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VIA ELECTRONIC MAIL
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Office of Administration
Mail Stop: TWB–05– B01M
U.S. Nuclear Regulatory Commission
Washington, DC 20555–0001
SalemEIS@nrc.gov or HopeCreekEIS@nrc.gov

Re: Dockets NRC–2009–0390 and NRC–2009–0391; Public Comment on Draft Supplemental GEIS for PSEG Relicensing

Dear Ms. Bladey:

On behalf of the Delaware Riverkeeper and Delaware Riverkeeper Network (collectively DRN), I appreciate the opportunity to provide the following comments. As you may know, DRN is committed to restoring the watershed's natural balance where it has been lost and ensuring its preservation where it still exists. DRN understands that the U.S. Nuclear Regulatory Commission Staff (NRC) has prepared a Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 45, Regarding Hope Creek Generating Station (Hope Creek) and Salem Nuclear Generating Station, Units 1 and 2 (Salem), Draft Report for Comment (hereinafter Draft SEIS or DSEIS). The notice of availability of and opportunity to comment on the DSEIS was published in the Federal Register on October 28, 2010 (75 FR 66398). Pursuant to NEPA, on November 5, 2009, DRN submitted scoping comments to inform the NRC environmental review in the license renewal proceeding.

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DRN's review of the DSEIS reveals glaring deficiencies which undermine the NRC's conclusion that the environmental impacts of Salem and Hope Creek's operations are not severe enough to preclude renewing its operating license. DRN absolutely disagrees with this determination, and submits that if the NRC Staff had performed the proper assessments, they would have reached the opposite conclusion, in particular with regard to impacts on aquatic resources. DRN urges the NRC Staff to fully consider and address our comments prior to issuing the Final SEIS for License Renewal of Salem. DRN would like to reaffirm its long-standing position to convert Salem to closed cycle cooling as mandated by Section 316(b) of the Clean Water Act. The Act states that generating plants such as Salem "shall be required that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact."

Background

Section 316(b) of the Clean Water Act requires that the location, design, construction and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing Adverse Environmental Impact. (AEI) AEI is interpreted by EPA to mean the impingement mortality of fish and shellfish and entrainment of their eggs and larvae. EPA implemented three rulemaking phases for section 316(b): the Phase I rule, promulgated in 2001, covered new facilities, the Phase II rule, promulgated in 2004, covered large existing electric generating plants, and the Phase III rule, issued in 2006, covered certain existing facilities and offshore oil and gas facilities.

Litigation followed promulgation of the Phase II rule. Following a decision in *Riverkeeper, Inc., v. EPA*, (2d Cir. 2007), EPA suspended the Cooling Water Intake Structure Regulations for existing large power plants. And of course, the Second Circuit decision was challenged to the Supreme Court in 2009. The Second Circuit decision held, in part, that use of restoration measures as a means of compliance is not authorized under §316(b) of the Clean Water Act (CWA), a decision not disturbed by the subsequent Supreme Court decision.

EPA is now looking to combine and re-promulgate rules for all existing Cooling Water Intake Structure facilities (Phases II and III). In the meantime, EPA, noting that "With so many provisions of the Phase II rule affected by the [2nd Cir.] decision, the rule should be considered suspended," it developed the following policy: "all permits for Phase II facilities should include conditions under section 316(b) of the Clean Water Act developed on a Best Professional Judgment basis." See 40 C.F .R. § 401. (EPA implementation memo).

As noted, the Phase II rule was appealed to the U.S. Supreme Court. In 2009, the high court held that the Agency *may* consider cost-benefit analysis in choosing among regulatory options, but did not hold that the Agency *must* consider it. According to certain industry predictions, EPA has signaled concerns with using a cost-benefit analysis. (NERC, *2010 Special Reliability Scenario Assessment: Resource Adequacy Impacts of Potential US Environmental Regulations*, October 2010, at 57)

EPA's new rulemaking is expected to set significant new national technology-based performance standards to minimize AEI. Current industry predictions expect EPA to favor performance commensurate with cooling towers. (NERC at 57) This regulatory process (combined for phases II and III) is anticipated quite soon – a revised draft rule is expected by February 2011 and a final rule by July 2012. DRN also notes with interest a recent news report that NJDEP and NYDEC "have begun forcing scores of their largest water users to either retrofit their plants with modern cooling systems which won't kill billions of fish annually or cease operating." Oyster Creek decision shows focus is on cooling systems, *New Jersey Newsroom*, December 13, 2010 at http://www.newjerseynewsroom.com/science-updates/oyster-creek-decision-shows-focus-is-on-cooling-systems.

The NRC DSEIS does not call for compliance with the Clean Water Act as it relates to best technology available, and even fails to acknowledge the significant environmental impact occurring in the absence of this technology. Every year the Salem Nuclear Generating Station kills over 3 billion Delaware River fish including:

- ✓ Over 59 million Blueback Herring
- ✓ Over 77 million Weakfish
- ✓ Over 134 million Atlantic Croaker
- ✓ Over 412 million White Perch
- ✓ Over 448 million Striped Bass
- ✓ Over 2 billion Bay Anchovy

The Salem facility is already clearly having a significant environmental impact on the Estuary, and another twenty years of this destruction will lead to further significant impacts.

Adequacy of Public Involvement

DRN objects to having been given less than 60 days to comment on this complex document, in particular in the midst of the holiday season. It is unreasonable that public review of the DSEIS should be forced into a compressed time window and it is unclear why NRC has taken this approach.

Age of GEIS

NRC Staff uses a 1996 License Renewal Generic Environmental Impact Statement, NUREG-1437 ("GEIS"). However, the GEIS is inadequate because it is more than 10 years old. The National Environmental Policy Act ("NEPA") requires that federal agencies take a "hard look" at the environmental impacts of a proposed action. This includes assessing "significant new circumstances or information relevant to the environmental concerns that bear on the proposed action or its impacts." To facilitate this process, NEPA requires a GEIS to be updated every 10 years. 10 C.F.R. Part 51, Subpart A, Appendix B. Moreover, evidence exists of material changes affecting the baseline environment since the GEIS was written, including heightened risks of terrorism, the failure of a permanent nuclear waste disposal solution, changes in population density, and progress in the viability of renewable energy technologies. Accordingly, the GEIS is no longer adequate to dispose of such issues, and they must be specifically assessed in the environmental review process for Salem and Hope Creek.

The Collective Effects of Impingement and Entrainment are not Small

The DSEIS concludes that "impacts to fish and shellfish from the collective effects of entrainment, impingement and heat shock at Salem during the renewal term would be SMALL." DSEIS 4-46. This is completely unsupportable position. As a starting point, NMFS has gone on record that:

> Evidence suggests that northeast coast estuaries have lost much of their rich former fishery productivity because of habitat degradation or loss, but lack of absolute species abundance data for early historical periods prior to significant human disturbances makes this conclusion somewhat inferential. Yet the linkage is supported by strong evidence, particularly that stock sizes for most estuarine dependent fishery resources under the jurisdiction of the Atlantic States Marine Fisheries Commission, New England or Mid-Atlantic Management Councils, or the states of New York and New Jersey fishery management agencies, are not currently over fished, but fall below historic levels (NEFMC 1998; ASMFC 2005). This observation suggests that the Hudson River's ability to support and produce living aquatic organisms has been compromised over the years by lost habitat quality and quantity as humans have dredged, filled, and withdrawn river water for a myriad of uses, resulting in conflicts of use with fishery resources.

Oct. 12, 2010 Letter from NMFS (Colosi) to NRC at 3-4. The DSEIS relies heavily on industry-provided data to evaluate effects of impingement and entrainment. However, the DSEIS concedes that its analysis is flawed, "due to the differences in methods used during the more than 30 years since Salem Unit 1 began commercial operation in 1978, it is difficult to compare impingement estimates across studies." DSEIS at 4-28. Additionally, study results reported in the GEIS are decades old, with the most recent information collected in 1990. This was identified as a concern by NMFS in a 2010 letter to NRC regarding another facility in the Northeast, noting, "This concerns us on two counts: 1) the data may not accurately depict contemporary habitat usage of the [mid-Hudson region] by fishes, invertebrates, and other aquatic life, and 2) the project proponents have not evaluated the effectiveness of adaptive measures that have been implemented since the original [agreement] was put into place." NMFS letter at 6.

The Draft SEIS fails to consider EPA's 2004 report entitled "Regional Analysis Document for the Final Section 316(b) Phase II Existing Facilities Rule." The report detailed EPA's section 316(b) Phase II benefits analysis and study results. This critical information is missing from the NRC analysis and provides evidence and data challenging the DSEIS's finding that "the Staff concludes that impacts to fish and shellfish from the collective effects of entrainment, impingement and heat shock at Salem during the renewal term would be SMALL." DSEIS 4-46.

EPA itself has acknowledged significant impacts from once-through cooling. EPA has determined that operation of industrial scale cooling water intakes results in a wide spectrum of undesirable and unacceptable adverse effects on aquatic resources including entrainment and impingement; disrupting the food chain; and losses to aquatic populations that may result in reductions in biological diversity or other undesirable effects on ecosystem structure or function. See, 66 Federal Register 65,256, 65,292 (December 18, 2001), 69 Federal Register 41,576, 41,586 (July 9, 2004); NMFS letter at 4.

Expert federal agency NMFS has also explicitly identified significant impacts from intake structures that are ignored in the DSEIS for Salem. According to NMFS' assessment of the DSEIS for another Northeastern facility:

The *intake* impacts for once-through cooling systems largely surround physical habitat loss associated with construction of the intakes themselves as well as the inability of aquatic species from being successfully able to use habitat within the volumes of water withdrawn from the source supply. These impacts may include changing particular ecological features such as local hydrological patterns as suggested in the foregoing section, but the preponderance of the impacts usually are associated with organism impingement and entrainment. Impingement impacts tend to accrue to larger species and life stages that cannot pass through the impingement screens nor avoid the intake current, but become trapped on cooling water screens and sometimes cannot escape before suffering exhaustion, injury or even mortality.

...

Unlike impingement impacts, which tend to exhibit some selective characteristics in that they largely accrue to larger taxa or more mature life stages, entrainment of organisms into the cooling water source stream are relatively indiscriminate and may adversely affect any organism that fits through the screens and cannot counter the suction force of the intake. While the review material indicate that the IP2 and IP3 cooling systems have been retrofitted with dual-speed and variable-flow pumps in order that intake flows can be regulated to some degree to provide some level of mitigation or protection, we note that the dGEIS also indicates that using planned seasonal outages or maximum pump speeds does not eliminate the losses of fishes and other organisms to entrainment.

Regarding these collective intake impact matters, NMFS disagrees with the NRCs approach to presenting and analyzing the impingement and entrainment data. We particularly dispute the NRCs decision to attempt correlating overall *population level* trends with operation of the Indian Point nuclear generating facilities.

First of all, analyzing the data over the entire range of a species instead of a more meaningful population segment does not follow the spirit of the National Environmental Policy Act nor the implementing regulations for EFH in the MSA because it ignores real and obvious impacts that could adversely affect a local stock.

It is rare for the preponderance of a particular species be extirpated unless it already is endangered or threatened, but it certainly is quite plausible that a more local segment of an otherwise healthy population could be effectively decimated in an acute event or after years of suffering chronic or cumulative impacts. Thus, when considering the impacts of cooling water withdrawal on more local stock contributions emanating from the Hudson River and potentially recruiting to a greatly dispersed coastal fishery, the effects of cooling withdrawal even from a limited portion of the total available habitat'(as it is construed in the dGEIS) could be quite profound. Finally, we are critical of this type of data transformation because it also has great potential for creating undesirable artifacts because it assumes all fishery habitats, regardless of their geographic location, size, and ecological condition, are equally valuable to the living resources that they support. The scientific literature is replete with studies that organisms do not use habitats uniformly over their ranges, and this observation is borne out in our own status and trends data that

> have been used to select closed areas or to make similar resource management decisions for certain federally managed fishery resources.

NMFS letter at 6-7.

Specific to this site, NJDEP reviewed PSEG data as part of its state permit application in 2006. NJDEP's expert (ESSA) found that PSEG's assertions were not credible and were not backed by the data and studies PSEG had presented. According to the ESSA report, PSEG "underestimated biomass lost from the ecosystem by perhaps greater than 2-fold." (ESSA report p. xi) And "... the actual total biomass of fish lost to the ecosystem ... is at least 2.2 times greater than that listed" by PSEG. (ESSA Report p. 75)

ESSA Technologies' 154 page review of PSEG's permit application documented ongoing problems with PSEG's assertions and findings including bias, misleading conclusions, data gaps, inaccuracies, and misrepresentations of their findings and damage. Some examples of ESSA's findings:

- ✓ With regards to fisheries data and population trends, ESSA said "The conclusions of the analyses generally overextend the data or results." (p. ix)
- ✓ PSEG "underestimates biomass lost from the ecosystem by perhaps greater than 2-fold." (p. xi) "... the actual total biomass of fish lost to the ecosystem ... is at least 2.2 times greater than that listed in the Application." (p. 75)
- ✓ "Inconsistency in the use of terminology, poorly defined terms, and a tendency to draw conclusions that are not supported by the information presented detract from the rigor of this section and raises skepticism about the results. In particular, there is a tendency to draw subjective and unsupported conclusions about the importance of Salem's impact on RIS finfish species." (p. 77)

Referring to PSEG's discussion and presentation of entrainment mortality rates ESSA found PSEG's "discussion in this section of the Application to be misleading." (p. 13) The NRC's DSEIS fails to take this analysis into account.

In concluding Section 4.5.6 of the DSEIS, NRC names several potential mitigation options, but neither arrives at the specific conclusions that the units should be retrofitted with closed-cycle cooling systems, nor selects particular alternatives that they would recommend in lieu of closed-cycle cooling.

