Appendix 2

Estimation and Verification of the 2008 Maryland Chesapeake Bay Blue Crab Harvest

Prepared for CBSAC
May, 2009

MDNR Fisheries Service
Linda S. Barker
Glenn Davis
Lynn Fegley

SUMMARY

In 2008, Maryland DNR detected significant bias in commercial harvest reports for the blue crab. In large part, this bias was due to management actions implemented by the Department in 2008 that limited access to the fall female fishery based on catch history, and assigned individual catch limits based on an individual's catch history. In addition, Maryland DNR proposed, but subsequently withdrew, regulation to freeze a large number of unused (latent) crab licenses. As a result, harvest in 2008 was inflated as crabbers changed reporting behavior in response to regulatory action. Harvest was inflated as licensed crabbers who had not filed reports in many years, filed some harvest in order to avoid being categorized as latent. The bulk of Maryland's 6,000 commercially licensed crabbers are in the latent category.

Maryland DNR has mechanisms in place to monitor the accuracy and veracity of commercial harvest reports. Since 2002, Maryland DNR has engaged a reference fleet of approximately 40 commercial crabbers. This fleet collects information on crab catch by market category. The fleet works throughout the crabbing season, is spatially comprehensive, and represents all fishery sectors (hard pot, peeler pot, trotline, etc.). Since 2003, Maryland DNR has contracted a commercial crabbing effort study that, through rigorously designed surveys and intensive field work, provides monthly estimates of the number of crab pots deployed in the Maryland portion of Chesapeake Bay. Together, these two survey allow Maryland DNR to estimate commercial crab harvest independently of harvest reports. Over the years that these surveys have been conducted, the harvest estimated from these surveys has been consistently higher than the harvest reported. In 2008, for the first time, harvest estimated from the surveys – especially for female hard crabs – was substantially lower than the 2008 reported harvest. Overall, Maryland commercial crabbers reported a 2008 harvest of 42.5 million pounds. By contrast, independent surveys produced a 2008 harvest estimate of 29.4 million pounds. This document provides a full description of the bias observed in Maryland's 2008 reported commercial crab harvest, and details the procedure by which the 2008 harvest was estimated.

BACKGROUND

A management control rule was adopted by the Bi-State Blue Crab Advisory Committee in 2001 to determine the status of the Chesapeake Bay blue crab stock and guide management decisions. The control rule represents the relationship between adult crab abundance (millions of

crabs), exploitation (the fraction of crabs removed by the fishery in a year) and management reference points:

abundance target	200 million spawning (age 1+) crabs
exploitation fraction target	46%
overfished threshold	86 million age 1+ crabs
exploitation fraction (overfishing) threshold	53%

Calculation of the annual exploitation fraction relies on commercial harvest reports to estimate fishery removals and on the Baywide winter dredge survey to estimate the available population.

At the beginning of the 2008 commercial season, results of the 2007-2008 WDS indicated an abundance of 120 million spawning age crabs available for the 2008 crabbing season. This was the 14th consecutive year of age 1+ abundance that was below the target of 200 million. In addition, based on the relationship between over-wintering abundance and the coming year's commercial harvest, the exploitation fraction was expected to above the overfishing threshold (53%) for the ninth time in 11 years. Finally, the abundance of newly recruited age 0 crabs beginning the 2008 crabbing season remained below historical levels. The total abundance of crabs estimated to be in Chesapeake Bay at the start of the 2008 season was approximately 280 million crabs – not measurably different from the previous 2 year's estimates of 256 million crabs in 2007 and 319 million crabs in 2006.

In response to this stock status, CBSAC recommended that management action be taken to constrain the 2008 fishery to the target of a 46% exploitation rate, meaning that expected harvest would need to be reduced by 17%. CBSAC also recommended that the jurisdictions extend protective measures for mature female crabs. The result was harvest limits aimed at reducing female harvest by 34%. Regulatory actions taken in 2008, designed to reduce the overall harvest and particularly the harvest of females, were coordinated among the three management jurisdictions (MD, VA, PRFC).

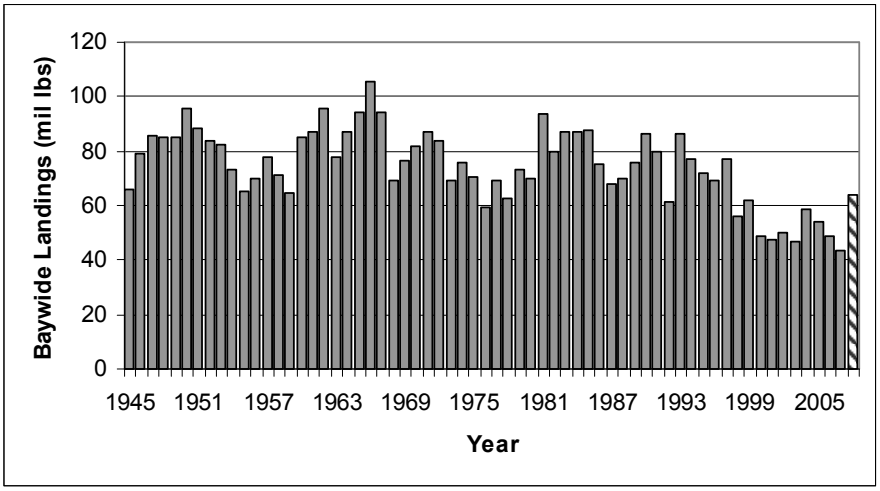
In Maryland, bushel limits were assigned to crabbers beginning September 1, 2008, based on their average harvest in September/October in 2004-2007. License holders with no historical reported female harvest were prohibited from harvesting female crabs in September and October of 2008. This management action, combined with the large number of latent crab licenses in Maryland resulted in inflated catch reports as previously inactive crabbers filed inaccurate, positive catches in order to position them selves for future regulatory action.

