EXHIBIT A

Stock Assessment Report

Stock Assessment Subcommittee

for the Horseshoe Crab

Atlantic States Marine Fisheries Commission

July 1998

Introduction

The status of the horseshoe crab populations along the Atlantic coast has recently received great attention. Horseshoe crabs play an important role in marine and estuarine ecosystems. In addition, the species serves as a primary bait source for several important commercial fisheries, supports a substantial eco-tourism industry, and is the backbone of a major biomedical process. Despite its importance, little is known about horseshoe crab abundance and stock dynamics. In light of concern that a decrease in abundance would be devastating to several major industries the Atlantic States Marine Fisheries Commission investigate the horseshoe crab stock. At the direction of the horseshoe crab technical committee, the stock assessment committee (SAC) was formed to review and analyze the status of the horseshoe crab stock using the best available data.

This document represents the first effort to synthesize available horseshoe crab data. Available data include commercial landings data, state and federal fisheries independent surveys, spawning counts, and egg abundance surveys. Surveys were analyzed to determine recent trends and patterns in stock abundance and fishery performance. Due to the short amount of available working time, data analysis has been restricted to data synthesis, summarization, and trend analysis. The SAC cautions that the findings of this report are preliminary and a more detailed analysis may lead to more comprehensive findings.

Commercial Harvest Data

Commercial landings data were available from the National Marine Fisheries Service (NMFS) commercial landings database. These data were supplemented with updated state commercial landings information where applicable.

Reported commercial landings have increased substantially in recent years (Figure 1). The SAC discussed three reasons for this increase.

1) An increase in total fishing effort

2) An increase in horseshoe crab population size

3) A change in reporting requirements

It is the view of the SAC that the increase in reported landings during the 1990's is due to a combination of increased fishing effort and modifications to state and federal reporting requirements. Relative abundance indices from state and federal fisheries independent trawl surveys show no evidence for an increase in population size. There is state data to show increases in total fishing effort (expressed as number of horseshoe crab harvest permits issued and participation in eel and conch pot fisheries), and reporting requirements. However, the SAC retains some reservations about the available landings data, and cautions that the data are

incomplete. Landings data by gear show inconsistencies in reporting. Consequently, the magnitude of the increase in landings may not accurately reflect true landings.

State Trawl Surveys

Peconic Bay Small Mesh Trawl Survey

In 1985, the New York Department of Environmental Conservation began a small mesh trawl survey in the Peconic Bay Estuary (eastern end of Long Island). The survey conducts 10 minute tows using a 16 foot semi-balloon shrimp trawl with 0.5" stretch mesh codend liner. The sample area is divided into 77 one minute square cells, of which 16 are randomly selected and sampled weekly from May to October.

Abundance information on horseshoe crabs has been collected by this survey since 1987. Figure 2 shows the geometric mean catch per tow since 1987. During this time period, horseshoe crab abundance has varied without trend ($R^2 = 0.23$, $P = 0.1313$) in the Peconic Bay Estuary.

Collection of horseshoe crab prosomal width data began in 1997. These data showed that the trawl survey is collecting primarily adult crabs. There was not sufficient prosomal width data to use in the assessment.

Stock Assessment of New Jersey's Near Shore Recreational Fisheries Resources

New Jersey has been conducting a stratified random trawl survey between Ambrose Channel and Cape Henlopen Channel from 18 to 90 feet since 1988. During 5 annual cruises, 20 minute tows are conducted in each of 15 strata using a two seam trawl net with a 100' footrope and a codend equipped with a 0.25" mesh liner.

Horseshoe crab data have been collected by this survey since 1988. Geometric mean number per tow are shown in Figure 3. Abundance has varied without trend ($R^2 = 0.2343$, $P = 0.1867$) during this time period. Prosomal width data were collected beginning in 1996. These data were not included in this assessment. Sex ratio information was also collected beginning in 1996. Overall sex ratio for 1996 is 1:1.4 males to females.

Delaware 30-Foot Trawl Survey

The Delaware Division of Fish and Wildlife began collecting statistics on horseshoe crabs in 1990, as part of its adult finfish trawl sampling program. The survey employed a 30.5-foot (headrope) otter trawl, with 3-inch stretch mesh in the wings and body and 2-inch stretch mesh in the cod end. The footrope is equipped with continuous ¼-inch chain hung loop-style . Sampling is conducted monthly from March through December at nine fixed stations in the Delaware Bay.

Horseshoe crabs were counted, weighed, sexed and measured for prosomal width. Indices of relative abundance were developed and expressed as the geometric mean catch per tow (Figure 4).

Annual relative abundance showed a significant ($P = 0.02$; $R^2 = 0.61$) decline from 1990 - 1997. The highest annual catch rates occurred in 1990 and 1991 and reached a low in 1994. Mean prosomal widths recorded in the survey (Table 1) indicated no significant ($P = 0.7061$; $R^2 = 0.03$) trend. Weights were not recorded in the survey until 1996 and therefore no analysis was conducted.

Chi-square analysis of annual sex ratios in the adult (>16cm) catch component were not significantly ($P \leq 0.05$) different from 1:1 for the period 1990 to 1992. Sex ratios were significantly skewed favoring males ($\approx$ 1.4:1) in 1993 and 1994, then returned to approximate 1:1 from 1995-97.

Delaware 16-Foot Trawl Survey

The Delaware Division of Fish and Wildlife conducted a trawl survey in the Delaware Bay to monitor primarily juvenile finfish and blue crab abundance. In 1992, the Division began collecting information on juvenile (<16 cm) horseshoe crab abundance. The survey used a 16-foot semi-balloon otter trawl with 1.5-inch stretch mesh in the wings and body and a 0.5-inch stretch mesh liner. Ten-minute tows were made from April through October at 34 fixed stations. Juvenile horseshoe crabs were counted and measured for prosomal width. A geometric mean catch per tow was calculated as a measure of relative abundance.

Relative abundance was highest in 1995 and the series low occurred in 1992 (Figure 5). No significant ($P=0.3453$; $R^2=0.22$) trend in relative abundance was noted. Several year-classes were represented in the annual relative abundance values, based on visual inspection of prosomal width frequencies. Development of a young-of-the-year or Age 1 recruitment index should be possible and is encouraged by the SAC.

Maryland Coastal Bays Trawl Survey

The Maryland Department of Natural Resources has conducted a trawl survey of Maryland's coastal bays since 1972. The survey employed a 16 foot semi-balloon otter trawl with a 0.5" stretch mesh liner. Prior to 1988, the survey was not standardized. Low sample sizes and erratic sampling periodicity make the data unreliable for this time period. Starting in 1988, six minute tows were conducted at 20 fixed stations monthly from April through October. Horseshoe crabs collected in the survey were counted and measured for prosomal width and sexed. Indices of relative abundance were expressed as geometric mean catch per tow (Figure 6).

Examination of horseshoe crab relative abundance since 1988 showed no significant trend ($P = 0.2712$; $R^2 = 0.15$). Prosomal width and sex ratio data have only recently been collected and this information was not provided to the SAC for inclusion.

Horseshoe Crab Spawning Count Survey

Delaware

Limuli Laboratories has sponsored a volunteer-based horseshoe crab spawning survey in the Delaware Bay every year since 1990. The survey technique has evolved from a one-day event to the current multiple-survey technique which emphasizes counts around the new and full moon phases within the traditional peak spawning period in May and June. The beach spawner surveys initially assumed that spawner abundance on pre-selected survey dates would provide an index of abundance of horseshoe crabs spawning on Delaware Bay beaches. Increased concerns over the fact that timing of "peak" horseshoe crab spawning is variable between years and between locations within years has led to the recent use of multiple surveys within a year, employing numerous standardized 5-meter segments of beaches as sampling units. This latter design has confirmed the suspicion that "peak" spawning events are temporally and spatially variable, and as such, indices based on pre-selected peak spawning dates (Figure 7) should be viewed with caution.

Multiple surveys per year were instituted in 1994 in an attempt to bracket the time when horseshoe crab appeared on spawning beaches in greatest numbers. This approach begins to better define the temporal and spatial distribution of horseshoe crab spawning, but still suffers from several biotic and design-related inconsistencies:

1) the number of beaches surveyed on each date differs between and within years,

2) significant spawning may have occurred prior to onset of survey and subsequent to termination of survey,

3) variable weather clearly affects the nature of the distribution curve for horseshoe crab spawning,

4) in the absence of any statistically rigorous information on absolute abundance, the beach spawner data has yet to be "groundtruthed" as being a truly representative or reliable index of actual numbers. This assumption bears further inspection.

The beach spawner index does correlate well with the ongoing horseshoe crab data from Delaware's annual trawl survey (Figure 8). The close association of these two independent measures does provide greater strength of evidence that each is in some way representative of actual horseshoe crab abundance in the Delaware Bay region.

Of interest in the Delaware Bay beach spawning survey data is the suggestion that the highest proportion of total spawners shifted from New Jersey beaches to the Delaware beaches around 1993 (Figure 7). It is unclear whether this trend results from a true preference shift by the animals, or if perhaps the segment which normally spawns on New Jersey beaches has decreased in abundance while Delaware spawners have remained relatively constant.

Maryland

Maryland DNR initiated horseshoe crab spawning surveys in 1994 , documenting spawning throughout Maryland's Chesapeake Bay, plus several other coastal bays and tributaries. The surveys were designed to document the between and within year variability in horseshoe crab spawning in Maryland waters, and as such are less suited for generating total abundance estimates. Survey data corroborate the suggestion (from the Delaware Bay spawner surveys) that peak spawning periods are not strictly determined by the lunar cycle and thus periods of "peak" spawning are difficult to predict and monitor with 1- or 2-day surveys. The Maryland surveys are useful in further defining the nature of the spatial and temporal distribution of horseshoe crab spawning in the Chesapeake region.

Recommendations

The decrease in horseshoe crab abundance suggested by the beach spawning data for the 1992 - 1995 period is of concern to the stock assessment committee, but is difficult to put in perspective due to the relatively short time series. The presence of annual variability in the technique and spatial and temporal coverage of the surveys, coupled with the uncertain relationship between spawner index and population abundance, further compromises the applicability of these data for stock assessment. For these reasons, the stock assessment committee has chosen to not use data from the spawning surveys in their quantitative stock assessment. The committee suggests, however, that the spawner surveys be continually refined for purposes of monitoring the horseshoe crab population. The ultimate objective should be to estimate the total number of spawners present in a system. Spawner surveys should initially encompass as much of the temporal and spatial extent of spawning as possible in order to better characterize the distribution of spawners through time and space. As this knowledge is institutionalized, efficiencies of sampling may become possible, such that key index areas or beaches may provide sufficient information to adequately index the abundance of spawning horseshoe crabs in the indexed system.

