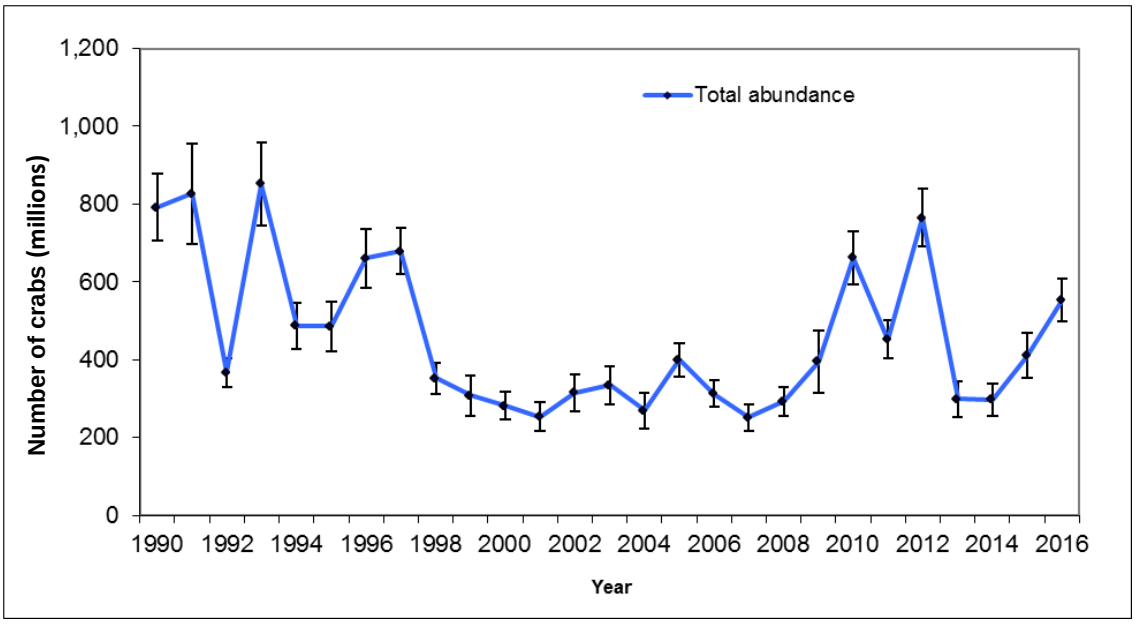

Figure 4. Winter dredge survey estimate of abundance of all crabs (both sexes, all ages) in Chesapeake Bay, 1990 through 2016. Error bars represent 95% confidence intervals.

3.2 Age-0 Crabs

Recruitment is estimated as the number of age 0 crabs (less than 60 mm or 2.4 inches carapace width) in the WDS. The estimate of age 0 crabs in 2016 was 271 million crabs, about the same as the 2015 abundance of 269 million crabs (Figure 5).