Moreover, NRC unfairly minimizes its role, and stresses NJDEP's responsibility to issue permits and impose mitigation requirements. This is completely separate from an analysis of environmental impacts for purposes of NEPA and should not prevent NRC from undertaking a full and fair analysis of the impacts.

Atlantic Sturgeon impacts

On October 6, 2010, NOAA's National Marine Fisheries Service (NMFS) issued a proposed rule to list five distinct population segments (DPS) of the Atlantic sturgeon as threatened or endangered under the Endangered Species Act (ESA). In recognition of the many threats to riverine habitat, including dredging, filling, and degraded water quality, facing Atlantic sturgeon in the Hudson and Delaware Rivers, NMFS proposed to list a DPS consisting of these populations, the New York Bight (NYB) DPS, as endangered. See, 75 Fed. Reg. 61,872 at 61,881(Oct. 6, 2010). We also note with alarm that the Delaware River population of Atlantic sturgeon is more precariously poised than the Hudson River population, according to research on the record. According to the *Delaware River State of the Basin Report, 2008*, which is based on science collected in the region, the status of the Atlantic Sturgeon is considered "poor and getting worse" with numbers "estimated to be less than 1,000 and probably less than 100 across the Estuary." Furthermore, there is scientific evidence that the Delaware River is home to a genetically unique population of Atlantic Sturgeon, and that this small but distinct population is currently reproducing. That the Delaware River population is not only genetically unique but also may have a population of fewer than 100 fish makes protection of this portion of the NYB DPS a critical priority.

This change in status means that a critical piece of information is missing from the DSEIS, and must be evaluated prior to NRC's issuance of a final SEIS. A lack of sufficient data relating to impingement, entrainment and thermal impacts of Salem on Atlantic sturgeon in the vicinity of Salem leads to an at best incomplete and at worst erroneous determination regarding the environmental impact of relicensing on this critical species. Given the impending designation of the Atlantic sturgeon NYB as endangered, NRC Staff's thinly supported assessment and indefinite conclusions are insufficient for purposes of meeting the obligations of NEPA. Thus, the DSEIS should consider and incorporate all relevant information contained in the Proposed Listing prior to reaching any final conclusions related to the impacts of license renewal of Salem on endangered aquatic resources.

Mitigation at Salem

In an effort to mitigate its significant impact on the Estuary, in 1996, NJDEP issued a NPDES permit with special conditions including a wetland restoration and enhancement program, fish ladder project and biological monitoring program. PSEG is required to engage in the wetland initiative until 2012 in New Jersey and 2013 for Delaware wetlands. The purpose of the restoration program was to enhance the production of fish in the Estuary in an effort to offset losses of fish associated with entrainment and impingement at the cooling water intake structure. In other words, to mitigate the harms caused by once-through cooling.

However , PSEG's wetlands restoration experiment fails to meet the requirements of the Clean Water Act. The experiment has resulted in over 22,000 pounds of herbicide to be dumped over valuable wetland resources. PSEG has failed to demonstrate that this experiment provides any environmental benefit - The fact remains that there has been no demonstrated increase in abundance values in representative important fish species. And importantly, PSEG has not shown that the wetlands will sustain themselves once the herbicide treatment has ended. This mitigation project is a clear failure, and in no way offsets the cost of the millions of fish lost each year as a result of the PSEG's failure to install a closed cooling system.

DRN commissioned a 2003 study that reviewed and evaluated the effectiveness of the wetland restoration project in increasing fish production – based on the success of the established plant community, plant densities, invasion by *phragmities* and other invasive species, utilization of marshes by fish, and the potential for the marshes to increase fish populations in the Estuary. (CEA study at 2).

With regard to wetland restoration efforts, the DRN study concluded that although some *phragmities* reductions were achieved, the sustainability of that reduction was dependent on annual herbicide treatment, and the true success of the program could not be determined until herbicide treatment and marsh manipulation efforts such as burning were discontinued. (CEA study at 24 -25.)

With regard to fish response, the study did not support the assertion that *phragmities* eradication was resulting in increased utilization of the sites and increased fish production. (CEA study at 39.)

For 20 years, PSEG has claimed that the exorbitant costs of conversion make an untenable option. The NJDEP has accordingly allowed PSEG to rely on mitigation practices in order to counter the negative effects of the continued operation of their cooling system on the fish. Since 1993, the DRN has addressed several concerns with the mitigation practices proposed by the PSEG including real data showing that the restoration plans are not working. Whereas, the 2009 Supreme Court decision in *Entergy Corp. v. Riverkeeper, Inc.* held that the cost-benefit analysis was an appropriate in determining the *best available technology* for cooling methods, it has not overturned a previous 2007 decision, in which determined that *after-the fact restoration measures* are not appropriate for addressing the environmental impacts highlighted by §316 (b). This means that, going forward, the failed Restoration measures at Salem should not "count" as valid means of minimizing Adverse Environmental Impact for purposes of 316(b), and should not be considered a positive environmental impact for purposes of NEPA.

DRN urges NRC to review the many flawed analyses and conclusions in the DSEIS prior to issuing a final SEIS. Thank you for your consideration of these comments.

Respectfully submitted,

Elizabeth Koniers Brown
Director of Strategic Initiatives

Appendices:
A – October 12, 2010 letter from NMFS to NRC.
B – Carpenter Environmental Associates, Inc., *Evaluation of Special Conditions Contained in Salem Nuclear Generating Station NJPDES Permit to Restore Wetlands, Install Fish Ladders, and Increase Biological Abundance Within the Delaware Estuary,* December 3, 2003.

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Received 10/18

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
NORTHEAST REGION
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Gloucester, MA 01930-2276

Mr. Brian E. Holian, Director
Division of License Renewal
Office of Nuclear Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

OCT 12 2010

Mr. David J. Wrona, Chief
Projects Branch 2
Division of License Renewal
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Re: Indian Point Generating Unit Nos. 2 & 3 License Renewal; Docket Nos. 50-247 and 50-268; Essential Fish Habitat Consultation

Dear Messrs. Holian and Wrona:

The National Marine Fisheries Service [NMFS] has reviewed the essential fish habitat [EFH] assessment and supplemental information provided within the United States Nuclear Regulatory Commission's [NRC] 'Generic Environmental Impacts Statement for License Renewal of Nuclear Plants, Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3' [dGEIS], and its attendant appendices. These documents evaluate the proposed renewal of the operating licenses for Indian Point Energy Center's Units 2 [IP2] and 3 [IP3] for a period of twenty years. The documents include a brief description and analysis of adverse effects to a variety of diadromous and estuary-dependent fishes, crustaceans and other invertebrates, as well as EFH that is designated in the immediate project vicinity. We will elaborate on the affected resources and our concerns regarding continued operations at IP2 and IP3 under present conditions in subsequent sections of this letter. However, upon our review of the available information, NMFS does not reach all of the same conclusions as the NRC with respect to adverse effects that relicensing IP2 and IP3 would have on fishery resources and their habitats. We appreciate the opportunity to provide comments at this time in accordance with Mr. Wrona's letter of 21 September 2010.

The current licenses for the two Indian Point nuclear generation facilities are due to expire in 2013 and 2015, respectively. Because IP2 and IP3 withdraw and discharge water into the Hudson River, a navigable surface water body, their operations are subject to Clean Water Act oversight. In New York, this oversight is administered by the New York State Department of Environmental Conservation, which issues Clean Water Act §401 Water Quality Certificate [WQC] decisions under its State Pollutant Discharge and Elimination System [SPDES] program. The New York State Department of State also has a bearing on these proceedings in that it is responsible for any decisions relating to the consistency of the proposed action with the state's Coastal Management Program. Entergy Corporation [Entergy], the current owner-operator of the Indian Point Energy Center [Indian Point] generating units, has made application for the necessary state and federal authorizations and has requested that they are issued to run concurrently. Since these state actions may effect EFH, the NMFS is invoking its option to share our comments and recommendations to the involved state agencies on their activities as provided by the EFH implementing regulations. We do so here by including them in the service list for this correspondence.

The dGEIS and EFH assessment prepared by the NRC evaluate the proposed action of the license renewal for IP2 and IP3 and form the base documentation for consultation between NRC and the National Marine Fisheries Service [NMFS]. The authorities under which we engage in consultation include the

NRC's environmental protection regulations in Title 10, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions", of the Code of Federal Regulations (10 CFR Part 51), which implement the National Environmental Policy Act of 1969, as amended (NEPA); the Fish and Wildlife Coordination Act (FWCA) , the Endangered Species Act (ESA), and the requirements of our EFH regulation at 50 CFR 600.905 of the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), which mandates the preparation of EFH assessments and generally outlines each agency's obligations in this consultation procedure. The comments provided in this letter pertain to the FWCA and MSFCMA coordination issues that are part of your NEPA and relicensing processes.[1] To summarize briefly, these documents acknowledge that operating once-through cooling systems at Indian Point has resulted in adverse environmental impacts, yet both documents nonetheless conclude with NRC's preliminary determination that the adverse effects associated with license renewal would have only minimal impacts on both living aquatic resources themselves and on EFH designated for federally managed species in the immediate Indian Point area. NRC's analysis of impacts relies upon comparing near field impacts that would occur in the immediate project vicinity versus all EFH designated for a particular species. We frame the issue differently, and instead consider both the adverse effects to the local fishery stocks emanating from the Hudson and the unusually high potential capacity of the mid-Hudson for recruitment of estuary-dependent fishes and production of forage species as important defining issues that lead us to a different conclusion.

Project Background:

The Indian Point Energy Center [Indian Point] is a three-unit power station located on the east shore of the Hudson River in the Village of Buchannan, Town of Cortlandt, Westchester County, New York. Only two of the generating units are operating. Indian Point Unit 1 was permanently shut down in 1974 because the emergency core cooling system did not meet regulatory requirements and therefore posed an unacceptable public risk; IP2 and IP3 continue to operate and are the subjects of upcoming license renewals requested by Entergy. Indian Point has a long presence in the Hudson and is one of the facilities included in the 'Hudson River Settlement Agreement' [HRSA] agreed among the U.S. Environmental Protection Agency and five New York electric utility companies in a controversy regarding coastal habitat and water uses, fish kills and ecological damage in the Mid-Hudson region.

Under the HRSA, the power plant owners and operators made several concessions to stakeholders representing various environmental interests in exchange for them agreeing to withhold imminent pursuit of forced installation of closed-cycle cooling at Indian Point and several other once-through cooled power plants in the mid-Hudson region. In particular, Consolidated Edison abandoned its plans for developing a major pumped storage [hydroelectric] facility at Storm King Mountain, and the various plant operators agreed to collect data and analyze impacts their facilities were having on living aquatic resources for a period of ten years. Subsequent modifications to the HRSA extended the study period by another decade and have allowed these plants to continue withdrawing about a trillion gallons of river water or more per year. Total river water consumption is dependent upon how many days each plant is operating annually and at what output level. Scheduled outages at Indian Point and more sporadic operation of the fossil fueled plants are all determining factors in terms of the actual water consumption levels at any given time. The biological and ecological effects of these withdrawals are somewhat seasonal in that they reflect the biomass and species assemblage present at the time that the water withdrawals are taking place. The extended study period included implementing a variety of measures that partially mitigated for impingement and entrainment impacts, but these individually and cumulatively did not achieve the level of impact reduction that would result from installing closed cycle cooling at Indian Point.

The Indian Point generating units alone consume about 2.5 billion gallons of water *per day* for their pressurized-water reactors. To meet this need, Indian Point relies upon the Hudson River as a cooling water source and heat sink. Water is withdrawn directly from the river through batteries of seven intake

[1] ESA issues have been coordinated in consultation with our counterparts in the Northeast Regional Office's Protected Resources Division and we do not address them here.

bays into each generating unit and distributed to once-through condensers and auxiliary cooling systems. Cooling water is drawn into the plants by variable- or dual-speed pumps. As it first enters, the withdrawn water is skimmed of floating debris and subsequently passed over modified, vertical Ristroph traveling screens designed to protect aquatic life by retaining water and minimizing vortex stress. These modified screens attempt to reduce, but do not eliminate, impingement mortality. A high pressure spray-wash system removes debris from the front of the traveling screen mechanism and a low pressure spray-wash system flushes impinged fishes off the screen and into a sluice system that returns them to the Hudson River.

Under the HRSA, the former owners of Indian Point conducted impingement monitoring between 1975 and 1990 using a variety of techniques; however, neither the previous nor the current owner-operators have performed validation studies to evaluate the actual performance of the modified traveling screens. The EFH assessment Table 6 contains impingement data for IP2 and IP3 collected between 1981 and 1990. Revised data populating this table were provided to the NRC in December, 2009. Upon NMFS' request, these data were provided for our use on October 01, 2010 and were used in our review. Entrained organisms are not removed from the cooling water stream and instead are carried into and through the plants' cooling systems, as they are first collected by the circulating pumps, and subsequently passed through the plant intakes into the condenser tubes used to cool the turbine exhaust steam. Within the condensers, the organisms are subjected to mechanical damage and shear stress, thermal shock, and exposure to chlorine, industrial chemicals and biocide residues. Both the entrained organisms and heated effluent streams then exit the generating plant and are returned to the Hudson River through a shared discharge channel. According to the dGEIS, the prior Indian Point owner-operators periodically conducted entrainment loss studies for IP2 and IP3 since the early 1970s. The most recent data of this nature reported in the dGEIS are from 1990.