2008 MARYLAND COMMERCIAL REPORTING ANOMALIES - EVIDENCE FOR INFLATED HARVEST REPORT

Blue crab commercial landings from the Maryland portion of Chesapeake Bay have been fairly stable over the past five years. Total harvest has fluctuated between 24.7 and 32.3 million pounds, deviating from the time series mean less than 25% for males and peelers, and less than 10% for females. Maryland has consistently harvested slightly more than half the crabs in Chesapeake Bay in the past five years (2003-2007).

The 2007 Baywide reported commercial blue crab harvest was 45.52 million pounds (the lowest recorded since 1945), and regulations were implemented in all three jurisdictions to further reduce the 2008 harvest. However, the 2008 reported harvest increased to 63.85 million pounds (Figure 1).

Figure 1. Time series of Baywide blue crab landings.



Since VA harvest decreased by 12% from 2007 and Potomac River landings were nearly unchanged, the 2008 increase in harvest was entirely due to increased Maryland reported harvest. The 2008 Maryland reported harvest of over 40 million pounds was an anomaly by all measures. Landings were above the eight year average every month except November and December when the fishery was closed to females (Table 1).

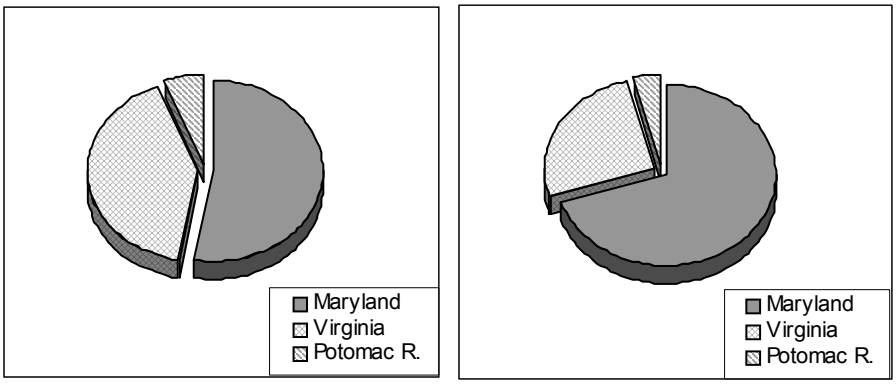
Table 1. Monthly blue crab harvest (pounds, all market categories) from Chesapeake Bay, MD.

Month	2007	2008	01-'08 Average	+/- from Average
April	238,172	987,614	434,747	552,867
May	1,551,047	3,286,543	1,789,085	1,497,458
June	3,796,306	6,154,300	3,740,524	2,413,776
July	3,815,987	8,328,057	4,797,379	3,530,678
August	3,918,250	9,137,954	5,056,926	4,081,028
September	3,686,678	8,148,704	4,720,949	3,427,755
October	4,823,052	7,456,474	5,677,627	1,778,847
November	1,785,242	1,101,420	1,679,363	**-577,943**
December	68,305	37,808	54,537	**-16,729**
Total	23,683,039	44,638,873	27,951,136	16,687,737

According to Maryland's 2008 commercial harvest reports, 2008 Maryland's harvest accounted for over 69% of the Bay-wide harvest, as opposed to the recent average of 50% (Figure 2).

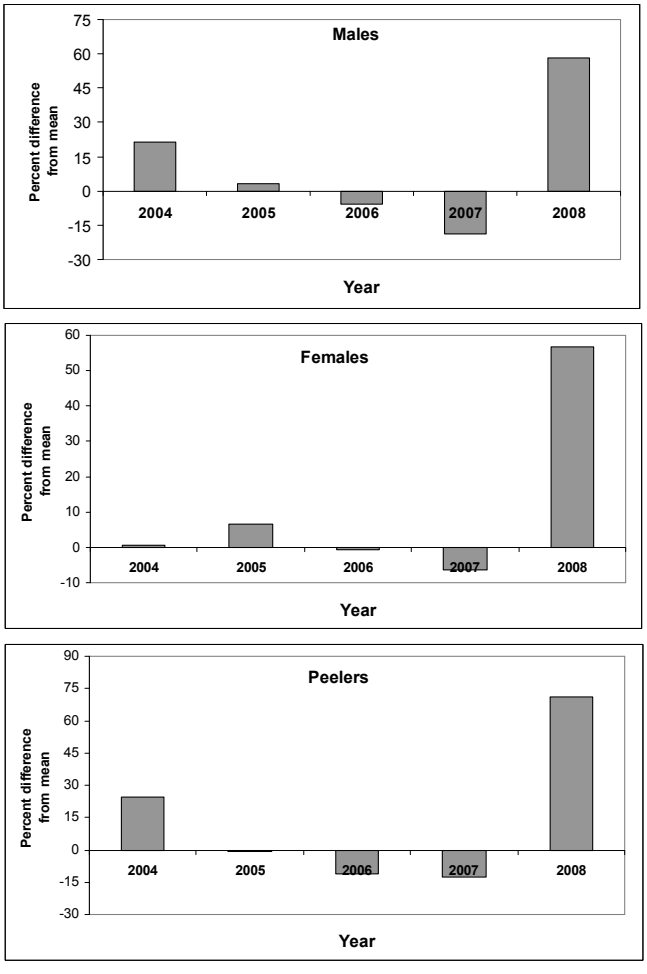
Figure 2. Distribution of commercial blue crab harvest among Chesapeake Bay jurisdictions,

2004-2007 vs. 2008.



