Massachusetts
Division of Marine Fisheries

Massachusetts 2011 Compliance Report to the Atlantic States Marine Fisheries Commission – Horseshoe Crab

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I. Introduction

a. Summary of the year highlighting significant changes in monitoring, regulations or harvest.

Due to unanticipated delays in data processing, summaries of trip-level harvester catch reports are not yet available for 2011. For now, we are providing summaries based on dealer reports. We will update and resubmit the 2011 Compliance report as soon as the harvester data are complied and analyzed.

In 2011, Massachusetts' dealers reported purchasing 85, 573 crabs for resale as bait, substantially more than the 54,782 crabs purchased in 2010. Market sampling of horseshoe crabs to obtain prosomal width measurements continued and efforts made to obtain crab measurements during routine sea sampling about draggers. We continued spawning surveys during the new and full moon periods in May and June using a modified Delaware Bay survey protocol. Observed numbers of spawning crabs continued to be low. This report includes data from surveys on 13 beaches in Massachusetts as surveyed by over 162 volunteers and staff from government agencies, environmental organizations, and local service groups.

II. *de minimis* status – not applicable

III. Previous calendar year's fishery and management program

a. Activity and results of fishery dependent monitoring.

Massachusetts requires any person harvesting more than six crabs per day to have a regulated fishery permit via trip-level reporting. These reports must include the date of harvest, trip start time and duration, port, gear type, disposition, the gender of the crabs, harvest location, and harvest method. If the crabs are sold, the harvester must identify the dealer or person purchasing the crabs. The single biomedical company located in Massachusetts, Associates of Cape Cod (ACC), must file monthly catch reports listing the names of individuals they purchased crabs from, in-state and out-of-state, the number of crabs purchased and how the crabs were used. ACC must also report the number of crabs received dead or rejected and the number of dead crabs returned to fishermen with a biomedical harvest permit. These fishermen must report monthly the number of dead crabs from the time of harvest to the time the crabs were returned to the water. Bait dealers are required to file electronic reports weekly under the SAFIS (Standard Atlantic Fisheries Information System) system. .

In 2010, Massachusetts issued 251 horseshoe crab bait permits and 18 horseshoe crab biomedical permits. Data compilation and analysis for Massachusetts harvester catch reports is incomplete at this time. Dealer reports are as follows:

Total purchased by MA dealers in 2011 as recorded by SAFIS: 140,800crabs
Total purchased for bait: 85,573 crabs
Total purchased for biomedical, personal use (food), and unspecified uses: 55,227 crabs
Percentage of harvest by fishing gear type as reported by SAFIS:

Hand & Rakes	70,253 crabs	Pots and Traps & Hook and Line & Dip net	20,015 crabs
Otter Trawl	40,213 crabs		
Dredge	4,658 crabs	Not Coded	5,661 crabs

MarineFisheries continues to characterize the commercial harvest of the crabs. Horseshoe crabs were sampled at local dealers and the biomedical processor to collect information on sex composition and prosomal width. Results are detailed in Section V.

b. Activity and results of fishery independent monitoring.

Resource Assessment Project

MarineFisheries' Resource Assessment Project has conducted seasonal spring (May) and fall (September) bottom trawl surveys in state waters since 1978. Approximately 100 tows are made in five bio-geographic areas, following a stratified random sampling design, with 22 total strata. The net's design, (¾-sized two seam 39' x 51' otter trawl with 3 ½" cookies on a chain sweep) is appropriate for sampling horseshoe crabs, however, the vessel size precludes towing inside most embayments or in water depths less than approximately 8 m. As a result, few horseshoe crabs are caught during these surveys. Nevertheless, due to the long time series these data are useful to illustrate trends over time (Figure 2).

Evaluation of Loess smoothed indices of stratified mean number crabs per tow for both spring and fall surveys indicate a trend of generally low abundance over time, with 2011 survey results lower than those noted in 2010. The fall 2011 index was at the same approximate level as 2010.

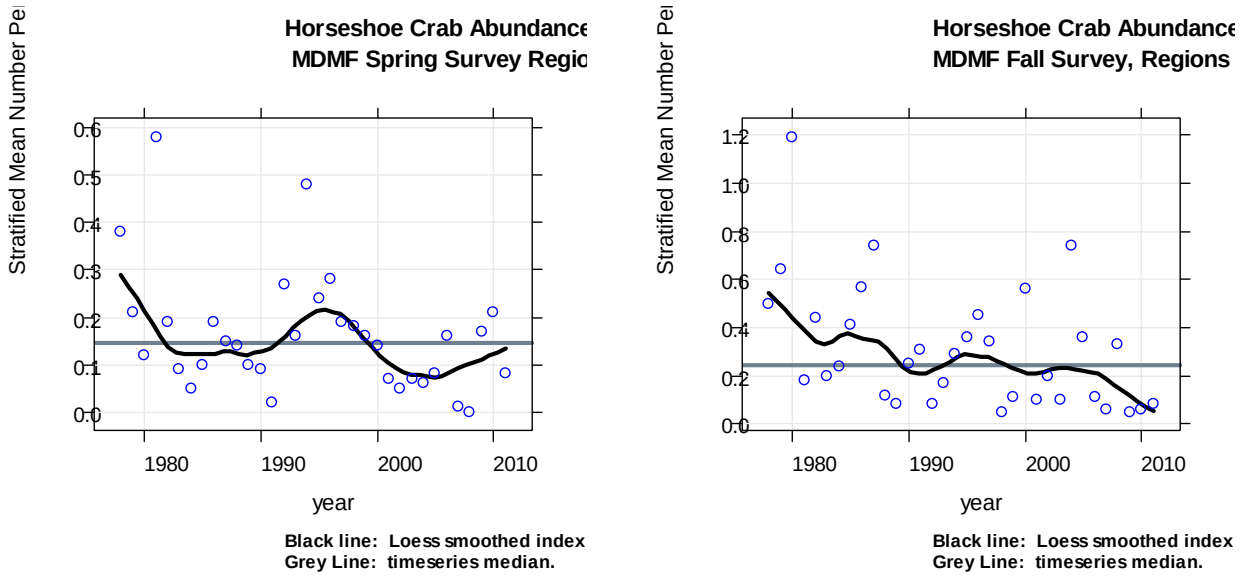


Figure 2. Results of the Massachusetts Resource Assessment spring and fall bottom trawl surveys 1978-2010.

Spawning surveys

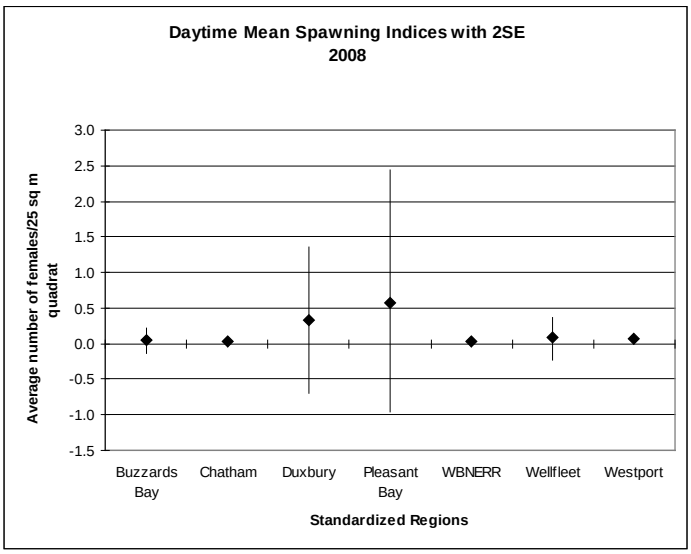
Over 162 volunteers and staff from 13 federal and state agencies, organizations, and universities conducted spring spawning surveys in 2011. Regional spawning indices (SI = number of spawning females per 25 m^2) are calculated and weighted by the number of quadrats sampled to reflect beach size. Since the inception of formalized spawning beach surveys in 2008, survey sites and effort have varied greatly depending on available resources. For comparisons between years, we use data from a standardized set of beaches that were sampled every year in each region.

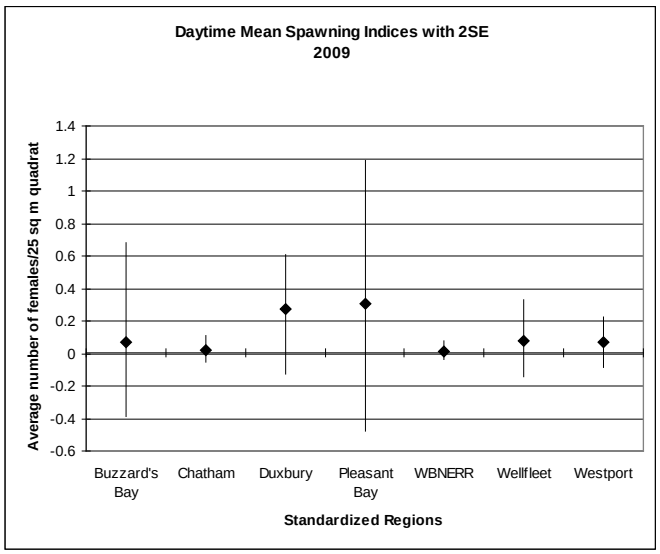
Spawning indices calculated for each region sampled in 2011 ranged from 0.07 to 0.5 spawning females per 25 m^2 (Table 1), which is similar to 2010 indices. Comparison of the average SI (with standard error) for each standardized region across the four-year time series is presented in Figures 3 (day) Figure 4 (night). Average SI values for these beaches/regions have never exceeded 0.6 spawning females per 25 m^2, although SI values at other MA survey beaches have approached 1 spawning female per 25 m^2. As noted for 2010, we had hoped to see greater numbers of spawning crabs on the beaches following enactment of the lunar spawning closure (five days around each new and full moon in May and June). However, this has not been observed. We will continue to investigate alternative methods for assessing spawning effort and success.

