Horseshoe Crab Technical Committee Report

January 17, 2008

The Technical Committee (TC) met on January 17th to review recent research, monitoring, and landings in anticipation of a Management Board discussion about starting a new addendum. Several researchers from the Virginia Tech Horseshoe Crab Research Center presented updates on their work. Some members of the HSC Stock Assessment Subcommittee also participated in the meeting. The meeting was held at the Holiday Inn – Inner Harbor in Baltimore. The following is a summary of the meeting.

Attendees

Technical Committee Members

Larry DeLancey (SC), Vice Chair
Tina Moore (NC)
Angie Machniak (FL)
Stew Michels (DE)
Steve Doctor (MD)
Penny Howell (CT)
Joe Grist (VA)
John Maniscalco (NY)
Alison Leschen (MA)
Mike Millard (USFWS), Chair
Scott Olszewski (RI)
Andrew Draxler (NMFS)
Derek Orner (NMFS)
Carl Shuster (VIMS)
Brad Spear (ASMFC), Staff

Stock Assessment Subcommittee Members

Dave Smith (USGS), Chair
Michelle Davis (Virginia Tech)

Virginia Tech

Eric Hallerman
Dave Hata
Jim Fraser
Sarah Karpanty

Others

Sheila Eyler, USFWS
Rick Robins, Chesapeake Bay Packing, HSC AP

Virginia Tech Horseshoe Crab Research Center

Virginia Tech's (VT) Horseshoe Crab Research Center is the only multi-investigator, multi-institutional research unit dedicated to providing information essential for the management of horseshoe crabs. Its goal is to provide information needed to sustainably manage the horseshoe crab for the benefit of all resource users. The Center has several ongoing research projects. The VT researchers presented updates on the projects at the TC meeting.

Benthic Trawl Survey (David Hata)

The survey has been run each fall since 2001. Dave presented data collected through 2007. The results and indications from the survey are:

- Relative abundance of all demographic groups in the Delaware Bay area continues an apparent increasing trend since 2003 (immature and primiparous) or 2004 (multiparous).
- Increasing trends are evident in the core survey area (ocean waters close to DE Bay) for all demographic groups, but not in the peripheral area (ocean waters beyond core area). [See Trawl Survey report for maps of survey area.]
- Catches of immature crabs in the New York apex may be decreasing, whereas primiparous and multiparous crabs show no trend.
- There was an apparent influx of small immature horseshoe crabs indicating recruitment of a new cohort to the survey.
- Smaller horseshoe crabs (<150 mm for males; <200 mm for females) are nearly absent from New York apex survey catches.

Also of note, the horseshoe crab size/age classification of the trawl survey matches very closely what is reported from the DE Bay Spawning Survey (discussed later in this report). This indicates that the age classification methods used for each survey appear to be consistent.

One of the major objectives of the study is to develop an easy and effective protocol to identify new recruits to the spawning population. A standard method has been used since 2005. The TC asked for a formal write up of this method so the TC may review it for potential use by port agents and other state staff.

The general conclusion of the survey reached by the TC is the increasing trend of crabs seems to continue through 2007 for the Delaware Bay region; trends in New York appear to be flat or slightly declining depending on the demographic unit in question.

Bycatch Study (Hata)

The 2005 and 2006 trawl surveys included tracking of species caught as bycatch. Composition and weight of species, depth, bottom type, temperature, and salinity were recorded. Seventy-six different species were identified as bycatch over the two years. No threatened or endangered species were encountered. Species composition was quite different between the northern and southern sample sites. The change in species composition was determined by two factors using multidimensional scaling: location and bottom temperature.

Genetics (Eric Hallerman)

The HCRC is working with Dr. Tim King and Mike Eackles (USGS) to better understand population genetics of HSCs. They have supplemented previously analyzed samples with samples from new areas of spawning assemblages, commercial fisheries, and other sources. The goal is to help inform HSC management by delineating stock structure and identifying contributions in any mixed-stock fisheries. While the project is a work in progress, several findings are becoming clear. The research shows four distinct genetic units of crabs along the Atlantic coast: Gulf of Maine, mid-Atlantic (MA-NC), southeast (SC & GA), and Atlantic coast of Florida. The crabs on the Gulf side of Florida also appear to be a genetically distinct unit. There is lots of noise in the data for crabs in the mid-Atlantic unit.