Delaware Bay Horseshoe Crab Egg Count Survey

A survey of horseshoe crab egg abundance was conducted on the New Jersey coast of Delaware Bay during the springs of 1990, 1991, 1996, and 1997. Core samples were taken at random sites along select beaches, and egg abundance was measured from 0-5 cm depth and 15-20 cm depth. Eggs from the top layer are available to feeding shore birds, while those from the lower layer will presumably hatch.

During the peak spawning period, most beaches showed a decrease in egg abundance of more than 70% between 1990-91 and 1996-97 in the 15-20 cm region, and at least 65% in the 0-5 cm region. However, the Delaware Bay spawning count survey showed that 80% and 57% of the horseshoe crabs spawning in Delaware bay spawned on New Jersey beaches in 1990 and 1991, and only 21% spawned on New Jersey beaches in 1996 and 1997. The decrease in egg abundance may therefore be attributed to a shift in spawning habitat, rather than a decrease in spawning abundance.

The horseshoe crab stock assessment committee has chosen to not use the results of this survey in the current stock assessment. The lack of a similar study on Delaware beaches, coupled with the short time series and uncertainty in the reason for the decline in egg abundance (resulting from problems with the spawning count survey methodologies) have led to this decision. The committee suggests, however, that the egg count survey be further investigated as a means to monitor the horseshoe crab population. A reliable egg count survey across all spawning habitats might be sufficient to monitor the health of the horseshoe crab population.

NMFS/NEFSC SURVEYS

The National Marine Fisheries Service / Northeast Fisheries Science Center (NMFS/NEFSC) provided data from various surveys conducted along the Atlantic coast including the winter, spring, summer, and autumn trawl surveys, clam dredge survey, and scallop dredge survey. The winter and summer trawl surveys, the clam dredge survey and the scallop survey were deemed inappropriate for use due to discontinuities in the series, gear inefficiencies, seasonal bias or abbreviated duration. The spring and autumn trawl surveys were deemed appropriate for inclusion.

Spring and autumn sampling was conducted using a stratified random sampling design. A #34 Yankee otter trawl equipped with 4-inch continuous cookies over 22.5-feet of the outer sweeps, and 5 x 16 - inch (w x d) rollers, separated by two 7 x 5 - inch spacers, over 35- feet of the center sweep. Tows were conducted at 3.5 knots in a randomized direction for 30-minutes. Sampling was conducted on a 24 hour basis. Horseshoe crabs were weighed, counted, sexed and measured for prosomal width. Indices were derived from only random tows, where no significant gear damage occurred and were expressed as the geometric mean catch per tow.

The NMFS/NEFSC spring and autumn trawl survey data was provided for the years 1975-97. Gear changes were noted in the two NMFS/NEFSC time series. The NMFS was forced to use the *R/V DELAWARE II* when the primary research vessel, the *R/V ALBATROSS IV*, was not available. The NMFS was also forced to change trawl door types in 1985, when the manufacturer could no longer provide doors built to the required specifications. Byrne et al. (1991) reported on the effects of these gear changes for numerous species and concluded that analyses using corrected and uncorrected survey data should be made and explored, until a clear judgement can be made as to which analysis is most appropriate.

Byrne et al. (1991) reported a conversion coefficient to be applied to the *DELAWARE II* horseshoe crab catch. Horseshoe crabs were collected in 16 paired tows. Byrne et al. (1991) cautioned the application of conversion coefficients where a species was collected in less than 30-paired tows. The SAC reviewed the application of the conversion coefficients and concluded that they did not change the overall trend. These conversion coefficients apply most aptly to more mobile pelagics, the catches of which are significantly impacted by retrieval speed differences in the research vessels. Therefore, it was the judgement of the SAC to exclude the vessel conversion coefficient.

The SAC committee also reviewed the effect of the door change on the analyses. No door conversion coefficients were reported for horseshoe crabs. The spring and autumn time series showed a discontinuity, with a higher equilibrium occurring from 1975-84 and a lower equilibrium occurring from 1985-97. The separatrix (or shift in equilibrium) coincided with the change in door type. Several pieces of corroborating evidence suggested the shift in mean relative abundance was an artifact of the gear change and not a true decline in relative abundance. Mean spring and autumn prosomal widths increased significantly ($P = 0.0157$; $R^2 = 0.30$: $P = 0.0143$; $R^2 = 0.32$) from 1979 - 97 (Table 2). Mean spring survey weights (1975 - 97) increased significantly ($P = 0.0018$; $R^2 = 0.41$) and mean autumn weights (1976 - 96) exhibited no significant ($P = 0.2269$; $R^2 = 0.07$) trend. Additionally, although landings data suffer many inadequacies, harvest increases on the order of magnitude necessary to induce such a population decline were not apparent.

Conversely, field observations and SCANMAR gear mensuration equipment suggested that the gear tended bottom better and spread the wings wider (Byrne et al. 1991). Relative abundance appeared to change gradually, as opposed to an abrupt change as might be expected with an abrupt change in sampling gear. Further, disagreement concerning the effect of the increased tension on performance of the roller gear lead to an inconclusive judgement regarding the effect of this gear change. The SAC concluded that the most prudent course of action was to use the post-1984 data.

After considerable review, the Stock Assessment Committee (SAC) selected an area of the coast between New York and Cape Hatteras and at depths ≤ 27 meters to develop indices of relative abundance. Beyond 27 m the intercept of horseshoe crabs appeared to be a rare event. Further, information from the New Jersey ocean trawl survey indicated that the preponderance of horseshoe crabs were collected at depths less than nine meters. The NMFS/NEFSC trawl surveys, generally, did not sample at these depths. Despite the complicating effects of the roller gear, the SAC concluded that the NMFS trawl surveys presented the most consistent long-term data and, as such, provided the most appropriate data for indexing horseshoe crab abundance trends since the mid-1980's.

The NMFS/NEFSC spring survey indicated no significant ($P = 0.5805$; $R^2 = 0.03$) trend in relative abundance since 1985 (Figure 9). Relative abundance peaked in 1995 and was lowest in 1991. Examination of the mean prosomal widths for the same period revealed no significant ($P = 0.5086$; $R^2 = 0.04$) trend. Annual mean weights similarly varied without significant ($P = 0.6354$; $R^2 = 0.02$) trend.

The NMFS/NEFSC autumn survey showed no significant ($P = 0.6354$; $R^2 = 0.02$) trend in relative abundance since 1985 (Figure 10). The peak annual catch rate occurred in 1991 and was lowest in 1995. The spring and autumn indices showed no significant ($P = 0.3406$; $R^2 = 0.09$) correlation. Annual mean prosomal widths varied without trend ($P = 0.2513$; $R^2 = 0.12$), as did annual mean weights ($P = 0.4513$; $R^2 = 0.06$).

The SAC recommended that NMFS personnel be invited to review the effect of the gear change and /or provide video of the nets performance. It was also recommended that the effects of this gear change be further investigated by examining the effect of the door change on the relative abundance of a similar semi-burrowing species, such as whelk.

Conclusions

Much of the available information on horseshoe crab abundance and stock dynamics is of limited use. Many of the surveys that collect information on horseshoe crabs have significant survey design inadequacies. State and federal trawl surveys have been consistently measureable and comparable only since 1985. Much more rigorous data analysis than could be performed prior to the development of this document will be required in order to incorporate data from the unstandardized surveys.

Analysis of the state and federal survey data that the SAC felt was "clean" enough to be used in this stock report suggests that the horseshoe crab population in the mid-Atlantic region has remained stable in recent years. Recent (no earlier than 1985 to present) data from four state and two federal trawl surveys show no increasing or decreasing trend in horseshoe crab abundance.

One state trawl survey (Delaware) shows a decreasing abundance trend, but this may be an artifact of a short time series (1990-1997) and two influential points at the beginning of the survey period. A high correlation was found between the Delaware trawl survey and the Delaware beach spawning count survey, lending more credence to the evidence for a decline; however, the decrease evident in the spawning count survey may be a result of a shift in spawning habitat and not a decrease in abundance. Further, the data from the beach count survey was not included for stock assessment based on survey design inadequacies.

Commercial landings data show a substantial increase in harvest during the 1990's. The SAC believes this is a result of both an increase in fishing effort and a tightening of harvest reportorting requirements. The SAC is also aware that the available landings data are incomplete. Based on these deficiencies, the mangnitude of the increase in reported harvest may be greater or less than that reflected in the available data. Regardless of the magnitude, the increase in reported landings seems not to have had an adverse impact on the horseshoe crab population, based on available trawl survey data.

Recommendations

The SAC makes the following recommendations to the States:

- All states should require mandatory landings reporting;
- Continue state trawl surveys and to include information on sex, prosomal widths, weights and numbers;
- Stock identification is needed to define the management units;
- Tagging program and genetic analysis; and
- Continue to refine spawning surveys for use as abundance indices.

The SAC makes the following recommendations to the Technical Committee:

- Examine the effect of gear change on the NMFS trawl time series and its overall efficiency in monitoring the relative abundance of horseshoe crabs; and
- Investigate horseshoe crab aging techniques.

Literature Cited

Byrne, C., J. Forrester and D. Hayes. 1991. Report of the twelfth Northeast Regional Stock Assessment Workshop (12th SAW). Northeast Fisheries Science Center Reference Document 91-03. Woods Hole, MA. pp. 20-27.

Table 1. Horseshoe crab mean prosomal width data from the Delaware small mesh trawl survey.

Year	Prosomal width (cm)
1990	21.95
1991	22.19
1992	22.92
1993	22.49
1994	21.65
1995	22.36
1996	23.07
1997	22.06

Year	Spring Survey		Autumn Survey	
	Mean Weight (Kg)	Mean Width (cm)	Mean Weight (Kg)	Mean Width (cm)
1975	*	*	2.42	*
1976	1.00	*	1.24	*
1977	1.32	*	1.83	*
1978	0.99	*	1.48	*
1979	1.12	20.1	1.27	19.4
1980	1.44	20.6	1.70	23.0
1981	1.38	22.2	1.48	22.6
1982	1.35	20.8	1.57	22.5
1983	1.24	22.0	1.72	19.4
1984	1.31	21.8	1.98	23.0
1985	1.73	22.0	1.57	22.4
1986	1.15	20.8	2.08	23.8
1987	1.37	21.6	2.00	24.2
1988	1.59	22.1	1.62	21.7
1989	1.42	23.5	1.62	22.6
1990	1.65	22.9	1.85	23.1
1991	2.07	24.3	1.77	23.3
1992	1.51	21.9	1.62	22.6
1993	*	21.5	1.95	24.3
1994	1.41	22.4	1.66	22.2
1995	1.67	21.8	2.21	24.6
1996	1.50	22.5	1.91	24.3
1997	1.57	22.5	*	*

Table 2

Table. Annual sex ratios (expressed as percentages) and chi-square values for adult horseshoe crabs collected during 30 - foot trawl sampling in Delaware Bay.