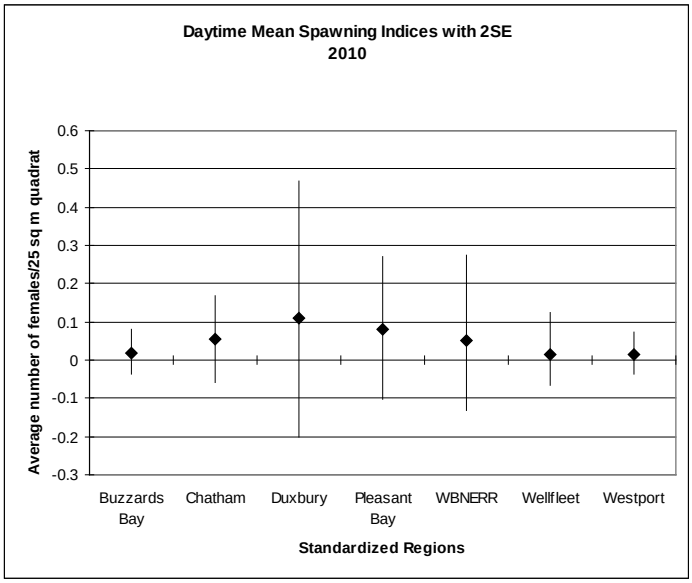
Table 1. Spawning indices (average number of spawning females per 25 m^2 quadrat and standard error) in MA regions for 2011. Data are combined from all beaches in each region and averaged across both moon phases.

2011	Day		2011	Night	
Region	**P**	**SE**	**Region**	**P**	**SE**
Buzzards Bay	0.1051	0.1172	Buzzards Bay	0.1742	0.1713
Duxbury	0.1253	0.0929	Duxbury	0.5316	0.7398
Chatham	0.0734	0.0813	Nantucket	0.1630	0.1000
Nantucket	0.0797	0.0607	Vineyard	0.1377	0.1744
Pleasant Bay	0.2361	0.2344	Wellfleet	0.0863	0.0458
Wellfleet	0.1042	0.0975			

During the four years of the spawning survey, most regions exhibited a male-skewed sex ratio (Figure 5). In particular, sex ratios in Pleasant Bay remain severely male-skewed, raising concerns about future productivity. As previously noted, these crabs are harvested only for biomedical purposes and a continuation of the highly male-skewed sex ratio may be an indication that bleeding is having a notable sub-lethal impact on the spawning behavior of females in this embayment. We will increase monitoring of this situation in 2012.







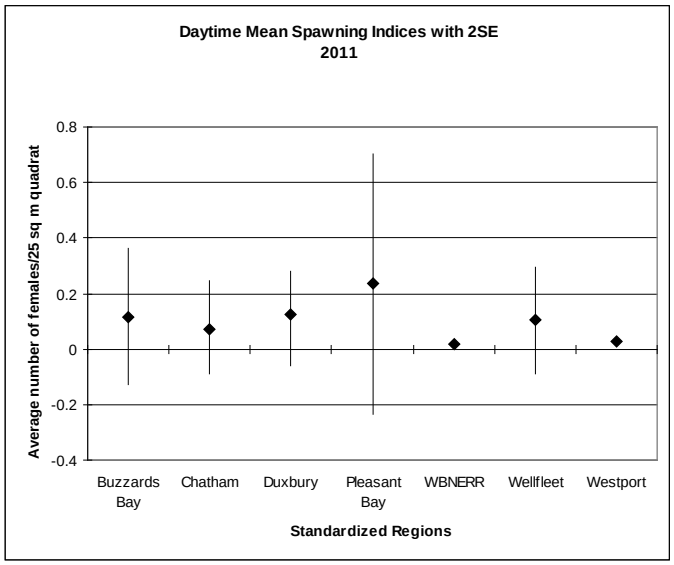
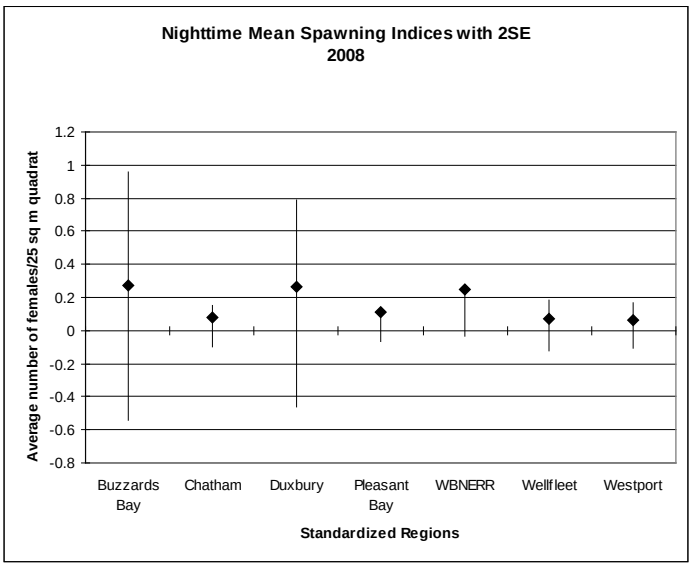
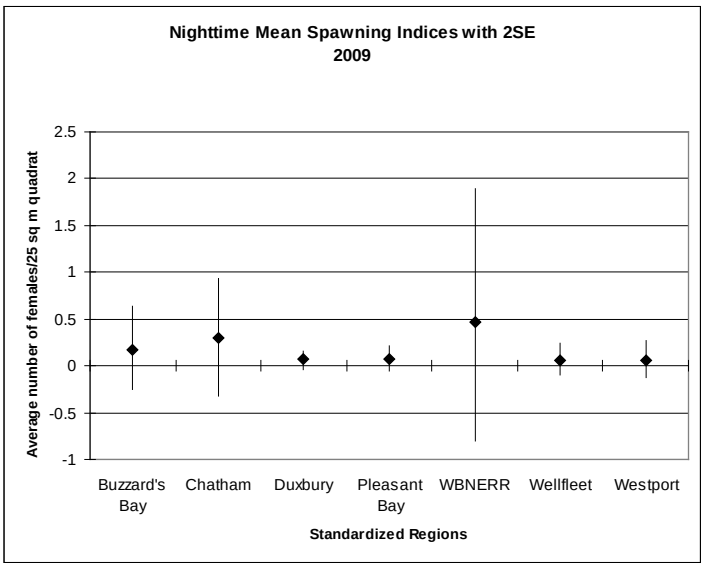
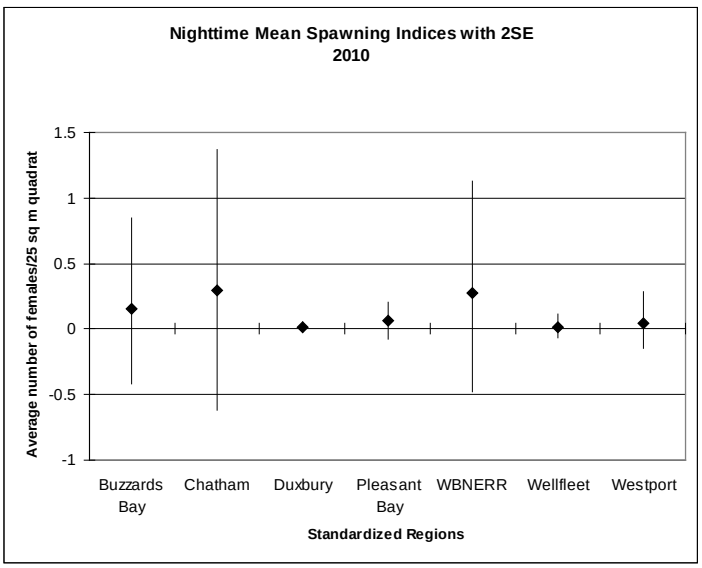


Figure 3. Day-time spawning indices (average number of spawning females per 25 m^2 quadrat) ± 2SE in standardized MA regions from 2008 through 2011. Data are averaged across both moon phases and combined from beaches that were sampled all four years in each region.