The TC concluded that when defining management units, all data sources (genetics, tagging, other demographic info) available should be considered. Morphometric studies were the first to indicate that there were discreet populations (Shuster 1979; Riska 1981). It expressed concern that the major genetic groups identified by the study not be construed as applicable for state or local management purposes. This is very broad-scale genetics, and management needs to be much more localized.

Horseshoe Crab/Shorebird Interaction; and
Diet and Stopover Dynamics in Coastal Virginia (Sarah Karpanty and Jim Fraser)

Virginia Tech is also collecting independent data on the interactions between horseshoe crabs and shorebirds to determine if HSC eggs are a limiting resource for migrating red knots. VT's first hypothesis was that if red knots are being limited by the availability of HSC eggs, then there should be evidence that red knot habitat selection in the Delaware Bay is driven by horseshoe crab egg abundance. Their study in 2004 showed that red knot habitat selection is driven by egg abundance.

The second hypothesis is if red knots are being limited by the availability of HSC eggs, then knots should deplete available eggs during the migratory stopover period. VT conducted a study in 2005 that allowed all birds to feed on eggs in the sample areas but focused on red knot use of eggs. Foraging shorebirds did not deplete surface horseshoe crab eggs from DE Bay beaches. The TC notes that the population of red knots is much lower than in the past, so if the "full" population were still utilizing DE Bay, we don't know if they'd deplete the eggs. It also notes that these findings occurred during season when the timing of horseshoe crab spawning and migratory shorebird arrival was the most disconnected in years.

The last hypothesis is if red knots are being limited by the availability of HSC eggs, then knots should not significantly use other food resources or stopover sites. The VT team conducted a banding study in 2006 and 2007 to determine if the DE Bay and Virginia red knot populations are separate and to understand habitat and prey selection in Virginia. The study indicates that most knots banded in Virginia bypass the DE Bay; 5 – 10% that stop in Virginia go to DE Bay. Also, these red knots tend to go to DE Bay near the end of the season and are not using DE Bay as much for weight gain. Red knots feed almost exclusively on coquina clams (*Donax*), crustaceans, and polychaetes in the study area of coastal Virginia. The study found that red knots are attracted to patches of larger *Donax* and there may be a correlation on feeding to the distance from night roosting areas. Research will continue to determine which habitats red knots

are selecting for night roosting. No horseshoe crabs or eggs were encountered during the study in Virginia.

Future plans for research are: analyzing red knot turnover rates to refine stopover population estimates, energetic implications of Donax diet, and continuing to explore the relative importance of Virginia as a stopover site.

The TC notes that it has not reviewed written reports of VT's shorebird-related research. However, in the interest of providing all information available to the Board, it is included in this report. The TC recommends that the Shorebird Technical Committee review this information and provide comment to the Board.

Future Work

VT is planning for 2008 continuation of the HSC trawl survey and shorebird work. It is also planning a juvenile HSC pilot study in conjunction with the trawl survey to assess the feasibility of developing a recruitment index for DE Bay crabs. VT will operate with fewer funds this year than in years past. As a result, the trawl survey will be run only in the DE Bay core and peripheral areas (leaving out the New York portion.). The FY2008 NOAA budget contains about $450K for VT, which is again less than in years passed. If this money comes through as expected, it will be used for projects in 2009.

Delaware Bay Spawning Survey Results

The redesigned spawning survey was completed for the ninth year in 2007. Estimates of spawning activity continue to be precise. Spawning activity peaked during May 30, June 1 & 3 sampling frame, similar to what was seen in 2005 and 2003. Baywide female spawning activity has been stable over the past nine years. Male spawning activity was reported because of concern over male-only harvest in Delaware. Estimates of baywide male spawning activity showed a significant increase over the course of the survey from 1999 through 2007.

Maryland Spawning Survey

Maryland coordinated the sixth year of its spawning survey in 2007. However, limited effort and data exists prior to 2006. The 2007 survey was expanded in area coverage and recorded water temperature and crab prosomal widths. This year's survey highlighted the importance of Skimmer Island, near Ocean City, as critical habitat for the crabs and birds. It also revealed a roughly three to one male to female ratio during spawning. The increased effort in this survey is expected to continue next year. The TC encourages Maryland to continue its expanded study.