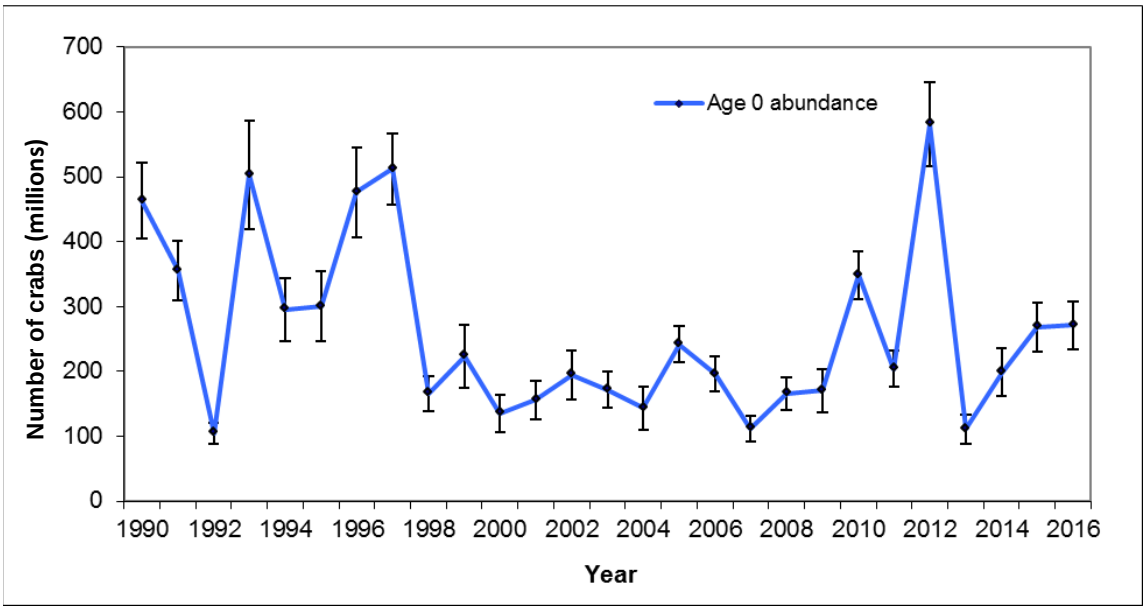

Figure 5. Winter dredge survey estimate of abundance of juvenile blue crabs (age 0), 1990-2016 calculated without the catchability adjustment for juveniles. These are male and female crabs measuring less than 60 mm across the carapace. Error bars represent 95% confidence intervals.

3.3 Age-1+ Male

In 2016, the number of age 1+ male crabs (greater than 60 mm or 2.4 inches carapace width) estimated to be present in the Bay was 91 million crabs (Figure 6), more than double the 2015 estimate of 44 million adult male crabs.

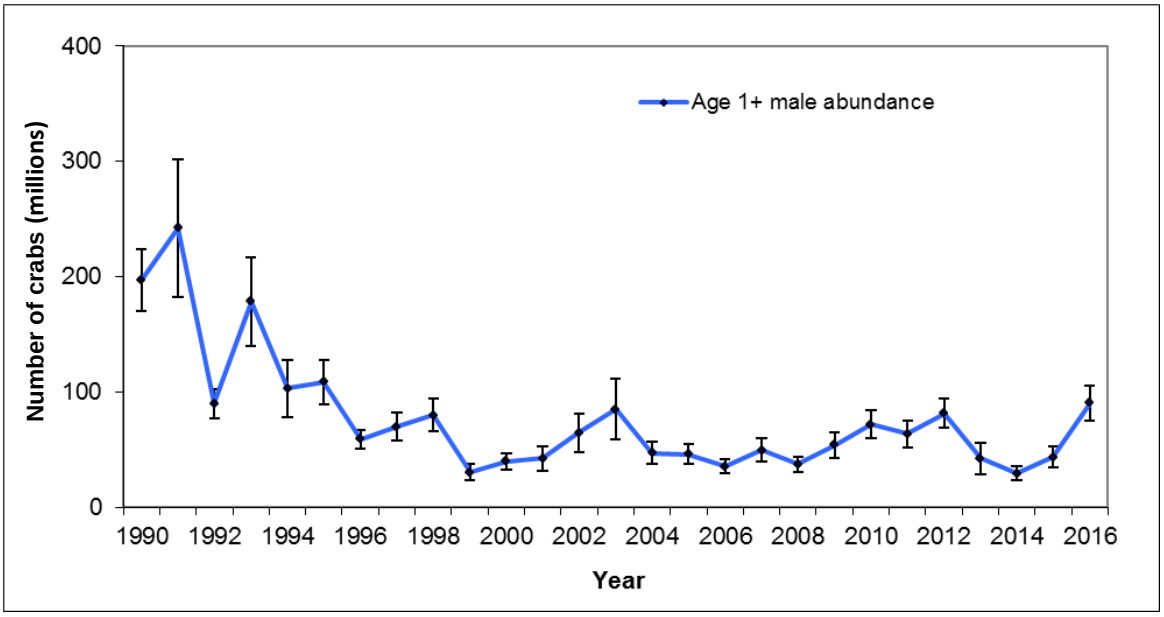

Figure 6. Winter dredge survey estimate of abundance of male blue crabs age one year and older (age 1+), 1990-2016. These are male crabs measuring greater than 60 mm across the carapace and are considered the 'exploitable stock' capable of mating within this year. Error bars represent 95% confidence intervals.

3.4 Overwintering Mortality

Overwintering mortality in 2016 was below average and lower than the high values seen in 2015 (Table 2).

Table 2. Percent dead crabs found in late winter dredge samples each year from 2012-2016 and the average for 1996-2011.

Baywide Age/sex group	1996-2011 average	2012	2013	2014	2015	2016
All crabs	4.78%	1.59%	4.00%	3.79%	15.68%	1.9%
Juveniles	1.00%	0.52%	0.00%	0.89%	10.84%	0.5%
Adult Females	9.53%	2.69%	3.00%	7.68%	19.25%	3.0%
Adult males	9.11%	4.90%	13.88%	13.58%	28.11%	1.1%

4. HARVEST

4.1 Commercial and Recreational Harvest

The three management jurisdictions implemented additional commercial harvest restrictions, mostly lower bushel limits, for females for the 2014 season in response to the depleted abundance of females in 2014. These harvest restrictions were generally maintained for the 2015 season. The 2015 commercial harvest for both males and females from the Bay and its tributaries was estimated as 26.7 million pounds in Maryland, 20.9 million pounds in Virginia and 2.0 million pounds in the Potomac River. This was an increase from 2014 commercial harvest levels for all three jurisdictions: a 62% increase for Maryland, 23% increase for Virginia and a 17% increase for the Potomac River. The total 2015 Baywide commercial harvest of 49.6 million pounds remains below average, but increased by 41% from the 2014 Baywide commercial harvest of 35.2 million pounds, which was the lowest harvest recorded in the last 25 years (Figures 7-8).