Year	Pct. Male	Pct. Female	Chi-square
1990	53.7	46.3	2.75
1991	47.9	52.1	1.78
1992	50.1	49.9	0.002
1993	61.7	38.3	*19.9
1994	61.6	38.4	*9.5
1995	50.8	49.2	0.64
1996	47.2	52.8	1.61
1997	54.8	45.2	2.67

Note: Chi-square values assume a 1:1 sex ratio.

* indicates significantly different
P=0.05; Critical value of chi-square = 3.841

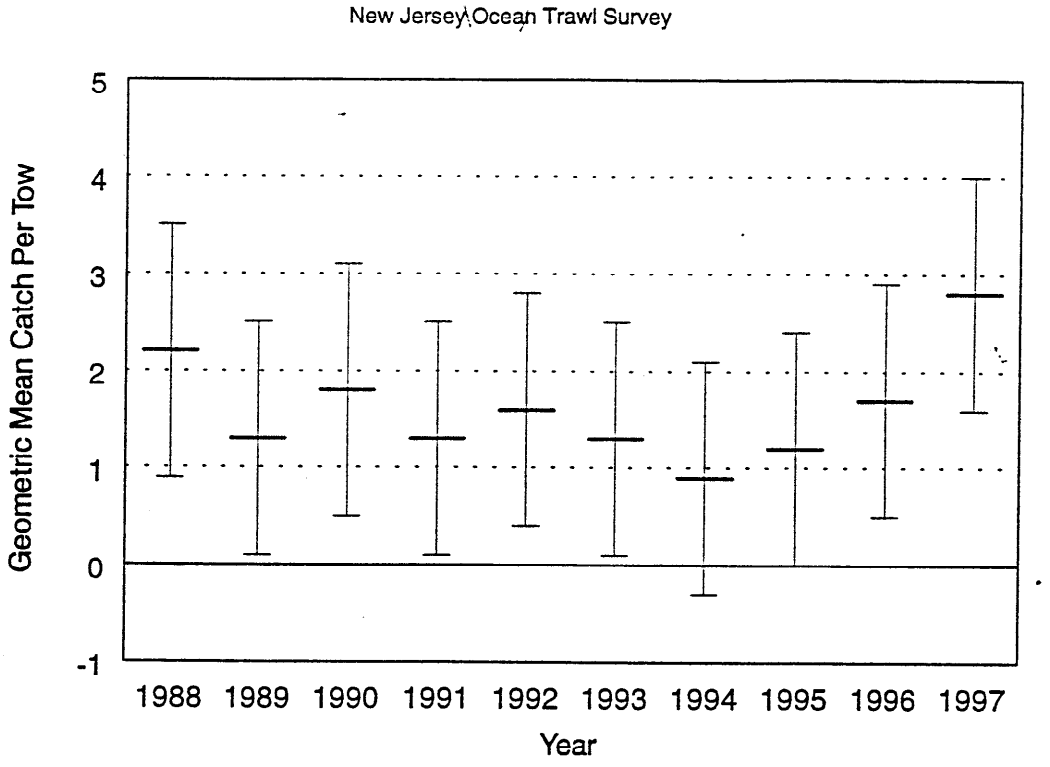

Figure 3. Geometric mean catch per tow from New Jersey's Near Shore Ocean trawl Survey.

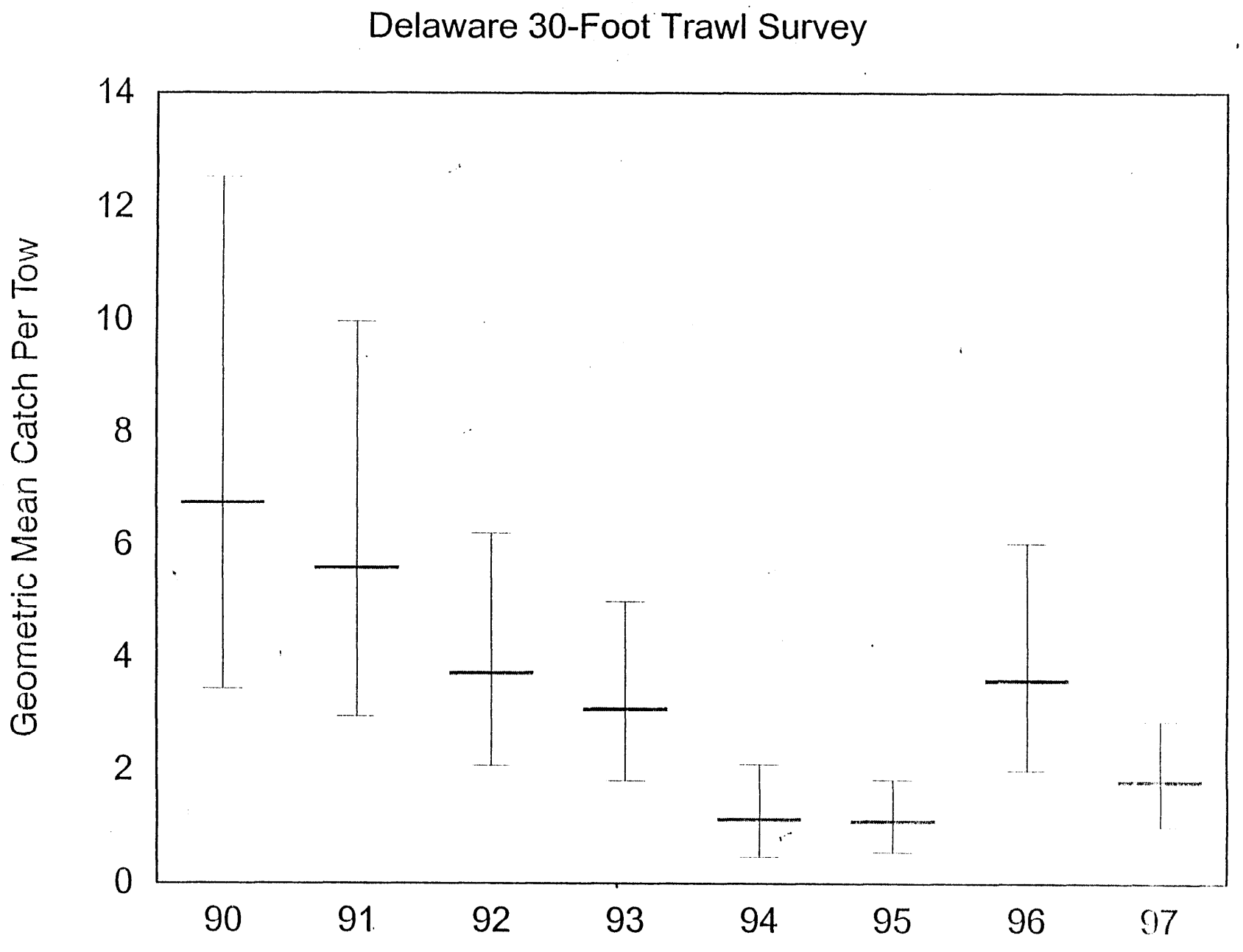
Delaware 30-Foot Trawl Survey
Geometric Mean Catch Per Tow
14
12
10
8
6
4
2
0
90
91
92
93
94
95
96
97