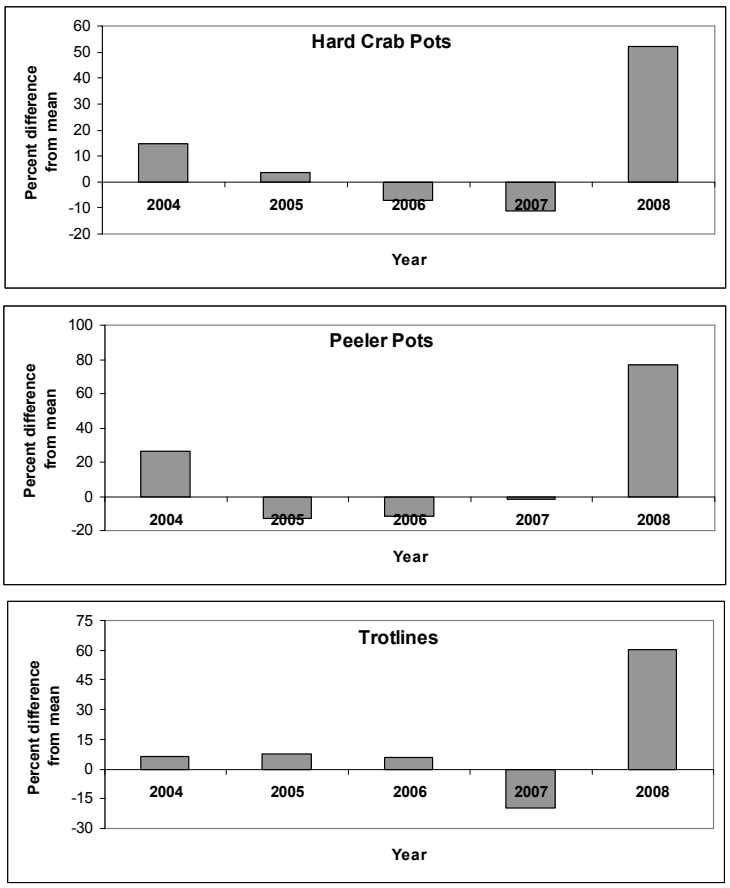
In Maryland's 2008 harvest reports, all market categories exhibited a strong positive (56%-71%) departure from the 2004-07 average harvest (Figure 3).

Figure 3. Percent deviation from 4-year harvest mean in Maryland commercial blue crab harvest reports by market category.



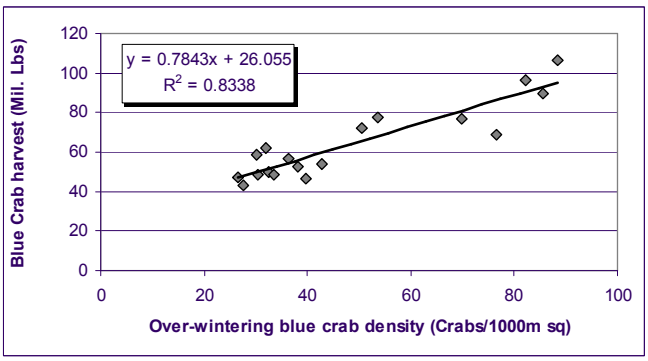
Maryland's 2008 reported harvest from all major gear types (hard crab pot, peeler pot, trotline) ranged from 54% to 76% above the previous four-year average (Figure 4).

Figure 4. Percent deviation from mean Maryland commercial blue crab harvest for the three most widely used gears, 2004-2008



Maryland's 2008 landings were also inconsistent with the historical relationship between harvest and survey data from the Baywide winter dredge survey. This survey has been used to generate abundance estimates of over-wintering blue crabs and has reliably predicted Baywide commercial harvest during the upcoming season for over 18 years (Figure 5).

Figure 5. Relationship between over-wintering blue crab mean density and future harvest in Chesapeake Bay, from Baywide winter dredge survey 1990-2007.



In the absence of additional regulation, a 2008 harvest of 58.15 million pounds was predicted from the 2007-2008 winter dredge survey. The 2008 regulations were intended to reduce landings by approximately 17% to approximately 48.26 million pounds. Further, separate relationships predicting male and female harvest, based on male and female dredge abundance can be calculated. Table 2 presents expected vs. reported harvest of males and females by jurisdiction. Both male and female hard crab landings were similar to projections in Virginia and the Potomac River. Since MD restrictions were targeted at females, their portion of the harvest was expected to be reduced by 34% below expected. However, reported male hard crab landings were 57% higher than projected and females were 106% higher than projected values.

Table 2. 2008 reported and projected hard crab landings (mil. lbs.) by market category and jurisdiction.

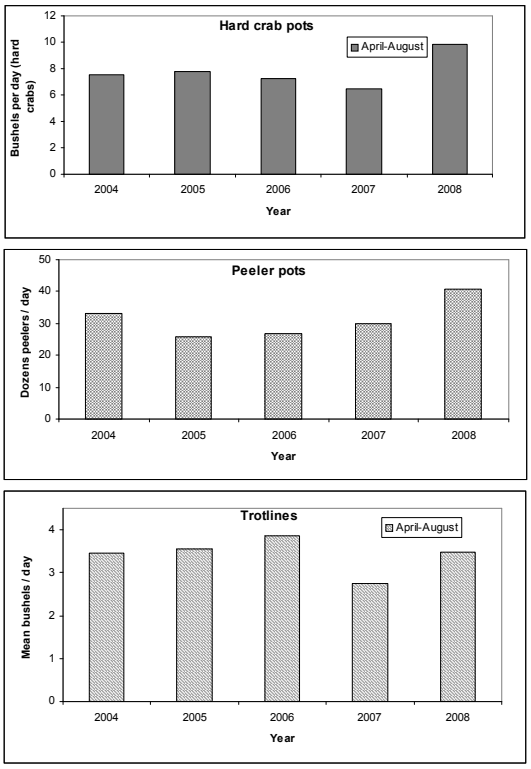
	Male			Female			
	% of Harvest	Reported	Projected	% of Harvest	Reported	Projected	Projected w/ Regulation*
Baywide	100	32.08	23.34	100	28.65	32.31	21.32
Maryland	67.5	24.68	15.75	40.9	17.96	13.21	8.72
Virginia	23.9	5.82	5.58	55.1	10.02	17.80	11.75
Potomac River	8.7	1.58	2.03	4.0	0.90	1.29	0.85

*-assumes 34% reduction.