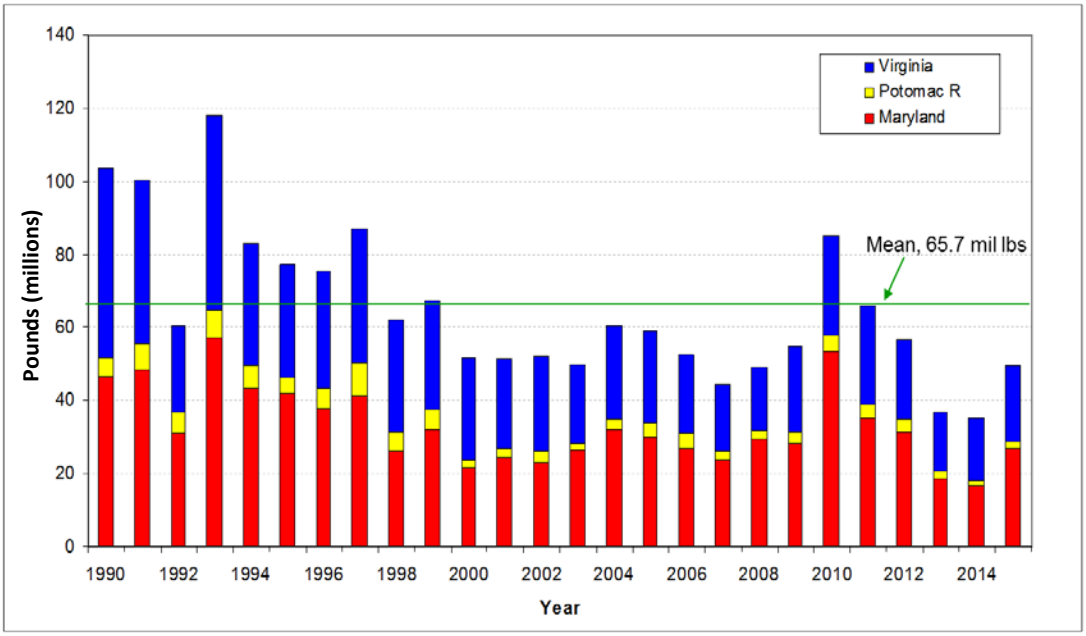

Figure 7. Total commercial blue crab landings (all market categories) in Chesapeake Bay, 1990-2015.

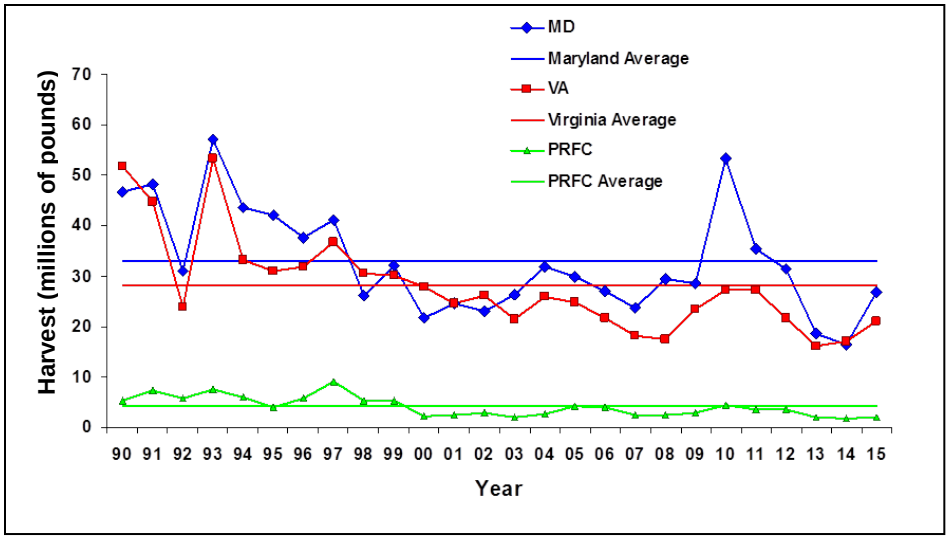

Figure 8. Maryland, Virginia and Potomac River commercial blue crab harvest in millions of pounds from Chesapeake Bay, all market categories, 1990-2015.

