

**REVIEW OF THE FISHERY MANAGEMENT PLAN FOR
HORSESHOE CRAB**
(Limulus polyphemus)

2002 FISHERY

Presented to the
ASMFC Horseshoe Crab Management Board

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REVIEW OF THE INTERSTATE FISHERY MANAGEMENT PLAN FOR HORSESHOE CRAB (*Limulus polyphemus*)

I. Status of the Fishery Management Plan

The framework for managing horseshoe crabs along the Atlantic coast was approved in October 1998 with the adoption of the Interstate Fishery Management Plan for Horseshoe Crabs (FMP). The FMP required the States of Maryland, Delaware and New Jersey to maintain their existing horseshoe crab harvest reduction strategies, and required all states to implement certain horseshoe crab research and monitoring programs in an effort to facilitate future management decisions.

In February 2000, the Horseshoe Crab Management Board approved Addendum I to the FMP. Addendum I established a state-by-state cap on horseshoe crab bait landings at 25 percent below the reference period landings (RPL's), and *de minimis* criteria for those states with a limited horseshoe crab fishery. Those states with more restrictive harvest levels (Maryland and New Jersey) were encouraged to maintain those restrictions to provide further protection to the Delaware Bay horseshoe crab population, recognizing its importance to migratory shorebirds. Addendum I also recommended that the National Marine Fisheries Service (NMFS) prohibit the harvest of horseshoe crabs in federal waters (3-200 miles offshore) within a 30 nautical mile radius of the mouth of Delaware Bay, as well as prohibit the transfer of horseshoe crabs in federal waters. A horseshoe crab reserve was established by NMFS in the area recommended by ASMFC on March 7, 2001.

In April 2001, the Horseshoe Crab Management Board approved Addendum II to the FMP. The purpose of Addendum II was to provide for the voluntary transfer of harvest quotas between states to alleviate concerns over potential bait shortages on a biologically responsible basis. Voluntary quota transfers require Technical Committee review and Management Board approval.

In March 2004, the Board approved Addendum III to the FMP. The addendum seeks to further the conservation of horseshoe crab and migratory shorebird populations in and around the Delaware Bay. It reduces harvest quotas and implements seasonal bait harvest closures in New Jersey, Delaware, and Maryland, and revises monitoring components for all jurisdictions.

II. Status of the Stock

The initial horseshoe crab stock assessment and peer review was conducted in 1998 (ASMFC 1999; ASMFC 1998). The Stock Assessment Subcommittee (SAS) and the Peer Review Panel (PRP) concluded that there was inadequate information for a coastwide stock assessment. Information was not available to establish biological reference points, fishing mortality rates, or recruitment estimates. The Technical Committee and PRP, based on their assessment of the available data, recommended a conservative, risk-averse management approach. This recommendation was based on localized population declines, increased catch and effort, slow maturation, susceptibility of spawning crabs to harvest, population resiliency, and the need for a superabundance of horseshoe crab eggs in the Delaware Bay.

Under the five-year trigger, a horseshoe crab stock assessment update was conducted in 2003 (ASMFC 2004), which employed trend, power and meta-analyses. The addition of several new datasets and the longer time series allowed for improved trend detection. Once again, the assessment methodology was not, in itself, considered a complete stock assessment as it did not provide estimates of biological reference points or stock status. Such estimates are not expected until sufficient data are obtained and incorporated into a model proposed by the Horseshoe Crab Stock Assessment Subcommittee (HSC SAS 2000).

Results from the most recent assessment indicated that horseshoe crab abundance trends varied regionally/sub-regionally. There was no evidence of a decline in the Southeast Region between 1995 and 2003. Four of five indices in western Long Island Sound showed significant or marginally significant positive trends. No trend was detected in eastern Long Island sound. However, indices trended downward since their peak in the early to mid-1990s and are at levels near or below those encountered in the mid-1980s. In the New England region, the Narragansett Bay data sets indicated population decline from the mid-1970s to present; however, the trends around Cape Cod were less clear. There was evidence that horseshoe crab abundance in Cape Cod was stable or declining.

Abundance measures in the Delaware Bay declined significantly during the 1990s. Declines from the late 1980s to early 1990s appear to be steeper than declines in recent years. However, the slopes of these declines were not statistically significant. The redesigned Delaware Bay spawning survey showed no significant change in relative abundance from 1999 to 2002, with changes in excess of 7 to 8% per year (28% decline or 36% increase over four years) unlikely.

