COMMONWEALTH of VIRGINIA

Marine Resources Commission
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Newport News, Virginia 23607

Molly Joseph Ward
Secretary of Natural Resources

John M.R. Bull
Commissioner

December 1, 2014

MEMORANDUM

TO: The Honorable Terry McAuliffe
Governor of the Commonwealth of Virginia
And,
Members of the Virginia General Assembly

THROUGH: The Honorable Molly Joseph Ward
Secretary of Natural Resources

FROM: John M.R. Bull

SUBJECT: Blue Crab Fishery Management Plan

On behalf of the Virginia Marine Resources Commission, I am writing to report on the status and current implementation of the blue crab fisheries management plan, in accordance with the provisions of § 28.2-203.1 of the Code of Virginia.

EXECUTIVE SUMMARY

Results from the 25th Bay-wide Winter Dredge Survey, conducted from December 2013 to March 2014 by the Virginia Institute of Marine Science and Maryland Department of Natural Resources, indicate the blue crab stock is depleted but overfishing was not occurring in 2013. The 2013/14 Winter Dredge Survey estimates of abundance of all size classes of crabs was 297 million crabs, and this total abundance was similar to the 2013 total abundance of 300 million crabs. The most recent total abundance of 297 million crabs was the sixth lowest observed during this survey, which started in the winter of 1989-1990. The abundance of juvenile crabs (both male and female crabs) that measure less than 2.4 inches in carapace width was the thirteenth lowest in 25 years, at 198 million crabs. The number of female crabs that could spawn in 2013 was 68.5 million and was the sixth lowest estimate for the 25 year Chesapeake Bay-wide survey. The low number of spawning-age female crabs has resulted in the depleted stock status determination.

Year-to-year variation in abundance of blue crabs can be expected as a result of the effects of environmental influences especially for early life stages of crabs. Juvenile crab abundance can vary because of inter-annual difference in entrainment of crab larvae from the ocean to the Virginia portion of the Chesapeake Bay. Environmental factors including weather conditions and predation can have an effect on all life stages of the crab population. Conservation of female spawning-age crabs is the primary management objective to ensure variability of the blue crab stock abundance is moderate. Since 2008, there has been a continuation, by all Chesapeake Bay jurisdictions, of management measures that conserve the spawning-age female crabs. Despite these management measures, the number of spawning-age female crabs estimated in 2014 was lower than 70 million, and successive years of that depleted condition can threaten the stability of the valued stock, even though overfishing was not occurring for the sixth straight year. The impact of environmental factors including weather conditions, an unusually cold 2013 winter, and predation may have contributed to the decline in the number of spawning-age female crabs. To address the decrease in the female spawning-age blue crab biomass, fishery managers from the three Chesapeake Bay jurisdictions enacted management measures to protect female spawning-age crabs and increase spawning stock potential by reducing the harvest of all crabs by 10%. A reduction in harvest for all blue crabs will not only protect spawning-age females, but will also protect juvenile blue crabs that may contribute to the 2015 spawning stock.

At its June 2014 meeting, the Commission established several short-term management measures to protect female spawning-age crabs and juvenile blue crabs that should bolster to the 2015 spawning stock. The Commission adopted reduced crab pot bushel and vessel possession limits for specific time periods and implemented a season closure for all other crab gear. The reduced crab pot bushels limits extend from July 5, 2014 through July 4, 2015 for all crab pot license categories. This time period is possibly a new commercial blue crab management season for the Chesapeake Bay jurisdictions that continue through cooperative management. The Commission also closed the winter crab dredge fishery season for seventh consecutive season to allow for continued rebuilding of the spawning stock biomass.

Virginia crab and oyster industries continue to benefit from disaster relief funds provided in 2009 by the Department of Commerce for the declared Fishery Disaster in the Chesapeake Bay blue crab fisheries. This Disaster Relief Fund has provided various crab industry members (harvesters, buyers, and processors) negatively impacted by poor crab stock conditions during many years, through 2007, a source of employment. These funds have provided an opportunity to work in resource or habitat enhancement projects. The total amount of funding from the Disaster Relief Fund was $14,995,000. Of the six project areas detailed in previous reports, the oyster aquaculture and the derelict blue crab pot and marine debris removal projects continues in 2014. The oyster aquaculture project has stimulated technical advances in hatchery production needed for spat-on-shell operations. The derelict blue crab pot and marine debris removal project has begun testing a crab pot gear alternative to reduce the unwanted catch of blue crabs that can occur when blue crab pot gear is lost.

Status of the Blue Crab Stock

The 2011 benchmark stock assessment control rule established female-specific reference points, based on the biological status of female crabs. Biological reference points are a primary output of stock assessments, and fishery regulations are implemented to conform to those biological standards. The 2011 blue crab stock assessment provided female-specific reference points for both the abundance of female crabs at least 2.4 inches in carapace width (spawning-age female crabs at least age-1) and the annual removal rate based on the percentage of female crabs of all sizes harvested in a year.

The abundance and exploitation rate targets and thresholds (biological limits) used to monitor the health of the blue crab stock in the Chesapeake Bay are provided in Table 1 below.

Table 1. Abundance and exploitation rate targets and thresholds for the Chesapeake Bay blue crab stock. This is the control rule.

2011 Stock Assessment – Biological Reference Points		
Abundance	Overfished (Threshold)	70 million age 1+ female crabs
	Target	215 million age 1+ female crabs
Exploitation Rate	Overfishing (Threshold)	34% of all female crabs
	Target	25.5% of all female crabs

The abundance estimate from the 2013/14 Bay-wide Winter Dredge Study of female spawning-age crabs (age 1+) was 68.5 million crabs, representing a 53% decrease from the 2012/13 Winter Dredge Survey results. Annual winter crab dredge survey results represent the population sampled from December through March. The survey straddles two calendar years but is referenced as the latter of the two calendar years. Spawning-age crabs are crabs at least 2.4 inches in carapace width sampled by the survey, and these crabs will spawn either in late May or during the July-August peak spawning period. This estimate is below the overfishing threshold of 70 million spawning-age female crabs, indicating the stock is in a depleted state. The most recent (2013) female crab exploitation rate estimate was 23%, which is below the target exploitation rate of 25.5% removal of female crabs on an annual basis, from fisheries, alone. This estimate is below the overfishing threshold of 34%, and overfishing is not occurring on this stock. For the last six consecutive years the target removal rate has been near or less than the target.

The total abundance of 297 million crabs was the sixth lowest estimate in the 25 year time series of the Winter Dredge Survey. There was a 61% decrease in total abundance from 2012 (765 million crabs) to 2013. Total abundance remained stable but low during 2013 (300 million crabs) and 2014 (297 million crabs). The decline in 2012 was assumed to be a result of the 2012 juvenile crabs not recruiting into the fishery because of low survival. Anecdotal comments from harvesters indicated this lack of recruitment may have been a result of predation. The number of juvenile crabs

increased from 111 million crabs in 2013 to 198 million crabs in 2014. The continued low total biomass in 2014 has been attributed to the decline in the number of female spawning-age crabs observed in the 2013/14 Winter Dredge Survey. The impact of environmental factors including, an unusually cold 2013 winter that caused a high percentage of mortality, as well as, predation from finfish species like red drum and striped bass, may have contributed to the decline in the number of spawning-age female crabs. The 2014 estimate of total spawning-age female crabs represents a 53% decline with respect to the over-wintering population of 147 million in 2013, indicating over-wintering mortality may have been extremely high this past winter.

In the 2014 Chesapeake Bay Blue Crab Advisory Report, the Chesapeake Bay Stock Assessment Committee (CBSAC) recognized several topics as critical data and analysis needs to aid in the understanding of the variability in the blue crab stock. The CBSAC identified a list of fishery dependent and independent data needs that would provide better information on blue crab abundance and survival, such as in 2013, for management measures, to include:

- Increased accountability and harvest reporting for both commercial and recreational fisheries;
- Gear efficiency pertaining to selectivity of the Winter Dredge Survey methods;
- Over-wintering mortality;
- Recruitment through development of shallow water surveys;
- Investigation of the potential for sperm limitation;
- Analyzing the magnitude of other sources of incidental mortality (e.g. sponge crab discards, unreported losses after harvest from the peeler crab fishery, and disease);
- Preparing for the next Chesapeake Bay blue crab stock assessment; and,
- Developing a collaborative bay-wide fishery independent survey focused on the spring through fall distribution of blue crabs.

Table 2 below provides a 25 year summary of the results from the Chesapeake Bay-wide Winter Dredge Survey conducted by the Virginia Institute of Marine Science (VIMS) and the Maryland Department of Natural Resources (MDDNR). The abundance of recruits (termed age-0 crabs) and the spawning-age crabs (termed age-1+) are differentiated according to size, with 2.4 inches in carapace width as the separator between the two size classes. Any abundance estimate represents the number of crabs that will be available to the Chesapeake Bay fisheries following the end (March) of the seasonal (December-March) Bay-wide Winter Dredge Survey (Figure 1).

Table 2. Bay-Wide Winter Dredge Survey results (1990 through 2014). All surveys begin in December and ended in March of the next year.

Survey Year (Year Survey Ended)	Total Number of Crabs in Millions (All Ages)	Number of Juvenile Crabs in Millions (both sexes)	Spawning-age Crabs in Millions (both sexes)	Number of Spawning-age Female Crabs in Millions	Commercial Harvest (Millions of Pounds)	Percentage of Female Crabs Harvested
1990	791	463	276	117	96	44
1991	828	356	457	227	90	34
1992	367	105	251	167	53	60
1993	852	503	347	177	107	35
1994	487	295	190	102	77	28
1995	487	300	183	80	72	32
1996	661	476	146	108	69	20
1997	680	512	165	93	77	22
1998	353	166	187	106	56	40
1999	308	223	86	53	62	37
2000	281	135	146	93	49	43
2001	254	156	101	61	47	42
2002	315	194	121	55	50	34
2003	334	172	171	84	47	33
2004	270	143	122	82	48	42
2005	400	243	156	110	54	24
2006	313	197	120	85	49	29
2007	251	112	139	89	43	35
2008	293	166	128	91	49	24
2009	396	171	220	162	54	23
2010	663	340	310	246	85	18
2011	452	204	255	191	67	24
2012	765	581	175	95	56	10
2013	300	111	180	147	37	23
2014	297	198	100	68.5	TBD	TBD

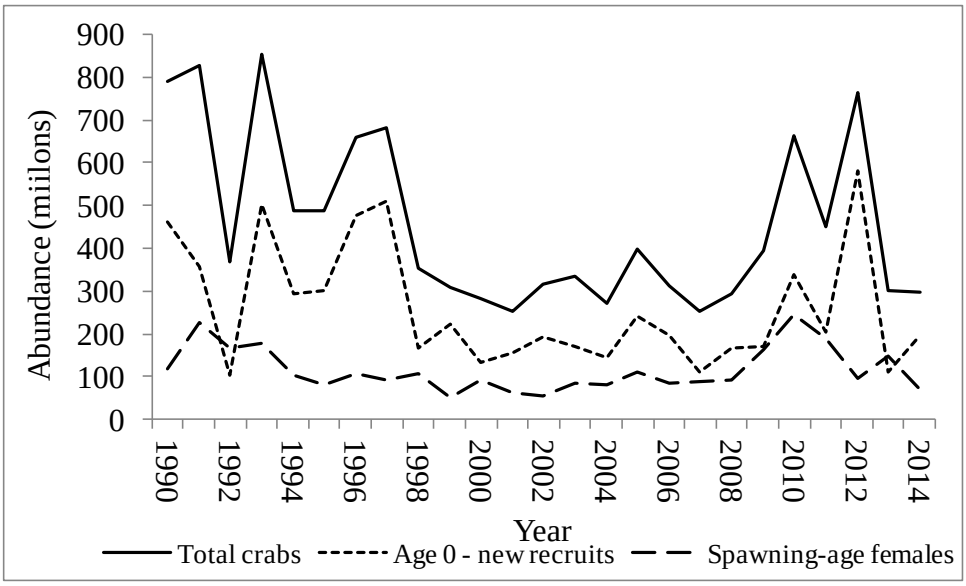

Figure 1. Abundance estimates (number of crabs in millions) for the 25 year Bay-wide Winter Dredge Survey for total crab abundance (male and female), juvenile (new recruits) crab abundance, and spawning-age (age-1+) female crab abundance, 1990 through 2014.