Figure 4

Horseshoe Crab Juvenile Index
Delaware 16 - Ft. Trawl

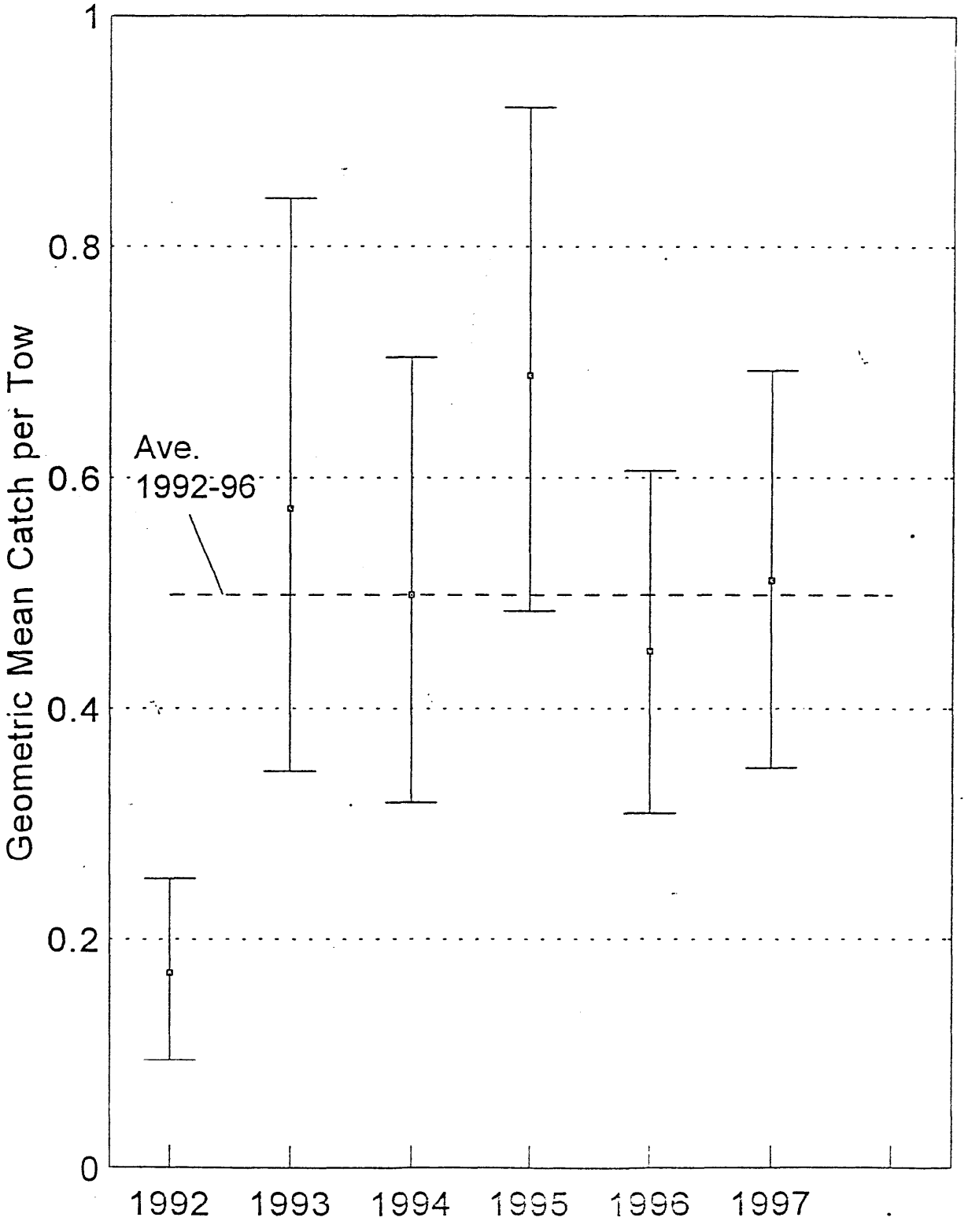

Figure 5

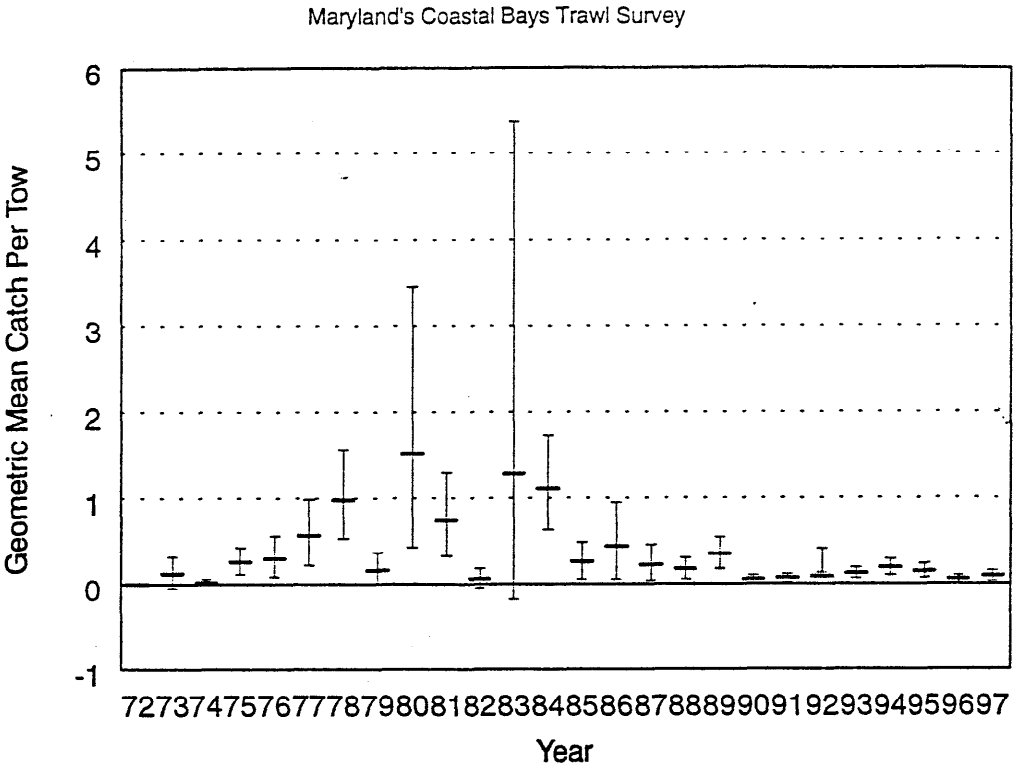

Figure 6. Geometric mean catch per tow from Maryland's Coastal Bays Trawl Survey.

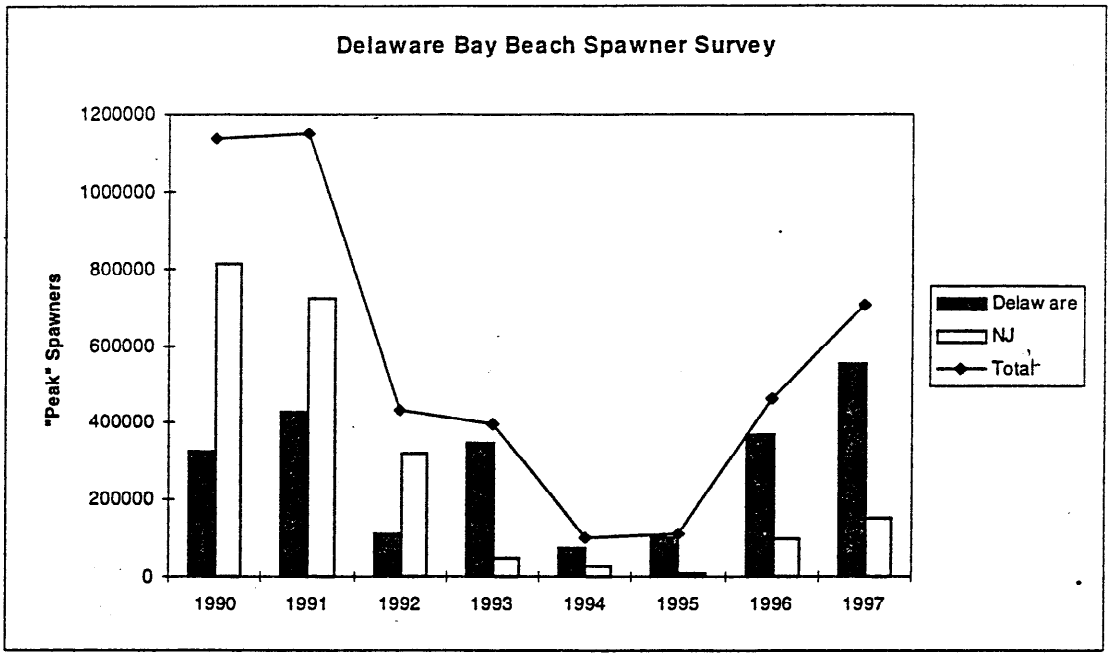

Figure 7. Delaware Bay Horseshoe crab spawner abundance indices based on pre-selected survey dates. Data from Swan, Hall, and Shuster, 1997. An Overview of Horseshoe Crab Spawning Activity along the Shores of Delaware Bay, 1990-1997.

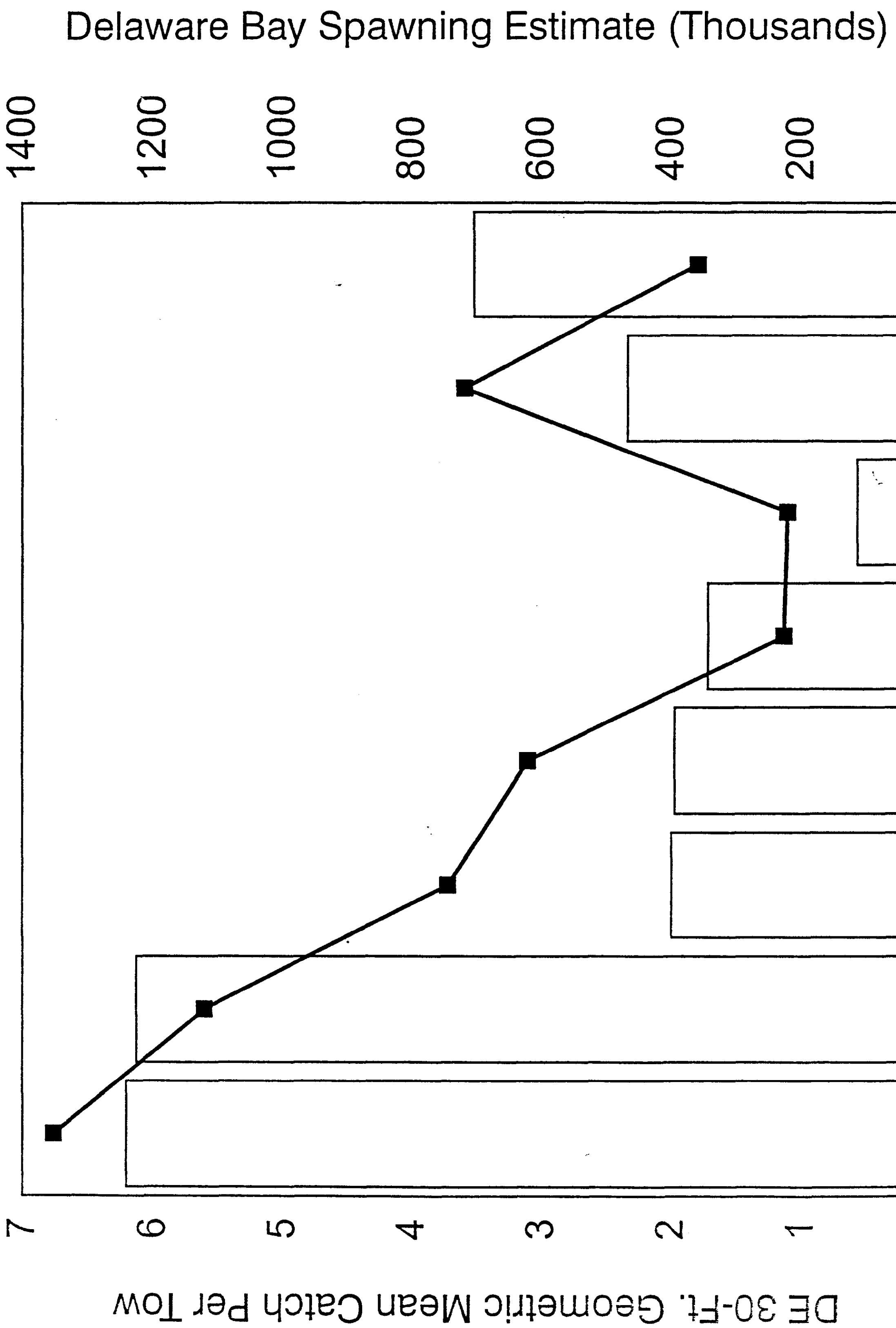
Delaware Bay Spawning Estimate (Thousands)
1400
1200
1000
800
600
400
200
0
90
91
92
93
94
95
96
97
7
6
5
4
3
2
1
0
DE 30-Ft. Geometric Mean Catch Per Tow