Based on these most recent findings, the SAS recommended a continued precautionary management approach coastwide, particularly in the Delaware Bay region.

III. Status of the Fishery

Bait Fishery

Reported coastwide horseshoe crab bait landings have declined relative to the reference period (1995-1997 for most states; 1998-1999 for others) (Table 1, Figure 1). There was a small increase in landings observed from 2001 to 2002. There was no clear explanation for this increase, other than response to market demand. Preliminary reported bait landings in 2003 were about 66% below the reference period.

An alternative bait/gear workshop conducted under the auspices of ASMFC in 1999 introduced the concept of using bait savings devices (bait bags) in whelk (conch) pots. Free bait bags were distributed to whelk potters in the Mid Atlantic and southern New England regions through a partnership with the Ecological Research and Development Group (ERDG), NOAA, the states of Delaware, Maryland, New Jersey, Virginia, New York, Connecticut, Rhode Island and Massachusetts. The reductions in reported bait landings in excess of the 25% reductions required under Addendum I were largely attributed to the success of this program, with the widespread use of the devices by the commercial fishery.

Coastwide reported bait landings in recent years slightly favored males, though a large percentage of the reported harvest in 1998 and 1999 was of an unspecified gender (Table 2). The American eel pot fishery prefers egg-laden female horseshoe crabs as bait, while the whelk (conch) pot fishery is less dependent on females.

The hand, trawl and dredge fisheries accounted for over 90% of the reported commercial horseshoe crab bait landings by gear type since 1998. The hand fishery alone accounted for over half of the reported coastwide landings each year since 1998. Though most state's landings were comprised of hand harvested crabs, the trawl fishery accounted for the most landings in Maryland and North Carolina during this period and the predominate gears used in Virginia state waters to land crabs were dredges and pounds.

The dominance of the hand fishery was reflected in the seasonal distribution of landings. Most of the coastwide harvest since 1998 came during May as the crabs come ashore to spawn and were thus readily available to the fishery. There was typically a secondary mode in monthly harvests during the late summer or fall. This secondary peak coincides with an increased demand for horseshoe crabs in the conch pot fishery.

Biomedical Fishery

The horseshoe crab is an important resource for research and manufacture of materials used for human health. Several companies along the Atlantic Coast continue to process horseshoe crab blood for use in manufacturing Limulus Amoebocyte Lysate (LAL). The State of North Carolina is no longer reporting a biomedical harvest, since Haemachem, Incorporated is closed and was sold. However, Georgia is now reporting a biomedical harvest for use by Endosafe, Incorporated in South Carolina. Georgia conducted a study to determine mortality of HSCs associated with their transport to and from South Carolina. For 2003, transportation mortality to the facility was 0.55% (55 of 9,984) and from was 1.59% (41 of 2,585). The large discrepancy between the animals that arrived at the facility and those that left was because of a die-off while in a holding pond. The HSC supplier attributed the die-off to a major rain event that lowered salinity levels in the holding pond.

The PRT believes it is important to better understand the biomedical harvest of horseshoe crabs. The Board supported this notion with the passing of Addendum III. States where horseshoe crabs are collected for biomedical use are now required to collect and report harvest data and characterize mortality. The landings will be reported as an aggregate, so as to keep individual company or state landings confidential.

IV. Status of Assessment Advice

A coastwide quantitative horseshoe crab stock assessment has not been completed. An internal review of the available data by the stock assessment subcommittee (SAS) was completed in August 1998, and reviewed by an external peer review panel (PRP) in October 1998. Both groups concluded that there was inadequate data to conduct a coastwide stock assessment.

The Stock Assessment Subcommittee and Peer Review Panel advised a conservative, risk-averse approach to the management of the horseshoe crab, and identified research needs to facilitate future assessments. Although the FMP maintained the risk-averse management initiated in NJ, DE, and MD, failure to cap harvest in other states resulted in a redistribution of landings and negated conservation efforts.