Harvest and Effort Statistics

In May 2014, the CBSAC reported (Attachment I) the 2013 Bay-wide crab commercial harvest was 37 million pounds, 33% lower than the 2012 Bay-wide crab harvest of 56 million pounds, and the lowest harvest record in 25 years. The Bay-wide recreational harvest was estimated as 3.9 million pounds. Of the Bay-wide commercial harvest, Maryland harvested 18.7 million pounds, Virginia harvested 16.1 million pounds, and 2 million pounds was harvested in the jurisdiction of the Potomac River Fisheries Commission. The total 2013 reported commercial harvest for all commercial gear allowed to harvest blue crabs for Virginia tidal waters, including the bays and tributaries seaside of the Eastern Shore and Virginia Beach, was 17.9 million pounds.

Figure 2 below displays the time series of Virginia commercial crab harvest for all Virginia waters in pounds and estimated dockside value (first sale from harvester). The dockside value has been adjusted to account for inflation using the Consumer Price Index. Harvest statistics have been collected from Virginia fisheries since the last 1920s; however, 1994 is the first representative year of the mandatory commercial harvest reporting system. Both harvest and dock-side value have been generally declining from 1994 through 2006, although dock-side value began to increase in 2006, while harvest continued to decline until 2008. There were increases in both values until 2010, followed by another decline in 2011 and 2012. In 2013, pounds harvested continued to decline while value remained stable compared to 2012, which indicates price per pound increased as supply was limiting.

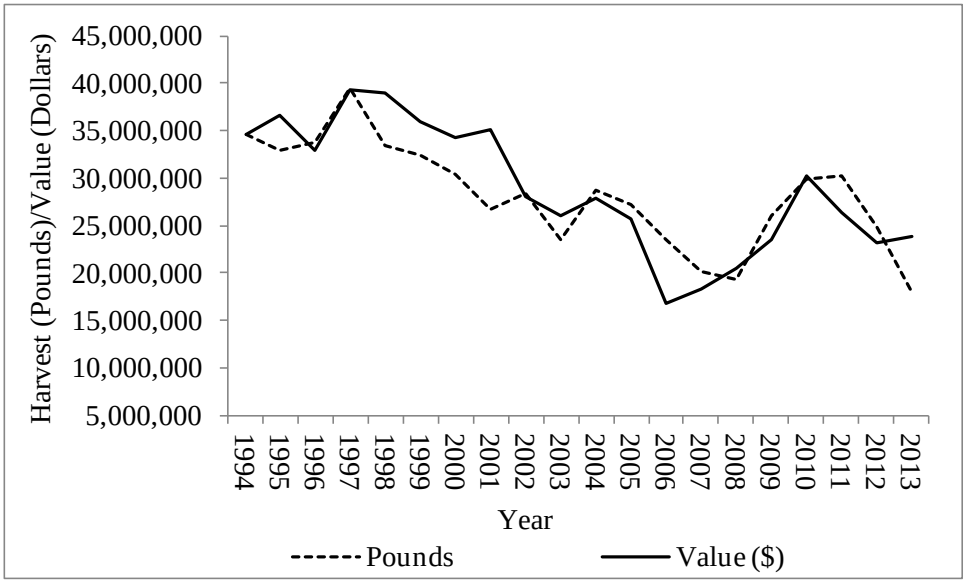

Figure 2. Virginia commercial harvest (state waters, in pounds) of blue crab and estimated dockside value (US dollars adjusted for inflation, first sale from harvester) for 1994 through 2013.

Table 3 below contains Virginia harvest data by market category (hard crabs and peeler and soft crabs), in pounds, for the last five years of complete data by month (2009 through 2013). The hard crab pot fishery has accounted for approximately 96% of the total crab harvest from Virginia tidal waters consistently since at least 2009. The hard crab pot harvest is dominated by female blue crabs. In 2013 the sex composition was 74% female, compared to 67% female in 2012, 65% female in 2011, 60% female in 2010, and 65% in 2009.

Table 3. Virginia harvest data (state waters only, in pounds) by market category (hard crabs and peeler and soft crabs) for 2009 through 2013, by month. CD indicates confidential data.

Hard Crab Market Catergory											
Year	March	April	May	June	July	August	September	October	November	December	Total
2009	332,795	4,074,518	3,156,071	3,383,328	3,281,241	3,516,976	3,066,435	3,020,202	1,053,335	0	24,884,902
2010	393,973	4,857,513	3,093,846	3,945,608	4,170,839	4,128,595	3,392,007	3,350,041	1,404,169	0	28,736,592
2011	1,207,562	5,095,178	3,674,679	3,848,966	3,892,883	3,741,769	3,464,975	2,964,889	1,358,723	0	29,249,623
2012	2,590,763	2,638,410	3,484,734	3,639,313	3,240,271	2,967,048	1,952,545	2,186,948	901,192	137,852	23,739,077
2013	37,614	2,329,359	2,619,070	2,454,622	3,026,392	2,401,739	1,719,153	1,602,044	759,473	24,875	16,974,340
Peeler and Soft Crab Market Catergory											
Year	March	April	May	June	July	August	September	October	November	December	Total
2009	0	15,540	405,920	159,267	168,643	141,055	86,870	20,659	0	0	997,954
2010	0	58,537	406,399	154,748	185,174	140,921	89,269	15,683	0	0	1,050,731
2011	0	26,694	351,434	135,827	161,634	121,332	89,891	3,438	0	0	890,249
2012	2,301	136,816	225,835	153,921	170,208	127,126	66,433	14,306	CD	0	896,890
2013	0	5,285	173,771	111,419	143,215	109,786	64,307	10,690	0	0	618,473

Tables 4 and 5 below show the number of active crab harvesters in the crab pot and peeler pot fisheries for the last five years of complete data, by month (2009 through 2013). June through September is the peak time period for active harvesters in the crab pot fishery. Harvester activity in the peeler pot fishery peaks in May and gradually declines from June through November.

Table 4. Number of harvesters by month for 2009 through 2013 active in the crab pot fishery.

Year	March	April	May	June	July	August	September	October	November	December	Total
2009	199	462	596	679	704	714	616	507	263	0	4,740
2010	171	492	636	669	667	629	556	433	231	0	4,484
2011	298	497	607	646	632	593	504	401	253	0	4,431
2012	384	493	600	637	608	569	499	391	213	44	4,438
2013	67	421	525	579	601	595	521	388	221	36	3,954

Table 5. Number of harvesters by month for 2009 through 2013 active in the peeler pot fishery. CD indicates confidential data.

Year	March	April	May	June	July	August	September	October	November	December	Total
2009	0	49	357	217	196	190	117	50	0	0	1,176
2010	0	88	302	173	151	137	99	38	0	0	988
2011	0	61	273	154	139	120	80	26	0	0	853
2012	8	171	233	156	137	138	95	34	CD	0	972
2013	0	23	216	153	154	142	111	36	0	0	835

Tables 6 and 7 below show Virginia trip data for the last five years of complete data, by month (2009 through 2013). The number of trips with reported crab harvest from crab pot gear totaled 47,317 in 2013 compared to 52,989 in 2012. The number of peeler pot trips in 2013 totaled 10,693, a decrease from 12,534 trips in 2012. The peeler and soft crab market category consists mainly of peeler crabs.

Table 6. Number of commercial trips by month for 2009 through 2013 taken in the crab pot fishery.

Year	March	April	May	June	July	August	September	October	November	December	Total
2009	938	5,899	6,924	9,114	10,051	9,590	7,444	5,772	2,096	0	57,828
2010	1,064	6,752	7,663	9,172	9,470	8,394	6,662	4,850	1,897	0	55,924
2011	1,985	6,675	7,475	8,972	8,813	7,976	6,392	4,635	2,212	0	55,135
2012	2,996	5,478	8,116	8,456	8,342	7,746	5,485	4,325	1,705	265	52,914
2013	247	4,857	6,424	7,278	8,396	8,040	5,943	4,152	1,856	124	47,317

Table 7. Number of commercial trips by month for 2009 through 2013 taken in the peeler pot fishery. CD indicates confidential data.

Year	March	April	May	June	July	August	September	October	November	December	Total
2009	0	248	4,368	2,872	3,032	2,687	1,552	320	0	0	15,079
2010	0	637	4,075	2,376	2,570	1,929	1,222	209	0	0	13,018
2011	0	329	3,605	2,134	2,282	1,714	1,155	118	0	0	11,337
2012	29	1,735	3,048	2,195	2,206	2,028	1,082	211	CD	0	12,534
2013	0	141	2,623	2,007	2,338	2,118	1,240	226	0	0	10,693

Blue Crab Conservation Actions in 2014

Since 1994, Commission actions that have attempted to promote sustainability of the blue crab stock and fishery through conservation measures are included in Attachment II. These measures have helped in rebuilding the crab stock and improving our fishery harvests. The continued low total abundance estimates and depleted status, resulting from the low number of female spawning-age in the 2013/14 Winter Dredge Survey, warrant continued caution in the relaxation of conservation measures, many of which have been in place since 2008. The depleted condition of the stock necessitates some form of a rebuilding plan. A short-term conservation approach for 2014 and 2015 was developed. Management measures for 2014 and 2015 have been modified to provide more protection for the female spawning-age and juvenile blue crabs that will contribute to the spawning stock in 2015. The three Chesapeake Bay jurisdictions have agreed to reduce the harvest of all crabs by 10% from the 2013 total harvest for 2014, based on the result of the 2013/14 Winter Dredge Survey. Other Virginia-specific management measures address crab harvest across all gear types lawful to harvest blue crabs commercially. After a presentation by the VMRC staff on several proposed management measures and hearing public comments, the Commission approved the following management measures at its June 2014 meeting:

> The Commission established several short-term management measures to protect female spawning-age crabs and juvenile blue crabs that will add to the 2015 spawning stock. The Commission adopted reduced crab pot bushel and vessel possession limits for specific time periods and added a season closure for all other crab gear lawful to harvest crabs. The reduced crab pot bushels limits extend from July 5, 2014 through July 4, 2015 for all crab pot license categories. This time period is effectively the new commercial blue crab management season for Virginia, shifting management measures from a commercial blue crab season of March through November each year. The Commission also closed the winter crab dredge fishery season for seventh consecutive season to allow for continued rebuilding of the spawning stock biomass.

- Reduction in crab pot bushel limits and vessel limits

The Commission established a reduction in crab pot bushel limits by specific time periods by license category. Crab pot bushel limits originally adopted by the Commission at its October 2013 meeting for the 2014 crab pot season were lowered by crab pot license category at its June 2014 meeting. The reduced crab pot bushels limits extend from July 5, 2014 through July 4, 2015 for all crab pot license categories. This time period is effectively the new commercial blue crab management season for Virginia, shifting management measures from a commercial blue crab season of March through November each year. Bushel limits will be updated in 2015, after results of the 2015/16 Winter Dredge Survey are available for use in management. Table 8 below gives the bushel limits by crab pot license category by time period for the new management season.

Table 8. Modified crab pot gear license category-specific bushel limits established by the Commission at its' June 2014 meeting for July 5, 2014 through July 4, 2015.

Crab Pot License Catergory	Crab Pot Bushel Limits Established in October 2013 through July 4, 2014	Crab Pot Bushel Limits July 5, 2014 through November 15, 2014	Crab Pot Bushel Limits November 16, 2014 through November 30, 2014	Crab Pot Bushel Limits March 17, 2015 through March 31, 2015	Crab Pot Bushel Limits April 1, 2015 through July 4, 2015
Up to 85 Crab Pots	16	10	8	8	10
Up to 127 Crab Pots	21	14	10	10	14
Up to 170 Crab Pots	27	18	13	13	18
Up to 255 Crab Pots	43	29	21	21	29
Up to 425 Crab Pots	55	47	27	27	47

Daily vessel harvest possession limits are related to crab pot bushel limits, so a reduction in crab pot bushel limits results in a reduction in the vessel possession limit. A vessel harvest possession limit corresponds to the highest crab pot bushel limit of only one licensee onboard a vessel. Commercial watermen fishing for blue crab can have multiple licensees onboard a vessel.

- Winter crab dredge fishery season

The Commission closed the 2014/15 winter crab dredge fishery season for the seventh consecutive season after reviewing the biomass estimates from the Winter Dredge Survey. The VMRC staff has been developing a winter crab dredge fishery season trigger to determine when the winter crab dredge fishery season can reopen in the future. The trigger would allow the winter crab dredge fishery season to open based on a combination of abundance estimates from the Winter Dredge Survey for juvenile and spawning-age female crabs and the exploitation rate. The VMRC staff developed four alternative triggers for consideration:

- An arithmetic mean of juvenile and spawning-age female abundance for years with an exploration rate less than 29 %;
- An arithmetic mean of juvenile and spawning-age female abundance for 24 seasons of Winter Dredge Survey data (1989/90 through 2013/14);
- A geometric mean of juvenile and spawning-age female abundance for years with an exploration rate less than 29 %; and
- A geometric mean of juvenile and spawning-age female abundance for 24 seasons of Winter Dredge Survey data (1989/90 through 2013/14).