Recent Horseshoe Crab Landings

Below is a spreadsheet with recent landings back to 2002, including preliminary numbers for 2007 for most states. Of note, Massachusetts landings have increased in the past couple years, which has led to internal regulation changes. Rhode Island's reported landings have shown the same trend. New York's reported landings increased in 2007, which has raised concern in the industry and the state. Virginia's landings are expected to be around 90K crabs – a decline. This may be attributable to Addendum IV regulations unexpectedly eliminating or reducing fishing in some coastal and ocean waters of the state.

Delaware's harvest was composed entirely of males. In the past two years, the sex ratio in the Maryland harvest went from more males to more females because of culling by a few harvesters. The majority of Maryland harvesters have expressed a willingness to restrict the harvest to no more than 50% females (i.e. 1:1, male : female). MD DNR is considering this as a management measure going forward if biological evidence is developed to support such a measure.

Reported Horseshoe Crab Bait Landings (in numbers) By State (as of 01/15/08)

Jurisdiction	Reference Period Landings (RPL)	Addendum IV Quota	2002	2003	2004	2005	Prelim. 2006	Prelim. 2007
ME	13,500	13,500	150	98	0	0	0	0
NH	350	350	120	0	0	0	0	
MA	440,503	330,377	138,613	125,364	69,436	73,740	171,901	150,829
RI	26,053	26,053	3,886	5,824	6,030	8,260	15,274	15,564
CT[b]	64,919	48,689	32,080	13,386	23,788	15,240	25,280	24,761
NY	488,362	366,272	177,271	134,264	142,279	155,108	172,381	284,120
NJ	604,049	100,000	281,134	113,940	46,569	87,250	3,444	
PA	-	0	0	0	0	0	-	-
DE	482,401	100,000	298,318	356,380	127,208	154,269	146,070	76,663
MD	613,225	170,653	278,211	168,865	161,928	169,821	136,733	172,117
PRFC	-	0	0	0	0	0	0	0
DC	-	0	0	0	0	0	0	0
VA	203,326	152,495	42,954	106,577	94,713	97,957	155,704	~90,000
NC	24,036	24,036	12,906	24,367	9,437	7,462	10,331	7,091
SC	-	0	0	0	0	0	0	0
GA	29,312	29,312	0	0	0	0	0	
FL	9,455	9,455	200	1,628	0	0	283	0
TOTAL	2,999,491	1,371,192	1,265,843	1,050,693	681,388	769,107	837,401	821,145

It is unclear how many crabs harvested from Maryland and Virginia coastal waters are crabs of Delaware Bay origin. Another way of asking this is 'how much of the DE Bay crab population depends upon other habitats outside of Delaware and New Jersey'. The TC is comfortable stating that there are less Delaware Bay spawners harvested from Virginia waters than from Maryland. Tagging studies have shown the percent of crabs tagged off the 'Delmarva' coast that have been recaptured in DE Bay has ranged from 38 to 64. However, these numbers can be misleading because DE Bay beaches and waters have much greater re-sighting effort (e.g. Delaware Bay Spawning Survey) than other areas of the coast. Through a series of field studies conducted prior to 1985, DE Bay crabs are shown to extend along Maryland's coast into the northern tip of coastal Virginia (Figure 1).

If the Board would like to look further into how many DE Bay crabs are harvested in other states, the TC recommends as a first step increasing tagging and recapture efforts. If designed correctly, this can lead to greater understanding of movement and provide population estimates.