The SAS has proposed a framework for assessing the Atlantic coast horseshoe crab population (ASMFC SAS 2000). The framework recommends a catch-survey method be used to assess the East Coast horseshoe crab population. This method employs survey data and harvest numbers to relate the number of adults and recruits (individuals that will mature the following year) present in year t to the number of adults available to the fishery in year $t+1$, and permits the estimation of catchability and abundance of adults and recruits. Application of this model is dependent upon a long-term survey to reliably monitor recruit and adult horseshoe crab relative abundance, and the proportion of recruit and adults in the commercial landings. As such, a formal quantitative stock assessment probably remains 5 to 10 years away once a reliable survey is fully implemented.

V. Status of Research and Monitoring

The Horseshoe Crab FMP set forth an ambitious research and monitoring strategy in 1999 and again in 2004 to facilitate future management decisions. Despite limited time and funding there were many accomplishments since 1999. These accomplishments were largely made possible by forming partnerships between state, federal and private organizations, and the support of over a hundred public volunteers. Statistically robust spawner and egg count surveys were designed and in some areas implemented in the Delaware Bay. The U.S. Fish and Wildlife Service coordinated the coastwide horseshoe crab tagging program. Virginia Tech has conducted a horseshoe crab benthic survey annually since 2001. The USGS - Biological Resources Division (USGS-BRD) completed the first phase of a genetics project to evaluate whether or not regional horseshoe crab populations exist along the Atlantic coast.

USGS Genetic Population Structure Project

Stock identification/delineation work by the USGS-BRD has been completed. The project led by Dr. Tim King included a sampling of 900 horseshoe crabs from Maine to Yucatan. The results suggest four distinct management units the Atlantic coast. However, more sampling and analysis is needed to test the hypothesis. King's assignment test will make a useful tool in identifying the management unit from which a horseshoe crab came from when caught at sea.

Virginia Tech Research Projects

In 2003, Virginia Tech received approximately \$643K from Congress for various horseshoe crab research projects. Dr. Jim Berkson, Virginia Tech, initiated four proposed horseshoe crab projects including one that expanded his pilot benthic trawl survey. In 2003, different areas had been sampled for either 2 or 3 years of abundance data. Areas showed different trends in abundance, but firm conclusions should not be drawn from 2 to 3 years of data. The survey continued in 2004. As part of the survey researchers from Virginia Tech have been working on

the development of criteria to identify horseshoe crabs newly recruited to the spawning population. To date, no quick, effective method has been developed.

Spawning Surveys

The Delaware Bay horseshoe crab spawning survey has been annually conducted following the modified design developed during an ASMFC workshop in 1999. The survey is being conducted through a unique partnership between various state and federal agencies, a biomedical company, conservation groups, and numerous private citizens. The spawning survey coordinator is being funded by the state of Delaware using Atlantic Coastal Grant funds, the state of New Jersey provides staff for data entry and verification, the state of Maryland has contributed volunteers, and the USGS-BRD completes the annual data analysis. The survey is currently providing an estimate of female spawner abundance with good CVs (<10%) and should serve as a good tool to monitor horseshoe crab population using the Delaware Bay. The conclusion is that spawning activity in the Bay over the past five years is either stable or slightly declining. This work lacks permanent funding and is funded through the partnerships and short term funding each year. Funding was expected to continue through 2004.

Egg Studies

Egg density studies continue in the Delaware Bay, although sampling methodologies differ between the states of Delaware and New Jersey. The State of Delaware funded a study to further refine egg-sampling methodologies in 2001. Delaware was expected to sample horseshoe crab eggs (0-5 cm and 5-20 cm) in 2003; however, available funding may not have been sufficient to ensure complete sample coverage. The State of New Jersey also was expected to sample surface (0-5 cm) egg densities in 2003. The New Jersey egg sampling effort lacks a long-term funding source necessary to insure its continuation. The Technical Committee has recognized the importance of the study in each state. It recommended that the SAS coordinate with the Shorebird TC, NJ and DE to make the study more useful. In 2004, a working group convened to address this issue.

Tagging Studies

The USFWS continues to maintain an "800" telephone number for reporting horseshoe crab tag returns and assists interested parties in obtaining tags. It continued a study in Delaware in 2003 to determine horseshoe crab movement, spawning frequency and site fidelity. Results from work in 2002 revealed that one-third of tagged crabs were resighted at the same beach within three weeks of being tagged. Tagged females were observed spawning up to five times and males were observed spawning up to ten times during the study period.