- Season closure for all other crab harvest gears

The Commission established a seasonal closure from September 16, 2014 through April 30, 2015 for all commercial gears that are lawful for the harvest blue crabs including peeler pot gear, trotlines, traps, and scrapes.

Ecosystem Constraints on the Blue Crab Resource

§ 28.2.203.1 of the Code of Virginia provides that the blue crab fishery management plan shall be

designed to reverse any fishing practices, environmental stressors, and habitat deterioration negatively impacting the short and long term viability and sustainability of the crab stock in Virginia waters. In recent years, the Commission has adopted effective conservation measures to reverse fishing practices that have negatively impacted the stock. The Commission relies on the efforts of its sister agencies to promote and sponsor improvements of the Chesapeake Bay's water quality in order to meet the requirements of §28.2.203.1 of the Code of Virginia dealing with environmental stress and habitat deterioration.

The Commission participated in a Harmful Algal Bloom (HAB) Task Force meeting to review updated information on the 2013 HAB season and emerging species of concern in April of 2014. During the 2013 season, there was a seasonal succession of dinoflagellate algal blooms and a range expansion of *Alexandrium monilatum*, an emerging species of concern in 2013. Algal blooms of a potential new emerging organism of concern were observed in 2013, but the organism has yet to be identified. The impact on blue crab meat safety or health is unknown at this time because no scientific studies have been conducted to assess the impact of HABs on blue crab meat. Algal blooms can result in hypoxic and anoxic conditions (low dissolved oxygen levels) in the Chesapeake Bay that cause blue crabs to be displaced or result in mortality.

The Commission and the industry recognize that improvements in blue crab habitat and water quality could increase the probability for improved recruitment to the stock and fisheries; however, many water quality and habitat impacts to the stock are not fully quantified or understood. The relationship between blue crabs and other components of the ecosystem is being explored by Chesapeake Bay scientists. Many natural and man-induced impediments continue to challenge the stability of the blue crab stock, including hypoxia, shoreline development, and pollution. The issue of climate change will continue to be important as well, as blue crab behavior is linked to water temperature.

Water quality in the Chesapeake Bay is improving due to the ongoing efforts of the Commonwealth and the signatories of the Chesapeake Bay Agreement. Additional work is being implemented to meet pollution reduction goals in the Chesapeake Bay. Each of the bay jurisdictions has developed a Watershed Implementation Plan to guide restoration plans through 2025. The federal government developed Executive Order 13508, which guides the federal agencies plan to meet pollution reduction goals and establishes the Federal Leadership Committee that will publish an annual Chesapeake Bay Action Plan. The fiscal year 2014 Action Plan and 2013 Progress Report was published by the Federal Government in May 2014. A Chesapeake Bay Watershed Agreement was signed in June 2014 by governors from all seven watershed states, the Chesapeake Bay Commission, and the Environmental Protection Agency. The Watershed Agreement contains ten goals and twenty-nine measureable, time-bound outcomes to improve the health of the Chesapeake Bay including sustaining blue crabs.

The reduction in submerged aquatic vegetation (SAV) beds has likely impacted the blue crab stock, especially juvenile crabs that use SAV beds as protection from predators. Seagrass beds provide nursery habitat for newly settled, young juvenile, and mating blue crabs. The importance of eelgrass habitat functions in Chesapeake Bay was first demonstrated by the VIMS in a 1961 report to the National Science Foundation. Eelgrass is the dominant SAV in Virginia waters. Subsequent studies by VIMS have led to a greater understanding of SAV Bay-wide distribution, abundance, and health. The VIMS established the first broad-scale aerial monitoring of SAV in 1974, and expanded the survey in 1978 to cover all of Virginia's tidal waters. The VIMS maintains

a research and monitoring program that has significantly expanded our understanding of SAV, its role in the greater Bay ecosystem, and its linkages with the health of the blue crab stock. Ongoing SAV research and monitoring programs include:

- Annual Bay wide aerial survey;
- Eelgrass restoration in Virginia's seaside bays;
- The use of restored eelgrass beds by estuarine fauna;
- Targeted water quality monitoring and study of key SAV locations in Virginia waters for effects from water quality changes, global warming, and climate change;
- Assessment and monitoring of the effects of certain fishing techniques on eelgrass beds;
- Water quality assessments for evaluation of water quality standards attainment (SAV distribution is a criterion for water clarity);
- The role of abiotic factors influencing the flowering of eelgrass;
- The roles of dispersal and seed predation in determining eelgrass population dynamics;
- The influence of climate change factors on the use of eelgrass and widgeon grass beds;
- Habitat suitability of exotic algae versus native seagrass as an alternative nursery habitat for juvenile blue crabs;
- The distribution of overwintering age-0 blue crabs in shallow water habitats; and
- The functional relationships between seagrass characteristics and juvenile blue crabs under high recruitment.

As is evident from some of the VIMS monitoring and research, there is great concern in the scientific community regarding the fate of SAV in Chesapeake Bay, and the effect that losses will likely have on blue crabs and other Bay fauna. The survival of most species of SAV is viewed as highly problematic as sea levels rise and water temperature continues to increase. The VIMS studies have shown there is a strong effect of high summertime water temperatures on the seagrass declines observed in Virginia waters in recent years (Moore and Jarvis 2008, Moore et al. 2012), and that short term periods of high temperatures can cause large die-offs. This is due, in large part, to the high temperature intolerance of eelgrass. Eelgrass is near its southern limits along the Atlantic coast in Virginia, so high summertime water temperatures can be especially harmful to eelgrass beds. Unusually high temperatures during periods in the summer of 2005 and 2010 resulted in severe diebacks in eelgrass beds. After each of these diebacks, some recovery was observed over the next few years; however, VIMS research (Jarvis and Moore 2010) has shown that since eelgrass seeds in the sediment are only viable for a year or less, consecutive years of diebacks would be especially deleterious. If water temperatures continue to increase as a result of climate change, losses of eelgrass beds in Virginia may accelerate. The VIMS research has demonstrated that increased water clarity can help eelgrass beds persist under higher temperatures. Therefore, VIMS is working with Virginia regulatory agencies, MDDNR, and the Environmental Protection Agency to assess the current water clarity goals for the Chesapeake Bay to determine if changes are appropriate and needed. Storms can also be stressful to SAV beds through direct physical disruption or by greatly increasing sediment and nutrient inputs into the Bay and its tributaries. Excess sediments and nutrients can promote increased turbidity, compounding the effects of high temperatures (Moore et al. 2013). Results of the VIMS' studies indicate that Virginia's SAV beds do relatively well in withstanding the direct physical disruption by storms.

Should regional climate change significantly affect SAV distribution and abundance in the Chesapeake Bay, VIMS scientists have found that the coastal bays on the seaside of Eastern Shore may ultimately be a prime refuge location for SAV due to the proximity of these beds to the cooler waters of the adjacent Atlantic Ocean (Orth et al. 2010, Moore et al. 2012). The SAV

restoration efforts have been highly successful within the Eastern Shore's coastal bays, and there is much promise of continued growth through natural processes and additional restoration (Orth et al. 2010).

The VIMS annual Bay-wide aerial survey serves as a significant indicator of Bay health, and as a tool for determining compliance with Virginia water quality standards. Virginia tidal waters are home to 12 species of SAV, with eelgrass (*Zostera marina*) and widgeongrass (*Ruppia maritima*) having the most overlap with the distribution of juvenile blue crabs in the Chesapeake Bay. Since the historically low abundances of 1984, SAV restoration has varied between tidal waters with different salinities. Seagrass beds have continually increased in lower salinity tidal waters; increased initially in areas of medium-salinity followed by irregular annual abundance levels; and increased initially in the high- salinity region followed by a general decline in abundance (Orth et al. 2010). These general trends remain accurate for the years since this study. Because of the complexity of the estuarine environment, it is difficult to accurately determine a primary factor behind SAV declines, especially in individual beds, but Orth et al. (2010) found strong negative correlations between SAV abundance and nitrogen levels. This provides strong evidence that water quality is a primary causative element in SAV distribution and decline. It is understood through numerous published studies that most estuarine fauna, including juvenile blue crabs, generally experience higher growth and survival rates in vegetated versus unvegetated shallow water habitats. A recent VIMS study (Ralph et al. 2013), has shown that juvenile blue crabs prefer denser SAV beds over thinner beds, further demonstrating the positive influence that the quality of seagrass beds have on blue crab population dynamics. The VIMS has also demonstrated a high value to juvenile blue crabs for unvegetated areas both adjacent to salt marshes in upriver areas of Bay tributaries and areas that contain an abundance of food such as clams and polychaetes (marine worms); and within areas of abundant macroalgae where native SAV nursery habitat has experienced reductions in aerial coverage (Seitz et al. 2003, Seitz et al. 2005, Johnston and Lipcius 2010, Seitz et al. 2011).

Blue crabs have a diverse assemblage of parasites and pathogens; and the presence and occurrence of these pathogens has been a long-time research focus at VIMS. Many pathogens are present in the tidal waters of Virginia, but only a few have the potential to damage the blue crab stock or fisheries (Shields & Overstreet 2007, Shields 2012). Two agents, in particular, occur at high prevalence levels and show signs of high pathogencity. These are *Hematodinium perezi* and a recently identified reo-like virus. *Hematodinium perezi* is a parasitic dinoflagellate found primarily in the higher salinity waters of the Bay, particularly in the seaside bays of the Eastern Shore and along the eastern portions of lower Chesapeake Bay (Messick & Shields 2000). Prevalence levels of *Hematodinium* have a small peak in early summer and a large peak in autumn, followed by a rapid decline with the onset of winter temperatures. Prevalence levels are associated with molting in juvenile blue crabs, which explains the bimodal peak occurrence of the parasite. Mortality levels of 87% have been observed in laboratory experiments (Shields and Squyars 2000). The VIMS scientists recently discovered and described the life cycle of *Hematodinium perezi* from the blue crab (Li et al. 2011), and this will lead to a greater understanding of the risk of mortality and the environmental and biological factors that may influence the effects of this pathogen. The reo-like virus from the blue crab was initially described from juvenile crabs held in the laboratory (Johnson & Bodammer, 1975). It has been implicated as a source of mortality in the production of soft-shell crabs based on infection trials and sampling of crabs from shedding facilities (Bowers et al. 2010). The VIMS continues to be actively engaged in research on these pathogens.

Blue Crab Disaster Relief Funding Updates

In 2008 Virginia was awarded $14,995,000 in disaster relief funds, by the National Marine Fisheries Service (NMFS), after the declaration of a blue crab fishery disaster. The Commission implemented a set of six projects (Items I through VI, below), beginning in December 2008 with the Derelict Crab Pot and Marine Debris Removal Project. The remaining five projects were initiated in 2009, and two have continued in 2014.

I. Derelict Blue Crab Pot and Marine Debris Removal Project

Discarded debris such as tires, gill nets, appliances, and crab pots can be found throughout the tidal waters of Virginia. Derelict crab pots may remain in the environment for years continuing to capture and kill fish, shellfish, birds and marine mammals, including endangered or threatened species. It is estimated that around 20% of crab pots deployed are lost each season, and each functional lost crab pot can continue to capture about a bushel of market-sized crabs per season, as well as other animals such as black seabass, Atlantic croaker, spot, flounder, and terrapins. There is an environmental benefit in removing marine debris from Virginia's waters, if the removal can be accomplished safely without damaging the marine habitat and ecosystem. This project includes work specifically aimed at removing marine debris from Virginia's tidal waters with the assistance of up to 70 watermen. This program recovered over 32,000 crab pots over the four winters, from 2008 through 2012. The project continued in the winters of 2012/13 and 2013/14 with funding from the National Oceanic and Atmospheric Administration (NOAA), the National Fish and Wildlife Foundation (NFWF), and the Office of the Virginia Secretary of Natural Resources to support four watermen (2012/13) and seven watermen (2013/14) who removed an additional 726 and 1261 pots, respectively, from targeted 'hotspots'. In addition, research into biodegradable escape panels to prevent 'ghost fishing' of lost and abandoned pots has resulted in a Virginia-based startup company selling 'biopanels' for fishing gear (including crab and lobster pots) worldwide.