Figure 8

19

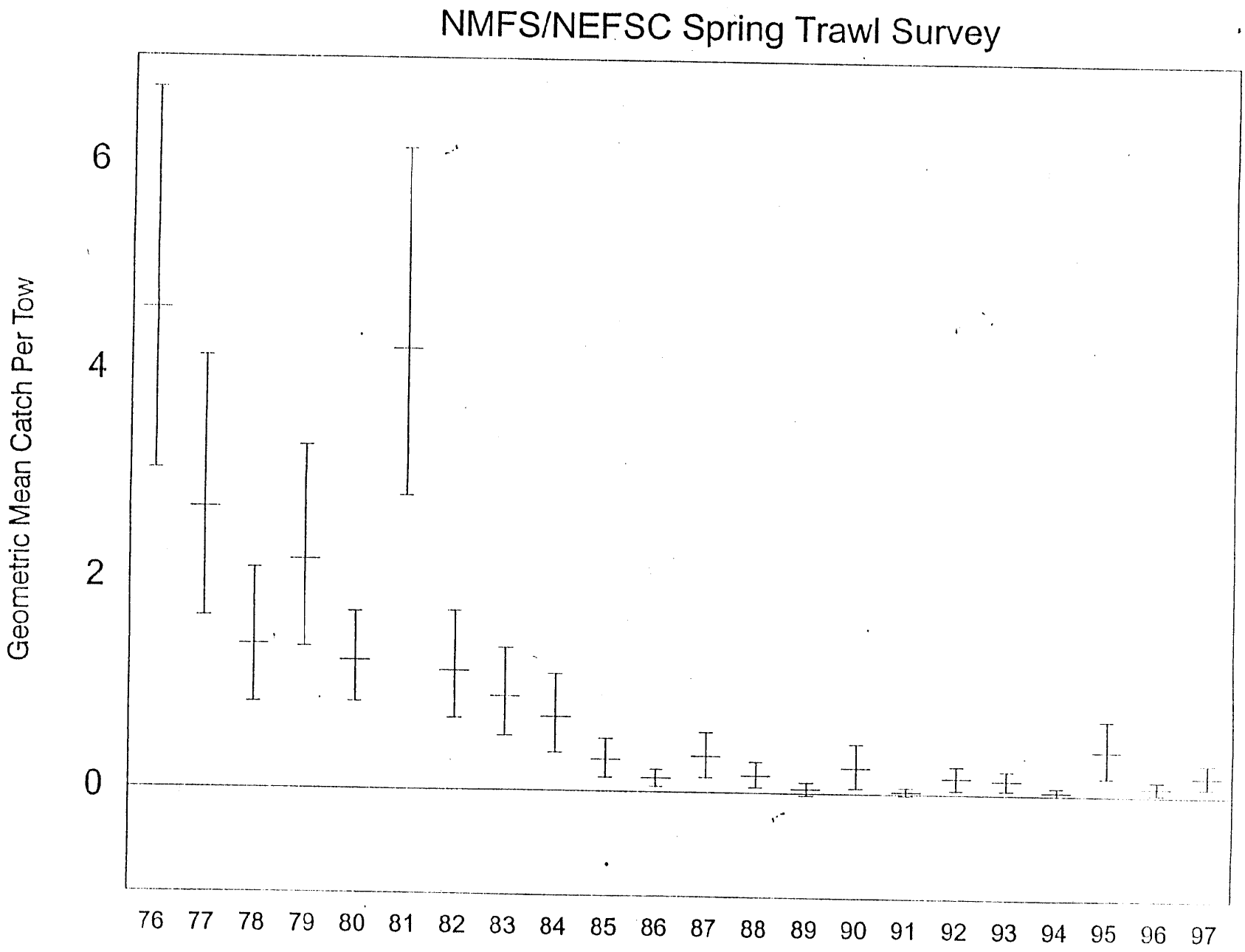
NMFS/NEFSC Spring Trawl Survey
Geometric Mean Catch Per Tow
0
2
4
6
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97

Figure 9

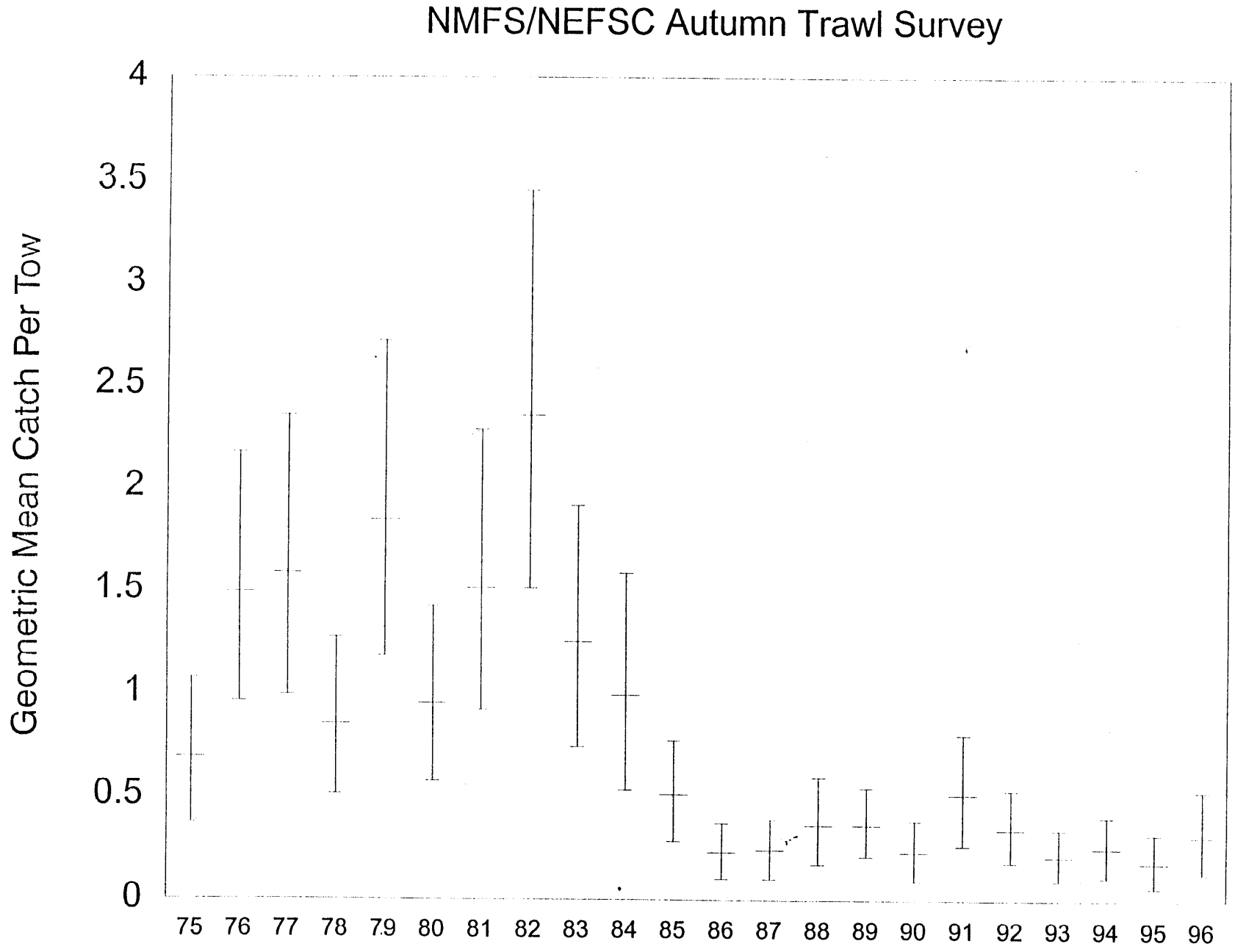
NMFS/NEFSC Autumn Trawl Survey
Geometric Mean Catch Per Tow
4
3.5
3
2.5
2
1.5
1
0.5
0
75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96

Figure 10

Stock Assessment Report No. 98-01 (Supplement)
of the

Atlantic States Marine Fisheries Commission

Horseshoe Crab Stock Assessment Report for Peer Review

Conducted on
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Richmond Virginia

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Preface

Summary of the Commission Peer Review Process

The Stock Assessment Peer Review Process, adopted in May 1997 by the Atlantic States Marine Fisheries Commission (Commission), was developed to standardize the process of stock assessment reviews and validate the Commission's stock assessments. The purpose of the peer review process is to: (1) ensure that stock assessments for all species managed by the Commission periodically undergo a formal peer review; (2) improve the quality of Commission stock assessments; (3) improve the credibility of the scientific basis for management; and (4) improve public understanding of fisheries stock assessments. The Commission stock assessment review process includes evaluation of input data, model development, model assumptions, scientific advice, and review of broad scientific issues, where appropriate.

The Stock Assessment Peer Review Process report outlines four options for conducting a peer review of Commission managed species. These options are, in order of priority:

1. The Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC) conducted by the National Marine Fisheries Service (NMFS), Northeast Fisheries Science Center (NEFSC).

2. A Commission stock assessment review panel composed of 3-4 stock assessment biologists (state, federal, university) will be formed for each review. The Commission review panel will include scientists from outside the range of the species to improve objectivity.

3. A formal review using the structure of existing organizations (i.e. American Fisheries Society (AFS), International Council for Exploration of the Sea (ICES), or the National Academy of Sciences).

4. An internal review of the stock assessment conducted through the Commission's existing structure (i.e. Technical Committee, Stock Assessment Committee).

Twice annually, the Commission's Interstate Fisheries Management Program (ISFMP) Policy Board prioritizes all Commission managed species based on species Management Board advice and other prioritization criteria. The species with highest priority are assigned to a review process to be conducted in a timely manner.

In June 1997, the horseshoe crab and Atlantic menhaden stock assessments were prioritized for an external peer review. An external review panel was formed of four stock assessment biologists with expertise in horseshoe crab biology, stock assessment techniques, and multispecies interactions. The external peer review for the horseshoe crab assessment was conducted September 28 - October 1, 1998 in Richmond, Virginia.

Purpose of the Terms of Reference and Advisory Report

The Terms of Reference and Advisory Report provides summary information concerning the horseshoe crab assessment and results of the external peer review to evaluate the accuracy of the data and assessment methods for this species. Specific details of the assessment are documented in a supplemental report entitled Horseshoe Crab Stock Assessment Report, while specific management measures are documented in the Draft Horseshoe Crab Fishery Management Plan. To obtain these documents please contact the Commission at (202) 289-6400.

Acknowledgments

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Executive Summary

The horseshoe crab, *Limulus polyphemus*, plays an important role in marine and estuarine systems, and supports several major industries, including commercial fisheries, biomedical products, and eco-tourism. Despite its importance, little is known about population dynamics of the species. This document synthesizes and analyzes available horseshoe crab data as a first step in the development of a fishery management plan for the horseshoe crab.