Environmental Setting:

The Hudson River Estuary supports an unusually large and diverse assemblage of fish and shellfish, and has long been recognized as a valuable national and regional resource. That is in part because the Hudson makes large contributions not only to local aquatic resource communities, but also to coastal and offshore fisheries that are supported by prey and other nutrients emanating from the estuary. Some of these fishery resources are managed by on an inter-state basis by the Atlantic States Marine Fisheries Commission [ASMFC] and others are managed federally pursuant to the Magnuson-Stevens Fishery Conservation and Management Act [MSFCMA] or the Endangered Species Act [ESA]. All of these aquatic organisms as well as non-managed species such as forage species and other lower trophic level organisms receive consideration under the federal Fish and Wildlife Coordination Act [FWCA] as NOAA trust resources.

More than 200 fish species have been recorded from within the entire Hudson watershed, and approximately two thirds of these occur in the estuary itself for all or part of their life cycles. More specifically, the Buchanan reach of the Hudson River is a tidally-dominated habitat that serves as a migratory corridor, spawning habitat, and nursery area for an unusually diverse species assemblage of resident or diadromous fishes, crustaceans, shellfish, and many lower trophic level prey items (Smith and Lake 1990). Ambient salinity conditions vary seasonally, and generally tend to lie in the mesohaline or oligohaline ranges. The immediate project reach is within the EFH designations for the Hudson-Raritan estuary and is significant with respect to the resources under the stewardship of the agencies mentioned above. As is true of other estuarine habitats, local temperature and salinity regimes, water depth, bottom type, sediment load and current velocities all influence the distribution and function of aquatic communities.

Evidence suggests that northeast coast estuaries have lost much of their rich former fishery productivity because of habitat degradation or loss, but lack of absolute species abundance data for early historical periods prior to significant human disturbances makes this conclusion somewhat inferential. Yet the linkage is supported by strong evidence, particularly that stock sizes for most estuarine dependent fishery resources under the jurisdiction of the Atlantic States Marine Fisheries Commission, New England or Mid-

Atlantic Management Councils, or the states of New York and New Jersey fishery management agencies, are not currently over fished, but fall below historic levels (NEFMC 1998; ASMFC 2005). This observation suggests that the Hudson River's ability to support and produce living aquatic organisms has been compromised over the years by lost habitat quality and quantity as humans have dredged, filled, and withdrawn river water for a myriad of uses, resulting in conflicts of use with fishery resources.[2]

As described above in the Project Background section of this letter, water withdrawals for once-through cooling systems that serve the mid-Hudson power plants has been a major conflict of use that has gone unresolved for decades. A total of five units remain in operation in the mid-Hudson: IP2, IP3, Bowline Point, Danskammer, and Roseton Generating Stations. All of these plants use one-through cooling systems. In the interim since the most recent relicensing was completed for the Indian Point plants, most fish species have experienced declines, and essential fish habitat [EFH] has been designated in order to better manage adverse anthropogenic effects on fisheries. For the immediate Indian Point area, designated EFH includes acreage that produces organisms that are under direct federal stewardship as well as prey items for species further downriver and offshore. The Hudson River is an important regional source for both harvested stocks and prey, so reductions in its productivity are of great significance to fishery ecology and fishery management.

Given the immense natural productive potential of the Hudson River Estuary, and taking into consideration the staggering numbers of organisms that are lost directly, indirectly and cumulatively through continued operation of electric generating stations that continue to use once-through cooling technology in the Mid-Hudson reach,[3] the National Marine Fisheries Service [NMFS] suggests that the current Indian Point relicensing process is an appropriate and opportune time to apply the Clean Water Act § 316(a) and 316 (b) provisions regarding large power generation facilities. We note that the Indian Point generating units comfortably fit under the criteria for being required to ensure that the location, design, construction, and capacity for cooling water intake structures reflect the best technology available [BAT] to protect aquatic organisms from being killed or injured by impingement or entrainment. We provide further rationale for this conclusion in the following sections of this letter.

General Comments on NRCs Exposition of Environmental Impacts of Operation in the dGEIS:

Nuclear power plant system operation may create a number of habitat disturbances that range from minor to major risk to aquatic resources. The evaluation of these impacts would have been enhanced by a more expanded discussion rather than being distilled to a series of summaries on pp. 4-3 to 4-6. These bullets address topics related to a variety of predominantly physical impacts that the NRC dismisses based upon prior experience at other nuclear plants or on the basis of information presented elsewhere in the EIS. We suggest that the NRC reconsider their evaluation before the GEIS and supplement is finalized. Several of these bullets mention subjects which have a potential bearing on EFH and other aquatic resources of concern, and some modifications would demonstrate adequate support for its conclusions. For instance, on page 4-3, the NRC considers altered currents at intake and discharge structures and finds:

> "Altered current patterns have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term".

[2] We note that the U.S. EPA generally has determined that operation of industrial scale cooling water intakes results in a wide spectrum of undesirable and unacceptable adverse effects on aquatic resources including entrainment and impingement; disrupting the food chain; and losses to aquatic populations that may result in reductions in biological diversity or other undesirable effects on ecosystem structure or function. See 66 Federal Register 65,256, 65,292 (December 18, 2001), 69 Federal Register 41,576, 41,586 (July 9, 2004). In addition,

[3] Described in NYSDEC's April 2, 2010 denial of Entergy's water quality certificate and also in the NRC's Supplement 38 to the generic Environmental Impact Statement for the proposed re-licenseing of IP2 and IP3

Given the large volumes of water consumed at Indian Point each day and the relatively narrow configuration of the Hudson River at the project reach, it seems plausible that under full operation, the plant *could* induce noticeable changes in the current regime or perhaps induce changes in the local erosion and accretion rates that have unintended adverse effects such as losses of submerged aquatic vegetation, chronic disturbances that discourage settlement of tiny prey items, and similar effects. Although NRC regulations do not compel the project proponents to provide plume modeling or field studies, our EFH regulations compel us to assume the worst case scenario that the effluent is creating a barrier to migrating fishes and other unacceptable environmental conditions that would adversely affect the amount and quality of available EFH. We understand that the plant operators have been using various measures to partially mitigate for these effects, but the lack of a detailed study that 1) evaluates the impacts of once-through cooling at Indian Point and the three other generating units ***and*** 2) clearly demonstrates that the measures they have been implementing are functionally equivalent to the installation of closed-cycle cooling leaves their position on the Clean Water Act § 316(a) and 316 (b) provisions as unsupported assertions. After several extensions of the HRSA, the situation remains fundamentally unchanged with regard to fish stocks and the plants are potential triggers for lost EFH in the form of direct habitat loss compounded by lost productivity in designated EFH.

There is similar concern in the statements for many of the other bullets in this section of the dGEIS, notably as regards the potential release of chemical or thermal pollution [and attendant adverse impacts to fishery resource movements, etc.]; entrainment of phytoplankton and zooplankton; induction of low dissolved oxygen; and other line items that would reduce the quality and quantity of designated EFH as described in the implementing regulations for the MSFCMA. As such, it is difficult for us to dismiss these topics so easily as problems that could be thoroughly assessed in our overall FWCA and EFH coordination. Along these same lines, existing entrainment study results from IP2 and IP3 collected from 1981-1987 do not seem to include hard data or discussion of the entrainment implications for fish eggs and larvae, copepods and other invertebrate prey items that are described clearly as prey in the EFH vignettes included for red hake, winter flounder, windowpane, bluefish and Atlantic butterfish. While Section H.1.2 of the dGEIS and its corresponding subsections do provide a short discussion of entrainment, and even casually observe that a wide variety of phytoplankton, zooplankton, and early life stages of fish and shellfish are vulnerable to becoming drawn into the generating plants via the cooling water stream, the review documents do not provide a thorough analysis of impacts to EFH with respect to their operations. Losses of this nature would have at least indirect and cumulative adverse effects on EFH not just in the mid-Hudson region, but extending into the marine portions of the coastal zone.

Coincidentally, the discussion noted in the foregoing paragraph touches upon the controversial nature of how different stakeholders view entrainment survival, which has a bearing on how a disagreement like the Hudson River power plant example can take deep root, intensify and perpetuate. For entrainment, the NRC documents note a wide range of perceptions on how different stakeholders view the potential for entrainment survival. As these documents suggest, the most conservative estimates consider entrainment 100% fatal, while some of the power companies suggest that some species or life stages could fare considerably better based upon 96-hour survival studies. The NRC correctly acknowledges in the dGEIS that the latter studies do not take into account indirect losses that arise to organisms becoming injured, disoriented or less able to forage in the event that they are fortunate enough to survive entrainment initially, and conclude for the purposes of their assessment that such losses are unknown. Consequently, NMFS does not see justification in the gDEIS to support a conclusion that impingement effects are not significant, or that any mitigation attempted to date has been as effective as the BAT for industrial scale operations, namely, closed-cycle cooling. This calls into question any progress claimed to have been made in implementing the HRSA in part because it gives the appearance that the various Indian Point operators did not follow through completely on their commitments under the HRSA. Moreover, it appears the operators are content to continue under the *status quo* without demonstrating that their mitigation to date has been functionally equivalent to best available technology as required under CWA §316(b).

NRCs Evaluation of Impacts on Aquatic Resources from Operation of the Cooling Water Intake:

The *intake* impacts for once-through cooling systems largely surround physical habitat loss associated with construction of the intakes themselves as well as the inability of aquatic species from being successfully able to use habitat within the volumes of water withdrawn from the source supply. These impacts may include changing particular ecological features such as local hydrological patterns as suggested in the foregoing section, but the preponderance of the impacts usually are associated with organism impingement and entrainment.

Impingement impacts tend to accrue to larger species and life stages that cannot pass through the impingement screens nor avoid the intake current, but become trapped on cooling water screens and sometimes cannot escape before suffering exhaustion, injury or even mortality. For the subject re-licensing proposal, we note that the most recent study results reported in the dGEIS and EFH assessment are decades old, with the most recent information collected in 1990. This fact concerns us on two counts: 1) the data may not accurately depict contemporary habitat usage of the mid-Hudson region by fishes, invertebrates, and other aquatic life, and 2) the project proponents have not evaluated the effectiveness of adaptive measures that have been implemented since the original HRSA was put into place. For instance, installation of the modified Ristroph traveling screens as a means of addressing some of the impacts associated with impingement injury and mortality was predicated on assumptions made in a limited pilot study. The review materials suggest that the actual performance of this gear has not been demonstrated *in situ*. This is an important consideration because gear does not always perform the same in the field as it does in a laboratory setting and its effectiveness can vary based upon the living aquatic resource assemblages it encounters in different geographic settings. Thus, we are left without empirical data to estimate the effectiveness of installing the modified screens and other mitigation measures against closed-cycle cooling. While the new gear may or may not have improved a less than ideal situation, neither NRC nor Entergy can definitively state how effectively the new screen designs are performing as a means of justifying an additional license renewal that permits continued use of once-through cooling in a potential license renewal.

Unlike impingement impacts, which tend to exhibit some selective characteristics in that they largely accrue to larger taxa or more mature life stages, entrainment of organisms into the cooling water source stream are relatively indiscriminate and may adversely affect *any* organism that fits through the screens and cannot counter the suction force of the intake. While the review material indicate that the IP2 and IP3 cooling systems have been retrofitted with dual-speed and variable-flow pumps in order that intake flows can be regulated to some degree to provide some level of mitigation or protection, we note that the dGEIS also indicates that using planned seasonal outages or maximum pump speeds does not eliminate the losses of fishes and other organisms to entrainment.

Regarding these collective intake impact matters, NMFS disagrees with the NRCs approach to presenting and analyzing the impingement and entrainment data. We particularly dispute the NRCs decision to attempt correlating overall *population level* trends with operation of the Indian Point nuclear generating facilities. First of all, analyzing the data over the entire range of a species instead of a more meaningful population segment does not follow the spirit of the National Environmental Policy Act nor the implementing regulations for EFH in the MSA because it ignores real and obvious impacts that could adversely affect a local stock. It is rare for the preponderance of a particular species be extirpated unless it already is endangered or threatened, but it certainly is quite plausible that a more local segment of an otherwise healthy population could be effectively decimated in an acute event or after years of suffering chronic or cumulative impacts. Thus, when considering the impacts of cooling water withdrawal on more local stock contributions emanating from the Hudson River and potentially recruiting to a greatly dispersed coastal fishery, the effects of cooling withdrawal even from a limited portion of the total available habitat (as it is construed in the dGEIS) could be quite profound. Finally, we are critical of this type of data transformation because it also has great potential for creating undesirable artifacts because it assumes all fishery habitats, regardless of their geographic location, size, and ecological condition, are equally valuable to the living resources that they support. The scientific literature is replete with studies that organisms do not use habitats uniformly over their ranges, and this observation is borne out in our own status and trends data that have been used to select closed areas or to make similar resource management decisions for certain federally managed fishery resources.

In concluding Section 4.1.5 of the dGEIS, upon which the NRC relies to support its overall EFH conclusions, the NRC posits that "impingement and entrainment from the operation of IP2 and IP3 are likely to have an adverse effect on aquatic ecosystems in the lower Hudson River during the period of extended operation", and goes so far as to name several potential mitigation options, but neither arrives at the specific conclusions that the units should be retrofitted with closed-cycle cooling systems, nor selects particular alternatives that they would recommend in lieu of closed-cycle cooling.

NRCs Evaluation of Impacts on Aquatic Resources from Operation of the Cooling Water Discharge:

As disclosed in the dGEIS, the *discharge* of heated water into the Hudson River can manifest a variety of lethal and sublethal effects on aquatic life, influence local ecological conditions, and create barriers to fish migrations. Direct effects tend to be thought of as mortalities that occur when an individual is exposed to conditions beyond their upper thermal tolerance limits. Indirect effects can result in changes to reproductive behaviors, changes in growth rate or survival of young, blocking migratory movements, altered predator-prey relationships, and similar community level disruptions. Oversight of these matters is regulated under a SPDES permit, which imposes effluent limitations, monitoring requirements, and other conditions to ensure that all discharges are in compliance with New York state code and the CWA. The most recent SPDES permit sets a maximum discharge temperature of 110^{0}F, and limits daily average discharge temperatures not to exceed 93.2^{0}F for a set number of days from mid-April through June. These terms have changed over a series of four consent orders since the original SPDES was let.