Prior to 2009, recreational harvest had been assumed to be approximately 8% of the total Bay wide commercial harvest.[4,5,6] Since recreational harvest of female blue crabs is no longer allowed in Maryland or in the Maryland tributaries of the Potomac River, recreational harvest is better described as 8% of male harvest in those jurisdictions. 2015 Baywide recreational harvest was estimated as 3.5 million pounds, a 52% increase from the 2014 recreational harvest estimate of 2.3 million pounds. Combining the commercial and recreational harvest, approximately 53.1 million pounds of blue crabs were harvested from Chesapeake Bay and its tributaries during the 2015 crabbing season.

---

5. STOCK STATUS

5.1 Female Reference Points

The Chesapeake Bay blue crab stock is currently **not depleted and overfishing is not occurring** (Figure 1-2). The estimated abundance of the stock is between the threshold of 70 million age 1+ female crabs and the target of 215 million age 1+ female crabs outlined in the current management framework. The 2015 exploitation fraction of 15% was below the target (25.5%) and threshold (34%). Abundance, harvest, and exploitation of all crabs are summarized in Appendix A.

5.2 Male Conservation Triggers

In 2011, CBSAC recommended that male abundance should not be allowed to decline to a critically low level relative to female abundance and that a conservation trigger based on male abundance should be developed. In 2013, CBSAC recommended a conservation trigger for male crabs based on the history of male exploitation. Under this trigger, conservation measures should be considered for male blue crabs if male exploitation rate exceeds 33% (calculated with

the juvenile scalar as described in section 1.2), which is the second highest exploitation fraction observed for male crabs since 1990. Choosing the second highest value in the time series ensures a buffer from the maximum observed value of exploitation. It should be noted that this value does not represent a fishing threshold or target. Rather, this trigger will ensure that the male component of the stock is not more heavily exploited, relative to females, than at levels that have occurred in the last 24 years. The 2015 male exploitation fraction was estimated at 22%, which is below the 33% male exploitation rate conservation trigger (Figure 9). Because the male conservation trigger was not exceeded, no management action is recommended at this time specific to male blue crabs.

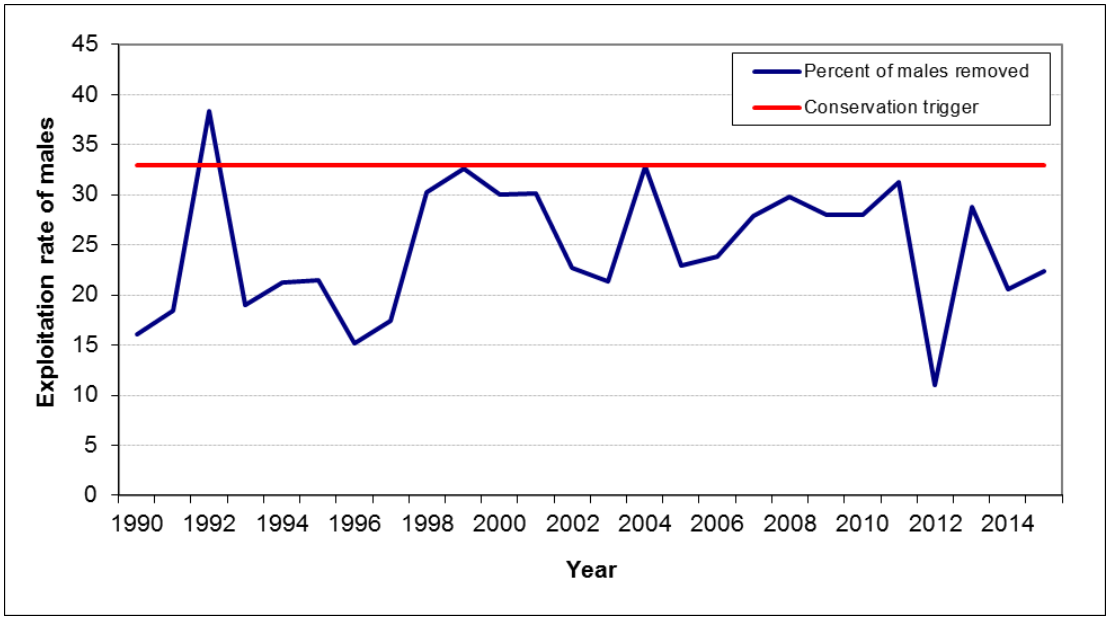

Figure 9. The percentage of male crabs removed from the population each year by fishing, 1990 through 2015. Exploitation rate (% removed) is the number of male crabs harvested within a year divided by the male population estimate (age 0 and age 1+) at the beginning of the year calculated with the juvenile scalar.