The increase in MD's reported harvest could either have been caused by an actual increase in harvest, a change in reporting behavior due to crabbers seeking to establish a greater volume of harvest in their catch history, or a combination of both.

A possible source of increased reported harvest would be an increase in daily catch per unit of effort (CPUE). A unit of effort is defined as a crab pot, or a given length of trotline. We examined a time series of CPUE for hard crab pots and trotlines. We constrained our analysis period to the months of April through August, since severe catch restrictions were implemented starting September 1, 2008. In April through August of 2008, both hard crab and peeler pots reported increased in CPUE that were disproportionate to the increase in abundance estimated from the winter dredge survey. The 2008 reported mean hard crab pot catch per day (bushels of hard crabs) was 36% higher than the 2003-07 average. The 2008 reported peeler pot catch per day (dozens) was 41% higher than the 2003-07 average. The 2008 reported mean trotline catch per day (bushels of hard crabs) was similar to the 2003-07 average (Figure 6).

Figure 6. Mean daily catch per day (bushels hard crabs – hard crab pots, trotlines; dozens peelers – peeler pots) by gear type.



If the increase in Maryland's reported harvest was a compensatory response to harvest restrictions occurring at the end of the season, an increase in effort (gear, days fished per month, participants, etc…) should have been reported. The amount of gear deployed (hard crab pots, peeler pots, trotlines (Figure 7) and the overall mean number of days fished per month (Figure 8) were both similar to the previous four years according to commercial harvest reports.

Figure 7. Reported mean amount of gear used daily within the three major commercial blue crab gear types in Chesapeake Bay, MD.

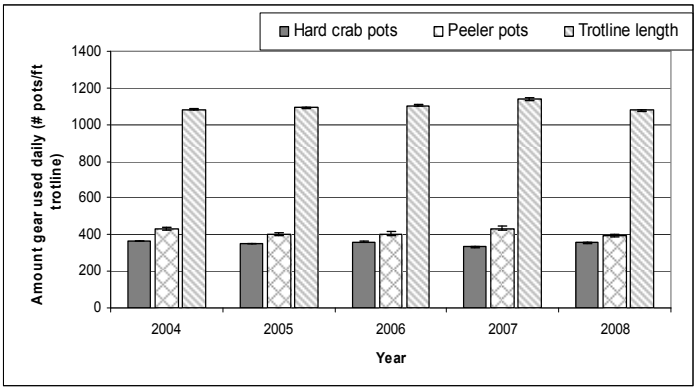
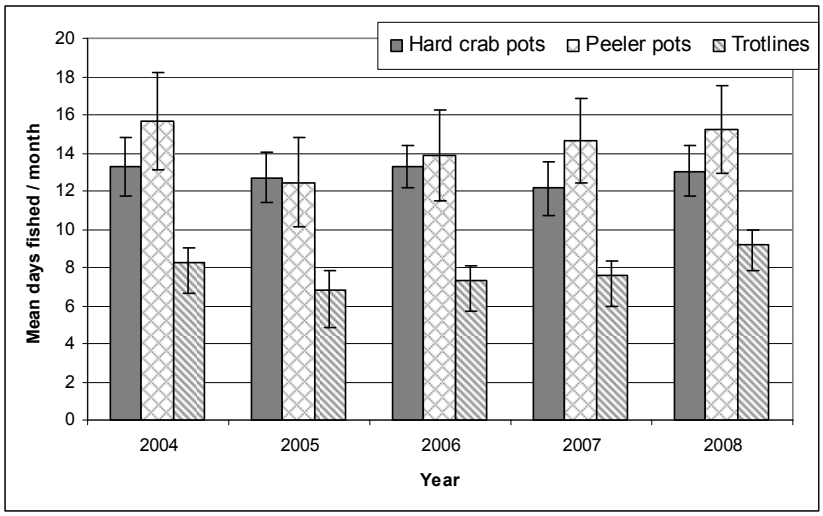
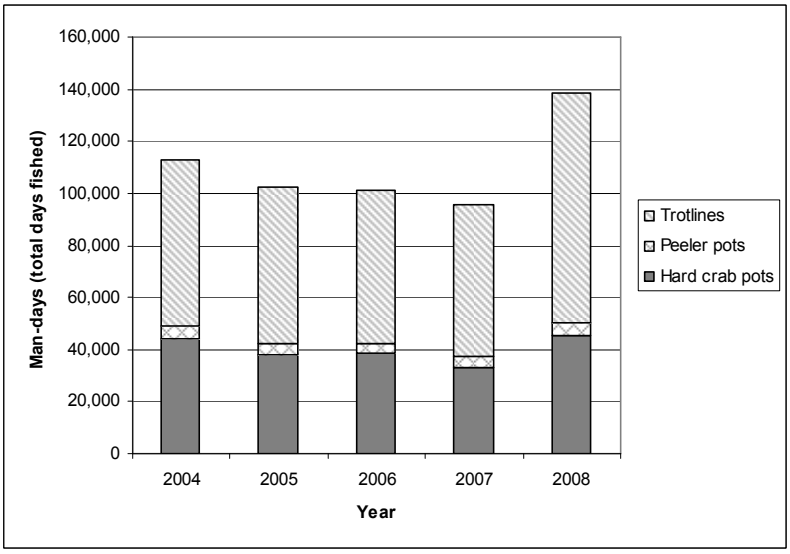


Figure 8. Reported mean days fished per month
within the three major commercial blue crab gear types in Chesapeake Bay, MD.