Additional tagging work continues to be conducted by biomedical companies and other parties involved in outreach and spawning surveys. In some cases, the tagging efforts would benefit by establishing clearly defined objectives and insuring better coordination among researchers. The Tagging Subcommittee has initiated several projects to address the issues mentioned above. First, an application to potential horseshoe crab taggers has been developed for the USFWS in Annapolis. The application will give reviewers discretion when issuing tags and better

understanding of taggers' objectives. Second, the subcommittee requested the creation of a horseshoe crab tagging program database within the existing website (www.fishtag.info) that houses information of many other species' tagging programs. The website now has a portal to input information on tagging programs. Last, the subcommittee developed guidelines for a coastwide tagging program. The intent of drafting such guidelines is to encourage existing tagging programs to follow a similar direction and to provide new programs with direction. Ultimately, it is hoped that all horseshoe crab programs along the coast will be coordinated to achieve common objectives that will benefit management of the species.

Supplemental Bait and Alternative Trap Design

ASMFC and Ecological Research and Development Group (ERDG) coordinated and New Jersey, Delaware, and University of Delaware Sea Grant funded a workshop to explore ideas to increase or maintain conch fishing success while lowering dependence on horseshoe crabs as bait. This workshop built on a similar workshop conducted in 1999. Watermen agreed that horseshoe crab is, without question, the most effective bait currently available to catch conch. Researchers confirmed through lab and field-testing that no other bait catches conch as effectively as horseshoe crabs.

One of the most promising opportunities to significantly reduce or even eliminate the use of crabs for bait may come from the work of a University of Delaware researcher and private company in Maine. The lab of Nancy Targett from University of Delaware Sea Grant believes they have isolated the natural compound from the horseshoe crabs that attracts conch. The ultimate goal is to synthetically develop the compound without dependence on horseshoe crabs. The other piece of the puzzle, the substrate to hold the attractant, is being developed by Hydrophilix. It produces 1' x 1' sheets of synthetic "scaffold" that have about 12 sq ft of surface area and can be used to release substances into the water. If conch fishing effectiveness can be demonstrated, which may be many years away, potential benefits include decreased dependence on horseshoe crabs, ease of handling "bait", decrease in cost of bait, and ability to reuse and recycle sheets.

Another way to decrease dependence on horseshoe crabs for bait may be to use hemolymph, the byproduct of the biomedical bleeding process, to attract conch. Watermen have experimented with bait made from injecting hemolymph into a substrate, such as menhaden, and had fishing success equal to that using horseshoe crabs. Associates of Cape Cod (Massachusetts) and Cambrex (Maryland), biomedical companies that bleed horseshoe crabs, offered to provide watermen hemolymph for testing its effectiveness in attracting conch.

VI. Status of Management Measures and Issues

ASMFC:

The Horseshoe Crab Management Board initiated the addendum process in 2003. Addendum III was approved in March 2004. Among other things, it further restricts bait harvest in Delaware, New Jersey, and Maryland.

Shorebird:

The US Fish and Wildlife Service formed the Shorebird Technical Committee in 2001 with the purpose of providing technical advice to the Board on how horseshoe crab management action might affect shorebird populations. This Committee is comprised of shorebird experts and a representative of the horseshoe crab Technical Committee and Stock Assessment Subcommittee. The group produced a peer-reviewed report that synthesizes current literature and data on the status of shorebirds in the Delaware Bay and to determine their energetic dependency on horseshoe crab eggs. The report's findings led to the initiation of Addendum III.

VII. Current State by State Implementation of Compliance Requirements

Currently, there are no compliance issues for any ASMFC jurisdictions with regard to their horseshoe crab programs. All states have implemented the necessary monitoring components of the plan. The Plan Review Team (PRT) is concerned that some states are using trawl survey data in place of characterizing their fishery. The PRT has referred this issue to the stock assessment subcommittee for input on whether or not the information collected in this component of the plan is necessary for future stock assessments. ME, NH, PA, DC, PRFC, NC, SC, GA and FL have requested and qualify for *de minimis* status. Please see the PRT report on State Compliance for detailed information on each state's program. State reports for 2004 must reflect the changes made with Addendum III.

Law Enforcement:

The ASMFC Law Enforcement Committee obtained and compiled this information for inclusion into the PRT Report on State Compliance. There were no significant enforcement cases regarding horseshoe crabs raised in 2003.