In the late 1800s and early 1900s, horseshoe crabs were commercially harvested for use as fertilizer and livestock feed. Millions of crabs were harvested annually from the 1870s to the 1930s at which point commercial landings appear to have dropped significantly. Commercial- scale harvest of crabs for fertilizer ceased in the 1960s.

In recent years, horseshoe crabs have been harvested for use as bait in the conch (whelk) and eel pot fisheries. Fishing effort for crabs is generally concentrated in mid-Atlantic coastal waters, but a significant fishery has been growing in the New England area. The major collecting methods include trawling as crabs migrate into and out of the spawning areas, dredging, and hand harvest during the spring spawning season. Reported commercial landings data collected by the National Marine Fisheries Service (NMFS) show a dramatic increase in harvest between 1990-1996.

Horseshoe crabs have been used for biomedical research and product development since the early 1900s. Currently, the major biomedical product is Limulus Amoebocyte Lysate (LAL), a clotting agent in horseshoe crab blood that is used to detect human pathogens in medical equipment. Approximately 250,000 crabs are collected, bled, and released annually to make LAL. Mortality on bled crabs is less than 15%, although mortality due to shipping and handling the crabs is unknown.

Relative to other fisheries, fishing regulations for horseshoe crabs are minimal or nonexistent. Several states along the Atlantic coast have recently initiated or proposed restrictive management measures.

Data from 9 state and federal fisheries independent sampling surveys (trawl and dredge), the Delaware Bay and Maryland horseshoe crab spawning count surveys, the Delaware Bay horseshoe crab egg count survey, and commercial landings were considered for use as horseshoe crab population indices. Many of the surveys suffered sampling design, gear or temporal inconsistencies. The most consistent surveys were used to investigate trends in relative abundance. Data from the Peconic Bay (New York), New Jersey, Delaware (30 foot and 16 foot), Maryland, and the NMFS (spring and fall) trawl surveys, as well as commercial landings data were used in the analysis.

The data analyzed suggest that the horseshoe crab population in the mid-Atlantic region has been stable or declining. Four state and two federal trawl surveys show no increasing or decreasing trend. Only the Delaware 30-foot trawl survey shows a significant decreasing trend in abundance. It must be noted, however, that the gears used for sampling may not be adequate to monitor horseshoe crab abundance trends, and these findings should be considered preliminary. Commercial landings show a significant increase in harvest during the 1990s. This can be attributed to both an increase in fishing effort and better reporting requirements.

Recommendations for future monitoring include mandatory reporting of horseshoe crab landings, evaluate the use of trawl surveys to monitor horseshoe crab abundance, analyze the effect of a gear change in the NMFS trawl survey, perform stock identification studies, develop a young of the year survey, and refine and expand spawning count and egg count surveys.

Advisory Report for the Horseshoe Crab Peer Review

State of Stocks

The available horseshoe crab data do not provide for any conclusions regarding trends in the horseshoe crab population coastwide. No trend could be identified in the data not because there is no trend, but due to the uninformative nature of the data. It is also not possible to identify whether the increase in landings has had an impact on the horseshoe crab population. Although no coastwide trends can be identified, several cases of apparent localized population declines were noted. These included the New Jersey spawning surveys and egg counts. While these cannot be extrapolated to the entire coast, they are cause for concern. This is especially true given the recent increases in catch and effort in the horseshoe crab fishery in these same areas.

Management Advice

The Panel has stated the following findings:

1. There is a lack of informative baseline stock abundance data on horseshoe crabs.

2. The catch in the horseshoe crab fishery has increased sharply in recent years, corresponding to a sharp increase in fishing effort in some areas.

3. There is no informative stock abundance data available on the response of the coastwide horseshoe crab populations to the recent increased catch and effort in the fishery.

4. As a species, horseshoe crabs are extremely vulnerable to overexploitation because spawning adults are easily harvested by anyone on the beach. In addition, horseshoe crabs take many years to mature (estimate is 10 years) and tagging studies suggest that they breed once per year which makes the population less resilient to overfishing than a species with a higher reproductive potential.

5. There is some evidence of localized population declines in recent years. Although not conclusive, the Panel is concerned about possible population declines in response to the increased catch and effort in the fishery.

6. The presence of the large number of shorebirds in the Delaware Bay

annually is due to the presence of a superabundance of horseshoe crab eggs. Maintaining this phenomenon in Delaware Bay requires large numbers of spawning horseshoe crabs.

In response to these findings, a conservative, risk-averse, coastwide management strategy is required to maintain the horseshoe crab population. The Panel cautions that the lack of available information on horseshoe crabs does not justify maintaining the status quo in terms of data collection and management strategies. A review of fisheries around the world in the past 50 years provides numerous examples of fisheries increasing catch and effort (without necessary data collection) resulting in fishery and population collapses.

The Panel strongly recommends initiating the research studies outlined in Term of Reference #4. This information is needed to manage the fishery properly. Until that time, a conservative management policy is required to decrease the probability of overfishing and population decline. The panel recommends reversing the increasing trend of catch and effort to substantially lower levels than has been the case in recent years.

Stock Identification and Distribution

Based on the morphological differences between populations and the limited dispersal ability of the larvae, juveniles and adults, it is likely that there are regional populations in this species. New studies should be carried out using fast-evolving genetic markers such as microsatellites because population differences have likely evolved recently following postglacial warming. Such information would be valuable for management if regional populations exist.

Management Unit

The current management unit is the horseshoe crab population from Maine to Florida. The Panel believes that it is necessary to identify whether or not regional populations exist. If regional populations are identified, management can occur at the regional level within a coordinated coastwide system. Without knowledge of population structure, the population to be managed must be defined as the population from Florida to Maine.

Landings

Commercial landings have increased coastwide (Figure 1) and have risen sharply in some regions. Data are imperfect but numbers clearly indicate increases in recent years. Data from NMFS on commercial landings coastwide are incomplete and underreported because reporting was not mandatory. In contrast, reports from Delaware for the years 1995-1997 were mandatory and showed a nearly two-fold increase in landings (Figure 2). The Panel recommends mandatory reporting of all landings data.

Data and Assessment

See Term of Reference #1.

Biological Reference Points

Not presently available due to lack of information. Estimating the biological reference points is identified as a research need above.

Fishing Mortality

Not presently available due to lack of information. Estimating fishing mortality is identified as a research need above.

Recruitment

Not presently available due to lack of information. Estimating recruitment is identified as a research need above.

Spawning Stock Size

Not presently available coastwide due to lack of information. Coastwide spawning surveys have been identified by the Panel as the highest research priority. As presented, the data from New Jersey suggest a decline in spawning in recent years on some beaches (Table 1).

Sources of Information

Status of the Horseshoe Crab (*Limulus polyphemus*) Population of the Atlantic Coast. Report to the Atlantic States Marine Fisheries Commission, Horseshoe Crab Technical Committee. August 1998. ASMFC, Washington, DC. 48p.

Public Hearing Draft for the Interstate Fishery Management Plan for Horseshoe Crab. Atlantic States Marine Fisheries Commission, Washington, DC. August 1998. 60p.

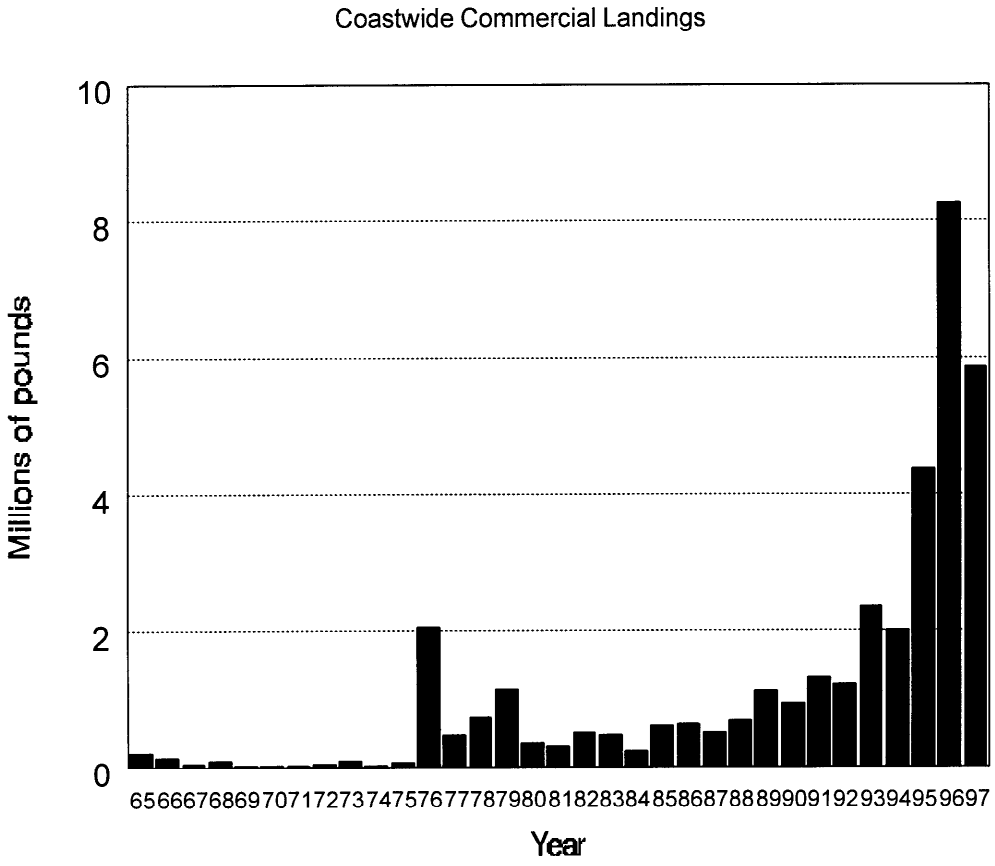

Figure 1. Coastwide commercial landings of horseshoe crabs, 1965-1997. *NOTE: The Peer Review Panel noted that data from the National Marine Fisheries Service on commercial landings coastwide are incomplete and underreported because reporting was not mandatory. Although the data are imperfect, the numbers clearly indicate increases in recent years.*

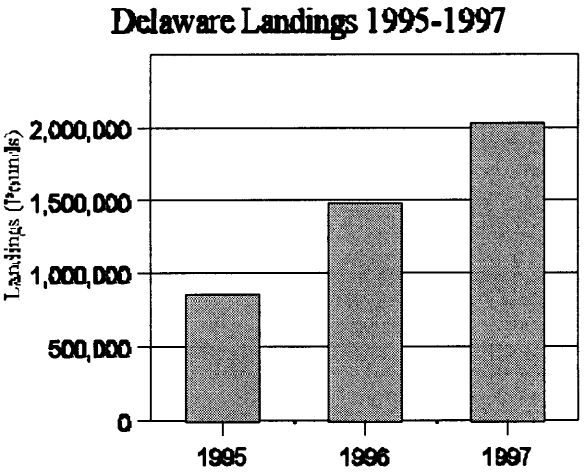

Figure 2. Delaware landings from the horseshoe crab mandatory reporting program for the period 1995-1997.