However, although the mean number of days was unchanged, more crabbers reported, resulting in an increase in the total number of reported man-days in 2008 (Figure 9). This increase came from the trotline sector. They reported 23% more work days per month and 35% more participants per month than the 2003-07 average, resulting in a 46% increase in reported man-days. When only the April – August period (before start of female bushel limits) is considered, they reported a 52% increase in man-days.

Figure 9. Total annual man-days reported by gear type, 2004-2008, in Chesapeake Bay, MD



Therefore, higher catch rates and similar effort (days, gear) were reported for pots, but historical catch rates and higher effort (number of crabbers) were reported for trotlines. Had the 2008 increase in reported harvest been an accurate reflection of catch, similar trends should have occurred between gears. CPUE and man-days both should have either increased or remained near average levels for pots and trotlines. Instead, CPUE increased for pots, but not for trotlines. Man-days increased to unprecedented levels for trotlines, but were within the recent historic range reported for pots. It is unlikely that, in response to increased abundance, participants moved into one segment of the fishery, particularly during a time of recessionary economic pressures. The increase in man-days reported by trotline crabbers was also evident within Maryland's harvest reports. Maryland DNR provides daily catch logs to commercial crabbers who have reported harvesting more than 20 bushels of crabs over the previous two years. These crabbers are required to file their daily logs each month. Crabbers who report less than 20 bushels over two years are provided with a single sheet reporting form that is returned to the Department after the end of the full crabbing season. Historically, two thirds of Maryland's commercial crabbers file on these annual report forms. This is indicative of the large number of latent and under-used commercial crab licenses in Maryland. These 'low level' crabbers, on average, account for three to four percent of Maryland's annual crab harvest. In 2008, these crabbers accounted for 12% of the harvest.

QUANTIFYING BIAS IN THE 2008 HARVEST REPORTS

In a 2006 report to CBSAC, it was noted that various concerns on the part of fishermen may result in biased reports of commercial catch and effort. Historically, enforcement of the reporting requirement has been poor, and there was some question about the accuracy of harvest reports. This concern was shared by the watermen themselves. In 2002, Maryland DNR conducted a survey of watermen and 68% of those interviewed stated that they do not believe that information provided to the Department accurately reflects what is happening in the fishery (MDDNR 2002).

Since 2003, MDNR has conducted/sponsored two surveys to develop the necessary data from which to quantify uncertainty in reported harvest. Through the Blue Crab Cooperative Data Collection Program, a reference fleet of commercial blue crab fishermen has been employed to develop catch per unit effort (CPUE) and biological characteristics of the harvest from the Maryland portion of the Chesapeake Bay. The Versar Crab Pot Survey estimates the number of commercial crab pots (EFFORT) in the Maryland portion of the Chesapeake Bay during the crabbing season (1 April through 15 December). CPUE developed from the Cooperative Data Collection Program is combined with the estimate of commercial effort (Versar crab pot survey) to calculate hard crab harvest.

$$\text{Hard crab harvest (pounds)} = \text{CPUE}\ \frac{\text{(pounds)}}{\text{(pot/day)}} \times \text{EFFORT}\ \frac{\text{(number of pots deployed)}}{\text{(day)}} \quad \text{Eqn. 1}$$

Because the Versar study does not address effort from trotlines or other gears, and is not conducted in the month of December, the effort derived from this study is applicable only to development of the hard crab harvest estimate from April-November. The total harvest is then determined by adjusting the hard crab harvest to account for remaining months, other gears (bank traps, scrapes, trot lines) and peeler crab harvest.

Total harvest (pounds) = Hard crab harvest + adjustment for other gears Eqn. 2

Annual harvest is created as a sum of harvest estimates: stratified by month and region. There are three regions of the Maryland portion of the Chesapeake Bay mainstem: upper Bay, or UBY, (North of the Route 50 Bay Bridge), middle Bay, or MBY, (Bay Bridge to Cove Point) and lower Bay, or LBY, (below Cove Point to the Virginia line). The Tangier Sound (TNG) region is comprised of Tangier and Pocomoke Sounds.
Because these surveys have been conducted since 2003, we now have a 5-year time series of comparisons of estimated and reported harvest. The following trends are noted for 2003-2007:

1. Reported vs. Estimated Harvest: Hard crab harvest reported by harvesters was consistently 8% lower than the harvest using independent surveys.
2. Males vs. Females: The difference between estimated and reported harvest has been consistently lower for females than for males.
3. CPUE: CPUE developed from the Cooperative Data Collection Program has been consistently higher than reported CPUE based on the same gear in the same region and month.

DETAILED ANALYSIS OF 2008 ESTIMATED HARVEST

Catch per Unit Effort (CPUE)

Calculated as: "pounds per pot per day", for males and females, month and region.

Data source: CPUE data are collected from three sources.
(1) Data are collected by a "sentinel fleet" of participating watermen, working with no supervising biologists.
(2) "Verification" data are collected by MDNR biologists that ride along with sentinel watermen on a certain % of trips as a means of data quality assurance – these data are compared to the values reported by the "sentinel fleet".
(3) "Observer" data are collected by MDNR biologists that ride along with a different set of watermen.