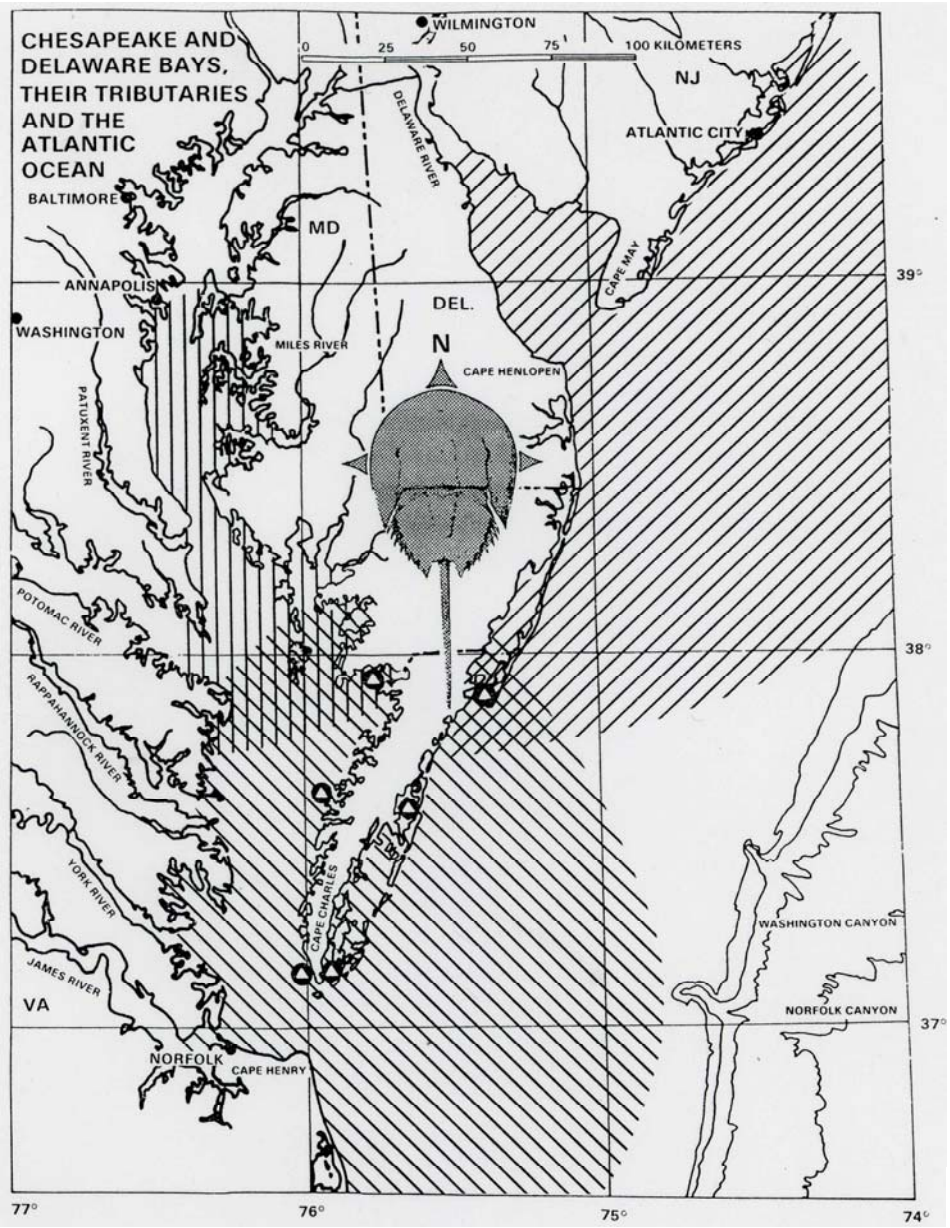

Figure 1. A deduced distribution of Chesapeake Bay and Delaware Bay horseshoe crabs, based on field studies and reported sites (Shuster 1985). Vertical lines = upper Chesapeake Bay populations, and NW to SE diagonal lines = lower Bay populations. SW to NE diagonal lines = Delaware Bay population. The six encircled triangles were study locations.

Tagging

Sheila Eyler presented the TC with a summary of horseshoe crab tagging efforts that used the USFWS white button tags. Over the course of the program, over 80K crabs have been tagged across most of the Atlantic coast. Nearly 10% of tagged crabs have been recaptured and reported. See Attachment A for a regional breakdown of tagging efforts.

The TC notes again that recapture rates inside and outside DE Bay are likely not directly comparable. This is because of increased re-sighting effort and spawning concentration in DE Bay compared to other areas along the coast. There may be data in the USFWS tagging database to determine differences in effort and recapture rates. However, this project would be time consuming and may not resolve the differences.

Penny Howell noted that a Sacred Heart University researcher has tagged and released about 9K crabs from the Connecticut beaches of Long Island Sound from 2003-2006 (the program is on-going). Students hired to tag and recapture animals everyday during spawning season have reported a recapture rate of about 7% over the four years. Movement of tagged animals appears to be very limited, as has been seen in tagging studies elsewhere, with less than 10% of returns crossing the Sound or traveling more than a few miles. Tag-recapture data has been used to estimate the spawning population size for the principal study area on a weekly basis over the six weeks bracketing peak spawning activity. Average annual spawning abundance has shown no trend over the four years at this one study site.

Adaptive Resource Management Work Group

The ARM Work Group is a subset of the group that met in October at the joint Horseshoe Crab (HSC) and Shorebird (SHBD) Technical Committee meeting. The ARM Work Group is being chaired by Jim Nichols (USGS-Patuxent) and Dave Smith (USGS-Leetown).