The NRC bases its evaluation of thermal effects on the status of the SPDES permits for Indian Point. According to the applicant's assessment, IP2 and IP3 are in compliance with terms of a SPDES permit issued by the State of New York as well as further mitigation required under the fourth HRSA consent order. The New York State Department of Environmental Conservation (NYSDEC), which maintains regulatory oversight over this arrangement, concludes that under certain circumstances, modeling demonstrates that discharges from the operating units at Indian Point allow greater than the four degree (F.) over ambient temperature limit, or a maximum of 83^{0}F, whichever is less, in certain estuary cross sections specified under New York State regulations. These matters have been, and remain, in dispute among the plant operators and the NYSDEC, culminating in the state denying a water quality certificate in April, 2010. An ongoing proceeding with the DEC has not resolved the problem, and the NRC notes in the dGEIS that the matter may not be concluded before the NRC issues its final SEIS.

The lack of a thermal study proposed by the NYSDEC or an alternative proposed by the applicant leaves the NRC in the position of having to use existing information to determine the appropriate thermal impact. This resulted in their finding that continued operations with once-through cooling and various mitigation measures would have a small to moderate effect, depending on the extent or magnitude of the plume, the sensitivity of aquatic life stages that were present, and related criteria. In addition to thermal discharges, the NRC considered the potential for plant operations resulting in other impacts to aquatic resources, and concluded that impingement and entrainment are likely to have adverse effects. The significance and extent of these impacts remain in dispute among the involved parties. The project proponents hold that existing operations adequately mitigate impingement and entrainment effects because dual- and variable-speed pumps as well as modified Ristroph were installed at IP2 and IP3, but the efficacy of these and related measures has not been verified by studies. The NYSDEC disagrees with their position, and has concluded that closed cycle cooling is the BAT to address the Hudson River utilities' impacts to aquatic resources. The NRC considered several additional mitigation options and determined that wedgewire screening systems are not feasible; and marine life exclusion systems and/or behavioral deterrents potentially would require further study.

We realize that the ongoing dispute between the plant operator and the State have hampered the NRC's ability to present a full analysis of additional mitigation options available for the existing cooling system, and its potential utility for conserving or protecting EFH functions and values. Nevertheless, we maintain that our analysis of the severity of the project impacts on NOAA trust resources is compelling, and that our conservation recommendations are necessary and appropriate to address the project impacts.

Essential Fish Habitat Comments:

Eight federally managed species with EFH designations within the mixing zone of the Hudson River estuary were identified in the NRCs EFH assessment. Of these, according to NRCs assessment, "there may be adverse individual or cumulative impacts on EFH in the project area for red hake larvae, winter flounder larvae, windowpane juveniles and adults, bluefish juveniles, and Atlantic butterfish juveniles and adults". However, the NRC went on to say in its preliminary EFH determination that they were of the opinion that none of these impacts would rise to a level of concern because "the proportion of EFH affected by IP2 and IP3 is small compared to EFH for the total managed stock". The NRC also proposed that continued operations of the open-cycle cooling systems for these units could continue in a renewed license scenario provided that appropriate mitigation measures were implemented to reduce thermal effluent as well as entrainment and impingement effects.

While the review materials include examples of measures that have been (or could be) implemented to reduce mortalities, it neither advocates a *particular* approach nor evaluates the effectiveness of those measures for protecting and conserving designated EFH or other fishery resource uses. We also note that because the EFH evaluation relies on comparing the immediate project waterfront against the total EFH designated coastally for selected species and life stages, it does not give adequate consideration to the fact that occupation and use of EFH is not uniform. The EFH designations are made on the basis of habitat that is supporting particular species and generic life stages, but does not currently discriminate more finely as to how that habitat is used within a designation. As an example, early juvenile life stages tend to focus on occupation of inshore nurseries and later [but still juvenile] fishes may be using coastal and offshore EFH that better meet their needs. Thus, we do not consider it appropriate to suggest that EFH for a one or two year old juvenile fish is equally suitable for supporting current young of the year juveniles.

Constraining the analysis of impacts to the immediate Indian Point reach and comparing that information against the habitat available to support the entire population and not the stocks originating from the Hudson River, erroneously creates the setting for not being able to find any impacts to EFH. A more appropriate analysis extends the view of entrainment, impingement and thermal discharge impacts to include the mortalities and reduced productivity of forage species, diadromous species, and resident fishes; to assess their impacts on coastal fisheries including species for which EFH is designated downstream; and to discuss how the lost productivity out of the mid-Hudson represents a net reduction in forage opportunities for offshore and downstream resources. This latter class of impacts is quite relevant in this situation and is not analyzed by the NRCs review materials. Nonetheless, the NRCs EFH assessment concluded that there may be adverse individual or cumulative effects of the proposed action on red hake larvae, winter flounder larvae, windowpane juveniles and adults, bluefish juveniles, and Atlantic butterfish juveniles and adults. However, in making this judgment, the NRC did not specify particular impacts of concern in the EFH assessment itself. Extrapolating from the dGEIS, NMFS notes that the primary impacts of concern regarding fishery resources and their habitat generally, and for EFH in particular, that would be associated with continued operations using an open-ended cooling system would be organism loss and habitat degradation. We could not enumerate these impacts based upon the materials provided for our review, but note that at over 2 billion gallons of water consumed per day, the amount of prey available to fishes in particular would be significantly diminished through entrainment alone.

While we recognize the impediments associated with lack of newer studies and related information, NMFS does not agree with some of the methods that the NRC used or assumptions that it made in performing its fish impact evaluations. According to the review materials provided, operating IP2 and IP3 as they currently are leads to direct impacts to EFH species and their prey in the mid-Hudson region. We also note that the EFH assessment and associated analyses were configured too narrowly to capture the breadth and implications that continued operations would have on living aquatic resources and their habitats both in the mid-Hudson and to coastal fisheries. As noted above, we are particularly concerned with the potential for Indian Point operations leading to reduced production or availability of prey, which constitutes an indirect or cumulative adverse effect that diminishes the quality of designated EFH as defined in the MSFCMA. Similarly, it is our opinion that a proper cumulative effects analysis for this situation should have included the adverse effects associated with operations at all of the mid-Hudson power plants that rely on Hudson River water to feed once-through cooling systems. We are not alone in this conviction. According to the NYDECs Final Draft Fact Sheet NY-0004472, dated November, 2003, regarding Indian Point's Surface Water Renewal Permit Action, "Pursuant to Section 316(b) of the CWA, and 6 NYCRR Section 704.5, the Department has determined that the site-specific best technology available (BTA) to minimize adverse environmental impact of the Indian Point Units 1, 2 and 3 cooling water intake structures is closed-cycle cooling." NMFS agrees with New York that a closed-cycle cooling system would significantly limit the amount of intake flow and thereby reduce impacts associated with especially impingement and entrainment. It is our opinion that implementing this measure is in the best interest of fishery resources and also is the most appropriate option for meeting our mutual EFH mandates while allowing continued electric generation at IP2 and IP3 in an otherwise sensitive ecological area.

Essential Fish Habitat Recommendations:

To minimize the impacts on EFH, pursuant to Section 305(b)(4)(A) of the MDFCMA, NMFS recommends that the following conservation recommendations be adopted in conjunction with the proposed federal action:

- Implement the best available practicable technology to mitigate impingement, entrainment, and thermal impacts. The BAT for Indian Point would be reconfiguring the facilities by replacing the once-through cooling system with a state-of-the-art, closed-cycle design. A closed cycle cooling system would minimize water intake rates and return little to no heated water back into the Hudson River. The reduced water withdrawals and greatly diminished, perhaps even non-existent, plume associated with a closed-cycle cooling system would avoid and minimize what NMFS considers to be highly significant mortalities of billions of aquatic organisms and their attendant impacts to coastal fisheries.

Please note that Secton 305(b)(4)(B) of the MSFCMA requires that the NRC provide NMFS with a detailed written response to the EFH conservation recommendation, including a description of the measures adopted by the NRC for avoiding, mitigating, or offsetting the impact of the project on EFH. In the case of a response that is inconsistent with NMFS' recommendation(s), Section 305(b)(4)(B) o the MSFCMA also indicates that the NRC must explain its reasons for not following the recommendation(s). Included in such reasoning would be the scientific justification for any disagreements with NMFS over the anticipated effect of the proposed action and the measures needed to avoid, minimize, mitigate, or offset such effects pursuant to 50 CFR 600.920(k).

Please note that a distinct and further EFH consultation must be re-initiated pursuant to 50 CFR 600.920(1), if new information becomes available or the project is revised in such a manner that it affects the basis for the above EFH conservation recommendation.

Endangered Species Act:

The federally listed, endangered SNS and the candidate species for listing Atlantic sturgeon may be present in the project area. The NRC is currently in consultation with NMFS NEROs Protected Resources Division pursuant to Section 7 of the ESA and the NRC will conclude the ESA consultation with our colleagues in this Division of NMFS. The contents of the above EFH and FWCA coordination does not replace or supersede any negotiations that you may have conducted or will conduct with our PR division, and only pertains to our mutual obligations under the FWCA and MSFCMA.

Should you have any question regarding these comments or need additional information, please contact Diane Rusanowsky at diane.rusanowsky@noaa.gov; 203-882-6504

Sincerely,

Peter Colosi

Peter D. Colosi, Jr.
Assistant Regional Administrator
For Habitat Conservation

References:

New England Fishery Management Council. 1998. Essential Fish Habitat Amendment. http://www.nefmc.org/habitat/index.html

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B

EVALUATION OF SPECIAL CONDITIONS CONTAINED IN SALEM NUCLEAR GENERATING STATION NJPDES PERMIT TO RESTORE WETLANDS, INSTALL FISH LADDERS, AND INCREASE BIOLOGICAL ABUNDANCE WITHIN THE DELAWARE ESTUARY

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1.0 Introduction

The Public Service Electric and Gas Company (PSE&G) Salem Nuclear Generating Station (Salem or Station) is located along the Delaware River Estuary at Artificial Island, River Mile (RM) 50, on the eastern shore of the Delaware River in Salem County, New Jersey. The Salem facility consists of two nuclear-powered units with once through cooling systems. Salem is permitted to withdraw 3.024 billion gallons per day of water from the Estuary for cooling through 12 separate intake bays. Approximately 1,050,000 gallons per minute (gpm) of water is withdrawn from the Estuary by Salem which equates to approximately 1% of the tidal flow that passes the Station. As water is withdrawn, fish and other aquatic organisms are drawn into the Station's intake structures and inner workings (entrained) or are trapped against the intake screens (impinged). Over 3 billion fish are killed each year due to Salem's cooling water intake. Clean Water Act (CWA) Section 316(b) requires that the location, design, construction, and capacity of a cooling water intake structure reflect the Best Technology Available (BTA) for minimizing adverse environmental impact. The requirements of the CWA are addressed through the wastewater discharge program administered by the New Jersey Department of Environmental Protection (NJDEP).

The 1994 and the 2001 New Jersey Pollutant Discharge Elimination System (NJPDES) permits for the Station concluded that the best technology available under 316(b) of the Clean Water Act was (1) reduction of the permitted intake flow of Salem from its maximum design capacity to its maximum actual operation capacity; (2) intake screen modifications; and (3) a feasibility study for a sound deterrent system. In addition to these specific measures meant to address 316(b), the permit contained special conditions including a wetland restoration and enhancement program in and around the Delaware Estuary, the installation of fish ladders, and a baywide biological monitoring program. The stated purpose of the wetland restoration program and the installation of fish ladders is to enhance the production of fish in the Delaware Estuary in an effort to offset losses of fish associated with entrainment and impingement at the cooling water intake structure. The presumption is that restoring marshes tidal influence to blocked coastal marshes, changing the dominant vegetation at Phragmites dominated marshes to mixed vegetation and reducing impediments to fish migration within the Estuary will provide additional or improved habitat for fish to spawn, forage, grow and survive.

Pursuant to its NJPDES permit, PSE&G purchased 20,500 acres of land to satisfy the special conditions of the permit. Of this land, 12,459 acres were wetlands and 2,649 acres were upland buffer. The wetlands included 4,398 acres of diked salt hay farms, 3,723 acres of *Phragmites*-dominated wetlands in New Jersey, and 4,338 acres of *Phragmites*-dominated wetlands in Delaware. PSE&G is using two marsh restoration methods on these lands: (a) opening former salt hay farms to tidal inundation in order to restore natural flows and vegetative conditions and (b) a combination of herbicide application, prescribed burning, and mowing to *Phragmites* dominated marshes in order to alter vegetation ratios so that mixed desirable vegetation species dominate and Phragmites are 95% eradicated. PSE&G is required to engage in these wetlands initiatives until 2012 for New Jersey and 2013 for Delaware wetlands, after which time their current required obligation ends. Herbiciding activities commenced in 1996. Figure 1-1 shows the locations of the wetlands restoration sites and the fish ladder sites.

Carpenter Environmental Associates, Inc., (CEA) on behalf of the Delaware Riverkeeper Network reviewed and evaluated the effectiveness of the wetland restoration project in increasing fish production. The effectiveness of the wetlands restoration methods was analyzed based upon the success of the established plant community, plant densities, invasion by *Phragmites* and other "undesirable" species, utilization of the marshes by fish and the potential for the marshes to increase fish populations in the Delaware Estuary.