II. Cull Ring and Terrapin Excluder Device Project

The goals of this study were to employ Virginia's watermen (1) to investigate the effects of different crab pot cull-ring sizes on blue crab catch, biomass, and survival, and (2) to determine the effects of bycatch reduction devices (BRDs) in crab pots on blue crab catch, finfish bycatch, and diamondback terrapin bycatch. The BRDs were found to exclude all but the smallest terrapins without affecting the catch of crabs (Rook et al. 2010). These pots have been accepted for use in the recreational crab fishery.

III. Supplemental Funding for the Fishery Resource Grant Program

Restoration activities for the blue crab population in the Chesapeake Bay have included several new restrictions on the harvest by Virginia. These new regulations affect the livelihoods of Virginia harvesters targeting blue crabs. In order to supplement the income of these harvesters to maintain their financial stability in response to the 2008 blue crab harvest restrictions, the state proposed to support harvesters by training them in oyster aquaculture. Two methods of oyster aquaculture were implemented, cultch less and remotes setting. Three full years of aquaculture

training were supported with additional educational effort in shellfish handling, storage, and transportation. Surveys of participants indicate a strong willingness to continue to develop their shellfish aquaculture enterprises.

IV. Oyster Aquaculture

In 2010, the Commission's Conservation and Replenishment Department began training crab industry participants in modern techniques for growing oysters on private grounds. These techniques are easily adaptable to boats and equipment available to crab harvesters, and should provide alternative sources of income for harvesters active in the blue crab fishery. More than 130 watermen were trained in cage aquaculture in 2010 and 2011; and all individuals have harvested their first crop of oysters. Many individuals have purchased additional oyster seed and equipment to continue growing oysters after the completion of their training projects. More than 110 crab industry participants have also been trained in spat-on shell oyster production from 2010 through 2013. With the spat-on-shell method, oyster larvae are purchased from hatcheries, and the larvae are deployed into large tanks filled with bay water and shell. Once the larvae have attached to shell, the oyster seed is very similar to wild oyster seed. The seed and shell is spread over the bottom, for later harvest by conventional methods. The oysters produced in this manner are primarily used for the shucking industry. In all of the training projects, selectively bred, disease tolerant, triploid (reproductively sterile) oysters are being grown. These oysters are highly marketable because of superior meat quality year round.

Blue crab industry participants were again trained in 2014 in oyster aquaculture, with more than 20 individuals participating in the spat-on-shell program. There were very significant problems in Virginia oyster hatcheries in 2014 due to water quality issues. Oyster larvae production was about one third of the previous year's production. In total, 7,980 bushels of shells were set with 293 million eyed larvae produced by Virginia hatcheries. These shells were deployed with 52 million small oysters on private oyster beds throughout Virginia's Chesapeake Bay and tributaries. This year was the least productive for this project, and many of the participants could not complete their projects. These water quality problems will hopefully not be an issue for 2015, and the individual projects can be completed. The private oyster hatcheries are also making improvements to their water filtration methods, and will be in production early in 2015. The oyster aquaculture industry is entirely dependent on the successful operation of these private hatcheries. Harvests of oysters from private oyster ground have increased significantly over the past five years due partly to the success of this project.

V. Crab Pot and Peeler Pot License Buy Out Program

The Crab License Buy-Back Program was initiated and completed in 2009, in order to reduce the overcapacity in the crab pot and peeler pot fisheries. In total, 75,441 crab pots or peeler pots and 359 crab licenses were purchased and removed from future fisheries. Overcapacity continues to remain an issue in the crab fisheries.

VI. Update of the blue crab stock assessment

In 2014, the CBSAC Report was completed (Attachment I). Findings of the stock assessment were endorsed by the Chesapeake Bay Program Sustainable Fisheries Goal Implementation Team's executive committee. The executive committee is represented by the VMRC, MDNR, the

Potomac River Fisheries Commission, the National Oceanic and Atmospheric Administration's Chesapeake Bay Office, Maryland Sea Grant, the Atlantic States Marine Fisheries Commission, and the District of Columbia's Division of Fish and Wildlife.

Managers and scientists expect the annual estimates of abundance and exploitation rate to vary. However, if at any time the Bay-wide Winter Dredge Survey results indicate the abundance of female spawning-age crabs has fallen below the overfished level of 70 million, then management measures would be implemented to protect the blue crab stock. Based on results from the 2013/14 Winter Dredge Survey, the female spawning-age biomass is below the overfished threshold and considered depleted. Management measures have been developed for the three Chesapeake Bay jurdictions to reduce harvest on all crabs by 10% in an effort to rebuild female spawning-age biomass.

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2014 Chesapeake Bay Blue Crab Advisory Report
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1. INTRODUCTION

1.1 Background

The Chesapeake Bay Stock Assessment Committee (CBSAC) combines the expertise of state representatives and scientists from the Chesapeake Bay region with 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 the NOAA Chesapeake Bay Office, the SFGIT is led by an executive committee of senior fisheries managers from the MD DNR, VMRC, PRFC, the Atlantic States Marine Fisheries Commission (ASMFC), and the District Department of the Environment (DDOE).

CBSAC adopted the Bay-wide 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 around the Bay (Figure 1). 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: Previous and Current Management Framework

The current framework annual estimates of exploitation fraction are calculated as the annual harvest of female crabs in a given year divided by the total number of female crabs (age 0+) estimated in the population at the start of the season. The 2014 exploitation fraction cannot be calculated until the completion of the 2014 fishery and is therefore listed as *TBD*. 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 overfishing threshold is not exceeded, resulting in a larger number of crabs than required by the overfished (depleted) threshold. Ideally, the fishery should operate to meet target values and should never surpass threshold values. Stock status levels that do not exceed threshold values are shown in green, exploitation values exceeding or abundance estimates beneath threshold are shown in red.

Control Rule	**Reference Points**			**Stock Status**			
	Period	**Target**	**Threshold**	**2011**	**2012**	**2013**	**2014**
Exploitation Fraction	Current, Female-specific	25.5%	34% (max)	24%	10%	23%	**TBD**
Abundance (millions of crabs)	Current, Female-Specific	215	70 (min)	190	97	147	68.5

(Table 1)

2. CONTROL RULES

2.1 Control Rule from 2011 Benchmark Assessment

The 2011 benchmark assessment recommended a revised control rule based on biological reference points for the female component of the population (Figure 2). 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 the MSY concept. 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 Fishery 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 75% N_{MSY} (target) and 50% N_{MSY} (threshold). The annual exploitation is calculated empirically as the number of female crabs harvested divided by the total number of age-0+ female crabs in the Bay at the beginning of the fishing season, as estimated by the WDS. As part of this calculation, the juvenile component of the total estimated number of crabs was scaled up by a factor of 2.5 to achieve the best fits of the empirical estimates to the modeled data.

2.2 Male Conservation Points of Reference

In 2011 CBSAC recommended that male abundance should not be allowed to decline to a critically low level relative to female abundance and a conservation trigger based on male abundance should be developed. The reference points from former management framework are used to develop the conservation points of reference below.

Previously, estimates of male exploitation were presented that did not utilize the juvenile scalar in calculations, as it has been when calculating female exploitation. The Male Conservation Points of Reference below have been revised to include the scalar (described in Section 2.1), so it is consistent with Female Reference Points that came out of the 2011 Stock Assessment. This change has no impact on the performance of the metrics or the application of the Male Conservation Points of Reference described below. Exploitation of males and females combined were calculated without the juvenile scalar so those values could be related to the prior management framework.

CBSAC recommended conservation triggers for male crabs based on male exploitation and on the former management framework. Under these triggers conservation measures should be considered for male blue crabs if either of the following occurs:

1) The male exploitation rate exceeds 33% (calculated with the juvenile scalar as described in section 2.1) which is the second highest exploitation fraction observed for male crabs since 1990 (Figure 3). 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 biologically significant 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 23 years.

2) If female exploitation is below the established overfishing threshold of 34% (Figure 4) and the total annual exploitation rate of male and female crabs exceeds the threshold defined by the previous control rule (53% of crabs, both sexes, Figure 5).

The 2013 male exploitation fraction is estimated as 29% (Figure 3). This fraction is not above the male conservation trigger. The total exploitation rate does not exceed the interim threshold. No management action is recommended at this time specific to male blue crabs.

3. POPULATION SIZE (ABUNDANCE)

3.1 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 68.5 million female spawning-age crabs were estimated to be present in the Bay at the start of the 2014 crabbing season (Figure 6). The 2014 estimate of total spawning age female crabs represented a 53% decline with respect to the over-wintering population of 147 million in 2013, and represents a return to abundance levels observed during the period between 1998 and 2008 when adult female abundance remained just above the threshold level, and dipped below that level in several years between 1999 and 2002. This 2014 abundance of spawning-age female crab is lower than the recommended threshold, placing the population in **depleted** status.

3.2 Exploitable Female Stock – Abundance of Female crabs Aged-0^+

After applying the scalar as described in section 2.1, the total abundance of female crabs increased by 13.5% from 296 million crabs in 2013 to 336 million crabs in 2014 (Figure 7). However, the 2014 abundance is still comparable to that observed during the period of low female abundance from 1998-2008. The total population of female crabs forms the basis for the annual calculation of the exploitation

rate of female crabs relative to the established target of 25.5% and threshold of 34%. The juvenile component of the female stock is scaled up by a factor of 2.5 when calculating the annual exploitation fraction as described in section 2.1.

3.3 Age-1+ Male

In 2014, 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 30.4 million crabs (Figure 8). The 2014 WDS estimate indicates that age 1+ males declined by approximately 30% from the level observed in 2013 and is among the lowest values in the time series.

3.4 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 increased by 78% from 111 million in 2013 to 198 million crabs in 2014 (Figure 9 - Figure 10). The abundance estimate of age-0 crabs in 2014 was similar to those levels observed between 1998 and 2008 when adult female abundance was low and sometimes below the threshold and fishing levels exceeded the threshold in numerous years. High recruitment variability is a characteristic of blue crab populations, although a sustained return to low levels seen prior to 2008 would be of concern.

4. HARVEST

4.1 2013 Commercial and Recreational Harvest

The 2013 Maryland commercial crab harvest from the Bay and its tributaries was estimated as 18.7 million pounds. The 2013 commercial harvest in Virginia's Chesapeake area was reported as 16.1 million pounds, and 2.0 million pounds were reported to have been harvested from the jurisdictional waters of the PRFC (Figure11-Figure 12). Maryland's 2013 commercial harvest declined 41% from 2012. Commercial harvest in 2013 in Virginia decreased by 24%, while Potomac River dropped 44%, when compared to 2012 levels. The bay-wide commercial harvest of almost 37 million pounds is the lowest harvest recorded in the last 25 years.

Prior to 2008, recreational harvest had been assumed to be 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. Therefore, 2013 Bay-wide recreational harvest was estimated to be 3.9 million pounds. Combining the commercial and recreational harvest, approximately 40.7 million pounds were harvested from Chesapeake Bay and its tributaries during the 2013 crabbing season. The 2013 Bay-wide blue crab harvest was the lowest seen this century.

4.2 Exploitation Fraction: Reference Points

The percentage of crabs removed by fishing (exploitation fraction) of female (ages 0 and 1+) crabs in 2013 was approximately 23%. This exploitation fraction is below the target of 25.5% and the threshold of 34%, for the sixth consecutive year (Figure 4).

5. STOCK STATUS

The Chesapeake Bay blue crab stock is currently below the abundance threshold of 70 million age 1+ female crabs outlined in the current management framework. The stock is **depleted** but **overfishing is not occurring** (Figure 6). Abundance, harvest, and exploitation of all crabs are summarized in Table 2.

6. MANAGEMENT ADVICE-SHORT TERM

6.1 Monitor fishery performance and stock status relative to recommended reference points and maintain a risk-averse management approach protecting 2014 recruits

The female exploitation fraction in 2013 was below the recommended target of 25.5% for the sixth consecutive year. Although the abundance of adult female crabs decreased in 2014, juvenile crab abundance increased in 2014 and the exploitable female stock increased by 13.5%. Additionally, the number of recruits year to year remains highly variable. Future catches and ability for the blue crab stock to reach abundance targets could depend heavily on the survival and successful reproduction of the 2014 exploitable female stock. Protection of this year class is expected to increase the number of spawning age crabs in 2015 thereby lowering the probability of continued poor recruitment. CBSAC finds this as further justification for a risk-averse and cautious management approach that ensures harvest is adequately constrained relative to abundance.