The Work Group has been tasked with developing models to estimate horseshoe crab harvest levels that will support recovery of the red knot population. At the joint meeting, the HSC and SHBD TCs determined that the models would link horseshoe crab abundance to red knot weight gain during their stopover in Delaware Bay.

A considerable amount of modeling work has begun, but funding is needed to hire and support a post-doc to work with the Work Group to continue the model development and implementation. At this time, funding is pending, but has not yet been secured. Funding for work beyond the first year is being explored.

The TC sees great value in such a model and strongly recommends the Work Group continue with its efforts. The Shorebird TC echoed these sentiments at the joint meeting in October 2007.

Economic Study

The ISFMP Policy Board tasked the Committee on Economic and Social Sciences (CESS) to find a contractor to study the potential impact that a harvest moratorium on horseshoe crabs in DE Bay would have on that fishery and dependent fisheries from New York to Virginia. Industrial Economics, Inc (IEc) conducted the study, '*Economic Assessment of Mid-Atlantic Horseshoe Crab and Dependent Fisheries*'. A draft report was provided to the TC at the meeting. IEc asked for comments on the draft. CESS will also be reviewing the draft prior to IEc's presentation to the Management Board.

General Conclusions to Inform the Board's Discussion on Initiating a New Addendum

The data from multiple lines of evidence indicate that the Delaware Bay horseshoe crab population is experiencing positive population growth. The VT trawl survey shows increases in

all demographic groups. The Delaware Bay spawning survey shows stable to increasing adult females and increasing adult males. The USGS/FWS tagging study conducted 2003-2005 showed increases in juveniles 7 to 8 years of age during that time.

The TC is concerned with harvest increases in regions outside of Delaware Bay (i.e. areas of Massachusetts and New York), which are coincident with harvest reductions within Delaware Bay. An overarching conclusion of recent coastwide assessments has been that management should be regional or embayment specific. It is now apparent that current harvest of the Delaware Bay population is consistent with population growth. However, it is unclear whether populations in the outlying regions can sustain increased harvest.

The HSC TC would appreciate the opinion of the Shorebird TC on recent studies by Virginia Tech's Horseshoe Crab Research Center that test hypotheses regarding horseshoe crab egg depletion by shorebirds and alternative sources of food for shorebirds. The studies (seem to) present results counter to the narrative that current egg availability is insufficient to support the needs and foraging capacity of migrating shorebirds.

References

Riska, Bruce. 1981. Morphological variation in the horseshoe crab *Limulus polyphemus*. *Evolution* 35(4): 647-658.

Shuster, Carl N. Jr. 1985. Introductory remarks on the distribution and abundance of the horseshoe crab, *Limulus polyphemus*, spawning in the Chesapeake Bay area. *The Chesapeake: Prologue to the Future. Proceedings, Chesapeake Bay Symposium (National Marine Educators Conference*): 34-38.

Shuster, Carl N. Jr. 1979. Distribution of the American horseshoe crab, *Limulus polyphemus*. In: Cohen, Elias (ed.) *Biomedical Applications of the Horseshoe Crab (Limulidae*). New York, NY: Alan R. Liss, Inc.: 3-26.

Attachment A

Horseshoe Crab Tagging Program

U.S. Fish and Wildlife Service, Maryland Fishery Resources Office, Annapolis, MD
Contact: Sheila Eyler
Compilation of horseshoe crab tagging data from 1999-2006
All of the tagging programs mentioned below used USFWS-issued white button tags, each with a unique identification number.

Program Overview 1999-2006

- 20 agencies participating
- Coastal range from Massachusetts to South Carolina
- Over 80,000 tagged
- Tagging done by
    - Researchers – 61%
    - Biomedical – 36%
    - Volunteers – 3%
- Tagging collection method
    - Dredge (prior to spawning season) – 45%
    - Hand (during spawning season) – 21%
    - Trawl (after spawning season) – 31%
- Over 8,000 recaptured (nearly 11,000 total reports)
    - Maximum reports per tag – 13
    - Recapture reports
        - 77% - live crabs
        - 17% - dead crabs
        - 6% - tag only or unknown
    - Reports from
        - Researchers – 55%
        - Public – 34%
        - Biomedical – 6%
        - Commercial fishermen – 5%
    - Recapture method
        - Hand – 90%
        - Fishing gear – 4%
        - Other/Unknown – 6%
- High recapture rate
    - 10% overall recapture rate
    - 8% recapture rate of live crabs
    - High visibility of spawning animals on beach
        - higher visibility of males and visit beach more frequently

Regional Summaries

For the regional summaries, only reports from *LIVE* crabs were used. Recaptures during the spawning season were recaptures from April through June, pre-spawning captures were from January through April, and post-spawning captures were from July through December.