Fish ladders were installed to provide adult river herring passage; adult herring spawning in impoundments and tributaries; and juvenile herring development in, and emigration from the impoundments. CEA evaluated existing data in an attempt to determine whether successful spawning runs of herring have been or can be established as a result of fish ladder installation and whether the increase in population of river herring have or will provide additional forage for the predator populations.

The evaluations contained in this report were based upon: documentation provided by PSE&G regarding the restoration efforts; information obtained from the scientific literature regarding salt marsh restoration and the use of fish ladders; and from visual observations of the marshes during the summer season. No in-stream testing or other bioassessment activities were conducted.

2.0 Ecology of the Delaware Estuary

The Delaware Estuary stretches for 134 miles from the mouth of Delaware Bay to Trenton, NJ. Over 200 species of fish use the Delaware Estuary, including both residents and migratory fish. Resident species live within the estuary for all aspects of their life history. Anadromous ocean migrants such as herrings and shad live in ocean waters and migrate to the fresh waters of the Estuary to breed. One species, the American eel, is catadromous; it lives in the fresh or brackish waters of the Estuary and breeds in the ocean. Migrant species are usually dependent on the Estuary as a spawning ground and/or nursery. Other migrant species use the Estuary only as feeding ground. The Delaware Estuary Program has identified a variety of species as being "priority species" within the Estuary including: various sharks, skates and rays, Shortnose and Atlantic Sturgeon, American Eel, Blueback Herring, Alewife, American shad, Atlantic Menhaden, common carp, catfish, White Perch, Striped Bass, Bluefish, Weakfish, Spot, Atlantic Croaker, Black Drum and various flounder species. These species are considered important to recreational and/or commercial fisheries as well as playing an integral role in the Delaware Estuary food web. *(The Delaware Estuary Plan, Delaware Estuary Program, September 1996).*

Fish populations in the Estuary have been impacted by poor water quality. For many years, the waters of the Estuary were oxygen depleted during the summer due to organic pollutant loadings. Since the 1960's there have been improvements in water quality. Improvements in industrial wastewater treatment have resulted in a decrease in the biochemical oxygen demand and decreases in nutrients such as nitrogen and phosphorus. PSE&G has concluded that the improvement of dissolved oxygen levels in the Estuary has resulted in increased spawning migrations of anadromous species such as American shad, blueback herring and alewife. Other resident and seasonal species such as white perch and striped bass have also increased in numbers since the improvement of dissolved oxygen levels. In addition to improvements in water quality, fisheries management programs have been instituted to restrict commercial landings and have produced positive benefits for protected fish species.

Salt marshes are the primary source of much of the organic matter and nutrients forming the basis of the coastal and estuarine food web. As salt marsh vegetation decays, a steady supply of detritus is released into surrounding waters, promoting the secondary production of finfish, shellfish, crustaceans and birds. Characteristic fishes in tidal creeks and flooded marsh areas include Atlantic silversides, sheepshead minnow, and mummichog. Many fish species reside in salt marshes for most of their life cycle, including mummichog, striped killifish, and sheepshead minnow. Atlantic silversides spawn in salt marshes. Other fish depend on salt marsh habitat, associated tidal creeks and adjacent mudflats for nursery areas include winter flounder, tautog, sea bass, alewife, menhaden, bluefish, mullet, sand lance and striped bass. Salt marsh areas provide critical habitat for the larval and juvenile stages of many fish and invertebrate species, and are used for spawning by adults of these species. Marshes are also important feeding and nesting grounds for many birds and other vertebrate species. *(New York State Salt Marsh Restoration and Monitoring Guidelines, New York State*

Department of State and New York State Department of Environmental Conservation, December 15, 2000.)

PSE&G has identified representative important species (RIS) for the Delaware Estuary which are the focus of its impingement and entrainment sampling. These PSE&G identified RIS fish species are: alewife, American shad, Atlantic Croaker, bay anchovy, blueback herring, spot, striped bass, weakfish, and white perch. These species were chosen because PSE&G considered them to be representative of plankton eating and fish eating organisms that inhabit the Estuary, and reflect multiple indirect and direct effects of the Salem facility. These species also have a commercial or recreational value to humans or are important in the transfer of energy within the system. Below is a brief description of the life history of the RIS and of two additional species, mummichog and Atlantic silverside which represent species that are significant in salt marshes and provide an important food source for predatory species.

Figure 2-1 depicts the Delaware Estuary.

2.1 Weakfish

Weakfish are an ocean migrant which generally inhabits the Estuary from April through November. Fisheries management plans for weakfish were issued by the ASMFC in 1991. Adults spawn and feed in the lower estuary (below River Mile 12); young weakfish use the entire bay and lower river (between River Mile 0 and 73) as a nursery during the summer. Spawning occurs in the lower half of the bay, mostly below River Mile 12, but can extend to River Mile 24. Larvae and juveniles move upriver to areas of lower salinity which serve as nursery areas. Feeding and growth of juveniles occurs in the bay and in marshes during the summer. Weakfish migrate to the warm waters of the ocean to overwinter.

2.2 Striped Bass

Striped bass are an anadromous fish which move into the estuary to spawn in fresh to slightly brackish waters. Data has shown that a large fraction of the striped bass population of the Delaware Estuary originate in the Chesapeake and travel to the Delaware Estuary through the Chesapeake and Delaware Canal (C&D Canal). Adults move downriver to estuarine and coastal areas. The majority of early life history stages of striped bass have been found near the C&D Canal. In the Delaware main stem, the principal spawning areas were between Wilmington (RM 72) and the Commodore Barry Bridge (RM 82). Adult striped bass are carnivorous and opportunistic feeders. Shad, river herrings, menhaden and bay anchovy are all consumed by adult striped bass. Striped bass feed in the marsh creeks.

2.3 White Perch

White perch are typically anadromous or semi-anadromous. They occur mostly in brackish water and migrate upriver for spawning in the spring, returning downriver in the fall. Spawning in the Delaware has been shown to be predominantly in upriver areas (RM 92-133). Adults move into deeper and more saline waters to overwinter. White perch larvae move downriver during the post-yolk sac stage, moving toward brackish nursery areas as they develop into juveniles. In tidal creeks, they feed while moving in and out with the tidal flow. All aspects of the early life history of white perch occur in both bay and marsh habitats.

2.4 Spot

Spot spend the winter over the continental shelf, south of Virginia, where they spawn from late September through March. Spawning appears to occur 30-50 kilometers offshore. Larvae remain in the ocean for several months, and are transported by currents toward estuarine nursery areas. Data indicates that the first recruits into the Delaware would be about two to four months of age. Juveniles are dispersed quickly throughout the estuary and tend to become concentrated in tidal marshes and areas of reduced salinity, where they remain throughout the summer, returning to the ocean to overwinter. Adults also move into the estuaries and nearshore coastal areas after spawning and return to the ocean as temperatures drop in the late fall. Spot feed within tidal marshes.

2.5 Atlantic Croaker

The Delaware estuary serves as a nursery area for this migrant species. Adults do not extensively use the estuary, but larvae and small juveniles use the Delaware Estuary marsh creek habitats. Juveniles move downriver in the fall to overwinter in offshore or deeper areas of the bay with warmer waters. Juveniles return to the estuary in the spring where they spend the summer.

2.6 American Shad

This anadromous species migrates into the Delaware estuary to spawn in April and May, spawning as far up the main stem as Hancock, New York (RM 329), with the greatest concentrations of spawning fish being above Dingman's Ferry, NJ (RM236). After spawning, adults return to the sea and migrate north. Larvae gradually move downriver in response to temperature and currents; leaving the estuary to return to the ocean as water temperatures drop in the fall.

2.7 River Herring (Alewife and Blueback Herring)

Alewife, an anadromous species, overwinter in the ocean and migrate up the main stem of the river as far as Milanville, NY (RM 298) from April through early June to spawn. Spawning also occurs in tributaries, where access is available. Juveniles leave the upper tidal portion of the Delaware River as water temperatures drop in early fall, remaining in the area near Artificial Island (RM 51) through early December and enter the lower bay by mid December.

Blueback herring is another anadromous species which travels upriver in the spring to spawn. They ascend both the main stem of the River and tributaries, where access is available. Spawning begins in April and May and may extend through mid-June. Spawning occurs in fast-flowing waters over hard substrates. Adults migrate downriver after spawning, but larvae and juveniles remain in the natal areas throughout the summer and leave the estuary in the fall when temperatures drop.

2.8 Bay Anchovy

Bay anchovy are abundant in estuaries, bays and nearshore coastal areas. Bay anchovy occur throughout Delaware Bay, its tributaries and the C&D Canal, and are seasonally abundant in the lower Delaware River. Bay anchovy are one of the most abundant fishes in the Delaware Bay. Adults move from overwintering areas in the deeper portions of the bay into shallow areas of the estuary where they spawn in spring. Spawning occurs from May through August. Adults remain in the estuary until late summer and early fall when they begin to move back to deeper, warmer waters of the bay. Larvae and juveniles spawned in the lower estuary during spring and summer move upriver into lower salinity nursery areas. Reproduction, feeding and growth of juveniles occurs both in bay and marsh habitats. Juveniles move downriver into deeper channel areas to overwinter. Bay anchovy play an important part in the estuarine food web, serving as the primary food source for juvenile weakfish and summer flounder.

2.9 Mummichog

Mummichog live mainly in tidal marshes and adjacent small creeks. Mummichogs spawn in fresh, brackish and saltwater. Spawning occurs from June through August, with eight or more spawns in a season. They are an important forage fish. They may play an important role in the movement of organic material within and out of salt marsh ecosystems. *(Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic): Mummichog and Striped Killifish, Army Corps of Engineers and U.S. Fish and Wildlife Service Biological Report 82(11.40), June 1985).*

2.10 Atlantic Silverside

Atlantic silversides are abundant in salt marshes, estuaries and tidal creeks and are often the most abundant species found in these areas. Spawning occurs from late March through June in the intertidal zones of estuaries. Juvenile and adult silversides live in intertidal creeks, marshes and shore zones of bays and tributaries in spring, summer and fall, moving towards the deeper warmer waters of the ocean to overwinter. Atlantic silverside serves as an important forage species, serving as a food source for striped bass and bluefish. *(Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic): Atlantic Silverside, Army Corps of Engineers and US Fish and Wildlife Service FWS/OBS-82/11.10, October 1983).*

3.0 Impact of Salem Generating Plant on Delaware Estuary Fish Populations

Aquatic organisms drawn into cooling water intake structures at the Salem facility can either be impinged on components of the cooling water intake structure or entrained in the cooling water system itself. Entrainment occurs when organisms are drawn through the cooling water intake structure into the cooling system. Organisms that become entrained are normally relatively small in size (i.e. fish larvae and juveniles, invertebrates, plankton, zooplankton, phytoplankton, shellfish species). As entrained organisms pass through a plant's cooling system they are subject to mechanical, thermal, and toxic stress. The mortality rate of entrained organisms is high. Impingement occurs when organisms are trapped against screening devices by the force of the water passing through the cooling water intake structure. Impingement can result in starvation and exhaustion, asphyxiation and descaling. In either case, a substantial number of these organisms are killed or subjected to significant harm as a result *(65 FR 49059, National Pollutant Discharge Elimination System, Cooling Water Intake Structures for New Facilities, Proposed Rules, August 10, 2000.)*. If they survive the impingement or entrainment, many of these species die shortly after the experience.

It is estimated that over three billion fish were impinged and entrained at the Salem facility in 1998 (this analysis was based upon consideration of RIS species and therefore likely under represents the number of fish and species impacted). Table 3-1 summarizes estimated entrainment and impingement losses at the Salem facility.

Table 3-2 compares approximate numbers of fish entrained and impinged to total abundance as determined by PSE&G in its permit application. As can be seen in Table 3-2, for most species, the greater the total baywide population, the higher the losses to impingement and entrainment. PSE&G has shown that peaks in impingement and entrainment losses correlate closely to peaks in population; for example, for striped bass, there were peaks in the striped bass population in 1989, 1993, and 1996. In both 1989 and 1993, there were also peaks in the numbers of striped bass entrained and impinged. (The same peak was not seen in 1996, because in that year Salem was undergoing maintenance and did not operate at full capacity.) In addition, losses of bay anchovy to impingement and entrainment have been correlated to years of locally high abundance in the vicinity of the Station.

4.0 Evaluation of Salt Marsh Restoration Vegetative Success

The wetland restoration project included 4,398 acres of diked wetlands (former salt hay farms), 3,723 acres of *Phragmites*-dominated wetlands in New Jersey and 4,338 acres of *Phragmites*-dominated wetlands in Delaware. Wetlands restoration efforts are on-going at a total of ten sites, three of which are former diked salt hay farms/lower bay sites (Commercial, Dennis and Maurice River Townships), the remainder of which are *Phragmites* dominated sites of the upper bay (New Jersey: Alloway Creek Watershed and Cohansey River Watershed and Delaware: Cedar Swamp, Lang Tract, The Rocks, Silver Run and Woodland Beach). Two reference marshes have been designated for comparison. These are (1) the tidal *Spartina*-dominated marsh Moores Beach in the lower bay serving as reference for salt hay farm reclamation, and (2) Mad Horse Creek in the upper bay serving as reference for *Phragmites dominated* sites. These reference sites were chosen due to their natural states, likeness, and proximity to the other sites. See Figure 1-1: Site Location Map.

Diked salt hay farms in the lower bay were historically *Spartina*-dominated salt marshes before impoundments were constructed to restrict tidal flow for the production of salt hay grass. (*Spartina* and other desirable marsh vegetation will be referred to as *Spartina*). Salt hay farming prevents tidal inundation of the marsh, thereby limiting fish access to the marsh and removing this as available habitat. Restoration of these areas involved creation of tidal channels to allow access to the marsh by fish and to provide the hydrology necessary to establish desirable salt marsh vegetation.