Calculation: Daily CPUE for male and female catch is calculated for each individual waterman participating in the study as

$$\frac{\text{total pounds}}{\text{total pots pulled on a particular day}} \qquad \text{Eqn. 3}$$

A monthly average for each waterman is then calculated for males and female hard crabs. The overall mean monthly CPUE for males and females is then calculated as the mean of the individual watermen's CPUEs.

There were no participating watermen in MBY or UBY in April, in LBY in November, and none in any area in December, so CPUEs for missing cells were imputed using historical values and 2008 May values.

Matrix results: 2008 Hard Crab Pot CPUEs for Females (imputed values indicated by italics)*

MONTH	LBY	MBY	TNG	UBY
4	0.72	*0.16*	0.14	*0.31*
5	0.92	0.40	0.40	0.62
6	0.89	0.40	0.92	0.90
7	1.20	0.88	0.97	0.78
8	0.73	1.07	1.48	1.64
9	0.88	0.88	0.79	1.53
10	1.45	1.14	0.71	2.06
11	*1.55*	1.99	0.68	1.28

HARD CRAB POT EFFORT

Calculated as: "number of hard crab pots estimated to be deployed on any given day", by month and region.

Calculation: Since 2003, MDNR has contracted with Versar to perform a pot count survey in the Maryland portion of Chesapeake Bay. The result of this study is an instantaneous estimate of the number of pots deployed by month and region. These instantaneous estimates must be converted pot-days in order to be used with our CPUE to calculate harvest.
This is done using three conversion factors:
(1) the fraction of pots within a given month and region that are hard crab pots,
(2) the average fraction of total pots deployed that a waterman fishes in a day in a given month and region,
(3) the average number of days during the month that watermen fish in a given region.

HARD CRAB POT EFFORT, Part 1: Versar's instantaneous pot count.

Calculated as: Versar estimates the total number of pots on a typical day for a given month and region (instantaneous pot count), using the same regions used in the CPUE calculation.

Data source: Versar survey data.

Calculation: The estimate is the mean of observations by month and region.

Matrix results: Versar 2008 Estimates of Crab Pots in MD Chesapeake Bay

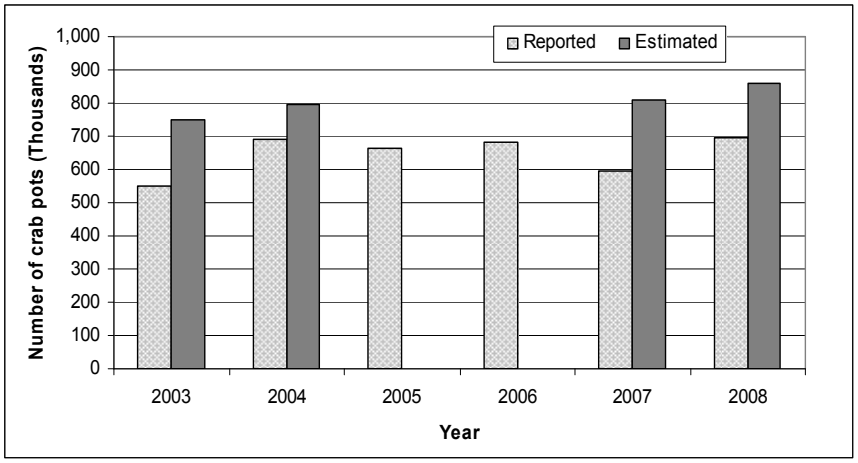
MONTH	LBY	MBY	TNG	UBY
4	6,259	6,404	9,775	107
5	21,776	23,063	22,668	25,283
6	34,505	35,092	67,134	21,503
7	29,167	40,809	41,145	18,051
8	24,508	33,418	32,818	43,257
9	11,287	15,255	22,214	39,759
10	39,884	44,858	2,485	45,741
11	5,814	27,092	265	12,926

Summation of Versar Monthly Pot Estimates 2004 through 2008

Region	2004	2007	2008
Lower Bay	179,199	168,749	173,200
Middle Bay	200,221	198,036	226,091
Tangier Sound	338,381	247,249	253,027
Upper Bay	77,648	193,627	206,625
Total	795,449	807,662	858,943

Verification: The 2008 Versar study (Slacum et al, 2008) reported that the total estimated number of crab pots used in 2008 in the MD portion of Chesapeake Bay was not significantly different from the 2007 estimate (Figure 10). In addition, the number of pots reported by commercial harvesters to MD DNR in 2008 was 81% of the Versar estimate. This finding is consistent with the relationship between estimated vs. reported effort. In the years the Versar study has been conducted (2003, 2004, 2007, 2008), total annual reported effort has been between 73% and 87% of estimated.

Figure 10. Reported and estimated number of crab pots used in Chesapeake Bay, MD



HARD CRAB POT EFFROT, Part 2: Fraction of pots within a given month and region that are hard crab pots.

Calculated as: mean by month and area.

Data source: DNR harvest reports provide daily information on whether the waterman crabbed hard crab pots or peeler pots. The reported proportion of hard pots has been consistent over the years. Therefore, we used the 2007 matrix to avoid incorporating problematic 2008 harvest reports into our estimate.

Matrix results: **2007 Proportions of Pots that are Hard Crab Pots by Month and Area**

MONTH	LBY	MBY	TNG	UBY
4	1	1	1	1
5	0.88	0.96	0.48	1
6	0.89	0.98	0.51	1
7	0.92	0.98	0.53	1
8	0.89	0.97	0.51	1
9	0.95	1	0.66	1
10	0.98	1	0.74	1
11	1	1	0.84	1

HARD CRAB POT EFFORT, Part 3: Fraction of total pots deployed that are fished on a typical day in a given month and region.