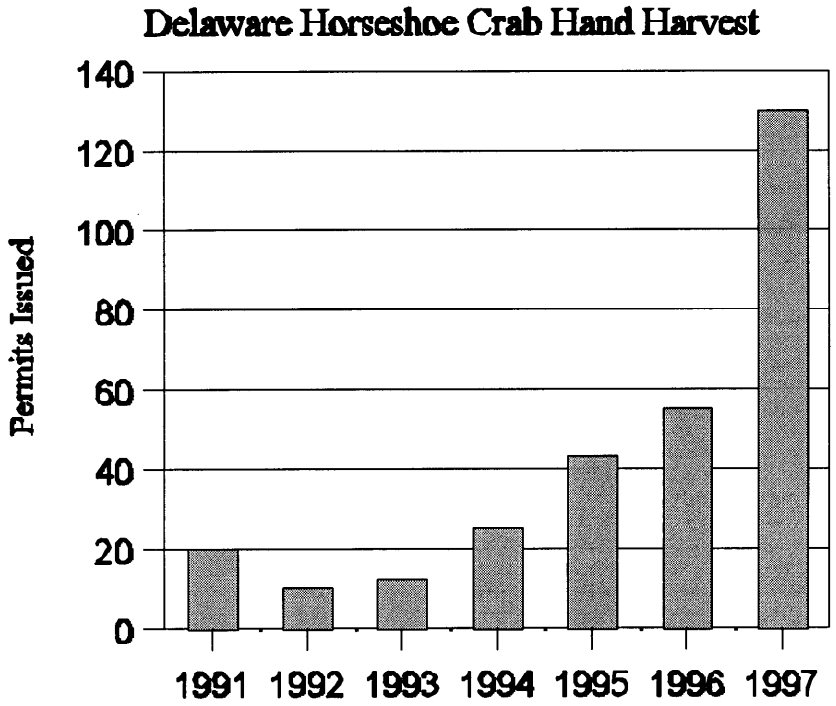

Figure 3. Number of horseshoe crab permits issued for hand harvest for the period 1991-1997.

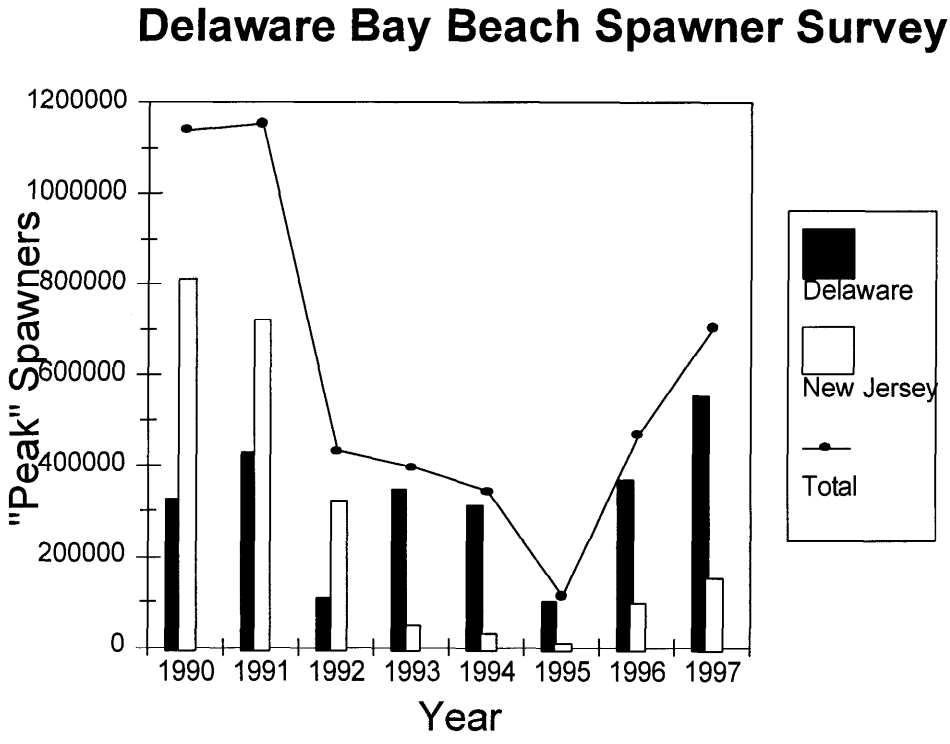

Figure 4. Results of the Delaware Bay horseshoe crab spawning count survey showing number of crabs seen during peak spawning count. *NOTE: The Peer Review Panel noted that the periodicity of the surveys did not match the periodicity of the crabs, the number of beaches sampled was limited, and sampling techniques varied over time for the periods 1992-1995.*

Table 1. Delaware Bay Egg Count Survey

NUMBER OF LIVE EGGS IN 0-5 CM												
Beach Name	1990		1991		1996				1997			
	5/24 5/25	6/1 - 6/7	April May	5/16 5/17	5/1 5/4	5/16 5/17	6/6	6/20 6/21	5/15 5/16	5/27 5/28	6/11 6/12	6/24 - 6/26
Reed's	175208	143444	138333	1456250	5104	208	63021	30916	0	119479	56354	2813
Moore's	273854	78229	1250	1061042	104			4688	0	24375	25208	3854
Cook's	17917	65104	12917	375104	0	208	6563	4063	0	17500	22292	4583
Pierce's Point	18021	42917										
N. Cape Shore		132500	18854	146458	5833	313	40833	2083	0	16875	47583	938
Norbury Landing	13333	21354		203229	0	30141	10417	8958	0	3646	2292	417
Villas	2083	21875	104	11771	0	0		17188	0	104	104	521
Higbees		0	0	0		0		5104				
NUMBER OF LIVE EGGS IN 15-20 CM												
Reed's		1421959			134594	125811	306724	124615	87447	457981	275460	246598
Moore's		760104			0			47669	0	80104	35455	62588
Cook's		377917			0	7917	66796	1042	0	50976	123498	227200
Pierce's Point		251372										
N. Cape Shore		462396			30000	273981	639200	400823	81048	345779	425455	292450
Norbury Landing		775803			833	18027	440905	313781	0	14579	58210	5833
Villas		439190			0	0		58300	0	0	0	7604
Higbees		417				0		22220				

PRESS PLUS
THE PRESS OF ATLANTIC CITY ONLINE

Monday, July 28, 1997

Bird business soaring, boosts Cape economy

•A new study shows there's money in warblers, hawks and owls -- more than $31 million a year is pumped into the county's economy by an estimated 100,000 birdwatchers.

By RICHARD DEGENER

Staff Writer

CAPE MAY POINT -- Back in 1988, Paul Kerlinger alerted Cape May County to the fact that the birding industry has a major impact on the local economy.

Kerlinger, then the director of New Jersey Audubon's Cape May Bird Observatory here on East Lake Drive, did a study showing birders were spending $10 million each year tromping around the peninsula searching for warblers, hawks, owls and other migrants.

An update of that study released Friday shows the $10 million has grown to $31 million: $31,145,000 to be exact.

New Jersey Audubon officials are pointing to the study as yet another reason why Cape May County should preserve open space.

"Just because there's no building on it doesn't mean it doesn't have value. Space and nature habitat is like a resource. It's a little bit like having gold, but you don't even have to dig it out of the ground," said Peter Dunne, the current director of the observatory.

Local officials are taking notice.

West Cape May Borough Commissioner Michelle Hassis says the best part is the birders visit in the spring and fall, extending the traditional summer tourist season. Hassis also noted birders present few negative impacts on the community.

"They're low-impact people. They're not asking to be entertained. They do not want arcades and they aren't asking for a lot of police protection," Hassis said.

Bill Thawley, who directs the Chamber of Commerce of Greater Cape May, said each year the society's World Series of Birding, which is held each spring, brings more and more people. Like the state fire convention that fills up Wildwood's motels each September, it's a key season extender.

"They come and they stay. They stay in Cape May and outside of Cape May. They even camp," said Thawley.

In fact, the study indicates the area's campgrounds make $400,000 a year on birders, although this is a fraction of the $8.6 million pulled in by motels and hotels or the $2.4 million from bed and breakfasts.

Meals are actually the largest revenue item, an estimated $11.2 million annually.

The study also shows that birding produces state tax revenue of $1.8 million and directly supports some 700 jobs.

The sheer number of birders is fueling the increase. While the original price of things outlined by Kerlinger has been increased, Dunne says many more birders are coming.

In 1988, Kerlinger estimated 35,000 birders per year. The estimate is now in excess of 100,000. That number is supported by research by the U.S. Fish and Wildlife Service and reflects a national trend.

A University of Georgia study found the popularity of birding nationally rose 155 percent between 1985 and 1996.

The 100,000 birders for the first time puts Cape May ahead of other birding meccas like Hawk Mountain in Pennsylvania and Point Pelee National Park in Ontario, Canada.

Dunne warns, however, that Cape May is competing globally for birders, and if habitat is lost, the market will suffer.

Dunne said some prices Kerlinger figured were raised, but the figures still represent conservative estimates. For example, food was upped from $15 to $28 a day; hotel rooms from $35 to $50 per person; and bed and breakfasts from $50 to $60.

CHAPTER 71 - ATLANTIC COASTAL FISHERIES COOPERATIVE MANAGEMENT
(Title 16, U.S. Code)

Sec. 5101. Findings and purpose

(a) Findings

The Congress finds the following:

(1) Coastal fishery resources that migrate, or are widely distributed, across the jurisdictional boundaries of two or more of the Atlantic States and of the Federal Government are of substantial commercial and recreational importance and economic benefit to the Atlantic coastal region and the Nation.

(2) Increased fishing pressure, environmental pollution, and the loss and alteration of habitat have reduced severely certain Atlantic coastal fishery resources.

(3) Because no single governmental entity has exclusive management authority for Atlantic coastal fishery resources, harvesting of such resources is frequently subject to disparate, inconsistent, and intermittent State and Federal regulation that has been detrimental to the conservation and sustainable use of such resources and to the interests of fishermen and the Nation as a whole.

(4) The responsibility for managing Atlantic coastal fisheries rests with the States, which carry out a cooperative program of fishery oversight and management through the Atlantic States Marine Fisheries Commission. It is the responsibility of the Federal Government to support such cooperative interstate management of coastal fishery resources.