The salt hay farm restoration program was started in 1995. Restoration at the Dennis Township Site began in January 1996 and was completed in September 1996; restoration at the Commercial Township site began in September 1996 and was completed in December 1997. The Maurice River Township dikes were breached naturally in 1992. PSE&G subsequent restorations efforts began in 1996.

Phragmites-dominated marshes do provide fish habitat. There is a perception that the quality of the habitat is reduced due to the dense root mat and poorer nutritional qualities of *Phragmites*.

Restoration efforts at the *Phragmites*-dominated sites include herbicide application and prescribed burning to eliminate *Phragmites* at these sites. Restoration efforts at the *Phragmites*-dominated sites in New Jersey are still in progress. Initial efforts to control *Phragmites* involved aerial application of Rodeo and surfactant in late 1996 and 1997 and controlled burning in the spring of 1998. Annual applications of herbicide and/or mechanical intervention continued annually thereafter. As of 2002, annual ongoing activities include follow-up Rodeo and surfactant application on approximately one third of the acreage per year, mowing and modifications to the marsh plain and continued monitoring.

PSE&G has established criteria to evaluate the success of the wetlands restoration efforts. Long term success criteria, according to PSE&G, include establishment of desirable (*Spartina* sp. and other native non-*Phragmites* species) vegetation and percent open water requirements (i.e. total marsh area is not to be more than 20% open water at the majority of the restoration sites). PSE&G has undertaken evaluations of geomorphology, hydrology, vegetation coverage, macrophyte productivity, faunal response and algal productivity. Before the project was started, PSE&G set some criteria for determining the success of the project over a twelve year monitoring period including:

- No less than 95 percent of the marsh plain (66 percent of the total marsh at the Maurice River Township Wetland Restoration Site and 76 percent at the other restoration sites) will be colonized by desirable vegetation
- Phragmites coverage will be reduced to less than 5 percent of the total vegetated area of the marsh plain (less than 4 percent of the total marsh).
- Open water and associated intertidal mud flats will be targeted to be less than 20% of the total marsh area with a potential range up to 30 percent of the total marsh at Maurice River.

A seven growing seasons benchmark was set for all salt hay wetland restoration sites following completion of the restoration implementation activities – i.e. at the end of 7 growing seasons these sites should reach an interim vegetation goal (non-*Phragmites* vegetation) of 45%. Implementation of restoration activities were completed at Commercial Township in December 1997. Dennis Township was completed August of 1996 and Maurice River Township was completed early 1998. Therefore, Dennis Township must reach 45% coverage of *Spartina* by 2003, Commercial Township by 2004, and Maurice River by 2005.

PSE&G also set an interim goal of 45% coverage by *Spartina* and desirable marsh vegetation in six growing seasons for *Phragmites*-dominated sites upon completion of the restoration implementation activities. According to PSE&G, Alloway Creek Watershed, Mill Creek, Cohansey River Watershed, Green Swamp, Lang Tract, Silver Run, The Rocks, Cedar Swamp, and Woodland Beach wetland restoration were completed in 1998. But, it must be recognized that although there has been continued spraying of Rodeo and surfactant application on approximately one third of the acreage per year at Cohansey and Alloways which has contributed to achievement of milestones. According to the milestones, the *Phragmites*-dominant sites must reach 45% coverage of desirable marsh vegetation by 2003.

4.1 Diked Salt Hay Farm Restoration

The main focus of this project was to convert the salt hay farm sites to a salt marsh ecosystem by breaching the dikes along the bay. It is important to reestablish a hydroperiod that returns inundation of the marsh during high tides and drainage during low tides to facilitate growth of *Spartina* spp. and other desirable, naturally occurring marsh species (*Spartina*). To restore the natural hydroperiod, dikes were breached and channels and inlets were excavated throughout the marshes. In this way, the cycle of importing sediment, nutrients, and seeds into the marsh and exporting detritus and other marsh by-products into the adjoining waters can be established. Fish and other aquatic organisms are then able to move up the tidal channels during high tides to feed and move back into deeper channels of the marsh and adjacent estuary during low tides.

4.1.2 Excavation and Removal of Dikes

The design of the diked Salt Hay Farm restoration was to restore the tidal flow into the marshes, and to open marsh channels and thereby restore *Spartina* to these areas. This was accomplished through the excavation of historic water channels and inlets to create the ideal hydroperiod for the growth of *Spartina* and other desirable marsh species. To protect the adjacent properties from flooding the restoration project had to create a design that would ensure that the frequency and depth of flooding would not increase. This was accomplished by the creation of dikes along the upland edges. Cross-drains were installed to allow for drainage of the upland areas. To further minimize any damage to adjacent properties from flooding PSE&G purchased adjacent properties that may be affected.

4.1.3 Phragmites Eradication at Lower Bay Sites

In addition to breaching the dikes and excavating channels, the salt marsh restoration program included a *Phragmites* eradication component. The Commercial Township and Dennis Township sites were treated with Rodeo and a surfactant during the late summer of 1996, 1997, and 1998. All application was done on the ground at a rate of 6 pints of Rodeo per acre. Ground crews sprayed 4, 3.15 and 0.9 acres of *Phragmites* in Dennis Township in 1996, 1997, and 1998 respectively. Commercial Township was sprayed only once, in 1998 27.04 acres were treated. After spraying dead reeds were removed by mechanical means rather than burning.

4.1.4 Commercial Township

The Commercial Township Wetland Restoration Site is located along the Delaware Bay in Port Norris and Bivalve in Cumberland County, NJ. The site is comprised of 4,171 acres of wetland, forested uplands and open fields. Prior to restoration activities in 1996 the site consisted of 7% *Spartina* and 42.6% *Phragmites*. The restoration required the construction of ten inlets along the existing dike and an estimated 75,500 linear feet of new tributaries. The tributaries were constructed at two feet below mean sea level to ensure inundation during low tide. Construction began on this site in September 1996 and was finished December 1997.

Initially, in 1996 the Commercial Township Salt Hay Farm Wetland site had only 7% *Spartina* and 42.6% *Phragmites*-dominated land. This is in contrast to the reference site, Moores Beach, which had on average only 1.5 % *Phragmites* and 88% *Spartina* from 1996 to 2002. After the initial application of Rodeo in 1997, *Spartina* covered less area, dropping from 7% to 5%. The *Phragmites* coverage declined from 42.6% to 26.3% in 1997. The next year the *Spartina* coverage had increased slightly to 6.2%, less than the original amount, but the *Phragmites*-dominated land was reduced to 19.1%. The *Phragmites*-dominated land decreased in 1999 to 8.4% and *Spartina* occupied 9.7%. In 2000, *Spartina* coverage reached 12.3% of the marshland and the *Phragmites* decreased to 7.7%. *Spartina* coverage reached 24.8% in 2001 and the *Phragmites* dominated only 7.1% of the land. In 2002 the *Phragmites* land coverage decreased to 5.3% with a *Spartina* increase to 30.5%. In the first six years of the program, results are beginning to be seen at the Commercial Township site, with reductions in Phragmites and increases in Spartina coverage. However, this site has not yet reached the interim goal of 45% Spartina coverage by 2004, and does not come close to the reference marsh at Moores Beach. See Figure 4-1: Moores Beach percent land coverage and figure 4-2: Commercial Township percent land coverage.

4.1.5 Dennis Township

The Dennis Township Salt Hay Wetlands Restoration Site covers 578 acres of wetland and adjacent uplands. It is located in Dennis Township, Cape May County, NJ. Pre-restoration vegetation consisted of *Spartina* spp., salt hay mix, cattails, *Phragmites* and other marsh vegetation. Restoration of the site required construction of six inlets and an estimated 17,000 linear feet of new tributaries. The channels were constructed approximately two feet below sea level to ensure subtidal habitat during low tide. Restoration began in January 1996 and was completed by September 1996 with the breaching of the dikes.

The Dennis Township Site has maintained a much higher percentage of *Spartina* than Commercial Township since restoration activities began in 1995. The *Spartina* coverage was 65.6% in 1995 before the first application of herbicide. The *Phragmites* dominated only 16.3% of the land. After one year the *Spartina* population had dropped (56%), but so had the *Phragmites* (7.1%). By 1997, the *Spartina* dominated 74.4% of the marsh and the next year, 78.6%, while the *Phragmites*-dominated land dropped from 6.2% to 6% in 1997 and 1998. In 1999 and 2000 the desirable plant populations remained high, reaching 78.5% and then 80.8% of the total land, as the *Phragmites*-dominated land was only 4.6% and 3.0%. This trend continued through 2002 with the *Spartina* maintaining 86.5% land coverage and the *Phragmites* holding at 2.3%. This site has reached the interim goal of 45% coverage by *Spartina*. The 12 year goals of 76% coverage by *Spartina* and 4% coverage by *Phragmites* were also achieved at this site within the first six years, reaching the levels seen in the reference marsh at Moores Beach. See Figure 4-3: Dennis Township percent land coverage.

4.1.6 Maurice River Township

Maurice River Township Salt Hay Farm Wetlands Restoration Site encompasses 1,396 acres and is located in Maurice River Township, Cumberland County, NJ. The perimeter dikes were breached in the winter of 1992-1993, which resulted in uncontrollable flooding and led to much of the area being ponded. As a result much of the vegetative cover was eliminated. PSE&G undertook to create four inlets and 40,000 linear feet of newly excavated channels to create the desired tidal exchange with the estuary. Natural processes are being relied upon to develop higher-class channels and vegetative cover. The construction was begun in 1996 and completed in February 1998.

In the Maurice River Township site, initially, desirable vegetation covered 11.3% of the land while *Phragmites* dominated 7.0%. The very low percentages of both plant groups were due to the previous breaching of the dike and extensive flooding which followed, creating a large area of open water. In 1997 and 1998 the *Phragmites* declined first to 4.4% then to 0.5% of the total land. The "desirable" species climbed steadily to 17.8% then 51.4% of the land cover. The large increase in *Spartina* followed the completion of the construction and dredging in 1998. In 1999 the *Phragmites* stayed steady at 0.5% and then rose slightly to 2.6% in 2000. At the same time the desirable species increased to 58.5% (in 1999) then dropped back down to 39.0% (in 2000). In 2001 *Spartina* increased to 70.9% and dropped to 69.4% in 2002. *Phragmites* coverage was 2.5% in 2001 and 2.3% in 2002. This site has reached the interim goal of 45% coverage by *Spartina* and other desirable vegetation and the 12-year goal of 66% coverage within the first five years of the program. The 12-year goal of reduction to 4% coverage by *Phragmites* was also achieved at this site. See Figure 4-4: Maurice Township Percent Land Coverage.

4.2 Phragmites Dominated Restoration Sites

The *Phragmites* eradication program was undertaken to return what is perceived to be more desirable vegetation to the *Phragmites* dominated sites. *Phragmites* dominated marshes do provide fish food and habitat, but there is a perception that the quality of the habitat is reduced due to the dense root mat and different nutritional qualities of *Phragmites*. Restoration efforts at the *Phragmites* dominated sites include herbicide application and prescribed burning to eliminate *Phragmites* at these sites. Restoration efforts began in 1996. Restoration at the *Phragmites*-dominated restoration sites in New Jersey is on-going. Initial efforts to control *Phragmites* involved application of Rodeo and surfactant in late 1996 and 1997 and controlled burning in the spring of 1998. Rodeo® application methods included aerial spraying and boat and truck applications. Hand application was done in smaller areas. On-going activities in *Phragmites* dominated sites included annual follow-up Rodeo and surfactant application, mowing, modifications to the marsh plain (microtopography), and monitoring of detritus production. Achievement of interim milestones is to be assessed by PSE&G upon completion of restoration. PSE&G asserts that restoration has been completed at all sites. To the contrary, annual spray and invasive activity have continued and appear to be necessary for the successes achieved.

4.2.1 Phragmites-Dominated Tidal Wetlands Spray and Burn Plan

The New Jersey *Phragmites*-dominated wetlands (Alloway Creek and Cohansey River Watershed) were both treated annually with Rodeo® and a surfactant during the growing seasons of 1996, 1997, and 1998. After the first treatment both sites received prescribed burnings in the winter of 1997. Alloway Creek was burned additionally in the winter of 1998. Efforts following 1996-98 spray and burn have been focused on the remaining stands of *Phragmites*.

The aerial Rodeo® application was accomplished using a helicopter equipped with spray system for widespread, even application. Some areas, due to flight misalignments and access complication were not initially sprayed at all. Alloway Creek had 1,844 and 1,760 acres treated in 1996 and 1997 respectively and received smaller spot treatments in 1998 and 1999 (approximately 40 and 230 acres respectively). Cohansey River was sprayed on 417 and 373 acres of land in 1996 and 1997, and two spot treatments were applied during 1998 and 1999 (approximately 40 and 100 acres respectively). Both sites were treated with Rodeo® (Monsanto Company, St. Louis, Missouri) and surfactant again in the year 2000. Some mowing and microtopography was performed as well. Annual spraying from 400-600 acres per year, mowing, and microtopography has continued through 2002 and beyond (specifics regarding 2003 spraying and future plans were not included in materials provided). In areas where aerial application was unsafe or unfeasible, ground application was used. The two sites also received ground applications in 1996, 1997,1998 1999, 2000, 2001, and 2002.