A. MASSACHUSETTS AND RHODE ISLAND

- Biomedical (Associates of Cape Cod)
- Tagging: Spawning Season 1999
- Collection method – unknown
- Number Tagged - 2462
- Number recaptured – 100 (4.1%)
- Recaptures
    - 97% - Tagging Area (MA/RI)
    - 3% - Delaware Bay

Recapture Location	Same Year	Following Years	Season
MA/RI – Ocean and South Coast Bays	1	67	Spawning
MA/RI – Ocean and South Coast Bays	1	29	Post-Spawn
Delaware Bay		***3***	***Spawning***

B. NEW YORK AND NEW JERSEY

- Research (Virginia Tech and Ocean Institute)
- Tagging Timing
    - Spawning Season 2006 (OI – no recaps)
    - Post –Spawn 2003-2006 (VA Tech)
- Collection method – hand and trawl
- Number Tagged - 878
- Number recaptured – 14 (1.6%)
- Recaptures
    - 64% - Tagging Area (NY-NJ Coast)
    - 36% - Delaware Bay*

Recapture Location	Same Year	Following Years	Season
RI – Block Island Sound	2		Post-Spawn
NY – Ocean		5	Spawning
NJ – Ocean	2		Post-Spawn
Delaware Bay*		***5***	***Spawning***

* There appears to be an area on the New Jersey coast that splits the spawning from Delaware Bay and points north. Delineation of NJ coast:

- Furthest north tagged on the NJ coast that went to DE Bay to spawn – Herford Inlet (Herford Inlet - 1, Wildwood – 2, Cape May – 2)
- Furthest south tagged on the NJ coast that did not go to DE Bay to spawn – none tagged in north NJ were recaptured, NY tagged ended up at Sandy Hook and Long Branch, NJ
- The cut off is probably somewhere between Long Branch and Hereford – Manasquan arbitrarily selected based on recapture data from USGS tagging

C. DELAWARE BAY

Hand Collection

- Research and Volunteer (Abbots Mill Nature Center, Bayshore Discovery Project, U.S. Fish and Wildlife Service)
- Tagged: Spawning Season 2001-2006
- Collection method – hand
- Number Tagged – 12,700
- Number recaptured – 3363 (26.5%)*
- Recaptures
    - 99.5% - Tagging Area (Delaware Bay)
    - 0.5% - NJ Coast, DE Coast and MD Coast

Recapture Location	Same Year	Following Years	Season
NJ – Atlantic Coast		1	Pre-Spawn
NJ – Atlantic Coast		2	Spawning
NJ – Atlantic Coast	1		Post-Spawn
Delaware Bay	7	41	Pre-Spawn
Delaware Bay	4536*	559	Spawning
Delaware Bay	6	4	Post-Spawn
DE – Atlantic Coast (Indian River Bay)		7	Spawning
MD – Atlantic Coast	1	1	Spawning
MD – Atlantic Coast	9	9	Post-Spawn

*(high recapture rate resulting from USFWS study with intensive effort to recover tagged crabs shortly after tagging)

Pre-Spawn Collection

- Research (U.S. Geological Survey)
- Pre-Spawning Season 2003-2005
- Collection method – dredge
- Number Tagged – 35,918
- Number recaptured – 1937 (5.4%)
- Recaptures
    - 97.9% - Tagging Area (Delaware Bay)
    - 2.1% - NJ Coast, DE Coast and MD Coast

Recapture Location	Same Year	Following Years	Season
NJ – Atlantic Coast		2	Pre-Spawn

NJ – Atlantic Coast	2	1	Spawning
NJ – Atlantic Coast	1	2	Post-Spawn
Delaware Bay	53	27	Pre-Spawn
Delaware Bay	1185	785	Spawning
Delaware Bay	44	68	Post-Spawn
DE – Atlantic Coast (inc. Indian River Bay)	1	18	Spawning
DE – Atlantic Coast (inc. Indian River Bay)	1	2	Post-Spawn
MD/VA – Atlantic Coast	3	2	Spawning
MD/VA – Atlantic Coast	10	2	Post-Spawn