(5) The failure by one or more Atlantic States to fully implement a coastal fishery management plan can affect the status of Atlantic coastal fisheries, and can discourage other States from fully implementing coastal fishery management plans.

(6) It is in the national interest to provide for more effective Atlantic State fishery resource conservation and management.

(b) Purpose

The purpose of this chapter is to support and encourage the development, implementation, and enforcement of effective interstate conservation and management of Atlantic coastal fishery resources.

Sec. 5102. Definitions

In this chapter, the following definitions apply:

(1) The term "coastal fishery management plan" means a plan for managing a coastal fishery resource, or an amendment to such plan, prepared and adopted by the Commission, that -

(A) contains information regarding the status of the resource and related fisheries; and

(B) specifies conservation and management actions to be taken by the States.

(2) The term "coastal fishery resource" means any fishery, any species of fish, or any stock of fish that moves among, or is broadly distributed across, waters under the jurisdiction of two or

more States or waters under the jurisdiction of one or more States and the exclusive economic zone.

(3) The term "Commission" means the Atlantic States Marine Fisheries Commission established under the interstate compact consented to and approved by the Congress in Public Laws 77-539 and 81-721.

(4) The term "conservation" means the restoring, rebuilding, and maintaining of any coastal fishery resource and the marine environment, in order to assure the availability of coastal fishery resources on a long-term basis.

(5) The term "Councils" means Regional Fishery Management Councils established under section 1852 of this title.

(6) The term "exclusive economic zone" means the exclusive economic zone of the United States established by Proclamation Number 5030, dated March 10, 1983. For the purposes of this chapter, the inner boundary of that zone is a line coterminous with the seaward boundary of each of the coastal States, and the outer boundary of that zone is a line drawn in such a manner that each point on it is 200 nautical miles from the baseline from which the territorial sea is measured.

(7) The term "fish" means finfish, mollusks, crustaceans, and all other forms of marine animal life other than marine mammals and birds.

(8) The term "fishery" means -

(A) one or more stocks of fish that can be treated as a unit for purposes of conservation and management and that are identified on the basis of geographical, scientific, technical, commercial, recreational, or economic characteristics; or

(B) any fishing for such stocks.

(9) The term "fishing" means -

(A) the catching, taking, or harvesting of fish;

(B) the attempted catching, taking, or harvesting of fish;

(C) any other activity that can be reasonably expected to result in the catching, taking, or harvesting of fish; or

(D) any operations at sea in support of, or in preparation for, any activity described in subparagraphs (A) through (C). Such term does not include any scientific research activity or the catching, taking, or harvesting of fish in an aquaculture operation.

(10) The term "implement and enforce" means to enact and implement laws or regulations as required to conform with the provisions of a coastal fishery management plan and to assure compliance with such laws or regulations by persons participating in a fishery that is subject to such plan.

(11) The term "person" means any individual (whether or not a citizen or national of the United States), any corporation, partnership, association, or other entity (whether or not organized or existing under the laws of any State), and any Federal, State, local, or foreign government or any entity of any such government.

(12) The term "Secretary" means the Secretary of Commerce.

(13) The term "State" means Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, the District of Columbia, or the Potomac River Fisheries Commission.

Sec. 5103. State-Federal cooperation in Atlantic coastal fishery management

(a) Federal support for State coastal fisheries programs

The Secretary in cooperation with the Secretary of the Interior shall develop and implement a program to support the interstate fishery management efforts of the Commission. The program shall include activities to support and enhance State cooperation in collection, management, and analysis of fishery data; law enforcement; habitat conservation; fishery research, including biological and socioeconomic research; and fishery management planning.

(b) Federal regulation in exclusive economic zone

(1) In the absence of an approved and implemented fishery management plan under the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801 et seq.), and after consultation with the appropriate Councils, the Secretary may implement regulations to govern fishing in the exclusive economic zone that are -

(A) compatible with the effective implementation of a coastal fishery management plan; and

(B) consistent with the national standards set forth in section 301 of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1851). The regulations may include measures recommended by the Commission to the Secretary that are necessary to support the provisions of the coastal fishery management plan. Regulations issued by the Secretary to implement an approved fishery management plan prepared by the appropriate Councils or the Secretary under the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801 et seq.) shall supersede any conflicting regulations issued by the Secretary under this subsection.

(2) The provisions of sections 307, 308, 309, 310, and 311 of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1857, 1858, 1859, 1860, and 1861) regarding prohibited acts, civil penalties, criminal offenses, civil forfeitures, and enforcement shall apply with respect to regulations issued under this subsection as if such regulations were issued under the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C.1801 et seq.).

Sec. 5104. State implementation of coastal fishery management plans

(a) Coastal fishery management plans

(1) The Commission shall prepare and adopt coastal fishery management plans to provide for the conservation of coastal fishery resources. In preparing a coastal fishery management plan for a fishery that is located in both State waters and the exclusive economic zone, the Commission shall consult with appropriate Councils to determine areas where such coastal fishery management plan may complement Council fishery management plans. The coastal fishery management plan shall specify the requirements necessary for States to be in compliance with the plan. Upon adoption of a coastal fishery management plan, the Commission shall identify each State that is required to implement and enforce that plan.

(2) Within 1 year after December 20, 1993, the Commission shall establish standards and procedures to govern the preparation of coastal fishery management plans under this chapter, including standards and procedures to ensure that -

(A) such plans promote the conservation of fish stocks throughout their ranges and are based on the best scientific information available; and

(B) the Commission provides adequate opportunity for public participation in the plan preparation process, including at least four public hearings and procedures for the submission of written comments to the Commission.

(b) State implementation and enforcement

(1) Each State identified under subsection (a) of this section with respect to a coastal fishery management plan shall implement and enforce the measures of such plan within the timeframe established in the plan.

(2) Within 90 days after December 20, 1993, the Commission shall establish a schedule of timeframes within which States shall implement and enforce the measures of coastal fishery management plans in existence before December 20, 1993. No such timeframe shall exceed 12 months after the date on which the schedule is adopted.

(c) Commission monitoring of State implementation and enforcement

The Commission shall, at least annually, review each State's implementation and enforcement of coastal fishery management plans for the purpose of determining whether such State is effectively implementing and enforcing each such plan. Upon completion of such reviews, the Commission shall report the results of the reviews to the Secretaries.

Sec. 5105. State noncompliance with coastal fishery management plans

(a) Noncompliance determination

The Commission shall determine that a State is not in compliance with the provisions of a coastal fishery management plan if it finds that the State has not implemented and enforced such plan within the timeframes established under the plan or under section 5104 of this title.

(b) Notification

Upon making any determination under subsection (a) of this section, the Commission shall within 10 working days notify the Secretaries of such determination. Such notification shall include the reasons for making the determination and an explicit list of actions that the affected State must take to comply with the coastal fishery management plan. The Commission shall provide a copy of the notification to the affected State.

(c) Withdrawal of noncompliance determination

After making a determination under subsection (a) of this section, the Commission shall continue to monitor State implementation and enforcement. Upon finding that a State has complied with the actions required under subsection (b) of this section, the Commission shall immediately withdraw its determination of noncompliance. The Commission shall promptly notify the Secretaries of such withdrawal.

Sec. 5106. Secretarial action

(a) Secretarial review of Commission determination of noncompliance

Within 30 days after receiving a notification from the Commission under section 5105(b) of this title and after review of the Commission's determination of noncompliance, the Secretary shall make a finding on -

(1) whether the State in question has failed to carry out its responsibility under section 5104 of this title; and

(2) if so, whether the measures that the State has failed to implement and enforce are necessary for the conservation of the fishery in question.

(b) Consideration of comments

In making a finding under subsection (a) of this section, the Secretary shall -

(A) give careful consideration to the comments of the State that the Commission has determined under section 5105(a) of this title is not in compliance with a coastal fishery management plan, and provide such State, upon request, with the opportunity to meet with and present its comments directly to the Secretary; and

(B) solicit and consider the comments of the Commission and the appropriate Councils.

(c) Moratorium

(1) Upon making a finding under subsection (a) of this section that a State has failed to carry out its responsibility under section 5104 of this title and that the measures it failed to implement and enforce are necessary for conservation, the Secretary shall declare a moratorium on fishing in the fishery in question within the waters of the noncomplying State. The Secretary shall specify the moratorium's effective date, which shall be any date within 6 months after declaration of the moratorium.

(2) If after a moratorium is declared under paragraph (1) the Secretary is notified by the Commission that the Commission is withdrawing under section 5105(c) of this title the determination of noncompliance, the Secretary shall immediately determine whether the State is in compliance with the applicable plan. If so, the moratorium shall be terminated.

(d) Implementing regulations

The Secretary may issue regulations necessary to implement this section. Such regulations -

(1) may provide for the possession and use of fish which have been produced in an aquaculture operation, subject to applicable State regulations; and

(2) shall allow for retention of fish that are subject to a moratorium declared under this section and unavoidably taken as incidental catch in fisheries directed toward menhaden if -

(A) discarding the retained fish is impracticable;

(B) the retained fish do not constitute a significant portion of the catch of the vessel; and

(C) retention of the fish will not, in the judgment of the Secretary, adversely affect the conservation of the species of fish retained.

(e) Prohibited acts during moratorium

During the time in which a moratorium under this section is in effect, it is unlawful for any person to -

(1) violate the terms of the moratorium or of any implementing regulation issued under subsection (d) of this section;

(2) engage in fishing for any species of fish to which the moratorium applies within the waters of the State subject to the moratorium;

(3) land, attempt to land, or possess fish that are caught, taken, or harvested in violation of the moratorium or of any implementing regulation issued under subsection (d) of this section;
(4) fail to return to the water immediately, with a minimum of injury, any fish to which the moratorium applies that are taken incidental to fishing for species other than those to which the moratorium applies, except as provided by regulations issued under subsection (d) of this section;
(5) refuse to permit any officer authorized to enforce the provisions of this chapter to board a fishing vessel subject to such person's control for purposes of conducting any search or inspection in connection with the enforcement of this chapter;
(6) forcibly assault, resist, oppose, impede, intimidate, or interfere with any such authorized officer in the conduct of any search or inspection under this chapter;
(7) resist a lawful arrest for any act prohibited by this section;
(8) ship, transport, offer for sale, sell, purchase, import, or have custody, control, or possession of, any fish taken or retained in violation of this chapter; or
(9) interfere with, delay, or prevent, by any means, the apprehension or arrest of another person, knowing that such other person has committed any act prohibited by this section.

(f) Civil and criminal penalties

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