The Delaware *Phragmites*-dominated sites were treated with Rodeo® and a surfactant in the growing seasons of 1995, 1996, 1997, and 1998. Parts of these sites were burned during the winters of 1996, 1997, and 1998. The aerial application was done with a helicopter. The spray mixture was discharged at five gallons per acre. In 1995 *Phragmites* areas were sprayed with a mixture containing 4 pints of Rodeo® per acre and 0.5% surfactant. In successive years any *Phragmites* that were missed or unaffected by the first application again received 4 pints of Rodeo per acre. Whereas, *Phragmites* that were somewhat damaged by the first application (ones that grew back stunted or didn't flower) received a rate of only half that much (2 pints/acre). Finally, areas where more desirable plants grew back received no additional spraying. During the 1997 spraying there were complaints of "streaking" that resulted from pilots lining up off their spray runs in the original 1995 application. These streaks were then incorrectly sprayed with 2 pints per acre of Rodeo® rather than 4, leaving high lines of *Phragmites*. Because there were many tasseled reeds in 1997, more than 4 pints of Rodeo® per acre solution were used than expected. Then in 1998 only tasseled *Phragmites* were sprayed and stunted plants were not. Additional information was provided about the 1999 and 2000 plans for Cedar Swamp and The Rocks. No additional information was available regarding the remaining Delaware sites. In 1999 Cedar Swamp received about 100 more acres of spray and planned to apply 235 more in 2000. The Rocks received about 30 acres of Rodeo® in 1999 and planned a 131-acre spray for the next year. Plans for the other three Delaware sites were not provided for 1999 through 2002.

4.2.2 Alloway Creek Spray and Burn Results

Prior to the original application of Rodeo, the Alloway Creek site contained 3,033 acres of land 71.5% of which was *Phragmites*-dominated (by land coverage), whereas only 14.7% was dominated by desirable vegetation. This is in contrast to the

Mad Horse Creek reference wetland used as a comparison by PSE&G for the upper bay *Phragmites*-dominated marshes. Mad Horse had on average from 1996 to 2000, 82.3% land coverage dominated by *Spartina*. Only 3.5% was dominated by *Phragmites*.

After the first application to the Alloway site in 1996 it was apparent that many of the smaller *Phragmites* were shielded by the taller plants and were unharmed by the herbicide. At the Alloway site the stands remaining after the first treatment ranged in density from 0.8 to 1.9 stems/square meter and in height from 10 to 180 cm. In 1997, the land dominated by *Phragmites* had been reduced from 71.5% to 35.8% of the total marshland. In the same time, the *Spartina* increased slightly from 14.7% to 16.8%. The area formerly dominated by Phragmites was classified as mud flat or bare land, prior to the regrowth of vegetation.

In 1998 the *Spartina* grew to 53.7% of the land coverage, while the *Phragmites* decreased to only 16.8%. In 1999 desirable vegetation decreased to 39.5%, and the *Phragmites* also increased to 37.4% of the marshland area. In 2000 the *Spartina* levels dropped again, going back to 32.3% of the land coverage and the *Phragmites*-dominated land grew to 47.1%. In 2001 the land consisted of 43.3% *Phragmites* and 41.1% *Spartina*. Between 2001 and 2002, approximately 1,000 acres of Phragmites dominated land was removed from the restoration program to be replaced with 1,000 acres of upland. Because of the removal of this area from the calculation of % cover types, it appears that there was an increase in *Spartina* coverage between 2001 and 2002 from 41.1% *Spartina* to 60.9% *Spartina* and a reduction of *Phragmites* from 41.1% to 21.4%. However, the total acreage of Spartina actually declined during this time period from 1155 acres to 975 acres. The *Phragmites* reductions claimed appear to be solely the result of the removal of 1,000 acres from the restoration program.

The interim goal of 45% coverage by desirable species was reached at this site in 2002, but only because PSE&G stopped restoration on 1,000 acres of Phragmites dominated land and removed them from their calculations. See Figure 4-6: Alloway Creek Watershed Percent Land Coverage.

4.2.3 Mill Creek Spray and Burn Results

Mill Creek, a region within the 3,033-acre Alloway Creek Watershed, is a 1,174-acre *Phragmites*-dominated marsh situated in the northwestern region of the watershed along the Delaware River. Spraying began in the Mill Creek region in 1996-97 and the region was burned over the winter of 1997-98.

In 1996 Mill Creek was dominated by *Phragmites* (82.1%) with a sparse cover of *Spartina* (5%). Following the burning in the winter of 1998, the *Spartina* increased to 61.2% with a reduction of *Phragmites* to 15.4%. In 1999, the *Spartina* dropped to 28% and 20.6% the following year. By 2001 the *Spartina* covered 28.5% of the site. The *Phragmites* coverage increased to 57.9% in 1999 and remained relatively level through 2001 at 56.3%.

No data was provided for Mill Creek separately in 2002. Mill Creek was incorporated into the 2002 Alloway Creek Watershed land coverage data. However, by 1998, Mill Creek had achieved the interim goal of 45% coverage by desirable vegetation, but this coverage was not sustained in 1999 and by 2002, Phragmites again dominated and Spartina dropped to below the interim goal. After 2002, the Mill Creek results were folded into the 2002 Alloway Creek Watershed land coverage data, making separate analysis impossible. See Figure 4-7 Mill Creek Percent Land Coverage.

4.2.4 Cohansey River Watershed Spray and Burn Results

In 1996, the Cohansey River Watershed site had 910 acres of land, of which 42.7% were *Phragmites*-dominated and 51.4% was *Spartina*. After the first spraying, the *Phragmites* density at Cohansey River was between 0.2 and 86.6 stems/square meter and heights ranged from 10 to 190 cm. This would allow *Phragmites* to grow back to full density if not treated again. In 1997, *Spartina* changed only slightly, dropping in fact to 50.1% of the total area. The *Phragmites* was only slightly affected by the first spray, dropping to 38.5%. In 1998, after two treatments, *Phragmites* reduction was evident, with 78.9% of the land covered by *Spartina* and only 9.0% of the land dominated by *Phragmites*. In 1999 the *Spartina* coverage was down to 61.7% and the *Phragmites* inhabited 10.1% of the area. In 2000, the *Phragmites* remained constant while the area dominated by *Spartina* increased to 75.3%. In 2001, the *Phragmites* dominated 10.9% of the marsh with about 74% of the marsh covered by *Spartina*. In 2002, *Phragmites* decreased to 8.5% coverage while *Spartina* increased from 3.6% to 77.6%. Cohansey River Watershed has exceeded both the interim goal of 45 % coverage by *Spartina* and the 12-year goal of 76% *Spartina* coverage. See Figure 4-8: Cohansey River Watershed Percent Land Coverage.

4.2.5 Silver Run

Silver Run initially, in 1993, before the first application of Rodeo, had 0.7% land covered by *Spartina* and 85.5% covered by *Phragmites*. In 1996 the *Spartina* coverage had increased to 8.5% and the *Phragmites* decreased to 60.9%. The next year the *Spartina* increased to 55.2% and finally 58.4% of the total area in 1998. At the same time, the *Phragmites* decreased to 20% and then finally 15.1%. No additional monitoring data is available for this site. However, the interim goal of 45% coverage by *Spartina* was achieved at this site by 1998. See Figure 4-9: Silver Lake Percent Land Coverage.

4.2.6 Lang Tract

Lang Tract initially had 0.7% *Spartina* coverage and 90.6% of the land dominated by *Phragmites*. In 1996 the *Spartina* coverage increased to 12.2% and *Phragmites* decreased to 54.3%. In 1997 and 1998 the *Phragmites* reached 0.0% and then increased slightly to 0.2%. The *Spartina* coverage reached 92.6% and then declined to 77.2% in 1997 and 1998, respectively. No additional monitoring data is available for this site. However, both the interim goal of 45% coverage by *Spartina* and the 12 year goal of 76% coverage was achieved by 1998. The 12-year goal of reduction to 4% coverage by *Phragmites* was also achieved at this site. See Figure 4-10: Lang Tract Percent land Coverage.

4.2.7 Woodland Beach Wetland

Woodland Beach Wetland contained 62.1% *Spartina* initially and 33.1% *Phragmites*-dominated land. In 1996 after the first spray, the site had 64.1% *Spartina* coverage and 31.6% *Phragmites* coverage showing little change. By 1997, 77.1% of the land was covered by *Spartina* and finally in 1998, 83.5%. The *Phragmites*-dominated land decreased from 18.6% to 9.6% in the same two-year period. No additional monitoring data is available for this site. However, both interim goal of 45% coverage by *Spartina* and the 12 year goal of 76% coverage was achieved by 1998. See Figure 4-11: Woodland Beach Percent Land Coverage.

4.2.8 The Rocks

The Rocks initially had only 10.5% *Spartina* and 87.1% *Phragmites*. In 1996 the *Spartina* coverage had increased to 19.7% of the land while the *Phragmites* dropped to 27.8%. In the next two years the *Spartina* coverage increased to 82.3% and then 88.3%, whereas the *Phragmites* declined to 13.3% and then 8.2% of the marshland area. In 1999, The Rocks had only 79.8% *Spartina* coverage and 11.1% *Phragmites* dominated coverage. In 2000 the percentage of *Spartina* increased to 87.4% and the *Phragmites* dropped further to 7.9%. Then in 2001 *Spartina* dominated only 62.4% of the land, a decrease from the previous year and *Phragmites* increased to 33.1%. By 2002, the *Spartina* increased to 70.9% and *Phragmites* decreased in land coverage to 22.9%. The interim goal of 45% coverage by *Spartina* has been reached at this site. See Figure 4-12: The Rocks Percent Land Coverage.

4.2.9 Cedar Swamp Wetlands

Before the first treatment Cedar Swamp Wetlands had 17.8% *Spartina* and 71.7% *Phragmites*-dominated land. In 1996 the *Spartina* land coverage was 19.2%, 33.1% in 1997, 37.0% in 1998, and 64.0% in 1999. The *Phragmites* coverage was 10.7% by 1996, declined further in 1997 to 3.0%, and increased slightly to 4.2% in 1998, increasing again to 11.3% in 1999. In 2000 Cedar Swamp had a high of 69.2% *Spartina* but the *Phragmites* coverage also increased to 12.2%. By 2001, the *Phragmites* coverage increased to 17.9% while the *Spartina* fell to 66.6%. The monitoring year 2002 saw a rise of *Spartina* to 71.7% coverage and a decline of *Phragmites* to 14.9%. The interim goal of 45% coverage by *Spartina* has been reached at this site See Figure 4-13: Cedar Swamp Percent Land Coverage.

4.2 Conclusion

The salt marsh restoration program is showing signs of success in terms of vegetative coverage and the return of tidal flow to the former salt hay farms. The *Phragmites* eradication program has reduced *Phragmites* coverage but appears to be depending on annual herbicide application.

Of the three salt hay farm sites, only Commercial Township has not reached the interim goal of 45% coverage, although a few more years of monitoring are necessary to reach a conclusion regarding success at this site. The Dennis and Maurice Township sites have also achieved the 12-year goals of desired plant coverage and *Phragmites* coverage.

All of the Phragmites dominated sites have achieved the interim goal *Spartina* coverage except Mill Creek. However, this goal was met at Alloway Creek only because PSE&G no longer considered 1,000 acres of *Phragmites* dominated land as part of the restoration program. The Cohansey, Lang and Woodland achieved the 12-year goal for *Spartina* coverage. The Lang Tract has also achieved the 12-year goal for

Phragmites coverage. However, the sustainability of the Phragmites reduction appears to be dependent on annual herbicide treatment. The true success of the *Phragmites* control program cannot be determined until herbicide treatment and marsh manipulation efforts such as burning have been discontinued.

5.0 Fish Response at Restored Marshes

The purpose of the marsh restoration program is to enhance fish production in the Delaware Estuary. Biological monitoring of the restored marshes began in 1996. Annual reports documented information regarding the fish assemblages including comparisons of abundance, size, and species richness. The treated *Phragmites* dominated sites were analyzed separately from the salt hay farm restored sites. The large creek or channels are analyzed separately from the small creeks and marsh plain at both the salt hay farm sites and the treated *Phragmites* sites due to differences in fish assemblages between the two distinct areas of the tidal marsh. The study sites were kept uniform and unchanged from year to year to ensure that there would be a basis for a long-term comparative study of the fish utilization of the restoration sites. To ensure a proper evaluation of the data over the course of the study period, sampling parameters were designed on the basis of creek size, depth, direction of current, sample time, number of sampling stations, and tides. The same areas were sampled each time.

In addition to the annual reports, PSE&G conducted supplemental analyses as part of its 1999 Permit Renewal Application to determine fish response to the restoration efforts. Fish species composition, life history stage, size and growth were compared by PSE&G in restored and reference marshes. Reproduction, feeding and growth of selected species were assessed. Habitat use, residency, and movement patterns were determined with mark-recapture techniques for striped bass, Atlantic croaker, sheepshead minnow and mummichog. Because these more detailed analyses were conducted over a limited time frame (1996-1999), they will be discussed separately from the information compiled from the Annual Reports.

5.1 Fish Response at Restored Salt Hay Farm Sites

Once a desirable hydroperiod was set up through the breaching of the salt hay farm dikes, fish and other aquatic species could utilize the salt marsh ecosystem. Biological monitoring of the restoration and reference sites by PSE&G began in 1996 to determine how the fish populations of the bay were utilizing the newly restored salt marsh sites.

Of the three salt hay farm restoration sites two, Dennis Township and Commercial Township have been monitored for fish assemblages since 1996. Maurice River has not been monitored. Moores Beach was chosen as a reference site due to its proximity to both sites.

5.1.1 Large Marsh Creeks Annual Report Data

Restoration efforts at the Dennis Township site were completed in August 1996 and at the Commercial Township site in 1997. Pre-restoration densities of fish were not sampled at Dennis Township, due to access difficulties, although it appears that fish responded quickly to the restoration, with large numbers of individuals present in 1996. Abundances of fishes using the large marsh at Commercial Township increased steadily from 1996 (pre-restoration) to 1998.