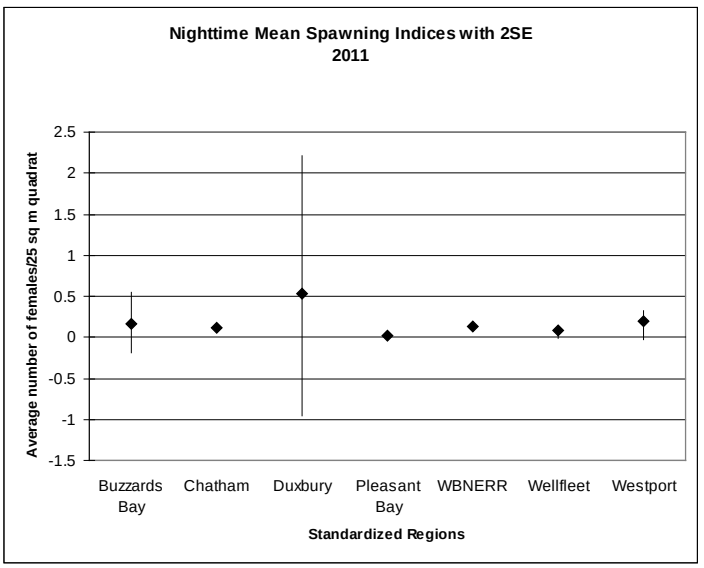
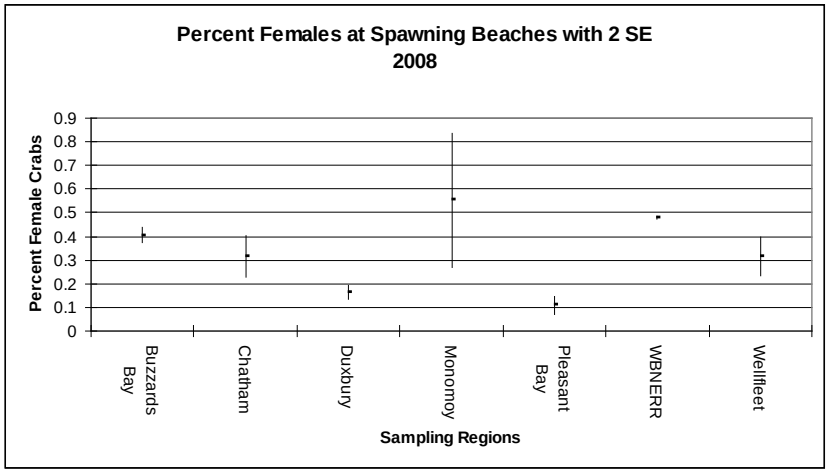
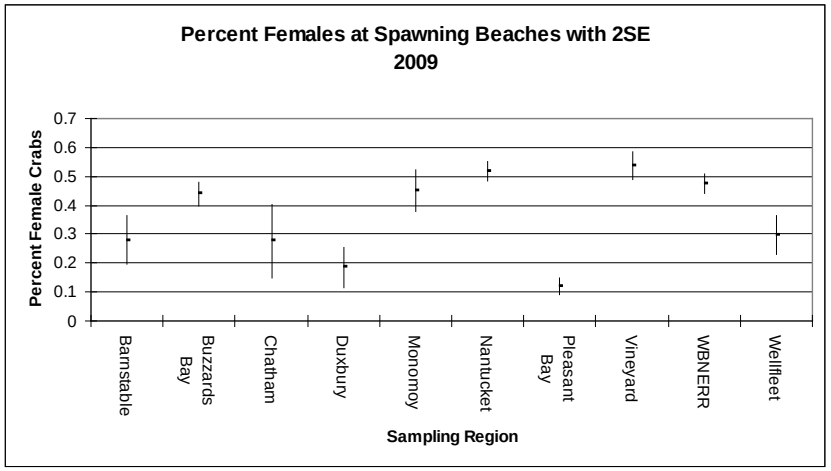
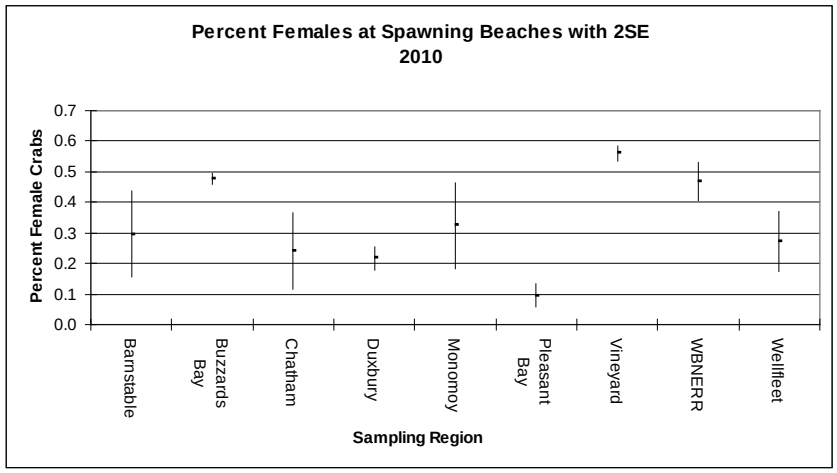


Figure 4. Night-time spawning indices (average number of spawning females per 25 m^2 quadrat) ± 2SE in standardized MA regions from 2008 through 2011. Data are averaged across both moon phases and combined from beaches that were sampled all four years in each region







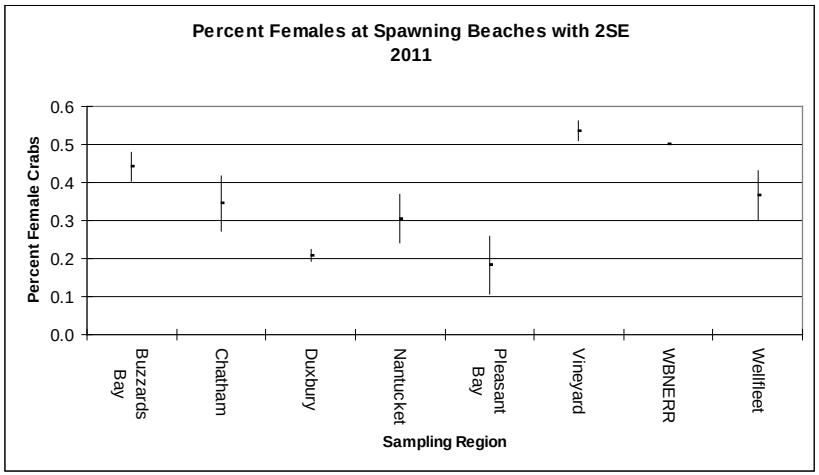


Figure 5. Percent females at spawning beaches by region ± 2SE, 2008 through 2011.

c. Regulations in effect for 2011

The Code of Massachusetts Regulations 322(CMR):

6.34 Horseshoe Crab Management

(1) Purpose. The purpose of 322 CMR 6.34 is to comply with the Interstate Management Plan for horseshoe crabs to manage horseshoe crab populations for continued use by current and future generations of the fishing and non-fishing public including the biomedical industry, scientific and educational research; migratory shorebirds; and, other dependent fish and wildlife. The plan requires the Commonwealth to monitor and control harvest levels by all sectors and conserve crabs through a commercial quota for crabs harvested as bait.

(2) Permit. It shall be unlawful for any person to take, land or possess more than six horseshoe crabs (*Limulus polyphemus*) per day for any purpose without a regulated fishery permit for horseshoe crabs issued by the Director. Licensed pot fishermen using horseshoe crabs as bait may possess more than six horseshoe crabs without a regulated permit, provided their documented source is a wholesale or bait dealer.

(a) Special Biomedical Harvest Permit. Harvesters collecting horseshoe crabs exclusively for use by the biomedical industry for the manufacture of limulus lysate or sale to a permitted scientific institution for research purposes must obtain a special permit limited to that purpose. The holder of the biomedical special permit shall not be allowed to obtain a Horseshoe Crab Permit.

(b) Permit Moratorium. As of March 28, 2008, the Director may not issue any new regulated fishery permit endorsements for horseshoe crabs. Failure to renew the horseshoe crab regulated fishery endorsement in any calendar year shall result in permit forfeiture to the Division.

(3) Bait Harvest Quota. The annual quota for horseshoe crabs harvested for bait purposes shall be 165,000 crabs. Horseshoe crabs harvested solely for biomedical or research purposes by harvesters licensed under 322 CMR 6.34(2)(a) which are bled and released alive in the area of capture or used for display or research shall not be counted against the annual quota established by the Atlantic States Marine Fisheries Commission . When 100% of the annual quota is reached, the Division shall file a notice of the horseshoe crab bait fishery closure with the Massachusetts Register, email a notice via the Marine Fisheries Listserv and post a notice on the Division's website.

(4) Quota Monitoring Closure. Beginning July 7th, the Director may prohibit commercial fisherman from landing and possessing horseshoe crabs taken for bait purposes to allow a comprehensive compilation of catch report information to assess the proportion of the annual quota taken. The Director may re-open the fishery if the quota has not been reached and may adjust the harvest rules if warranted to extend the season and to avoid overages.

(5) Possession Limits. Possession limits shall be vessel limits and shall apply regardless of the number of persons or permit holders aboard a vessel or working in conjunction with a vessel. It shall be unlawful for any person to harvest more than the possession limit in a day regardless of the number of permits held.

(a) Bait crab harvesters It shall be unlawful for any horseshoe crab harvester permitted to take crabs for bait purposes to take, land or possess:

1. more than 400 horseshoe crabs during any 24 hour period beginning at 12:00 P.M. (noon). Exception: After June 30, trawlers may lawfully possess up to 600 horseshoe crabs during any 24 hour period.

2. any horseshoe crabs once 100% of the horseshoe crab bait harvest quota has been taken.

(b) Biomedical crab harvesters. It shall be unlawful for any horseshoe crab harvester permitted to take crabs for biomedical purposes to take, land or possess more than 1,000 horseshoe crabs during any 24 hour period beginning at 12:00 P.M (noon).

(c) Exemption. Possession limits shall not apply to lawfully harvested horseshoe crabs held in storage by licensed conch pot or eel fishermen or dealers.

(6) Biomedical/Research Harvest.