Some watermen have more pots than can be checked every day, so only some fraction of the population of pots is fished each working day. Watermen report to DNR both the total number of pots they have deployed AND the number of these pots they pull each day.

Calculated as: mean by month and area.

Data source: DNR harvest reports provide information on gear deployed and gear checked (daily pot pulls), as well as maximum number of pots deployed during the month.

Matrix results: 2008 Proportions of Pot Fished Daily by Month and Area

MONTH	LBY	MBY	TNG	UBY
4	0.91	0.89	0.80	0.94
5	0.85	0.82	0.80	0.81
6	0.86	0.82	0.84	0.81
7	0.86	0.84	0.83	0.83
8	0.83	0.82	0.86	0.81
9	0.85	0.83	0.89	0.82
10	0.88	0.79	0.90	0.83
11	0.92	0.72	0.77	0.83

HARD CRAB POT EFFORT, Part 4: Number of typical working days during the month.

Watermen do not check their gear every day (regulatory restrictions and fishing habits), so each waterman's monthly "working days" is some fraction of total days.

Calculated as: mean by month and area.

Data source: DNR harvest reports provide information on daily activity.

Calculation: Number of days fished each month is calculated for each waterman.
The number of working days in each region is then calculated as the mean of the individual watermen's working days fractions in that region.

Matrix results: Number of Working Days in 2008 by Month and Area

MONTH	LBY	MBY	TNG	UBY
4	10.35	9.27	15.00	5.22
5	14.39	15.22	18.85	12.33
6	17.15	16.82	18.52	12.83
7	18.03	18.91	21.71	14.21
8	16.48	17.61	20.69	15.33
9	14.82	16.32	18.51	14.58
10	18.22	16.98	15.61	12.77
11	13.63	11.59	8.29	5.97

Verification: The 2008 total number of working days is consistent with time series values. Daily reports show a mean rate of work in which pots are checked about every other day, and 2 days out of 3 at the height of the season, which is consistent with what is known of fishery practice.

Number of Working Days by Year and Area

REGION	2003	2004	2005	2007	2008
Lower Bay		15.16		13.97	13.83
Middle Bay		17.4		11.24	12.17
Tangier Sound		13.76		17.02	16.02
Upper Bay		12.66		8.37	8.22
TOTAL	479	518	499		476

HARD CRAB POT EFFORT, Part 5: Calculation of hard crab pots pulled by month and region

Calculated as: "number of hard crab pots pulled or checked per day", by month and region.

Calculation: (1) total number of pots on a typical day for a given month and region x

(2) fraction of pots that are hard crab pots within a given month and region x

(3) fraction of pots deployed that are pulled on a typical day in a given month and region x

(4) number of typical working days during the month for a given month and region.

Eqn. 4

Example: for 2008 June LBY

34,508 pots/day x
0.89 (fraction hard crab pots) x
0.86 (fraction pots fished daily) x
17.85 days fished
456,685 pots pulled during June 2008 in the Lower Bay (LBY)

Matrix results: Hard Crab Pots Fished in 2008 by Month and Region

MONTH	LBY	MBY	TNG	UBY
4	58,696	52,921	117,800	524
5	235,072	275,371	162,672	252,653
6	456,685	475,563	532,289	223,363
7	415,765	631,350	395,084	212,859
8	298,612	469,944	296,473	535,938
9	135,551	206,023	242,673	476,753
10	622,864	599,427	25,803	483,865
11	72,940	226,671	1,419	63,744

CALCULATION OF HARD CRAB HARVEST *(from hard crab pots)*

Because there are no effort data from the Versar pot survey for December, calculations are confined to April-November.

Part 1: April-November 2008 hard crab harvest.

Calculated as: "pounds", for males and females.

Calculation: Harvest by month and area is calculated for males and females

CPUE (pounds per pot) * EFFORT (pot pulls per month) = pounds per month

Example: 2008 June LBY harvest for males and females
male hard crab harvest (pounds) 404,166
female hard crab harvest (pounds) 274,011

Part 2: December 2008 hard crab harvest.

Calculation: December hard crab harvest for males and females was estimated as:

(reported Dec harvest) / (reported April - November harvest) Eqn. 5

The December 2008 hard crab harvest was estimated as 0.3% (males) and 0.004% (females) of April–November hard crab harvest.

Matrix results: December Hard Crab Harvest Proportion of Reported Harvest (pounds)

MONTH	MALE	FEMALE
4	340,178	539,438
5	898,751	922,108
6	1,701,917	1,519,356
7	2,173,907	2,495,837
8	2,137,664	2,507,633
9	2,242,497	1,930,325
10	2,407,054	3,222,868
11	960,354	38,829
12	33,886	592
DEC proportion	0.003	0.0004

Verification: These values are reasonable, since the season ended December 15.

The MDNR Fisheries Statistics Program report of "Monthly Percent of Annual Total Reported Harvest" for hard crabs shows that December harvest has been approximately 0.3% of the total harvest since 2003.

December fraction for female harvest in 2005 and 2006 were 0.05% and 0.06%. With 2008 additional regulatory control on the female harvest, a value of 0.04% is reasonable.

Part 3: Total 2008 hard crab harvest.

Calculation: Annual harvest for males and females were calculated as sum of monthly area estimates.