5.3 Potential Management Impact

Female exploitation fractions from 1990-2007 were much higher than the exploitation fractions seen from 2008-2014. These lower exploitation fractions in recent years illustrate the probable influence of the female-specific management measures implemented by the jurisdictions starting in 2008. Male exploitation fractions have not shown the same pattern (Figure 10). Additionally, the rapid increase in abundance from 2008 to 2010 and again from 2014 to 2016 may indicate that the current management framework has allowed the stock to regain some of its natural resilience to environmental perturbations.

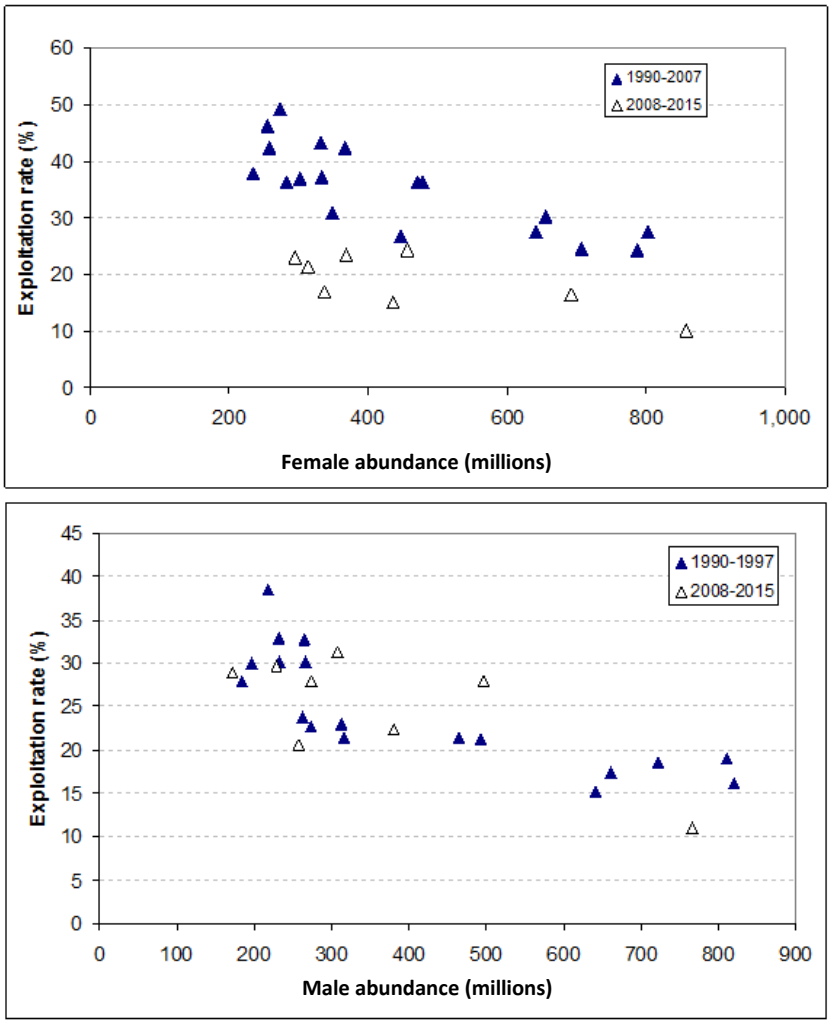

Figure 10. Female (top) and male (bottom) exploitation rate comparison of the time periods prior to and after the 2008 implementation of female-specific management measures.

6. MANAGEMENT ADVICE--SHORT TERM

6.1 Monitor fishery performance and stock status relative to reference points

The female exploitation fraction in 2015 was below the target of 25.5% for the eighth consecutive year. The abundance of adult female crabs increased in 2016, and the abundance of juveniles stayed about the same. While all signs are currently positive for the status of the stock, it has only been two years since the adult female abundance dropped below the threshold of 70 million crabs. The inherent variability of the stock means that management should continue a risk-averse and adaptive management strategy to ensure that harvest is maintained at an appropriate level relative to abundance and the target exploitation fraction.

Beginning in the 2014 crabbing season, the three management jurisdictions adjusted their management timeframe to run from July 2014 through July 2015. CBSAC recommended this

switch in the 2014 Blue Crab Advisory Report, which allows for consideration of the WDS results in the spring before management decisions are made in the summer. However, it places more importance on the estimate of juvenile abundance, as each year class is presumed to be the majority component of the fishery within this time frame, and the current control rule does not account for juvenile abundance as a management-setting metric. In the context of the management year starting in July or August, CBSAC is further exploring if the jurisdictions should more formally consider juvenile abundance levels in management decisions, and how best to do so. CBSAC will report back with findings at a future date.