6.2 Catch Reports

CBSAC again recommends that the jurisdictions implement procedures that provide accurate accountability of all commercial and recreational harvest. If the jurisdictions continue with a sex-specific regulatory strategy, CBSAC again recommends greater efforts to determine the biological characteristics of all catch, both harvested and discarded. CBSAC also recommends that the jurisdictions implement additional harvest validation protocols.

6.3 Shifting management time frame: July to July

CBSAC recommends management jurisdictions consider a July to July adaptive management framework that allows for the results of the Winter Dredge Survey and the Blue Crab Advisory report to be utilized in the year immediately following the completion of the WDS as well as the Advisory Report. This timeline would support management by providing the most current abundance information to be considered by managers in the following crabbing season.

7. MANAGEMENT ADVICE- LONG TERM

7.1 Catch Control

A management strategy that sets annual catch levels based on estimates of abundance from the WDS and that accounts for sex-specific seasonal distribution of crabs could potentially balance annual harvests with highly variable recruitment events. The CBSAC recommends that jurisdictions evaluate the benefits of quota-based management systems. Allocating annual quotas to each jurisdiction would improve performance of a Bay-wide quota and lead to jurisdictional accountability of harvest relative to the Bay-wide exploitation target.

7.2 Annual sanctuary and complementary management measures

CBSAC recommends that the jurisdictions consider establishing a year-round sanctuary for mature females in the lower Bay, and 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.

7.3 Abundance specific exploitation

In the upcoming 2016 stock assessment CBSAC recommends the development of variable targets and thresholds based on the fluctuating abundance of all sectors of the female segment of the population. Development of abundance based variable targets and thresholds should be considered in the upcoming assessment.

7.4 Jurisdictional Management Controls

The blue crab fishery is primarily managed under an effort control framework with limited entry, size limits, and seasonal closures serving as the principal tools. Additionally, the blue crab fishery is also managed by output controls such as harvest and bushel limits. In many cases, the amount of effort expended in the fishery remains poorly quantified. CBSAC recommends an increased investment in Bay-wide effort monitoring that should include actions in all jurisdictions to implement a pot marking system and a bay wide survey of crab pot effort to estimate the total, spatial, and temporal patterns of the crab pot fishery. Should efforts to develop and implement real time verifiable harvest reporting as described in section 7.1 be successful, this recommendation can be ignored.

7.5 Latent effort

In both states, significant numbers of commercial crabbing licenses are unused. An increase in the blue crab population may increase the use of licenses that have, for some time, been inactive. CBSAC recommends that the level and possible re-entry of latent effort into the fishery be estimated and monitored. In addition to increases in latent effort, CBSAC also recognizes that temporal and seasonal shifts in blue crab abundance may alter existing effort exerted by active licenses. The impact of inherent variability of blue crab abundance on both latent and active effort should be investigated as a part of this recommendation.

8. CRITICAL DATA AND ANALYSIS NEEDS

Blue crab management now employs sex-specific regulatory strategies. Given this, current efforts could be expanded to better quantify sex ratios and size compositions of the harvest specifically in the peeler crab fishery. CBSAC has identified the following list of fishery-dependent and fishery-independent data needs as well as the benefits provided to management. CBSAC is planning on meeting mid July 2013, to discuss the prioritization of the needs identified below as well as the potential investigators, cost and duration of the projects.

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. Maryland will be implementing an electronic reporting system in 2015 for all commercial harvesters that will include daily random catch verification and a "hail–in, hail-out" protocol, which should greatly improve the accuracy of landings data. Virginia implemented an electronic reporting program in 2009 as an optional reporting method for harvesters. The majority of harvesters still prefer the original paper version of the Virginia Mandatory Reporting Program, but an increase in crab harvesters signing up for electronic reporting has been reported.

8.2 Gear efficiency pertaining to selectivity of WDS methods:

The WDS survey methods to estimate gear efficiency differ between the two states. CBSAC recommends continuation of a comprehensive comparison between MD and VA WDS methodologies and gear efficiency and selectivity with regard to age 0 and age 1+ crabs.

Following the comprehensive comparison, the accuracy and reliability of current scalars and efficiency corrections should be reevaluated. MD-DNR and VIMS will meet to discuss survey design in an attempt to develop this comparison over the course of the next year. Costs and required time are unknown.

In 2013-2014 a new framework was tested to determine and evaluate the accuracy of the current depletion method used to quantify gear selectivity in the dredge survey. The experimental selectivity methodology compared the previous depletion design of continuously sampling the exact area until zero crabs were captured from the selected site. The new design employed an overlapping dredge pattern where perpendicular tracks were used to derive a selectivity estimate.

Considerable progress was made evaluating the new experimental design. Future analysis and discussion should be prioritized this summer to determine the efficacy and application of the new design. Additional personnel may be needed to analyze the results of the comparisons.

8.3 Over-wintering mortality:

The WDS data should be further examined to estimate overwintering mortality. Continuing this data mining exercise could provide CBSAC and managers with a more complete understanding of inter-annual variability in natural mortality and potentially improve future assessments. CBSAC recommends that initial efforts be focused on determining a statistical approach to use with existing data that can be developed to provide a more reliable bay-wide mortality estimate.

8.4 Improving recruitment estimate through shallow water survey:

Based on the results of the 2012-2013 WDS, a large number of recruits observed in the 2011-2012 WDS did not recruit to the fisheries in 2012-2013. Based on the stock assessment and pilot field experiments by VIMS and the Smithsonian Environmental Research Center, a large fraction of juvenile blue crabs (76-86%) in shallow water are not sampled by the WDS[7]. For the former, CBSAC recommends

analyzing pertinent environmental and ecological variables to examine potential hypotheses to explain the poor survival of this record recruitment event and improve the accuracy of the WDS. Anticipated time to completion is three to four months; this examination includes the definition of viable hypotheses, not the assessment of their veracity. For the latter, CBSAC recommends that funding be pursued at the state and federal levels for shallow-water surveys to assess the potential for interannual bias in the fraction of juveniles that is not sampled by the WDS.

8.5 Investigation of the potential for sperm limitation:

CBSAC recommends continued examination to quantify and better understand the role male crabs on reproductive success and overall population productivity. The potential for sperm limitation resulting from a lower abundance of sexually mature male crabs is discussed in several recent studies[8,9,10]. Further clarity could be brought to this issue through an analysis of the age composition of mature females over the history of the WDS to determine whether the proportion of females in their second reproductive year has increased.

8.6 Other sources of incidental 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, disease, and predation. An analysis of non-harvest mortality could improve reliability of exploitation fraction estimates and inform future assessments. Initial efforts should be focused on better defining analyses that could address the problem.

8.7 Prepping for next stock assessment:

CBSAC recommends that measures to secure funding, establish terms of reference, and identify any additional resources needed for the 2016 stock assessment begin over the next year.

8.8 Collaborative Bay-wide fishery independent survey:

A collaborative and coordinated Bay-wide, fishery-independent survey focused on the spring through fall distribution and sex-specific abundance of blue crabs remains important, especially if agencies are considering regional or spatially-explicit management strategies. Costs and time commitments are unknown.

CBSAC Participants:

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Lynn Fegley	Maryland Department of Natural Resources
Tom Miller	UMCES, Chesapeake Biological Laboratory
Mike Wilberg	UMCES, Chesapeake Biological Laboratory
Daniel Hennen	NMFS, Northeast Fisheries Science Center
Alexei Sharov	Maryland Department of Natural Resources
Rob O'Reilly	Virginia Marine Resource Commission
Mike Seebo	Virginia Institute of Marine Science
John Hoenig	Virginia Institute of Marine Science
Rom Lipcius	Virginia Institute of Marine Science

Ellen Cosby	Potomac River Fisheries Commission
Amy Schueller	NMFS, Southeast Fisheries Science Center
Eric Johnson	University of North Florida
Glenn Davis	Maryland Department of Natural Resources
Sally Roman	Virginia Marine Resources Commission
John McConaugha	Old Dominion University

CBSAC Coordinator:

Andrew Turner	NOAA Chesapeake Bay Office/Versar

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Table 2. Estimated abundance of blue crabs from the Chesapeake Bay-wide 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	Bay-wide Commercial Harvest (Millions of Pounds)	Percentage of Female Crabs Harvested
1990	791	463	276	117	96	44
1991	828	356	457	227	90	34
1992	367	105	251	167	53	60
1993	852	503	347	177	107	35
1994	487	295	190	102	77	28
1995	487	300	183	80	72	32
1996	661	476	146	108	69	20
1997	680	512	165	93	77	22
1998	353	166	187	106	56	40
1999	308	223	86	53	62	37
2000	281	135	146	93	49	43
2001	254	156	101	61	47	42
2002	315	194	121	55	50	34
2003	334	172	171	84	47	33
2004	270	143	122	82	48	42
2005	400	243	156	110	54	24
2006	313	197	120	85	49	29
2007	251	112	139	89	43	35
2008	293	166	128	91	49	24
2009	396	171	220	162	54	23
2010	663	340	310	246	85	18
2011	452	204	255	191	67	24
2012	765	581	175	95	56	10
2013	**300**	**111**	**180**	**147**	**37**	**23**
2014	**297**	**198**	**100**	**68.5**	**TBD**	**TBD**

* 2013 Bay-wide commercial harvest and exploitation rate are prelimi

Figure 1. Winter dredge survey index of total blue crab abundance (density of males and females, all sizes combined) in Chesapeake Bay, 1990 through 2014. Error bars represent 95% confidence intervals.

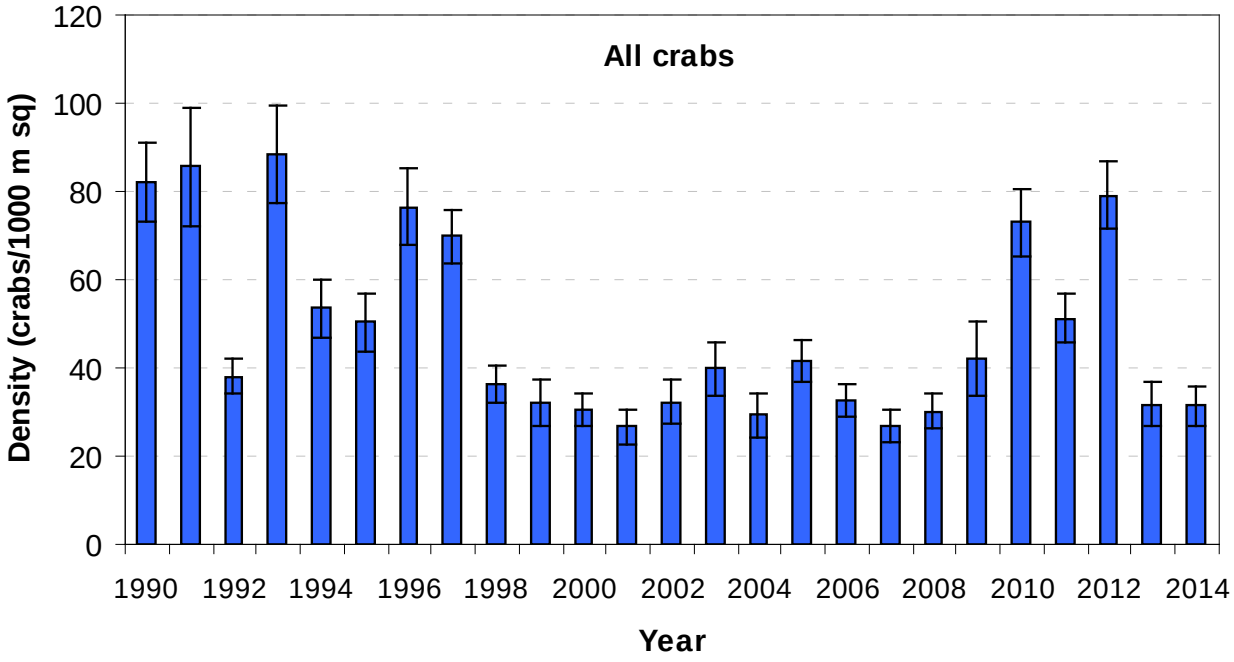
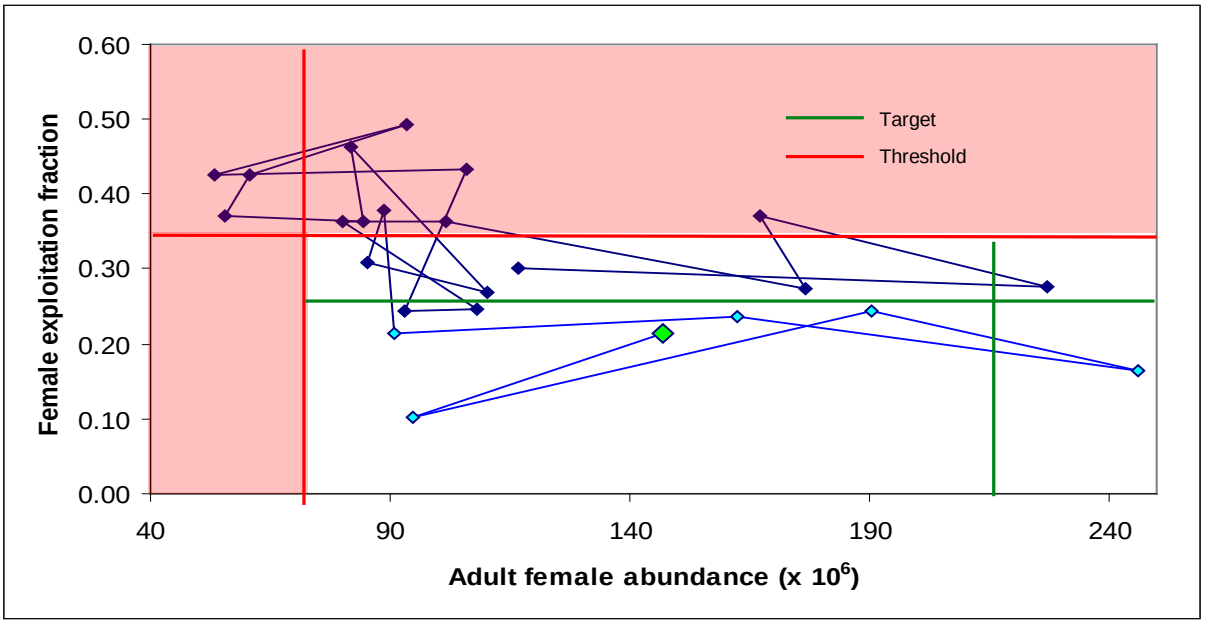