VIII. Recommendations by the Plan Review Team

Funding for Research and Monitoring Activities:

The PRT strongly recommends the continuance of a benthic trawl survey in order to provide the necessary information for future stock assessments. A long-term benthic sampling program for horseshoe crabs has been repeatedly identified as a critical stock assessment need. The pilot trawl study conducted in 2001 clearly showed that this project could provide a statistically reliable estimate of horseshoe crab relative abundance at a relatively low cost. If congressional funding does not continue to support Dr. Berkson's research, the PRT recommends a state and federal partnership to fund a 'coastwide' trawl survey.

Tagging:

The Technical Committee has recognized the need for reconvening the horseshoe crab tagging subcommittee. This need is supported by the PRT, recognizing the potential benefits to defining management units, gleaning life history information and the potential for estimating mortality and determining stock size. The PRT recognizes that a number of tagging efforts are underway along the coast, some of which lack clearly defined objectives. All entities that currently have tagging programs are encouraged to continue. The PRT recommends using USFWS tags and reporting all data to the repository in the USFWS office in Annapolis.

Biomedical Industry:

The PRT reminds states that they are required to obtain the information outlined in Addendum III. This became a requirement in 2004. Please refer to Monitoring Requirement Component A₂. States must report that information in their annual compliance reports. The Commission would reevaluate potential restrictions on biomedical harvest if mortality exceeds 57,500 horseshoe crabs per year.

IX. Literature Cited.

ASMFC. 1998. Terms of Reference & Advisory Report for the Horseshoe Crab Stock Assessment Peer Review. Stock Assessment Report No. 98-01 of the Atlantic States Marine Fisheries Commission. Washington D.C. 15pp.

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ASMFC Horseshoe Crab Stock Assessment Subcommittee. 2000. Stock Assessment of Atlantic Coast Horseshoe Crab: A Proposed Framework. 19pp.

Table 1. Reported commercial horseshoe crab bait landings by jurisdiction.

Jurisdiction	RPL	Quota ^a	1998	1999	2000	2001	2002	Preliminary 2003
ME	13,500	13,500	13,500	1,500	1,391	100	150	
NH	350	350	200	350	180	0	120	0
MA	440,503	330,377	400,000	545,715	272,930	134,143	138,613	125,364
RI	26,053	26,053		26,053	13,809	3,490	3,886	5,824
CT ^b	64,919	48,689	34,583	45,050	15,921	11,508	32,080	13,386
NY	488,362	366,272	352,462	394,026	628,442	129,124	177,052	133,034
NJ	604,049	453,037	241,456	297,680	398,629	261,239	281,134	113,940
PA	-	-	75,000	-	0	0	0	0
DE	482,401	361,801	479,634	428,980	248,938	244,813	298,318	356,380
MD	613,225	459,919	114,458	134,068	152,275	170,653	278,211	168,865
PRFC	-	-		-	0	0	0	0
DC	-	-		-	0	0	0	0
VA ^c	203,326	152,495	1,015,700	650,640	145,465	48,880	42,954	106,577
NC ^d	24,036	24,036	21,392	28,094	14,973	9,130	12,906	10,860
SC	-	-		-	0	0	0	0
GA	29,312	29,312		29,312	0	0	0	0
FL	9,455	9,455	0	4,566	10,462	0	200	1,628
TOTAL	2,999,491	2,275,296	2,748,385	2,586,034	1,903,415	1,013,080	1,265,624	1,035,858
Pct. Reduction Relative to RPL			8.4	13.8	36.5	66.2	57.8	65.5
Pct. Reduction Relative to Quota					16.3	55.5	44.4	54.5

^a States that qualify for de minimis status are not required to reduce landings by 25%

^b CT landings prior to 2000 are estimated based on bait usage in the eel and conch fisheries.

^c VA preliminary 2003 landings do not include by-catch from non-permitted fishermen (limited to 100 crabs).

^d 2003 NC landings through September only

Table 2. Commercial horseshoe crab bait landings by sex by jurisdiction.