6.2 Catch Reports

CBSAC again recommends that the jurisdictions implement procedures that provide accurate accountability of all commercial and recreational harvest. All three Chesapeake Bay management jurisdictions have ongoing efforts to improve the quality of catch and fishing effort information submitted by commercial and recreational harvesters. Maryland, Virginia, and PRFC all require daily harvest reports to be submitted on a regular basis and are also collaborating with industry groups to pursue new reporting technologies. Maryland has implemented a pilot electronic reporting program that allows for daily harvest reporting in real time and harvest validation. Virginia continues to promote its online reporting system that began in 2009. PRFC is exploring the use of electronic reporting to potentially begin in the next few years.

While implementing systems for greater accuracy, efforts should also be made, where possible, to better determine the biological characteristics of the catch, both landed and discarded. Note that when changes in reporting requirements are implemented, it is vital that an analysis be undertaken to quantify the impact of these changes on the estimates of harvest. Efforts should also be undertaken to assess the reliability of estimates of recreational harvest Baywide.

---

7. MANAGEMENT ADVICE--LONG TERM

7.1 Catch Control

A management approach that sets annual catch levels based on estimates of abundance from the WDS and that accounts for sex-specific, spatial, and seasonal distribution of crabs could potentially balance annual harvests with highly variable recruitment events. The CBSAC supports the commitment by the blue crab management jurisdictions in the 2014 Chesapeake Bay Watershed Agreement to evaluate the establishment of a Baywide allocation-based management framework, which refers to the development of one or more methods to allocate an annual total allowable catch (TAC) of female and male crabs for the Chesapeake Bay blue crab fishery among the three management jurisdictions. CBSAC will assist the jurisdictions with any scientific and/or data analysis needs during their evaluation of a potential framework, although a comprehensive evaluation of these schemes will require a stock assessment.

7.2 Annual sanctuary and complementary management measures

CBSAC recommends that Virginia consider establishing a year-round sanctuary for mature females in the lower Bay, and Maryland and PRFC consider complementary sanctuaries or other management measures in the upper Bay and Potomac River that would promote survival of mature females in their first and subsequent spawning seasons. Protection of mature females in multiple spawning seasons should bolster the spawning stock and recruitment, and provide a buffer for the population from the combined effects of environmental disturbance and high fishing pressure. The VMRC Crab Management Advisory Committee has discussed possible adjustments to the current Virginia blue crab sanctuary areas and corresponding closing dates in the past. Discussion will continue as needed.

7.3 Characterizing and Quantifying Effort

The blue crab fishery is managed by both effort control and output control strategies. Most regulations in place focus on effort control in the form of limited entry, size limits, daily time limits, pot limits, spatial closures, spatial gear restrictions, and seasonal closures. Output controls currently used are daily harvest limits. In many cases, the amount of effort expended in the fishery is recorded at a broad resolution that makes it difficult to quantify. CBSAC recommends further quantification of effort data in the next stock assessment and increased investment in Baywide effort monitoring, which may include a pot marking system and a Baywide survey of gear-specific effort to estimate the total, as well as spatial and temporal patterns of effort in the blue crab fishery.

7.4 Latent effort

In both Maryland and Virginia, significant numbers of commercial crabbing licenses are unused. The risk posed by this situation is that unused effort could enter the fishery, causing unforeseen impacts on the fishery and the blue crab population. Given recent fluctuations in the crab population, CBSAC recommends analyzing effort levels over time, relative to crab abundance, to evaluate the potential for significant changes in overall effort due to changes in latent effort. A comprehensive analysis of latent effort would, ideally, include a socio-economic component. CBSAC also recognizes that temporal and seasonal shifts in blue crab abundance may alter existing effort exerted by active licenses. The impact of this variability on both latent and active effort should be investigated as a part of this recommendation.

---

8. CRITICAL DATA AND ANALYSIS NEEDS

CBSAC has identified the following prioritized list of fishery-dependent and fishery-independent data needs as well as the benefits provided to management. CBSAC recognizes the importance

and high priority of the next stock assessment in providing in-depth analyses of the Chesapeake Bay blue crab population and scientific guidance to managers.

8.1 Increased accountability and harvest reporting for both commercial and recreational fisheries

CBSAC recommends jurisdictions continue to develop, explore and evaluate implementation of real time electronic reporting systems to increase the accuracy of commercial and recreational landings. Improving commercial and recreational blue crab harvest accountability would provide managers with a more accurate exploitation fraction each year and better support mid-season management changes.