Figure 2. The female-specific control rule for the Chesapeake Bay blue crab fishery. In 2013, adult female abundance was below the overfished target, while the female-specific exploitation rate was below the overfishing target. Reference points were derived from a statistical assessment model incorporating multiple surveys.

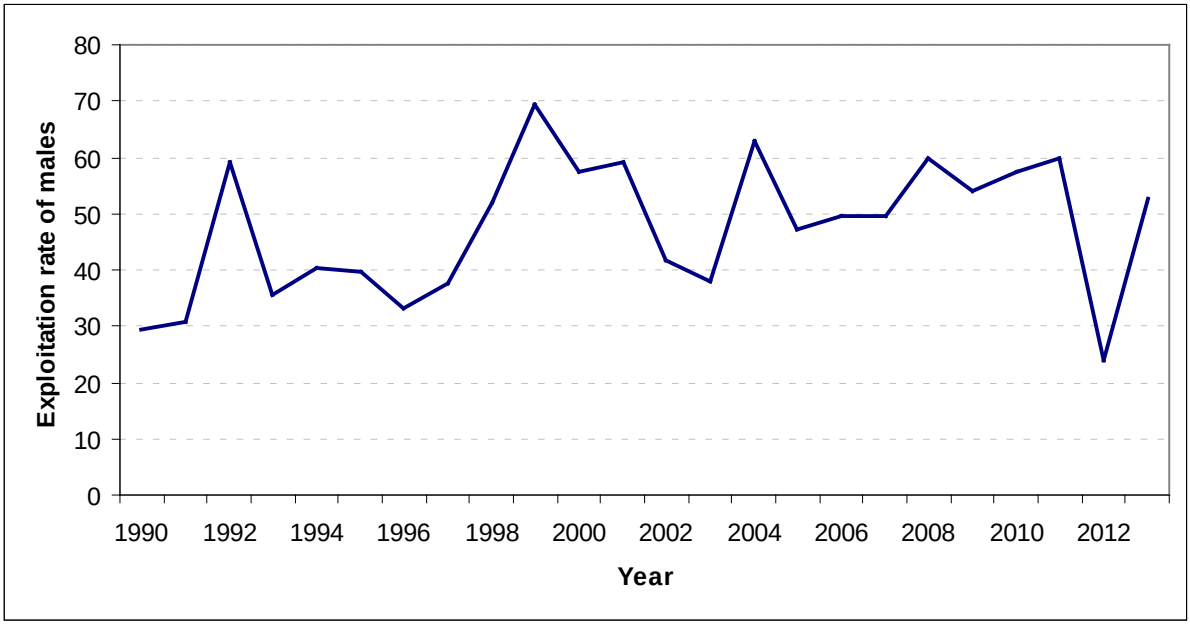
Exploitation: target is 25.5%, threshold is 34%

Abundance: target is 215 million crabs, threshold is 70 million crabs



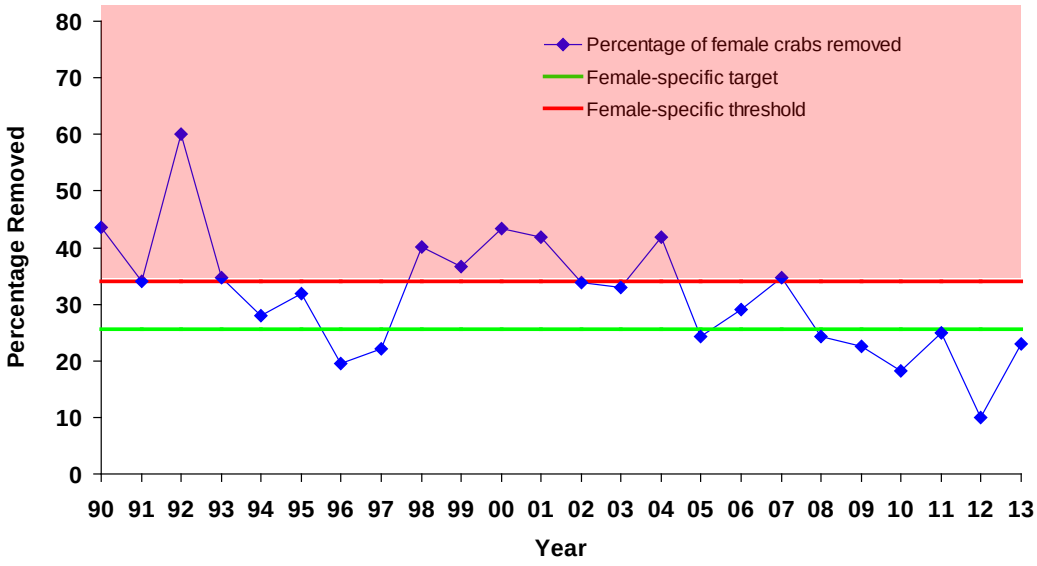
Exploitation fraction is (harvest / abundance). Abundance of Age 0 + Age 1+ females calculated using catchability adjustment for juveniles.

Figure 3. The percentage of male crabs removed from the population each year by fishing, 1990 through 2013.
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.



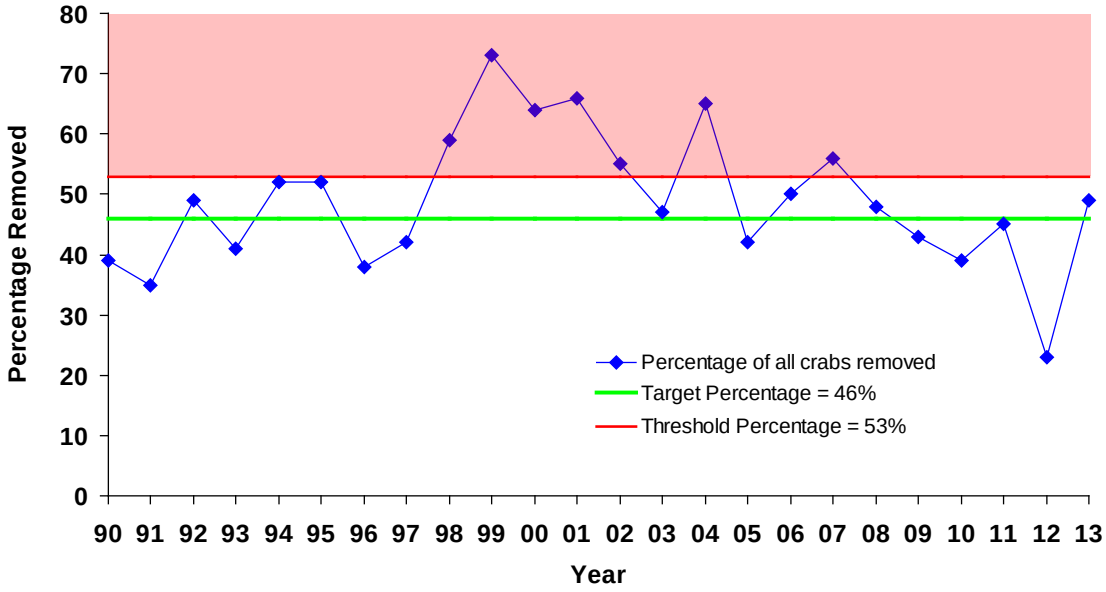
Abundance calculated without catchability adjustment for juveniles.

Figure 4. 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 2013.
Exploitation rate (% removed) is the number of female crabs harvested within a year divided by the female population (age 0 and age 1+) estimated at the beginning of the year.



Abundance estimate calculated using catchability adjustment for juveniles.

Figure 5. The percentage of male and female crabs removed from the population each year by fishing relative to previously used target (46%) and threshold (53%) exploitation rates, 1990 through 2013. Exploitation rate (% removed) is the number of crabs harvested within a year divided by the population of all crabs estimate at the beginning of the year.



Abundance estimate calculated without catchability adjustment for juveniles.

Figure 6. Winter dredge survey estimate of **abundance of female blue crabs age one year and olc** (age 1+) 1990-2014 with female-specific reference points. These are female crabs measuring greate than 60mm across the carapace and are considered the 'exploitable stock' that will spawn within the coming year.

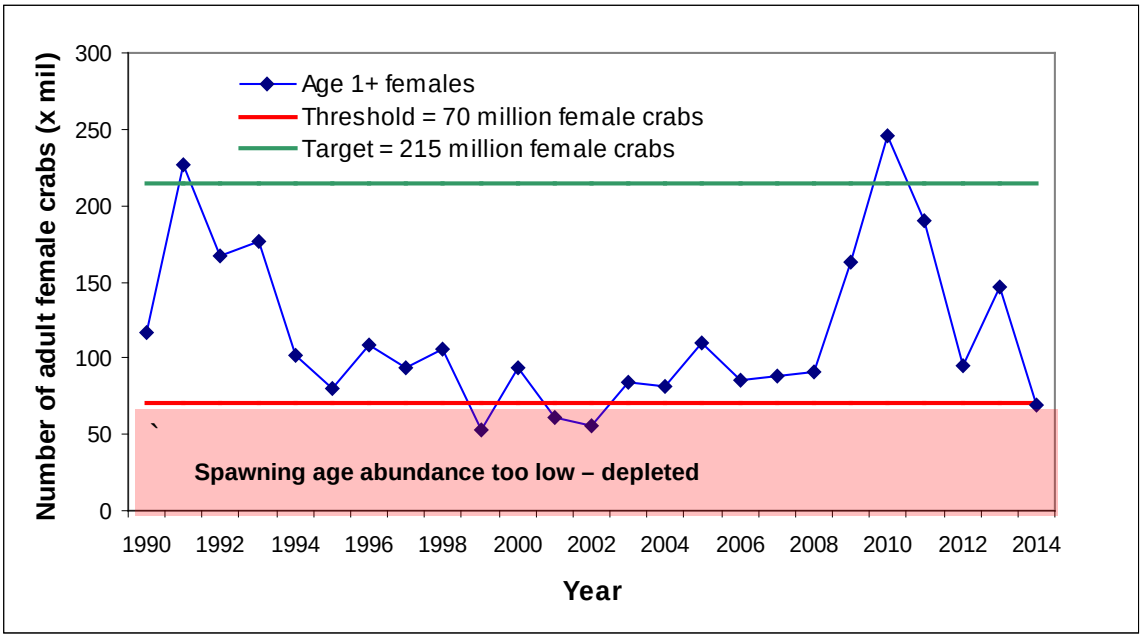
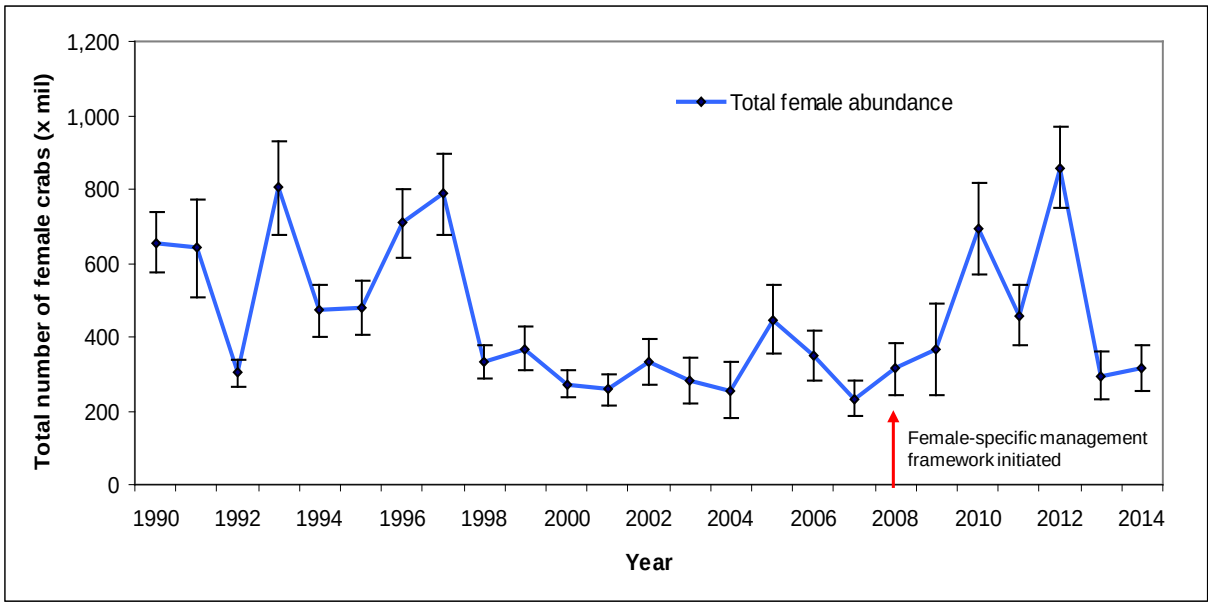