(a) Authorization. Biomedical harvest permit holders must sell horseshoe crabs only to a dealer authorized by the Director to receive crabs harvested exclusively for biomedical purposes.

(b) Live Release.

1. Biomedical permit holders shall return all horseshoe crabs not used for display or research, other than bleeding, alive to the area of capture.

2. Dealers authorized by the Director to receive crabs harvested exclusively for biomedical purposes shall:

a. keep horseshoe crabs supplied by biomedical permit holders separate from horseshoe crabs supplied by bait permit holders; and

b. ensure horseshoe crabs supplied by biomedical permit holders are returned for live-release back into the same area of capture.

(c) Temporary Use of Horseshoe Crabs Harvested for Bait Purposes. If a biomedical company or permitted scientific institution chooses to purchase horseshoe crabs from bait dealers:

1. the company or institution shall keep records sufficient to show the number and source(s) of said horseshoe crabs;

2. horseshoe crabs purchased by a biomedical company from bait dealers may be returned to bait dealers to be sold as bait.

(d) Horseshoe Crabs Imported from Other States for Biomedical Purposes shall be counted against the quota of the producing state or returned to the producing state for release, according to established rules and regulations of the state of origin.

(7) Reporting.

(a) Harvesters. Each holder of a regulated fishery permit for horseshoe crabs, or a scientific collecting permit shall file a monthly catch report on forms supplied by the Division. Failure to report shall be grounds for suspension or non-renewal of the permit.

(b) Dealers. Wholesale Dealers and Bait Dealers who purchase horseshoe crabs from licensed fishermen shall register with the Division and record purchases on forms supplied by the Division. Failure to report purchases by the fifth day of each successive month shall be grounds for administrative action.

(8) Closed Days.

(a) May and June Lunar Closures. It shall be unlawful to harvest horseshoe crabs within a series of five day periods coinciding with each new and full moon during May and June as published by the US Naval Observatory and adjusted for Eastern Daylight Savings Time. Lunar closures shall commence at 12:00 AM two days prior to, and end at 11:59 PM two days after the date of the full or new moon.

(b) Mobile gear no-fishing days. In addition to closures described in 6.34.8(a), permit holders using mobile gear shall be prohibited from fishing for horseshoe crabs on Fridays and Saturdays during the summer flounder season beginning on June 10th and ending when the summer-time summer flounder quota is reached.

(9) Closed Areas. The Director may close any area to the taking of horseshoe crabs provided:

(a) A majority of the members of the Massachusetts Marine Fisheries Commission approve, and;

(b) A notice of closure has been filed with the Massachusetts Register stating the rationale for the closure, the duration of the closure and a description of the area to be closed, and;

(c) All permit holders and dealers are notified.

(10) Minimum Size. It is unlawful to posses horseshoe crabs for commercial purposes with a prosomal width of less than 7 inches.

(11) Fishery Limit Adjustments.

(a) The Director may, by declaration, adjust the manner and times of taking horseshoe crabs, and the legal size limits, numbers and/or quantities of horseshoe crabs to be taken as prescribed by M.G.L. c. 130, § 17A and specified by the Atlantic States Marine Fisheries Commission (ASMFC).

(b) Declaration Process

1. a two-week comment period has been conducted by the Division;

2. it has been approved by a majority of the members of the Massachusetts Marine Fisheries Advisory Commission;

3. a notice has been filed with the Massachusetts Register;

4. a notice has been published by at least one local newspaper; and

5. a copy of the notice has been emailed via the Marine Fisheries Listserv and posted on the Division's website.

Closed areas

In addition to the above regulations, Monomoy National Wildlife Refuge (federal closure) and the National Season (NPS - federal) remain closed to all HSC harvest, and Pleasant Bay (state closure) remains closed to bait fishing only (Figure 6).

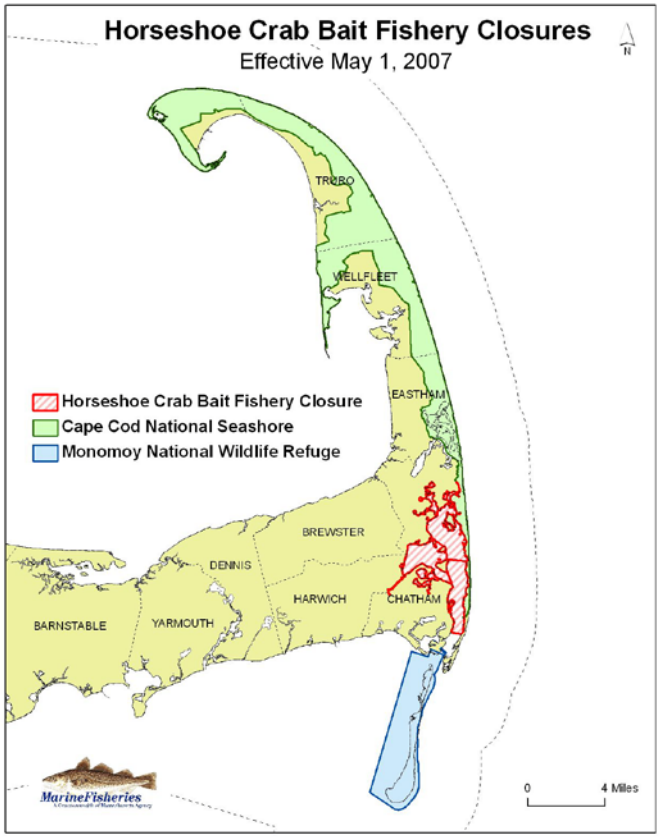


Figure 6. Areas closed to bait and/or biomedical harvest.

e. Review of progress in implementing habitat recommendations.

MarineFisheries' Environmental Review Project makes recommendations on state and federal coastal alteration permits to protect horseshoe crab spawning and nursery areas. These typically take the form of recommendations to limit certain activities during the crab's May –

July spawning season. Known spawning beaches have been entered into a GIS database to facilitate the environmental review process and a time-of-year guidance document authored by DMF is under review and will reiterate specific recommendations regarding dredging, beach fill, and construction projects vis à vis their potential impact on horseshoe crabs.

IV. Planned management programs for 2012

a. Summarize regulations that will be in effect (copy of current regulations if different from III c).

No regulatory changes are under consideration by the Division of Marine Fisheries at this time.

b. Summarize monitoring program that will be performed.

- Spring spawning beach surveys will be continued.
- *MarineFisheries* will continue collecting catch reports from all crab harvesters, dealers, and scientific permit holders. The biomedical company will submit monthly reports and an annual questionnaire. *MarineFisheries* will also continue to identify horseshoe crab spawning and nursery habitat and to characterize the commercial fishery. The *MarineFisheries* spring and fall trawl surveys will continue to monitor and record weight, number and prosomal width by sex of individuals collected.
- *MarineFisheries* will continue to encourage ACC to bleed as many bait crabs as possible in order to reduce the demand for biomedical crabs, particularly in light of our bleeding mortality study results.

c. Highlight changes from previous year.

No regulatory changes are under consideration by the Division of Marine Fisheries at this time.

V. Monitoring Program Requirements – Including Addendums I-III

Component A_1: Addendum III requires monthly reporting of all harvest of horseshoe crabs (bait fisheries, biomedical, industry, by-catch, educational and scientific research) by number landed, by sex and harvest method. Continue characterization of the commercial catch based on prosomal width by sex. States will be required to characterize a portion of the commercial catch based on maturity once an appropriate technique is developed and approved by the Technical Committee.

Massachusetts' existing regulations comply with Addendum III of the FMP. The Code of Massachusetts Regulations 322(CMR) 6.34 requires any person harvesting, taking or landing more than six horseshoe crabs per day for any purpose to have a regulated fishery permit from

the Director of the Division of Marine Fisheries. Permit holders are required to report at the trip-level the number of crabs harvested daily by gender, the beach or embayment of harvest, type of gear used and the intended use of the harvested crabs. If the crabs are sold, as a directed fishery or as by-catch, the fisherman must identify the dealer or individual buying the crabs. Failure to report shall be ground for suspension of the permit and non-renewal.

Wholesale or bait dealers purchasing horseshoe crabs from licensed fishermen are now required to submit weekly electronic SAFIS reports. Biomedical facilities must report the name of the harvester, number of crabs and the use of horseshoe crabs monthly.

Commercially harvested horseshoe crabs were sampled during the beach harvest season by *MarineFisheries* biologists at bait dealer and the biomedical facilities. In 2011, crabs were measured to the nearest mm instead of cm to enable greater discrimination of trends in length frequency distribution going forward. However, length frequencies are presented in this report in cm to allow for comparison between years. A total of 1,125 horseshoe crabs (625 female and 500 male crabs) were identified by sex and measured to determine prosomal width. The mean prosomal width for female crabs was 24.6 cm and 20.1 cm for male crabs (Figure 7). The center of the distribution of prosomal widths for females was again slightly shifted to smaller sizes and the male distribution remained stable in 2011. (See Attachment 1).