Example:	2008 male hard crab harvest (pounds)	10,034,166
	2008 female hard crab harvest (pounds)	7,487,493

Matrix results: Estimated 2008 Male Hard Crab Harvest (pounds) by Month and Area

MONTH	LBY	MBY	TNG	UBY	total
4	42,550	8,203	15,909	10	66,676
5	215,152	109,647	65,659	155,751	546,214
6	404,166	189,997	487,577	200,357	1,282,103
7	498,918	558,321	381,256	166,456	1,604,958
8	217,987	504,335	439,074	878,402	2,039,806
9	119,285	181,300	192,440	728,002	1,221,036
10	903,153	680,704	18,372	997,628	2,599,866
11	113,275	451,660	960	81,296	647,201
12	6,624	7,071	4,219	8,451	26,378
ANNUAL	2,521,111	2,691,239	1,605,464	3,216,353	**10,034,166**

Estimated 2008 Female Hard Crab Harvest (pounds) by Month and Area

MONTH	LBY	MBY	TNG	UBY	total
4	35,547	4,703	42,860	5	83,119
5	141,043	48,942	110,316	4,424	304,730
6	274,011	188,280	593,848	30,299	1,086,444
7	418,800	302,050	134,329	34,057	889,243
8	385,792	104,690	100,801	140,491	731,781
9	154,528	234,866	184,432	195,469	769,304
10	965,439	1,816,265	40,769	196,130	3,018,613
11	148,213	420,402	3,798	31,895	604,319
12	113	140	54	28	348
ANNUAL	2,523,487	3,120,338	1,211,206	632,798	**7,487,830**

CALCULATION OF HARD CRAB HARVEST (from other gears)

Because the hard crab harvest estimate based on the Versar pot survey only addresses harvest from pots, the value must be expanded to reflect harvest due to other gears.

Part 1: Harvest from trotlines.

Calculation: On average, between 1985 and 2004, trotlines comprised 18% by weight of the females and 45% of the males harvested in pots and trotlines.

Total annual trotline harvest was calculated for males and females using these historical proportions of estimated harvest.

Males: $T/(H+T) = 0.45$ so $T = 0.8182\ H$ Eqn. 6
Females: $T/(H+T) = 0.18$ so $T = 0.2195\ H$ Eqn. 7

Result: Males: $T = 0.8182 \times 10{,}034{,}166 = 8{,}209{,}772$ pounds
Females: $T = 0.2195 \times 7{,}487{,}830 = 1{,}643{,}670$ pounds

Part 2: Harvest from other gears.

Calculation: There are no data to estimate harvest from other gears, such as bank scrapes, etc… . Historical values have fluctuated around 4-5% of harvest reported from hard crab pots. The 2008 reported harvest from other gears was 3%, which was reasonable, and the harvest is a very small percentage of the total harvest, so we used the reported value.

Result: Males: 436,121 pounds (as of 4/15/09)
Females: 171,291 pounds (as of 4/15/09)

CALCULATION OF PEELER CRAB HARVEST

Calculated as: Pounds per year (peeler harvest is not divided by male/female).

Calculation: Historical values have shown a fairly steady relationship between the reported peeler harvest and the hard crab harvest.

However, the 2008 reported peeler harvest was higher than what would be expected from the historical trend, so the 2008 peeler harvest was estimated from this historical relationship.

Matrix result: Historical Relationship of Peeler Harvest to Male hard Crab Harvest

YEAR	REPORTED MALE HARD CRABS	REPORTED PEELERS	%
2007	12,920,903	1,013,409	7.8
2006	16,545,309	1,089,195	6.6
2005	14,645,335	1,118,921	7.6
2004	19,017,373	1,467,537	7.7
2008	24,374,124	1,997,069	8.2
04-07 MEAN			**7.6**

Therefore, the peeler harvest was estimated as the mean historical proportion (7.4%) of the estimated male hard crab harvest.

18,680,059 male hard crabs x 0.074 = 1,387,509 peeler crabs Eqn. 8

CALCULATION OF TOTAL HARVEST

Calculated as: Pounds per year (peeler harvest is not divided by male/female).

Calculation: Male and female total hard crab harvest was added to peeler harvest.

Result: **Total 2008 Maryland crab harvest was estimated as 29,370,359 pounds.**

Matrix result: Calculation of total 2008 MD harvest

	MALE	FEMALE
POTS	10,034,166	7,487,830
TROTLINES	8,209,772	1,643,670
OTHER GEARS	436,121	171,291
TOTAL HARD CRABS	**18,680,059**	**9,302,791**
PEELERS	1,387,509	
TOTAL CRABS	**29,370,359**	

COMPARISON OF 2008 ESTIMATED AND PROJECTED HARVEST

The 2008 MD estimated harvest was very close to the projected harvest. For Maryland, 25.83 million pounds were projected, and a harvest of 29.37 million pounds was estimated. The Baywide harvest was projected as 46.86 million pounds and, using MD estimated values, a total of 48.64 million pounds was harvested.

Comparison of reported, projected, and estimated 2008 Maryland blue crab commercial harvest (in millions of pounds).

	Reported	Projected	Proj. w/reg*	Estimated
Males	24.68	15.75	15.75	18.68
Females	17.96	13.21	8.72	9.30
Peelers	2.00	1.36	1.36	1.39

* - accounts for desired 34% reduction in female harvest.

CONCLUSIONS

The 2008 Maryland crab harvest was clearly anomalous based on:
-deviations from historical harvest trends,
-a harvest increase that is unsupported by the abundance of crabs estimated by the dredge survey to be present in the Bay at the start of the crabbing season.
-the disconnect between 2008 reported harvest and reported effort
-the unprecedented occurrence of reported CPUE for crab pots being substantially higher than CPUE observed via the blue crab reference fleet.

The estimated harvest is a more accurate reflection of actual 2008 catch and has been adopted as the 2008 Maryland harvest estimate.