The jurisdictions have been working to implement new harvest reporting technologies over the past few years. Since pilot efforts were introduced in 2012, MD DNR has been using an electronic reporting system that allows commercial crabbers to enter each day's harvest from their vessel. The system includes random daily catch verification and a "hail-in, hail-out" protocol. Maryland is continuing to expand the use of this system for the commercial crabbing fleet. Virginia implemented electronic reporting in 2009 as an alternative mandatory harvest reporting option, but growth has been slow. Through cooperative work among VMRC, Virginia Sea Grant and various industry groups, promotional products were produced and participation of commercial crab harvesters has increased. There is interest among PRFC stakeholders, and it is possible that PRFC may begin using an electronic reporting system in the next few years.

CBSAC recommends a survey of recreational catch and effort be undertaken to ensure the reliability of estimates of recreational removals. The last available estimate for Maryland waters was that for 2011[4,5,6,7]. The last available estimate for Virginia was 2002[5]. Future surveys should ensure that recreational harvest from the Potomac River is also included. A license for recreational crabbing in all jurisdictions would greatly increase the accuracy of catch and effort estimates.

8.2 Gear efficiency pertaining to selectivity of WDS methods

There is no update from 2015-16 regarding how gear efficiency is estimated. Data from paired tows between the two survey vessels were again collected, and the multi-year dataset should be analyzed to help guide the process dealing with the evaluation of efficiency corrections and, possibly, juvenile catchability.

Planning discussions for an upcoming stock assessment have included the possible use of the winter dredge survey as an index of abundance rather than an index of absolute abundance. This approach was recommended by the independent review panel of the last stock assessment. If successful, this approach would provide an estimate of the survey efficiency directly.

8.3 Improving recruitment estimate through a shallow-water survey

Based on the 2011 stock assessment and field experiments by VIMS and the Smithsonian Environmental Research Center, a large fraction of juvenile blue crabs in shallow water is not sampled by the WDS[8]. CBSAC recommends that funding be pursued at the state and federal levels for Bay-wide shallow-water surveys to assess the potential for interannual bias in the fraction of juveniles not sampled by the WDS.

8.4 Application of fishery independent survey data

CBSAC recommends continued review of existing fishery-independent survey data and potential application to provide additional information on the blue crab population, complementing the population estimates from the WDS. Characterizing the spring through fall distribution and sex-specific abundance of blue crabs remains important, especially if agencies are considering spatial management strategies.

8.5 Fishery-dependent data

Mandatory harvest reporting is currently the only fishery-dependent data in Virginia and the Potomac River. Understanding catch composition, by size, sex, and growth phase, spatially and temporally, as well as effort characterization (mentioned in 7.3), would help improve the effectiveness of regulations and assure they were compatible at a Baywide level. CBSAC recommends that the jurisdictions consider options for future fishery-dependent sampling programs.

8.6 Other sources of mortality

CBSAC also recommends analyzing the magnitude of other sources of incidental mortality, specifically sponge crab discards, unreported losses after harvest from the peeler fishery, and predation. An analysis of non-harvest mortality could improve reliability of exploitation fraction estimates and inform future assessments.

8.7 Investigation of the potential for sperm limitation

CBSAC recommends continued examination to quantify and better understand the influence of male crabs on reproductive success and overall population productivity. The evidence for sperm limitation resulting from a lower abundance of sexually mature male crabs is ambiguous and has been discussed in several recent studies[9,10,11].

8.8. Biological parameters

Longevity, age structure and growth rates, particularly with respect to the timing of recruitment to the fishery within the season) are not fully characterized and remain as sources of uncertainty**.**

CBSAC Members:

Glenn Davis (Chair)	Maryland Department of Natural Resources
Joe Cimino	Virginia Marine Resources Commission
Ellen Cosby	Potomac River Fisheries Commission
Lynn Fegley	Maryland Department of Natural Resources
Daniel Hennen	NMFS, Northeast Fisheries Science Center
John Hoenig	Virginia Institute of Marine Science
Eric Johnson	University of North Florida
Katie May Laumann	Virginia Marine Resources Commission
Rom Lipcius	Virginia Institute of Marine Science
John McConaugha	Old Dominion University
Tom Miller	UMCES, Chesapeake Biological Laboratory
Rob O'Reilly	Virginia Marine Resource Commission
Amy Schueller	NMFS, Southeast Fisheries Science Center
Mike Seebo	Virginia Institute of Marine Science
Alexei Sharov	Maryland Department of Natural Resources
Mike Wilberg	UMCES, Chesapeake Biological Laboratory
Emilie Franke (Coordinator)	ERT/NOAA Chesapeake Bay Office

Literature Cited

1. Miller, T. J. et al. 2011. Stock Assessment of Blue Crab in Chesapeake Bay. 2011. Final Report. Ref: [UMCES] CBL 11-011. UMCES Tech. Ser. No. TS-614-11-CBL.