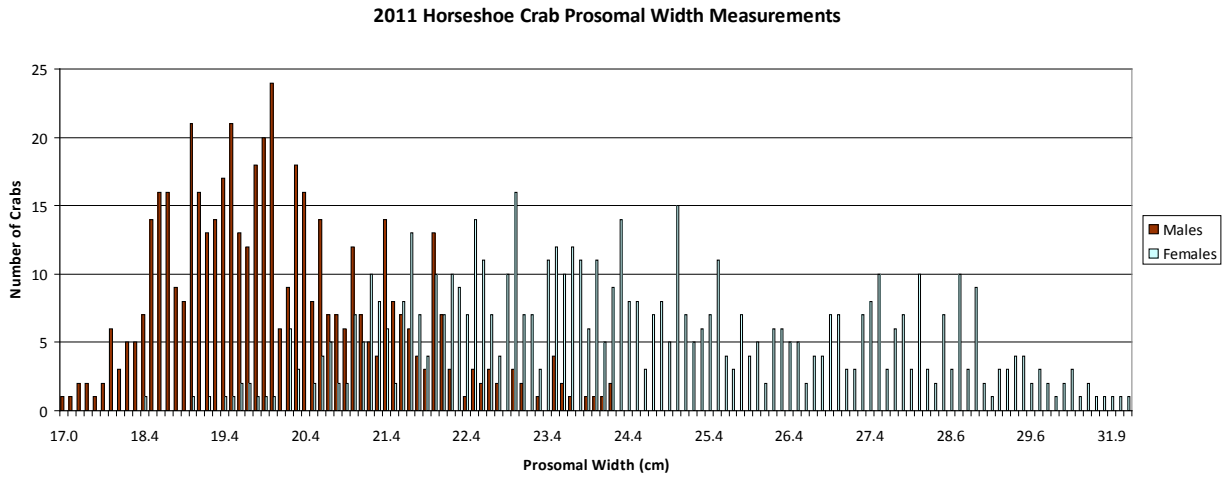


Figure 8. Prosomal widths (cm) for female and male horseshoe crabs sampled during market surveys.

Component A_2: To comply with Addendum III, states where horseshoe crabs are captured for biomedical use must monitor and report monthly and annual harvest of horseshoe crabs by biomedical facilities. All states must identify percent mortality from the point of harvest to release. States are required to use the HSC TC biomedical survey or some other means to obtain the required information.

The Massachusetts biomedical company, Associates of Cape Cod (ACC) obtained crabs from three licensed bait dealers, and four fishermen. Massachusetts regulations allow the biomedical company to purchase bait crabs for bleeding. Once bled, the crabs are returned to the bait dealers for sale as bait or to a biomedical dealer to be released at the site of capture.

As nearly half of the crabs used by the biomedical company came from the bait dealers, the number of crabs harvested by biomedical permit holders is reduced, reducing the total number of crabs harvested in the Commonwealth.

In an effort to comply with Addendum III, the biomedical company is required to file monthly reports noting the number of crabs received from each dealer, the number of dead or rejected crabs and the number of dead crabs returned to the dealers. The biomedical company reported a rejection rate of approximately 5-6% for both the biomedical and bait dealers. Crabs from the biomedical dealer rejected by the biomedical company because of injury, size, etc. were returned to the water near the harvest site. Rejected crabs obtained from bait dealers were sold as bait.

Component A_3: States must identify spawning and nursery habitat. States that have completed this work must report changes in spawning and nursery habitat over time. States must actively intervene to the extent of their authority to ensure that spawning and nursery habitat is conserved and the quality and productivity is maintained.

A comprehensive survey of horseshoe crab spawning and nursery habitat along the Commonwealth's 1,800 miles of coastline was completed in 2004 and partially updated in 2007 (Attachment 2). This assessment will be updated in the coming years as staffing allows. All crab harvesters are required to identify embayments on the catch reports. As in previous years, staff limitations allowed no updates to this map in 2011. Therefore the maps in Attachment 2 are from 2004 and the table is from 2007.

MarineFisheries annually solicits public assistance by issuing postings on the website and in the *MarineFisheries* newsletter. Anyone observing spawning horseshoe crabs is asked to contact *MarineFisheries*.

MarineFisheries' Environmental Review Project also recommends conditions to all coastal alteration projects to protect horseshoe crab habitat and requests time-of-year restriction on any activities on known horseshoe crab spawning beaches.

Monitoring Program Recommendations – Including Addendums I-III

<u>Monitoring of Horseshoe Crab Populations and Habitat</u>

Component B_1: Continue working towards expanding the annual coastwide benthic trawl survey following methods described in Hata and Berkson (2003).

MarineFisheries continues working towards expanding the annual coastwide trawl survey. However, due to fiscal and manpower limits, the Commonwealth is unable to participate in a coastwide trawl survey at this time. *MarineFisheries*' Coastal Resource Assessment Project currently records the number, and prosomal width by sex of all horseshoe crabs collected during the annual spring and fall bottom trawl surveys. Survey data is forwarded to the Stock Assessment Committee.

Component B_2: Continue existing benthic sampling programs.

As noted in Component B_1, *MarineFisheries*' Resource Assessment Project currently records the number, and prosomal width by sex of all horseshoe crabs collected during the annual spring and fall bottom trawl surveys. Survey data is forwarded to the Stock Assessment Committee.

Component B_3: Continue monitoring spawning populations based upon standardized and statistically robust methodologies.

Massachusetts started annual spawning surveys in 2008 modeled after Delaware Bay's (with modification of quadrat size to 5 x 5 m^2 due to much lower populations in MA).

Component B_4 A coordinated tagging program should be implemented by the Tagging Subcommittee based upon the draft coast-wide framework developed in 2003.

MarineFisheries worked with NPS and USFWS to develop a smaller tag more suited to our smaller crabs. These tags were successfully used in 2009, primarily in Pleasant Bay, Monomoy NWR, and to a limited extent in Waquoit Bay.

Joint Monitoring of Delaware Bay Horseshoe Crabs and Shorebirds

Component B_5 Continue existing state egg abundance surveys, particularly in the Delaware Bay region.

MarineFisheries has explored funding and implementation options to implement crab egg abundance surveys. Because there is no strong HSC-shorebird connection in MA, it may make more sense for MA to survey juvenile horseshoe crabs. Work began on this in 2009, but it was a "learning year" without substantive results. We hope to pick it up again in 2012.

Component B_6 Continue existing state shorebird monitoring programs.

Shorebird monitoring in Massachusetts is conducted by other agencies and organizations.

Component E: Evaluate the post-release mortality of horseshoe crabs used by the biomedical industry by initiating a tagging program.

MarineFisheries conducted a study in 2009 examining mortality in bled and unbled female crabs. The study results were published in 2010: *Leschen, A. S. and Correia, S. J.(2010) 'Mortality in female horseshoe crabs (Limulus polyphemus) from biomedical bleeding and handling: implications for fisheries management', Marine and Freshwater Behaviour and Physiology, 43: 2, 135 — 147.*

Component F: Identify potential horseshoe crab spawning and nursery habitats.

See Component A_3.

Changes to Research Needs Section.

Section 6.1 Develop an effective and efficient field protocol to identify critical life history stages. At a minimum, the protocol should identify horseshoe crabs that have spawned previously, those that are within one year of spawning for the first time and those that are more than one year from spawning for the first time.

Once developed, Massachusetts will incorporate the protocol into the sampling design.

<u>Section 6.2</u> In addition to investigating, encouraging and funding alternative bait sources, the Committee suggested focusing on alternative trap design (i.e. traps with bait bags).
In 2004, *MarineFisheries* in concert with several fishermen began trial use of bait cups and alternative baits. Preliminary results indicated that the use of the cups and bait bags reduced the amount of horseshoe crab required to bait a pot and extended the time between rebaiting. Over the course of the year quite a few conch fishermen began using modifications of the bait cups and bags. Almost all reported a significant reduction in the number of crabs needed per trip.

In 2005, fishermen continued modifying bait cups and bags and several new modifications were tested. All appeared to work well, allowing for smaller pieces of horseshoe crabs and other baits such as herring, skate or green crabs to be added to the containers. Based upon returns of a questionnaire sent to conch pot fishermen, nearly all are using some form of bait bag or bait cup.

From meetings with conch fishermen, we learned there is a wide variety of techniques and number of pots/crab that people use. We hope to gather more information from the most efficient users of crabs, and share this information with other fishermen to potentially cut down on the need for crabs.

VI. Law enforcement reporting requirement: Horseshoe Crabs

b. Interstate Fishery Management Plan for Horseshoe Crabs

The ASMFC Law Enforcement Report form was sent to the Massachusetts Office of Environmental Law Enforcement (OLE) in the Executive Office of Energy and Environmental Affairs with a request to submit the form to the ASMFC Law Enforcement Committee.