Figure 7. Winter dredge survey estimate of **abundance of all female blue crabs (age 0 and age 1+)** 1990-2014. The population of over-wintering females is the basis of female exploitation rate calculations. Error bars represent 95% confidence intervals.



Abundance calculated using catchability adjustment for juveniles.

Figure 8. Winter dredge survey estimate of **abundance of male blue crabs age one year and older (age 1+)** 1990-2014. These are male crabs measuring greater than than 60mm across the carapace and are considered the 'exploitable stock' capable of mating within the coming year. Error bars represent 95% confidence intervals.

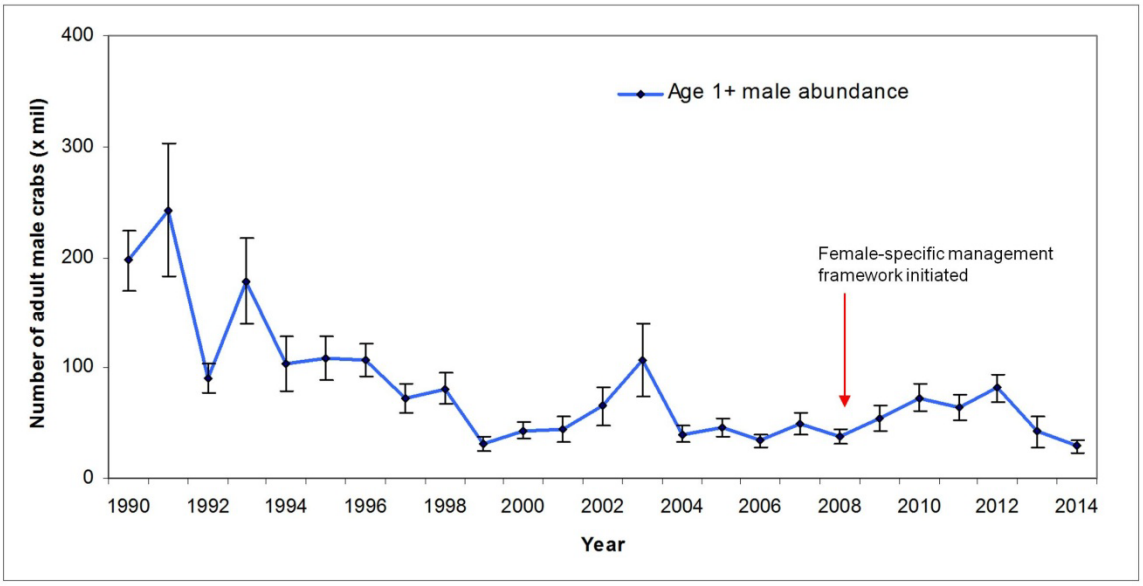
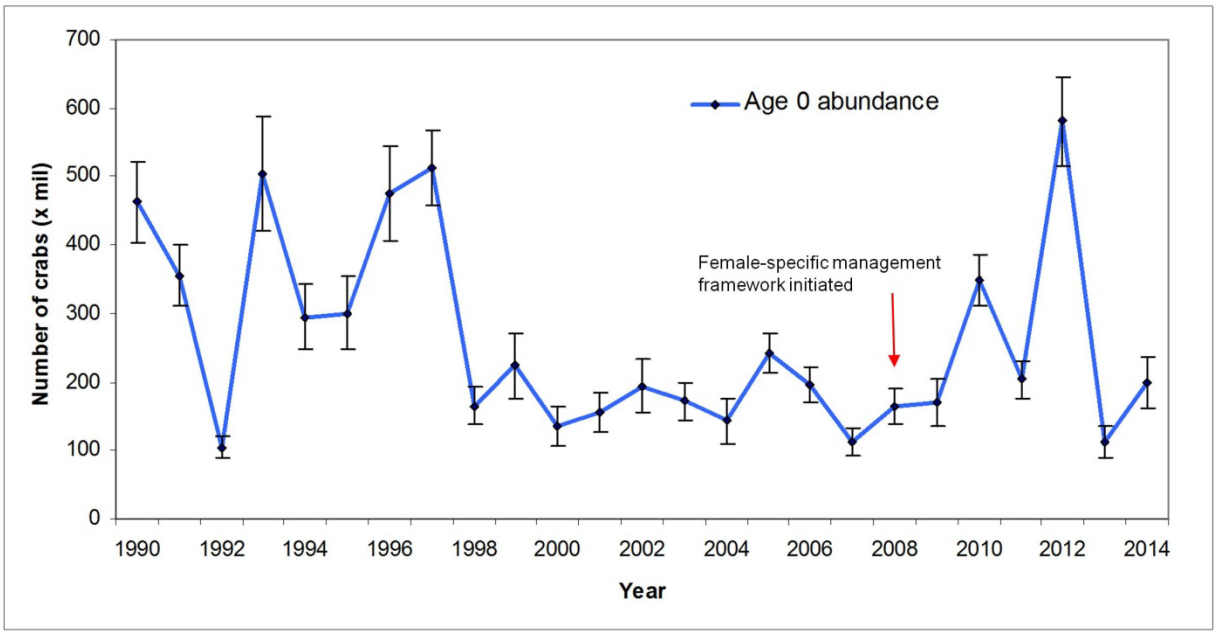
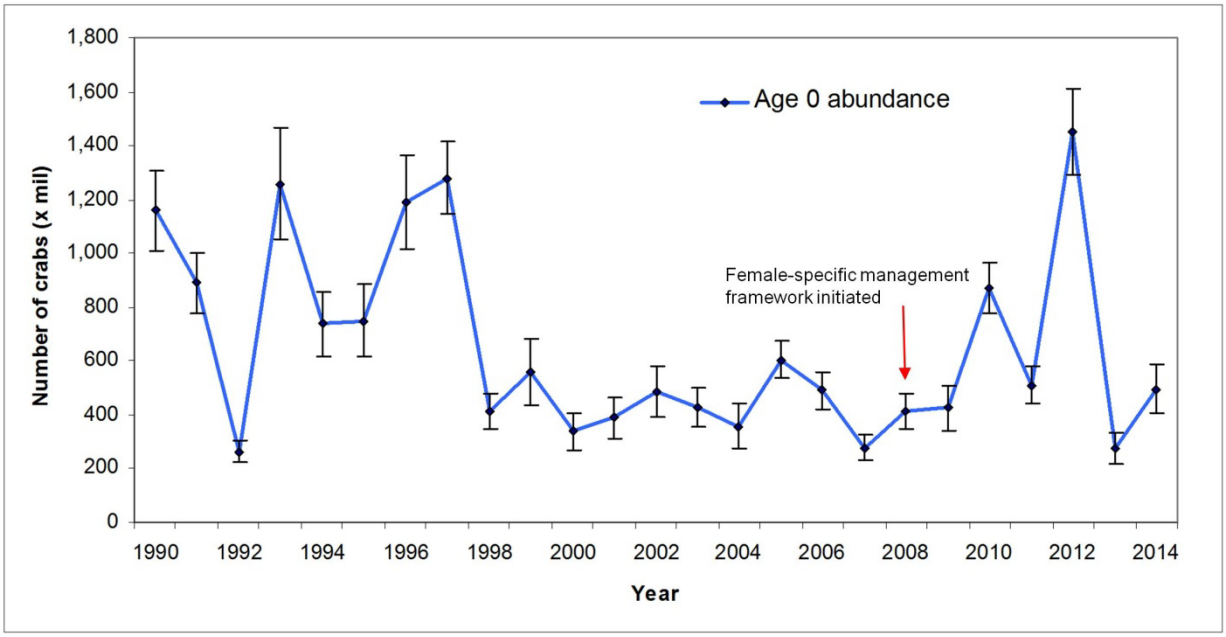


Figure 9 . Winter dredge survey estimate of **abundance of juvenile blue crabs (age 0)**, 1990-2014 calculated without the catchability adjustment for juveniles. These are male and female crabs measuring less than 60mm across the carapace. Error bars represent 95% confidence intervals.



Abundance calculated without catchability adjustment for juveniles.

Figure 10. Winter dredge survey estimate of **abundance of juvenile blue crabs (age 0)**, 1990-2014 calculated using the catchability adjustment for juveniles These are male and female crabs measuring less than 60mm across the carapace. Error bars represent 95% confidence intervals.



Abundance calculated using catchability adjustment for juveniles.

Figure 11. Maryland and Virginia Chesapeake Bay commercial blue crab harvest in millions of pounds, 1990-2013.