	1998			1999			2000			2001			2002		
	Males	Females	Unknown	Males	Females	Unknown	Males	Females	Unknown	Males	Females	Unknown	Males	Females	Unknown
ME	*	*	13,500	*	*	1,500	*	*	1,391	*	*	100	*	*	150
NH	*	*	200	*	*	350	*	*	180	0	0	0	0	0	120
MA	*	*	400,000	269,153	276,562	0	118,596	154,334	0	65,072	69,071	0	63,072	67,380	8,161
RI	*	*		*	*	26,053	*	*	13,809	*	*	3,490	*	*	3,886
CT	*	*	34,583	27,631	17,419	0	5,525	10,396	0	6,870	4,638	0	14,617	17,463	0
NY	*	*	352,462	*	*	394,026	288,305	338,637	1,500	48,381	80,743	0	77,937	99,115	0
PA	*	*	75,000	0	0	0	0	0	0	0	0	0	0	0	0
NJ	173,660	67,796	0	199,216	98,464	0	303,381	95,248	0	192,999	68,240	0	200,375	78,745	2,014
DE	220,326	259,308	0	237,137	191,843	0	153,860	95,078	0	109,496	135,317	0	180,700	117,618	0
MD	30,539	68,524	15,395	19,234	91,032	23,802	67,243	76,380	8,652	83,725	84,607	2,321	176,642	101,569	0
PRFC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VA	*	*	1,015,700	*	*	650,640			145,465	*	*	48,880	*	*	42,954
NC	*	*	21,392	*	*	28,094			14,973	*	*	9,130	*	*	12,906
SC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GA	0	0	0	*	*	29,312	0	0	0	0	0	0	0	0	0
FL	*	*	0	*	*	4,566	*	*	10,462	*	*	0	*	*	200
Total	424,525	395,628	1,928,232	752,371	675,320	1,158,343	936,910	770,073	196,432	506,543	442,616	63,921	713,343	481,890	70,391
Grand Total	2,748,385			2,586,034			1,903,415			1,013,080			1,265,624		

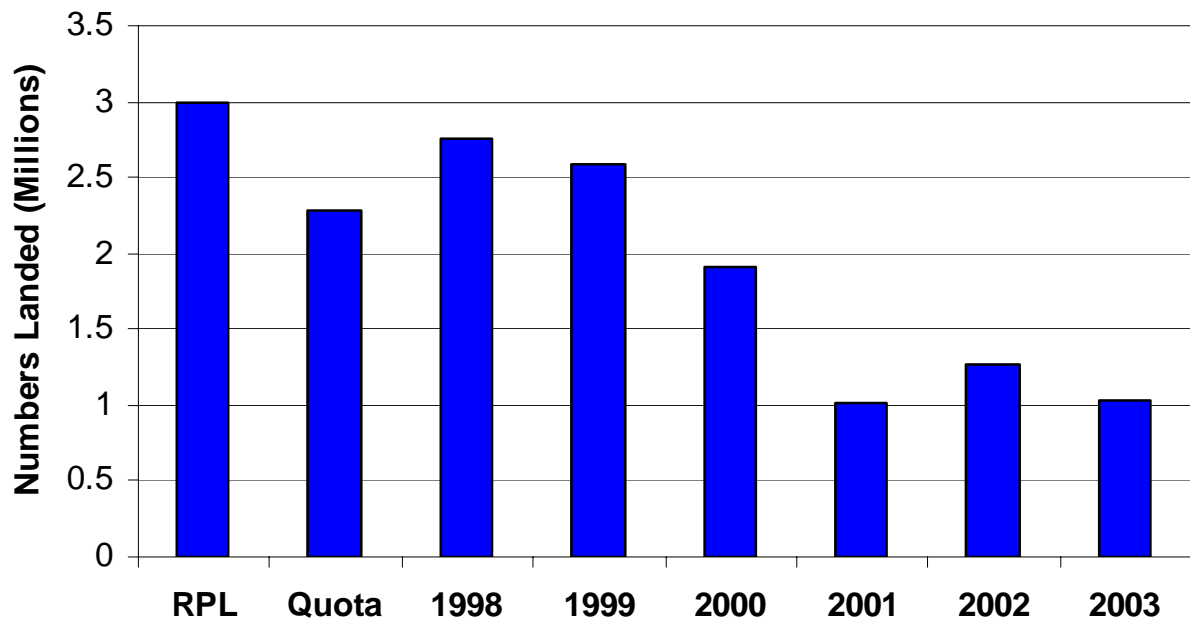


Figure 1. Coastwide horseshoe crab landings expressed as number of crabs (millions).
(RPL = Reference period landings)