ATTACHMENT 1
HORSESHOE CRAB PROSOMAL WIDTHS
2000 - 2011

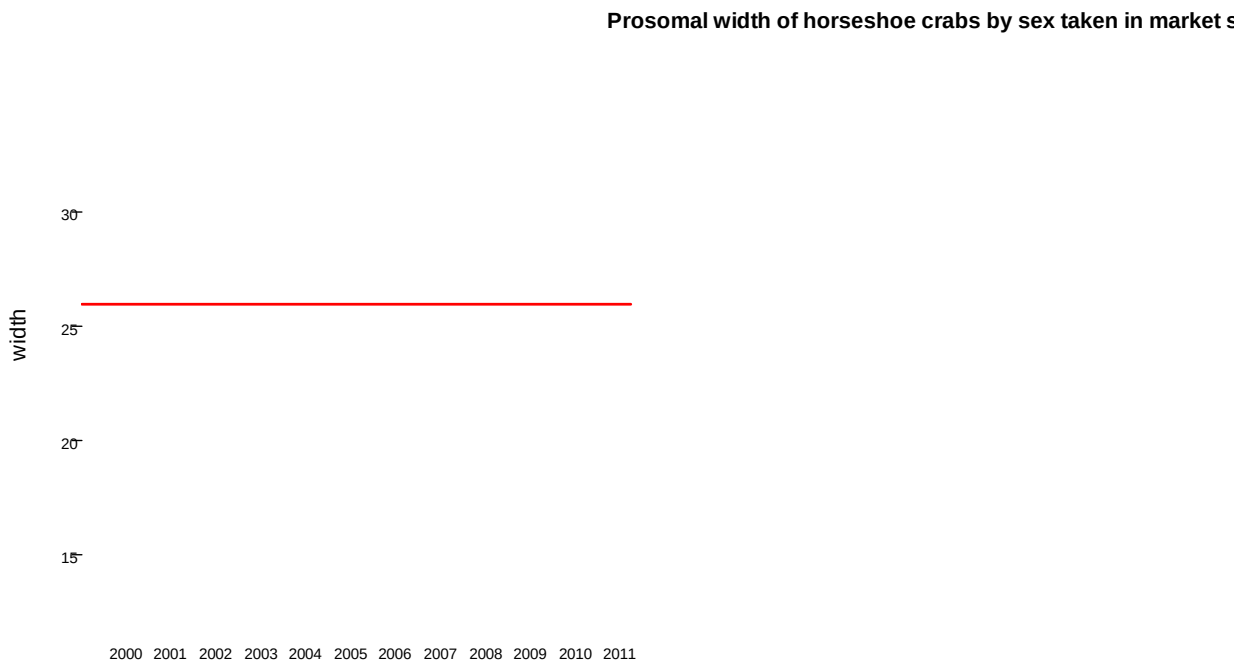


Figure 1. Box plots of prosomal widths taken in market sampling of horseshoe crabs for all areas combined (2000-2011). Solid red line is median, dashed lines are 25 and 75th quantiles (unweighted). Left panel: female horseshoe crabs. Right panel: male horseshoe crabs. Width of box is proportional to the square root of sample size.

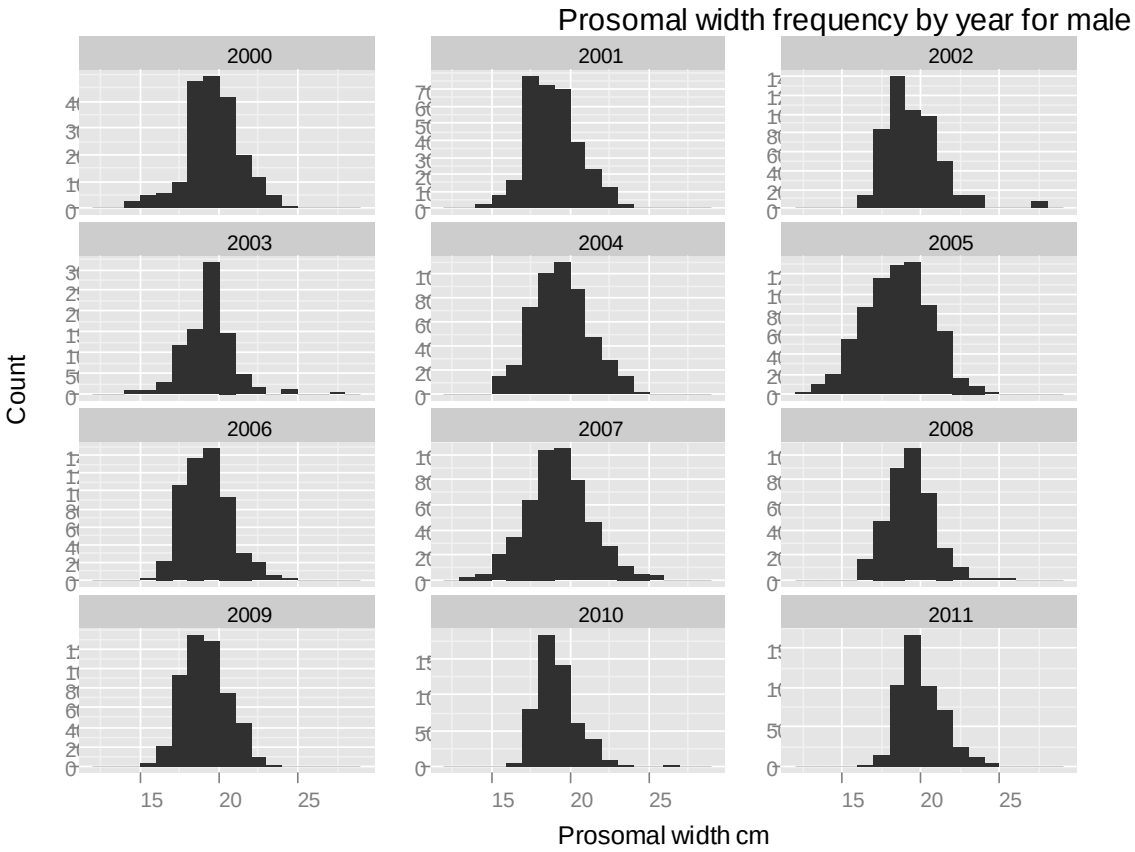


Figure 2. Prosomal width frequency from market sampling for male horseshoe crabs (2000-2011).