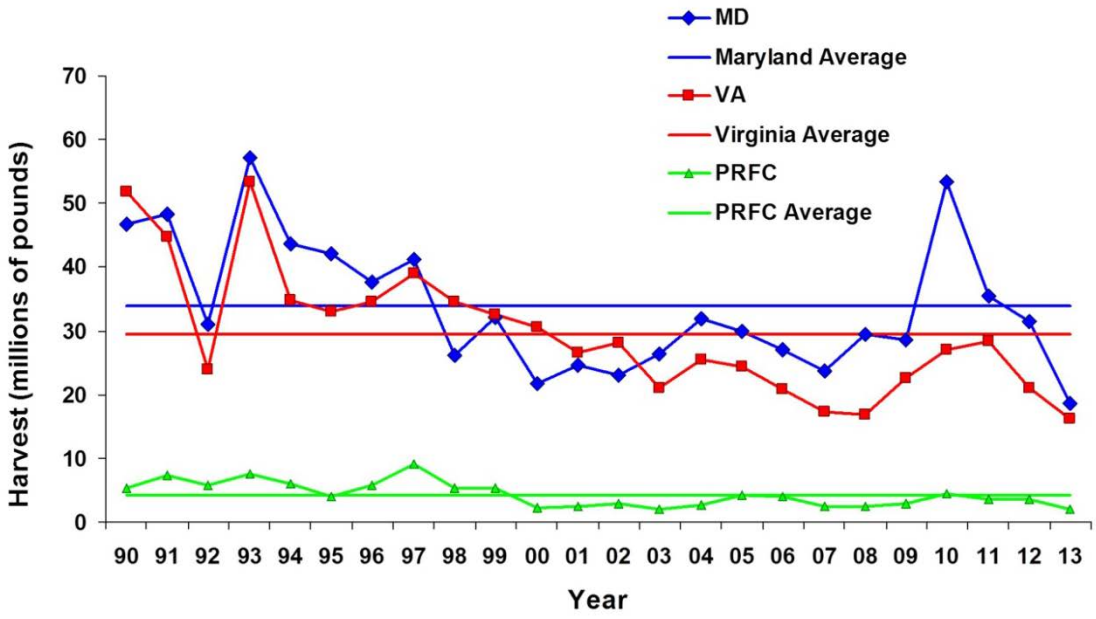
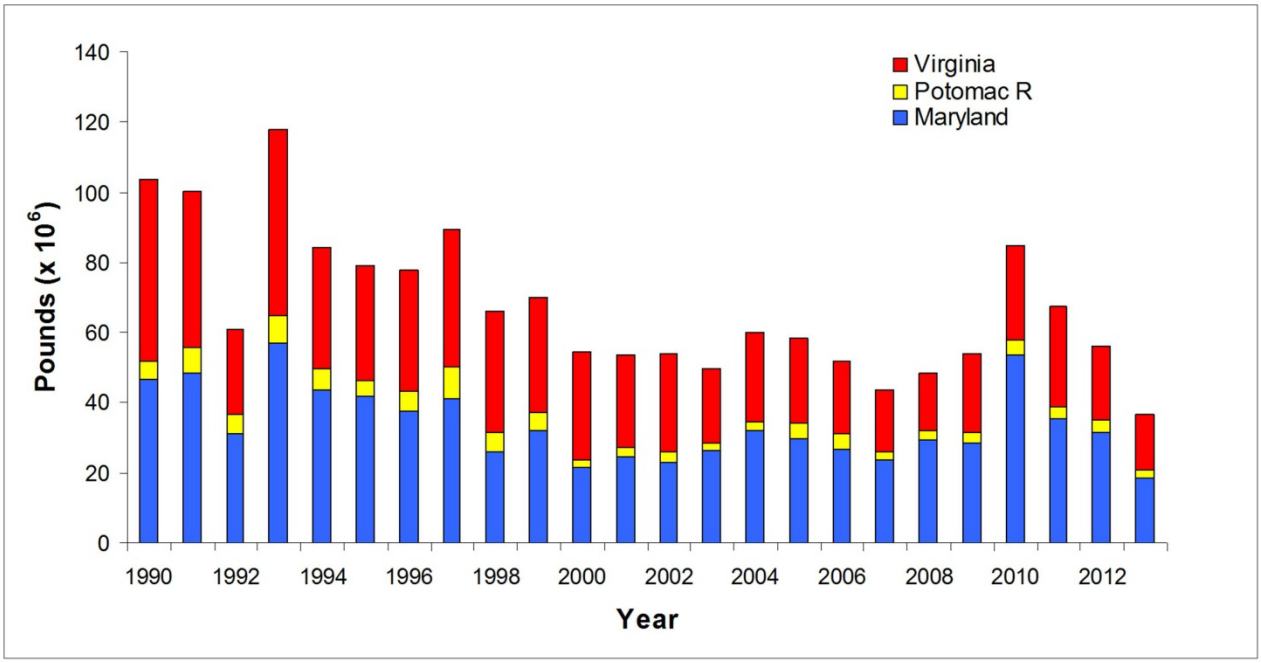


Figure 12. Total commercial blue crab landings (all market categories) in Chesapeake Bay, 1990-2013



VIRGINIA'S 21 -POINT BLUE CRAB MANAGEMENT PLAN

October 1994, the Commission established the following 7-point blue crab management plan:

- Expanded the spawning sanctuary (146 sq. mi.) establish in 1942 by 75 sq. mi., with no crab harvest allowed from June 1 through September 15.
- Established a 14,500-acre winter-dredge sanctuary in Hampton Roads.
- Shortened the crab pot season to April 1 through November 30.
- Required two cull (escape) rings in each commercial and recreational crab pot.
- Required four cull rings in each peeler pound that allows escapement of small peeler crabs.
- Capped the number of peeler pots per license to prevent expansion of the fishery.
- Limited the crab dredge size to 8 feet to prevent increases in effort.

The Commission reinforced the 7-point management plan in January 1996.

- Prohibited the possession of dark-colored (brown through black) sponge crabs (adult female hard crab which had extruded her eggs on her abdomen), with a 10-sponge crab per bushel tolerance.
- Limited license sales of hard crab licenses, based on previous eligibility or exemption requirements.
- Established a 300-hard crab pot limit for all Virginia tributaries of the mainstem Chesapeake Bay. Other Virginia harvest areas were limited to a 500-hard crab pot limit.
- Established a 3 1/2-inch minimum possession size limit for all soft shell crabs.

Concerns over excess effort in the fisheries and a persistent trend of low spawning stock biomass during most of the 1990's led to additional crab conservation measures in 1999 and 2000.

- Lowered the maximum limit on peeler pots from 400 to 300 pots in 1999. Harvest by this gear type increased by 90%, from 1994 through 1998, while the overall harvest remained relatively static.
- Initiated a moratorium on additional commercial licenses for all commercial crabbing gear. This moratorium became effective May 26, 1999 and continued until May 26, 2004.
- Established (in 2000) a Virginia Bay-wide Blue Crab Spawning Sanctuary, in effect June 1 through September 15. This additional sanctuary (435 sq. mil) allows for increased spawning potential.

A cooperative Bay-wide agreement (October 2000) to reduce harvest 15% by 2003 led to new measures.

- Enacted an 8-hour workday for commercial crabbers (2002) that replaced Wednesday closures of 2001.
- Established a 3-inch minimum size limit for peeler crabs (2002).
- Reduced peeler pot limits from 400 to 300 pots (for 2001).
- Reduced the winter dredge fishery limit from 20 to 17 barrels (2001).
- Augmented (2002) the Virginia Blue Crab Sanctuary by 272 sq. mi. (total sanctuary area = 928 sq. mi.).
- Reduced unlicensed recreational harvester limits to 1 bushel of hard crabs, 2 dozen peelers (2002).
- Reduced licensed recreational harvester limits to 1 bushel of hard crabs, 2 dozen peelers, with vessel limit equal to number of crabbers on board multiplied by personal limits (2001).

ACTIONS TO PROMOTE REBUILDING OF CHESAPEAKE BAY BLUE CRAB STOCK (2008 through 2013)

February 2008
- Larger cull ring (2-5/16") required to be open at all times in all tidal VA waters to promote additional increases in escapement
- Peeler crab minimum size limit increased from 3" to 3 ¼" (through July 15) and to 3 ½" (as of July 16)
- Use of agents modified to prevent license "stacking" and to curtail use of agents
- Winter dredge fishery capped at 53 licensees (from previous 225 licensees), all being active harvesters in previous two winter seasons

March 2008
- Adopted an extended closure (May 1 - September 15) of blue crab spawning sanctuary, to protect spawning females, except for the historical sanctuary (146 square miles) managed by law

April 2008
- Established a fall closure for female harvest (October 27 – November 30)
- Implemented a 15% reduction in pots per individual for 2008 crab pot fishery and a 30% reduction for 2009 crab pot and peeler pot fishery
- Closed 2008/09 winter dredge fishery season
- Required use of two 3/8" cull rings for all areas (except Seaside of Eastern Shore) effective July 1
- Eliminated 5-crab pot recreational license
- Revamped revocation procedures, to allow a hearing after just two crab violations in a 12-month period

November 2008
- In an attempt to address the latent effort, the Commission placed crab pot and peeler pot fishermen who had been inactive (no harvest) for a 4-year period (2004-07) on a waiting list until the abundance determined from the Bay-wide Winter Dredge Survey of age-1+ crabs exceeds the interim target of 200 million

May 2009
- Shortened closed season for female crabs to November 21 - November 30
- Closed 2009/10 winter dredge fishery season
- Lowered percentage reduction of crab pots from 30% (2008) to 15% (2009)
- Reestablished 5-pot recreational crab pot license but prohibited harvest on Sunday and from Sept 16 - May 31
- Right to hold revocation hearing for crab licensee after two crab violations by authorized agent (agents cannot be licensed for any crab fishing gear)
- Regulation tolerance of 10 per bushel (Previously March 17 – July 15)

May 2010
- Made it unlawful (from March 17 - June 30) to possess dark sponge crabs exceeding regulation tolerance of 10 per bushel (Previously March 17 – July 15)
- Made it lawful (indefinitely) that commercial licenses (crab/peeler pot, scrape, trap, ordinary/patent trot line, dip net) shall be sold only to commercial fishermen eligible in 2010, except those placed on the waiting list established in November 2007
- Closed 2010/11 winter dredging fishery season

April 2011
- Changed closed season on harvest from Virginia Blue Crab Sanctuaries from May 16 to May 1
- Changed boundary line of Blue Crab Sanctuary in upper Bay near Smith Point Light

September 2011
- Closed 2011/12 winter dredging fishery season
- Established 5-day maximum tending requirement for crab pots and peeler pots

November 2012
- Closed 2012/13 winter dredge fishery season
- Funded the Winter Dredge Gear Study using Marine Fishing Improvement Funds
- Extended the 2012 season until December 15, 2012 for both male and female crabs and applied conservation equivalent bushel limits to the 2013 crab pot season by gear license categories as follows:
    - For up to 85 crab pots a maximum limit of 27 bushels.
    - For up to 127 crab pots a maximum limit of 32 bushels.
    - For up to 170 crab pots a maximum limit of 38 bushels.
    - For up to 255 crab pots a maximum limit of 45 bushels.
    - For up to 425 crab pots a maximum limit of 55 bushels.
- Restricted crabbing in the Virginia portion of the Albermarle and Currituck watersheds to crab pots and peeler pots only

February 2013
- Established a vessel harvest and possession limit equal to only one of the largest legal bushel limits on board any vessel
- Limited the use of agents in the hard pot fishery to 168, with priority going to those licensees who received approval for agent use in 2012

June 2013
- Established daily individual and vessel harvest and possession limits for the 2013 season

October 2013
- Closed 2013/14 winter dredge fishery season
- Results of the Winter Dredge Mortality Project were presented
- Extended the 2013 season until December 15, 2013 for both male and female crabs and applied conservation equivalent bushel limits to the 2013 season extension and the 2014 crab pot season by gear license categories as follows:
    - For up to 85 crab pots a maximum limit of 16 bushels.
    - For up to 127 crab pots a maximum limit of 21 bushels.
    - For up to 170 crab pots a maximum limit of 27 bushels.

    - For up to 255 crab pots a maximum limit of 43 bushels.
    - For up to 425 crab pots a maximum limit of 55 bushels.
- Established the 2014 crab pot season as March 17 through November 30, 2014 for both male and female blue crabs
- Established a declaration date for agent use requirements in the crab pot fishery for the 2014 season.

June 2014

- Closed the 2014/15 winter dredge fishery season
- Enacted management reductions in response to the current scientific determination that the Chesapeake Bay blue crab abundance of spawning-age female crabs is depleted. The basis for this 10 percent reduction, which equals a potential savings of 1,316,726 pounds of female blue crab, is to augment spawning in summer 2014 and spring 2015 and help reverse the depleted stock condition of blue crab.
- From July 5, 2014 through November 15, 2014 and April 1, 2015 through July 4, 2015
    - 10 bushels, or 3 barrels and 1 bushel, of crabs, if licensed for up to 85 crab pots.
    - 14 bushels, or 4 barrels and 2 bushels, of crabs, if licensed for up to 127 crab pots.
    - 18 bushels, or 6 barrels, of crabs, if licensed for up to 170 crab pots.
    - 29 bushels, or 9 barrels and 2 bushels, of crabs, if licensed for up to 255 crab pots.
    - 47 bushels, or 15 barrels and 2 bushels, of crabs, if licensed for up to 425 crab pots
- From November 16, 2014 through November 30, 2014 and March 17, 2015 through March 31, 2015
    - 8 bushels, or 2 barrels and 2 bushels, of crabs, if licensed for up to 85 crab pots.
    - 10 bushels, or 3 barrels and 1 bushel, of crabs, if licensed for up to 127 crab pots.
    - 13 bushels, or 4 barrels and 1 bushel, of crabs, if licensed for up to 170 crab pots.
    - 21 bushels, or 7 barrels of crabs, if licensed for up to 255 crab pots.
    - 27 bushels, or 9 barrels of crabs, if licensed for up to 425 crab pots.
- The lawful season for the commercial harvest of blue crabs by all other commercial gears shall be March 17, 2014 through September 15, 2014 and May 1, 2015 through November 30, 2015. It shall be unlawful to place, set, fish or leave any lawful commercial gear used to harvest crabs, except crab pots, in any tidal waters of Virginia from September 16, 2014 through April 30, 2015.