D. DELMARVA COAST

Hand Collection

- Research and Volunteer (Center for the Inland Bays, Ocean City Christian School, U.S. Fish and Wildlife Service, Virginia Tech)
- Tagging: Spawning Season 2002-2006
- Collection method – hand
- Number Tagged – 1951
- Number recaptured – 58 (3.0%)
- Recaptures
    - 60% - Tagging Area (Delmarva Coast)
    - 38.3% - Delaware Bay
    - 1.7% - Chesapeake Bay

Recapture Location	Same Year	Following Years	Season
Delaware Bay	2	21	Spawning
DE – Atlantic Coast (inc. Indian River Bay)	13	1	Spawning
DE – Atlantic Coast (inc. Indian River Bay)	1		Post-Spawn
MD/VA – Atlantic Coast		1	Pre-Spawn
MD/VA – Atlantic Coast	4	6	Spawning
MD/VA – Atlantic Coast	5	5	Post-Spawn
VA – Chesapeake Bay		1	Spawning

Post-Spawn Collection

- Research (Maryland Department of Natural Resources) and Biomedical (Biowhittaker/Cambrex/Lonza)
- Tagging: Post-Spawning Season 1999-2006
- Collection method – trawl
- Number Tagged – 23,970
- Number recaptured – 451 (1.9%)
- Recaptures
    - 32.9% - Tagging Area (Delmarva Coast)
    - 64.3% - Delaware Bay
    - 1.7% - NJ Coast and north
    - 1.0% - Chesapeake Bay

Recapture Location	Same Year	Following Years	Season
MA – Cape Cod		***1***	***Spawning***
NY – Atlantic Coast		***1***	***Spawning***
NJ – Atlantic Coast		1	Pre-Spawn
NJ – Atlantic Coast		2	Spawning
NJ – Atlantic Coast	2	2	Post-Spawn
Delaware Bay		5	Pre-Spawn
Delaware Bay		319	Spawning
Delaware Bay	1	5	Post-Spawn
DE – Atlantic Coast (inc. Indian River Bay)	1	7	Spawning
DE – Atlantic Coast (inc. Indian River Bay)		3	Post-Spawn
MD/VA – Atlantic Coast		13	Pre-Spawn
MD/VA – Atlantic Coast	7	10	Spawning
MD/VA – Atlantic Coast	93	35	Post-Spawn
VA – Chesapeake Bay		***2***	***Spawning***
VA – Chesapeake Bay		***3***	***Post-Spawn***

E. CHESAPEAKE BAY

- Research (U.S. Fish and Wildlife Service)
- Tagging: Spawning season 2005-2006
- Collection method – hand
- Number Tagged - 93
- Number recaptured – 1 (1.0%)
- Recaptures
    - 100% - Tagging Area (Chesapeake Bay)

Recapture Location	Same Year	Following Years	Season
MD - Chesapeake Bay	1		Spawning

F. NORTH CAROLINA

- Research (U.S. Fish and Wildlife Service) and Biomedical (Haemachem)
- Tagging Timing
    - winter 2003-2006 (USFWS – no recaptures)
    - post-spawn 1999 (Haemachem)
- Collection method – Trawl and unknown
- Number Tagged - 268
- Number recaptured – 5 (1.9%)
- Recaptures
    - Virginia Coast – 20%
    - Chesapeake Bay – 20%
    - North Carolina Inland Areas – 60%

Recapture Location	Same Year	Following Years	Season
VA – Ocean (north)		1	Spawning
VA – Chesapeake Bay		1	Spawning

NC – Inland Waterways	3	Spawning

G. SOUTH CAROLINA

- Biomedical (Endosafe)
- Tagging: Spawning Season 1999
- Collection method –unknown
- Number Tagged – 2,500
- Number recaptured – 406 (16.2%)
- Recaptures
    - South Carolina coast and inland areas – 99%
    - Georgia coast and inland areas 1%

Recapture Location	Same Year	Following Years	Season
SC – Ocean and Inland areas	31	472	Spawning
SC – Ocean and Inland areas	4	2	Post-Spawn
GA – Ocean and Inland areas		3	Spawning
GA – Ocean and Inland areas		3	Post-Spawn