2. Sharov, A. F., J. H. Volstad, G. R. Davis, B. K. Davis, R. N. Lipcius, and M.M. Montane. 2003. Abundance and exploitation rate of the blue crab (*Callinectes sapidus*) in Chesapeake Bay. Bulletin of Marine Science 72:543-565.

3. Bi-State Blue Crab Advisory Committee. 2001. Taking Action for the Blue Crab: Managing and Protecting the Stock and its Fisheries. A report to the Chesapeake Bay Commission; Annapolis, Md, Richmond, Va. 24p.

4. Ashford, J. R., and C. M. Jones. 2001. Survey of the blue crab recreational fishery in the Chesapeake Bay, 2001. Final Report to the Maryland Department of Natural Resources. Annapolis, MD. 61p.

5. Ashford, J. R., and C. M. Jones. 2003. Survey of the blue crab recreational fishery in Maryland and Virginia, 2002. Final report from Old Dominion University to the National Oceanic and Atmospheric Administration Chesapeake Bay Office, Annapolis, Maryland. p.

6. Ashford, J. R., and C. M. Jones. 2005. Survey of the blue crab recreational fishery in Maryland, 2005. Final Report to the Maryland Department of Natural Resources. Annapolis, MD. 31p.

7. Ashford, J. R., and C. M. Jones. 2011. Survey of the blue crab recreational fishery in Maryland, 2009. Final Report to the Maryland Department of Natural Resources. Annapolis, MD. 29p.

8. Ralph, G.M., and R.N. Lipcius. 2014. Critical habitats and stock assessment: age-specific bias In the Chesapeake Bay blue crab population survey. Transactions of the American Fisheries Society *in press*.

9. Ogburn, M.B., P.M. Roberts, K.D. Richie, E.G. Johnson, and A.H. Hines. 2014. Temporal and spatial variation in sperm stores in mature female blue crabs (*Callinectes sapidus*) and potential effects on brood production in Chesapeake Bay. Marine Ecology Progress Series *in press*.

10. Hines, A.H., and M.B. Ogburn. 2014. Evaluating population level impacts of sperm limitation on the Chesapeake blue crab stock. Final Report to NOAA Chesapeake Bay Office for NA11NMF4570230.

11. Rains, S.A. 2014. Potential for sperm limitation in blue crabs of Chesapeake Bay. M.S. thesis, University of Maryland.

Appendix A. Estimated abundance of blue crabs from the Chesapeake Baywide winter dredge survey, annual commercial harvest, and removal rate of female crabs.

Survey Year (Year Survey Ended)	Total Number of Crabs in Millions (All Ages)	Number of Juvenile Crabs in Millions (both sexes	Number of Spawning-Age Crabs in Millions (both sexes)	Number of spawning age Female crabs in Millions	Baywide Commercial Harvest (Millions of Pounds)	Percentage of Female Crabs Harvested
1990	791	463	276	117	104	43
1991	828	356	457	227	100	40
1992	367	105	251	167	61	63
1993	852	503	347	177	118	28
1994	487	295	190	102	84	36
1995	487	300	183	80	79	36
1996	661	476	146	108	78	25
1997	680	512	165	93	89	24
1998	353	166	187	106	66	43
1999	308	223	86	53	70	42
2000	281	135	146	93	54	49
2001	254	156	101	61	54	42
2002	315	194	121	55	54	37
2003	334	172	171	84	49.5	36
2004	270	143	122	82	60	46
2005	400	243	156	110	58.5	27
2006	313	197	120	85	52	31
2007	251	112	139	89	43	38
2008	293	166	128	91	49	21
2009	396	171	220	162	54	24
2010	663	340	310	246	85	16
2011	452	204	255	191	67	24
2012	765	581	175	95	56	10
2013	300	111	180	147	37	23
2014	297	198	99	68.5	35	17
2015	411	269	143	101	**50**	**15**
2016	**553**	**271**	**284**	**194**	**TBD***	**TBD***

* 2016 Baywide commercial harvest and exploitation rate are preliminary (TBD= to be determined)

Baywide harvest totals and female exploitation rates listed on this page for 2010 and prior were updated to reflect final Baywide harvest totals. Previous reports listed preliminary harvest data on this page.