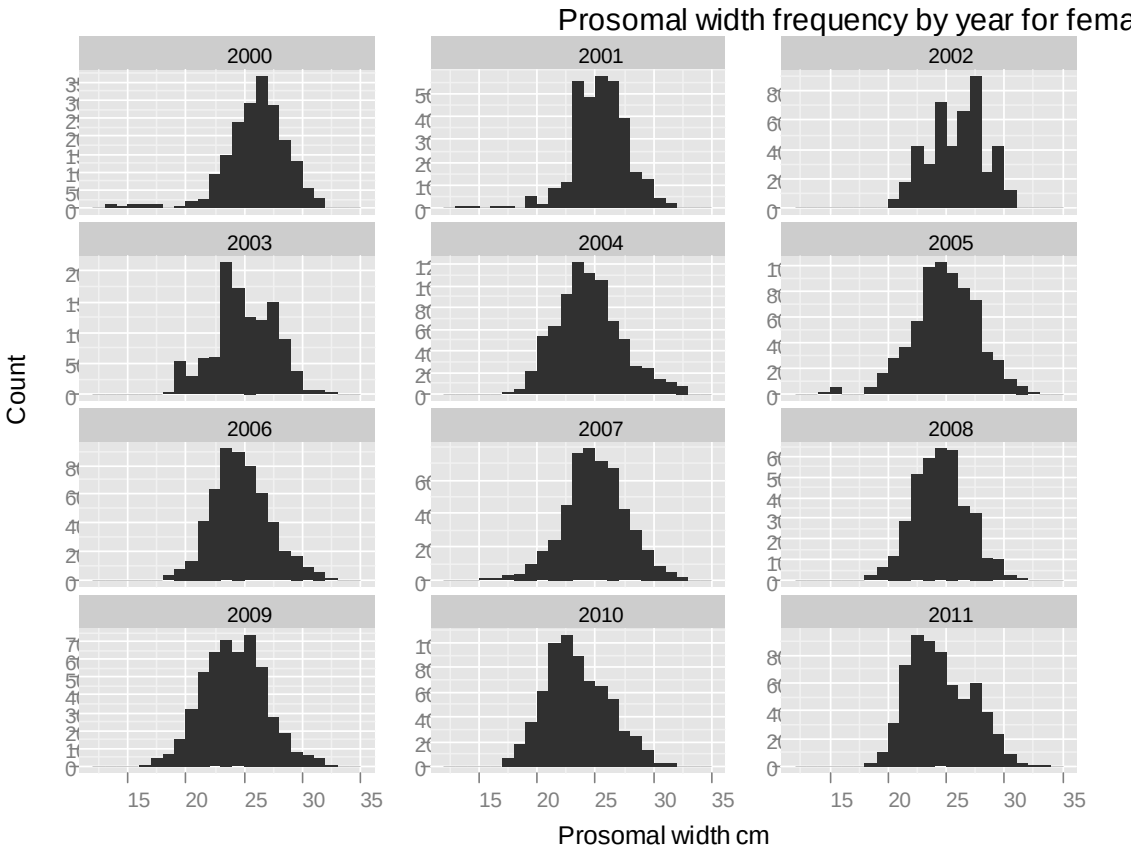
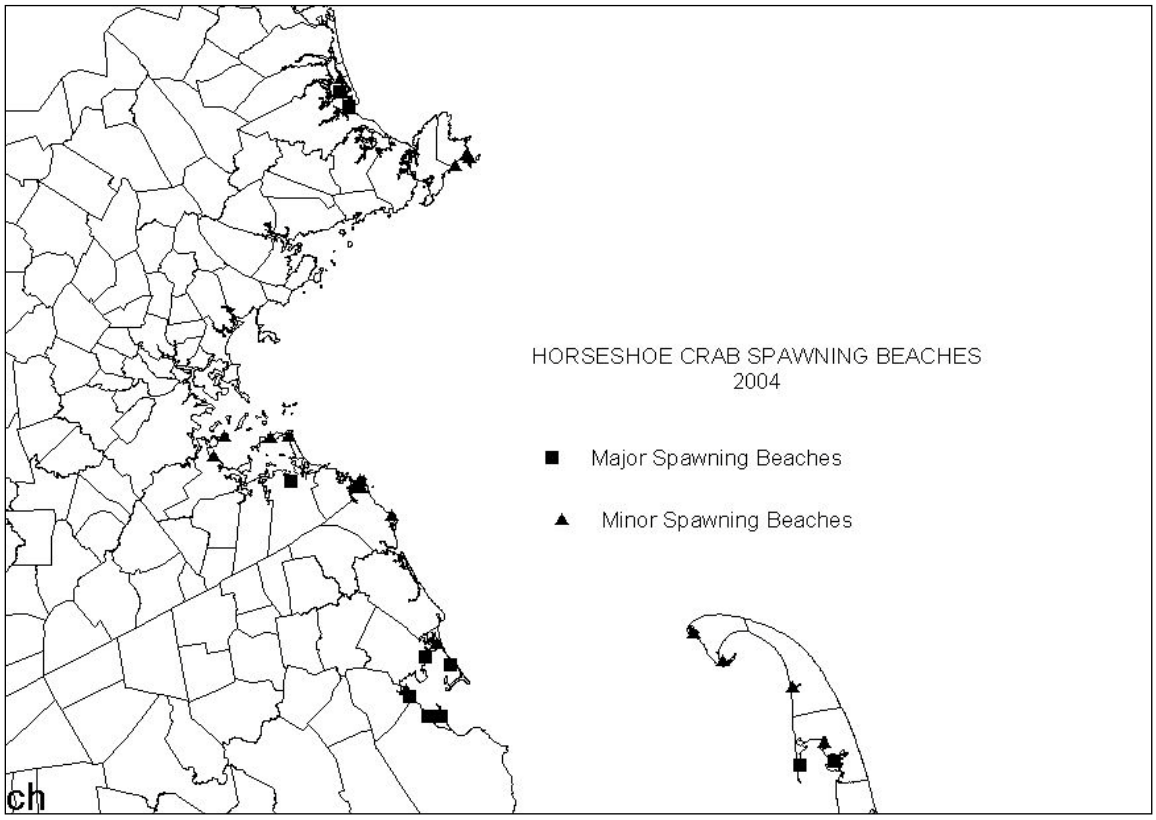
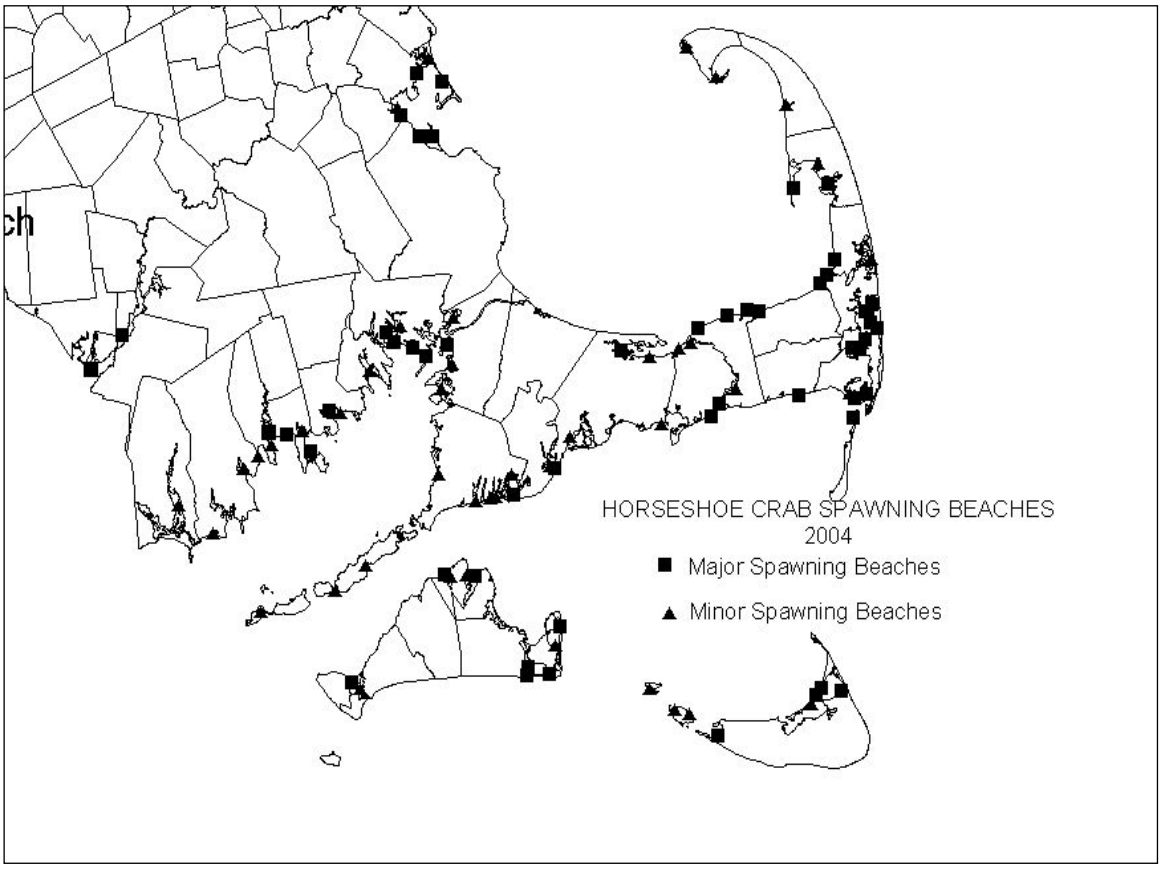


Figure 3. Prosomal width frequency from market sampling for female horseshoe crabs (2000-2011).

ATTACHMENT 2
HORSESHOE CRAB SPAWNING BEACHES
AND NURSERY AREAS





HORSESHOE CRAB SPAWNING BEACHES
2007

MOUNT HOPE BAY			
Town	**Embayment**	**Beach**	**Density**
Somerset	Mount Hope Bay	Brayton Pt Beach	High
	Taunton River	Pierce Town Beach	High
Fall River	Taunton River	Ark Bait Cove	High
Swansea	Coles River	Bluffs Beach	High
	Coles River	Ocean Grove	High
	Coles River	Cedar Cove	Moderate
BUZZARDS BAY			
Bourne	Buttermilk Bay	Hideaway Village	Moderate
	Phinney's Harbor	Monument Beach	High
	Phinney's Harbor	Mashnee Dike	High
	Phinney's Harbor	Toby Island	Moderate
	Pocasset Harbor	North Cove	Moderate
	Pocasset Harbor	Tahanto Beach	Moderate
Dartmouth	Allen's Pond	South Beaches	Moderate
	Clarks Cove	Anthony Beach	Moderate
	Apponagansett Bay	Apponagansett Park Beach	Moderate
	Little River	Beach at mouth	Reported
	Slocum River	Demarest Lloyd State Beach	Reported
	Clarks Cove	Jones Beach	Moderate
	Apponagansett Bay	Little Bridge Beach	Reported
Fairhaven	Nasketucket Bay	Deacon's Cove	High
	Nasketucket Bay	Edgewater Ramp Beach	Moderate
	Acushnet River	Fairhaven Common's Beach	High
	NB Outer Harbor	Fort Phoenix Beach	Reported
	Nasketucket Bay	Knomere Beach	Reported
	NB Outer Harbor	Priest Cove, Red Rock Beach	High
	Nasketucket Bay	Raymond Street Beach	Reported
	NB Outer Harbor	Silver Shell Beach	Reported
	Acushnet River	Tin Can Island	High
	Nasketucket Bay	Association Beach	Moderate
Falmouth	Great Sippewisset	Black Beach	Reported
	Buzzards Bay	Old Silver Beach	Reported
Gosnold	Cuttyhunk Pond	Church Beach	Reported
	Pasque Pond	Beach	Reported
	Vineyard Sound*	Tarpaulin Cove	Moderate
Mattapoisett	Aucoot Cove	Hollywood Beach	Moderate

	Mattapoisett Harbor	Neds Point	Reported
	Mattapoisett Harbor	Shining Tides Beach	Moderate
	Buzzards Bay	Point Connett Beach	Reported
Marion	Sippican Harbor	Meadow Island	Moderate
	Sippican Harbor	Ram Island	Reported
	Sippican Harbor	Planting Island	Moderate
	Aucoot Cove	Converse Pt Beach	Reported
New Bedford	Acushnet River	Palmer Cove	High
	NB Outer Harbor	East Beach	Moderate
	NB Outer Harbor	Ebb Tide Beach	Moderate
	NB Outer Harbor	Davy's Locker Beach	Reported
Wareham	Buttermilk Bay	Jefferson Shores	Moderate
	Wareham River	Long Beach	High
	Little Harbor	Little Harbor Beach	High
	Wareham River	Pine Hurst Beach	Reported
	Wareham River	Swifts Beach	High
	Buzzards Bay	Stony Point Dike	Moderate
Westport	Westport Harbor	Cherry & Webb Beach	Moderate
	East Branch	Upper Islands	Reported
	West Branch	Sanford Flat Area	Reported
	Westport Harbor	Boat Ramp Beach	Reported
SOUTH CAPE			
Barnstable	Centerville Harbor	Craigville Beach(5th Ave)	Reported
	Cotuit Bay	Ropes Beach	Reported
	East Bay	Dawes Beach	Moderate
	Hall Creek	Backside Beach	Reported
	Hyannis Harbor	Kalmus Beach	Reported
	Cotuit Bay	Sampson Island	High
	Cotuit Bay	Pirate Cove	High
Chatham	Nantucket Sound	Cockle Cove Beach	High
	Nantucket Sound	Monomoy Island	High
	Stage Harbor	Harding Beach	High
	Stage Harbor	Morris Island	High
	Oyster Pond	Beaches at mouth	Reported
	Oyster River	Sear's Point Beach	High
Dennis	Bass River	Opposite High Bank	Moderate
	Bass River	Old Field Point	Reported
	Bass River	W. Dennis Beach	High
	Bass River	Georgetown Flats	Reported
Falmouth	Bourne's Pond	Old Mouth	Reported
	Great Pond	Entrance Beaches	Moderate
	Green Pond	Entrance Beaches	Moderate

	Eel River	Washburn Island	Reported
	Waquoit Bay	WBNERR Beach	Reported
Mashpee	Waquoit Bay	Sage Lot Pond	High
	Nantucket Sound	South Cape Beach	Reported
	Popponesset Bay	Popponesset Beach	Reported
	Popponesset Bay	Daniel Island Beach	Reported
	Popponesset Bay	Pirates Cove Landing	Moderate
Yarmouth	Bass River	Wind Mill Beach	Moderate
	Nantucket Sound	Sea Gull Beach	Moderate
	Nantucket Sound	Lighthouse Beach	Moderate
	Parker River/ Lewis Pond	Landing Beach	Reported
MARTHA'S VINEYARD			
Aquinnah	Menemsha Pond	Red Beach	High
Chilmark	Menemsha Pond	Landing	Moderate
Edgartown	Cape Poge Bay	Simon Point	Moderate
	Katama Bay	SE Corner	High
	Katama Bay	South Side	High
	Salt Pond	Fuller Street Beach	Reported
Oak Bluffs	Lagoon Pond	Worcester St.	Reported
	Vineyard Haven	Eastville Point	Moderate
Tisbury	Lake Tashmoo	Flats at mouth	High
	Lagoon Pond	Cedar Neck	Reported
NANTUCKET			
Nantucket	Madaket Harbor	Hither Creek	Moderate
	Muskeget Island	Coves	Reported
	Nantucket Harbor	Backside Outer Beach	Reported
	Nantucket Harbor	Pocomo Point Beach	High
	Tuckernut Island	Coves	Reported
OUTER CAPE			
Chatham	Bassing Harbor	Fox Hill	Moderate
	Crows Pond	Nickerson Neck	Moderate
	Chatham Harbor	North Beach	Reported
	Chatham Harbor	Outermost Marine Cove	High
	Pleasant Bay	Muddy Creek Landing	Reported
	Chatham Harbor	South Beach	Reported
	Pleasant Bay	Strong Island, East Side & Creeks	High
	Pleasant Bay	Ryders Cove	Reported
Eastham	Nauset Harbor	Stony Island	Reported
	Nauset Harbor	Outer Beach	Reported
Harwich	Round Cove	Landing	Reported
Orleans	The River	Barley Neck	High
	Little Pleasant Bay	Hog Island	High

	Little Pleasant Bay	Jack Knife Cove	High
	Kesczyogansett Pond	Town Landing	Moderate
	Town Cove	YC Landing	Moderate
	Little Pleasant Bay	National Seashore	High
	Little Pleasant Bay	Pochet Island	High
	Little Pleasant Bay	Sampson Island	High
	Little Pleasant Bay	Old Field Point	Reported
	Pleasant Bay	Strong Island	High
Cape Cod Bay			
Barnstable	Barnstable Harbor	Scudder Lane	High
	Barnstable Harbor	Sand Island	High
	Barnstable Harbor	The Cove	Reported
	Barnstable Harbor	Calves Pasture Point	High
	Barnstable Harbor	Bone Hill	Reported
	Barnstable Harbor	Eastern end	High
	Barnstable Harbor	Salten Point	High
Brewster	Cape Cod Bay	Brewster Flats	High
	Cape Cod Bay	Ellis Landing	High
	Cape Cod Bay	Namskaket Creek	High
	Cape Cod Bay	Paine's Creek	Moderate
Dennis	Cape Cod Bay	Chapin Beach	High
	Cape Cod Bay	Corporation Beach	High
	Cape Cod Bay	Cold Storage Beach	Moderate
	Cape Cod Bay	Quivett Creek	Moderate
	Cape Cod Bay	Chase Garden Creek	Reported
Duxbury	Duxbury Bay	Back River	High
	Duxbury Bay	Duxbury Beach	High
	Duxbury Bay	Ship Yard Lane	High
	Duxbury Bay	Bradford Street	High
Eastham	Cape Cod Bay	First Encounter	High
	Cape Cod Bay	Sunken Meadow	High
	Cape Cod Bay	Boat Meadow Sand Spit	Reported
Kingston	Kingston Bay	Gray's Beach	Reported
	Kingston Bay	Rocky Nook Association Beach	Reported
Orleans	Cape Cod Bay	Rock Harbor Beach	Moderate
	Cape Cod Bay	Skaket Beach	Reported
Plymouth	Plymouth Harbor	Plymouth Beach	High
	Duxbury Bay	Saquish Cove	Reported
	Plymouth Harbor	Steven's Field	High
Provincetown	Hatches Harbor	Entrance Beach	Reported
	Inner Harbor	Wood's End	Moderate

Truro	Pamet Harbor	Harbor Bar	Reported
	Pamet Harbor	Landing Beach	Reported
	Cape Cod Bay	Corn Hill Beach	Reported
Wellfleet	Wellfleet Harbor	Chipman Cove	High
	Wellfleet Harbor	Great Island	Moderate
	Wellfleet Harbor	Mayo Beach	Reported
	Wellfleet Harbor	WBWS	High
	Wellfleet Harbor	Indian Neck	Moderate
Yarmouth	Cape Cod Bay	Bass Creek	Moderate
	Chase Garden Creek	Gray's Beach	Moderate
MASSACHUSETTS BAY			
Cohasset	Cohasset Harbor	Bassing Harbor Beach	Moderate
	Cohasset Harbor	Briggs Cove	Reported
Hingham	Hingham Harbor	Hingham Beach	Reported
Hull	Hull Bay	Pt Allerton Beach	Reported
	Hull Bay	Windmill Pt Beach	Reported
Scituate	Scituate Harbor	Jericho Landing Beach	Reported
NORTH SHORE			
Ipswich	Ipswich Bay	Cranes Beach	Reported
Newbury	Plum Island Sd.	Parker River Refuge	High
Quincy	Quincy Bay	Wollaston Beach	Reported
Rockport	Sandy Bay	Old Garden Beach	Moderate
		Back Beach	Reported
		Front Beach	Reported

HORSESHOE CRAB NURSERY AREAS
2007

MOUNT HOPE BAY		
TOWN	**EMBAYMENT**	**DENSITY**
Somerset	Mount Hope Bay	High
	Taunton River	High
Swansea	Mount Hope Bay	High
	Coles River	High
BUZZARDS BAY		
Bourne	Buttermilk Bay	High
	Phinney's Harbor	High
Fairhaven	Nasketucket Bay	High
	Outer Harbor	Moderate
Mattapoisett	Mattapoisett Harbor	Reported
New Bedford	Outer Harbor	Moderate

Wareham	Buttermilk Bay	Reported
	Outer Wareham River	Moderate
Westport	Westport Rivers	Reported
SOUTH CAPE		
Barnstable	Lewis Bay	Reported
	Cotuit Bay	Moderate
Chatham	Cockle Cove Beach	High
	Stage Harbor	High
	Monomoy Island	High
Dennis	Bass River	High
Falmouth	Waquoit Bay	Reported
Mashpee	Waquoit Bay (Sage Lot Pond)	High
	Popponesset Bay	Moderate
Yarmouth	Bass River	High
MARTHA'S VINEYARD		
Aquinnah	Menemsha Pond	Moderate
Chilmark	Menemsha Pond	Moderate
Edgartown	Cape Poge Bay	Moderate
	Katama Bay	High
Oak Bluffs	Lagoon Pond	Reported
	Vineyard Haven Harbor	Reported
Tisbury	Lake Tashmoo	Moderate
NANTUCKET		
Nantucket	Madaket Harbor	Reported
	Muskeget Island	Reported
	Nantucket Harbor	High
	Tuckernuck Island	Reported
OUTER CAPE		
Chatham	Bassing Harbor	Reported
	Chatham Harbor	High
	Crowes Pond	Reported
	Pleasant Bay	High
Eastham	Nauset Marshes	Moderate
Harwich	Pleasant Bay	High
Orleans	Little Pleasant Bay	High
	Pleasant Bay	High
CAPE COD BAY		
Barnstable	Barnstable Harbor	High
Brewster	Brewster Flats	High
Dennis	Dennis Flats	High
Duxbury	Duxbury Bay	High
	Back River Marsh	High

Eastham	Eastham Flats	High
Kingston	Kingston Bay	Moderate
Orleans	Orleans Flats	High
Plymouth	Plymouth Harbor	High
Provincetown	Hatches Harbor	Reported
Truro	Pamet Harbor	Reported
Wellfleet	Wellfleet Harbor	High
Yarmouth	Yarmouth Flats	High
	Chase Garden Creek	Reported
MASSACHUSETTS BAY		
Cohasset	Cohasset Harbor	Reported
Hull	Hull Bay	Reported
Scituate	Scituate Harbor	Reported
NORTH SHORE		
Ipswich	Plum Island Sound	High
Newbury	Plum Island Sound	High