In 1998, the dominant species at the restored and reference sites were similar, but Dennis Township had the greatest species abundance and Moores Beach the lowest. Overall fish abundance at Dennis Township was greater by an order of magnitude than the reference site at Moores Beach. At Commercial Township, early in the second year after restoration, the fauna was similar to the reference marshes and abundance was as high or higher than the reference marsh.

In 1999, Dennis Township had the highest abundance of fishes, followed by Moores Beach and Commercial Township. Differences in abundance were attributed to the much greater abundance of Atlantic croaker at the Dennis Township site. Bay anchovy and spot were also in greater abundance at Dennis Township. Commercial Township had the highest species richness, Moores Beach the lowest. Species assemblage as determined by rank dominance was similar among all three sites, with greater similarities seen between the two restored sites than between the restored sites and the reference site.

In 2000, fish assemblages differed among all sites, with Atlantic croaker being high at Dennis Township, weakfish abundant at Commercial Township and Atlantic silverside high at Moores Beach, but low at the other two sites. Greater similarities were seen in assemblage as characterized by order of abundance of the dominant species among the restored Commercial Township site and the reference Moores Beach site than between the two restored sites. Dennis Township had the highest species richness at 37 species collected with Commercial Township having 22 species and Moores Beach 20 species. Size differences were seen as well, with larger fish collected at Commercial Township than at the other two sites.

In 2001, of the three sites, Dennis Township had the highest abundance of fish, with Commercial Township and Moores Beach having similar abundance levels. Fish assemblage was similar between all three sites, with Atlantic croaker being the most abundant. PSE&G determined that greater similarities were seen between the restored Dennis Township site and the reference site, rather than between the two restored sites. Size of fishes collected was also similar between Dennis Township and Moores Beach, with large fish seen at the Commercial Township site.

In 2002, fish abundance was lower at the restored Commercial and Dennis sites than at the Moores Beach reference site. In 2002, Moores Beach had the highest abundance of fish, followed by Dennis Township. Dennis Township had the highest species diversity, followed by Commercial Township. Differences were seen between the species of fish that were dominant between the reference site and the restored marshes, with Atlantic Croaker the most abundant species at all three sites. PSE&G determined that the species assemblage was more similar between the restored sites than between the either of the restored sites and the reference marsh at Moores Beech. In addition, differences were seen in the size class of the fish found in the reference marsh as compared to the restored sites, with more smaller sized fish at Moores Beach than at either of the two restored marshes.

Tables 5-1 through 5-3 show the numbers of fish collected at the three sites. Figures 5-1 though 5-7 compare the numbers of each of the target species collected in the large creeks of the salt hay farm restoration sites and the reference site from 1996-2002. Figures 5-8 through 5-10 compare the numbers of each of the target species within each individual site.

Overall the fish assemblages in the large marsh creeks at the restored sites are similar to that seen in the reference sites with slight differences in the rank abundances of species between all sites. The restored Dennis Township site was shown to have a greater abundance and species richness than the reference site in most years.

5.1.2 Small Marsh Creeks Annual Report Data

According to the 1996 Annual Report, abundance was greater at the reference site than at Dennis Township, but species diversity was greater at the Dennis site. Based upon data collected at the diked Commercial Township site, relatively few fish utilized the small marsh creeks prior to restoration.

In 1998, a greater abundance of fishes was seen at Dennis Township than at the reference marsh while species richness was similar. The size distribution of fishes was similar between Dennis Township and the reference site.

In 1999, abundance and species richness was greatest at the Dennis Township site, and lowest at the Commercial Township site. Differences were seen in the rank order of dominance between Dennis Township and the other two sites as well with Dennis Township showing an abundance of young of the year Atlantic Croaker, and Commercial and Moores Beach being dominated by Atlantic silverside, mummichog and blue crab.

Fish were more abundant at the Moores Beach site and least abundant at the Dennis Township site according to the 2000 Annual Report. Fish assemblages, as determined by rank dominance of species were similar at all three sites. Dennis Township had the highest species richness, Commercial Township the lowest. Fish size was similar at all three sites.

Based upon the 2001 Annual Report, Dennis Township had the highest abundance of fish, followed by Commercial Township, then the reference site at Moores Beach. Atlantic croaker was very abundant at Dennis Creek as compared to the other two sites, while mummichog and Atlantic silverside were abundant at Commercial Township. The fish assemblages were more similar between the two restored sites than to the reference site. Fourteen species were collected at Dennis Township, 13 at Commercial and only seven species were collected at Moores Beach. Size of fishes was similar between all three sites.

In 2002, Commercial Township had the highest abundance of fish, followed by Dennis Township. Fish assemblages differed at each of the sites. Dennis Township had the highest species diversity, followed by Commercial Township. The reference site, Moores Beach, had a greater abundance of larger fish than either of the two reference marshes.

Tables 5-4 through 5-6 show the numbers of fish collected in the small creeks at the three sites. Figures 5-11 through 5-17 compare the numbers of each of the target species collected in the small creeks of the salt hay farm restoration sites and the reference site from 1996-2002. Figures 5-18 through 5-20 compare the numbers of each of the target species within each individual site.

As was seen in the large marsh creeks, Dennis Township had the highest abundance of fishes in most years sampled. According to the annual reports "the overall greater catch rates and abundance of dominant species at the restored salt hay farm at Dennis Township "indicate a much richer fauna, possibly due in part to the greater amount of flooding and increased hydroperiod at the lower elevation within that site". Overall, the annual reports indicate that the salt hay farms are responding well to the restoration efforts and are being utilized by fish in a similar manner to the reference marsh.

5.1.3 Supplemental Studies Conducted by PSE&G

Supplemental studies were conducted by PSE&G to compare fish species composition, life history stage, size and growth in restored and reference marshes. The analyses included comparison of fish assemblages of different ages and different trophic levels, and an assessment of marsh functions such as reproduction, feeding and growth for selected species. Habitat use, residency and movement patterns were determined with mark-recapture techniques for select species.

5.1.3.1 Fish Assemblage

These supplemental studies concluded that young of the year fish assemblages were similar in the restored sites and the reference marshes including size composition, seasonal patterns of occurrence, and species composition, with higher abundances of young of the year fish species in the restored marshes.

5.1.3.2 Large Fish Use of Marshes

Sampling was conducted from June to November 1998 to assess the use of the marshes (Dennis Township and Moores Beach) by large (typically predatory) fish.

Striped bass and white perch were the most abundant predators collected, with smaller occurrences of weakfish and bluefish. It was determined that predatory fish utilize the marsh in both the restored and reference marshes primarily during low tide, when prey are concentrated at the creek mouths. Collection of predators in the upper creek mouths was rare in both the restored and reference marshes. A greater density and species richness of large fish was seen in Dennis Township as compared to the reference marsh at Moores Beach. This study demonstrated that the restored marshes are functioning in a similar manner to the reference marsh as predator habitat.

5.1.3.3 Residency Studies

Studies were conducted in 1998 to determine if fish were using the restored marshes as part or full time residents. Four species of fish were studied using tag-recapture methods including mummichog, sheepshead minnow, Atlantic croaker, and striped bass. Mummichog was determined to be a resident species, with the marsh serving as a habitat for feeding for young of the year. Sheepshead minnow was also determined to reside in the marshes. Young of the year Atlantic croaker typically use the marshes in the summer as young of the year and retreat to deeper waters of the bay and ocean as temperatures drop. The tag recapture studies showed that young of the year Atlantic croaker spend a large portion of the summer and early fall in the restored Dennis Creek marsh as well as the reference marsh. Within the marsh, the studies showed that young of the year croaker use the upper portion of the creek on high tides and either leave the creeks and move into adjacent larger creeks or accumulate in the mouth of the creeks during low tides. Both large juvenile and adult striped bass were shown to move up the main channel during ebb tide when prey are typically concentrated at the creek mouths.

5.1.3.4 Reproduction

The two species of fish, mummichog and Atlantic silverside, that typically reproduce in marsh creeks in the Delaware Estuary were determined to reproduce in both the restored marsh at Dennis Township and the reference marsh.

5.1.3.5 Food Habits

Food habits were assessed to determine whether the restored and reference marsh provide equivalent habitat for fish foraging. It was determined that the diets of mummichog, bay anchovy spot, weakfish, white perch indicate that similar food types were consumed at the restored marsh as compared to the reference marsh. Similarly, the diets of the predatory species striped bass and white perch were determined to be similar between the reference marsh and Dennis Township.

5.1.3.6 Growth and Survival

Tag and recapture studies conducted in 1998 were utilized to determine that growth rates of young-of-the year bay anchovy, spot and croaker within the restored marsh was shown to be similar between the restored and reference marsh. Based upon the size of sheepshead minnow, mummichog, and Atlantic silverside, it was determined that these species survive in the marsh to reach the approximate size of reproduction in both the restored and reference marsh.

5.2 Fish Response at Upper Bay Treated Phragmites Dominated Marshes

Biological monitoring of the restoration and reference sites by PSE&G began in 1996 to determine how the fish populations of the bay were utilizing the treated *Phragmites* dominated sites.

Originally, two treated *Phragmites* sites, Browns Run and Mill Creek were studied, with Mad Horse Creek being the reference marsh. In 1999, Alloway Creek monitoring was initiated including monitoring of a naturally *Spartina* dominated area, a naturally *Phragmites* dominated area and a treated *Phragmites* area. The addition of Alloway Creek allows comparisons within a watershed which may be more meaningful than comparisons between disparate locations. The use of Alloway Creek for comparison purposes is particularly important because there are large differences between the locations and salinities of the treated sites (Browns Run and Mill Creek) and the reference site (Mad Horse Creek) making comparisons between the reference site and the treated sites difficult. According to the PSE&G annual reports, many of the differences in richness, size and abundance among the upper bay sites may be due to assemblage differences resulting from a strong among-site salinity gradient in this part of the salinity range.

In general, fish abundance is less at the upper bay sites than at the lower bay sites.

5.2.1 Large Marsh Creeks Annual Report Data

In 1998, abundance was greatest at the treated Mill Creek site, while Browns Run and the reference site at Mad Horse Creek had similar abundances. Fish assemblage and size distribution was similar at all three sites.

No clear trends in overall abundance were seen in 1999. Monitoring at Alloway Creek was initiated in 1999, with monitoring conducted at a naturally *Spartina* dominated area, a naturally *Phragmites* dominated area and a treated *Phragmites* area. Within Alloway Creek, the *Spartina* site had the lowest abundances, followed by the site under treatment. Abundance was greatest at the *Phragmites* site. Outside of Alloway Creek, the reference marsh had a greater abundance of fishes than one of the treated sites, Browns Run, but a lower abundance than the other treated site at Mill Creek. Abundance at all three sites was less than at the Alloway Creek *Phragmites* site. Fish assemblages were similar between the sites.

In 2000, fish abundance was similar between all three sites in Alloway Creek. Overall, the Mill Creek site had the highest abundance and Browns Run had the lowest abundance. Differences in the size of fishes collected was observed among the sites, with the Alloway Creek sites showing similarities among the sites in the shape of the size distribution. The fish assemblage at all sites was similar both in species richness and the rank of dominant species, although fewer weakfish were collected at Browns Run and Atlantic croaker and brown bullhead were abundant at Mill Creek. The Alloway Creek sites showed utilization by striped bass. Within Alloway Creek, the *Spartina* reference site and the Treated site showed greater similarities in rank abundance than the *Phragmites* site. The *Phragmites* site had the greatest species richness (27) and the treated site the lowest (25).

In 2001, fish abundance was lower at the treated site in Alloway Creek than at either the *Spartina* site or the untreated *Phragmites* sites. The Mill Creek site had the highest abundance, with the reference site at Mad Horse Creek having the second highest abundance. Restored Brown's Creek had the lowest abundance. Bay anchovy dominated at all upper bay sites, but different assemblages of fish were seen at each site. Species richness was similar, with Mill Creek having 25 different species, and Browns Run and Mad Horse Creek each having 23 species. Based upon rank abundance, among the Alloway Creek sites there was a greater similarity between the *Spartina* reference site and the treated site than with the *Phragmites* site. Size differences in the fish collected at the lower bay sites was evident, due in most part to the different assemblages found at each site, rather than dissimilar sizes of the same species. Differences in richness, size and catch per unit effort (CPUE) among the upper bay sites may owe to assemblage differences resulting from salinity gradients.

No apparent trend was seen by PSE&G in fish abundance in the upper bay in 2002. Within Alloway Creek, the *Phragmites* site had the highest abundance of fish. Fish abundance at the treated and *Spartina* sites was lower than at the *Phragmites* site, but similar to each other. Fish abundance at the *Phragmites* dominated site at Alloway Creek was approximately twice as great than that seen at *Spartina* dominated site and the treated site at Alloway Creek. Mean length and species richness was similar at all three sites in Alloway Creek. The reference site (Mad Horse Creek) had fewer fish than Mill Creek but more than Brown's Run. Fish assemblages were similar among all sites, with bay anchovy, white perch, Atlantic croaker and hog choker the four most abundant species.

Tables 5-7 through 5-12 show the numbers of fish collected at the large marsh creeks. Figures 5-21 through 5-27 compare the numbers of each of the target species collected in the large creeks and the reference sites from 1996-2002. Figures 5-28 through 5-33 compare the numbers of each of the target species within each individual site.

The best measure of the success of the *Phragmites* restoration program in enhancing fish utilization of the marshes appears to be the comparison of fish utilization of the three different sites within Alloway Creek. In three of the four years analyzed (1999, 2001 and 2002) fish abundance was greater at the untreated *Phragmites* site than at the treated *Phragmites* site indicating that the restoration program is not increasing, and may not increase, fish utilization of the marshes.

5.2.2 Small Marsh Creeks Annual Report Data

In 1998, Mill Creek had the highest abundance of fishes and the greatest species richness, followed by the reference site at Mad Horse Creek. Browns Creek had the lowest abundance. Species assemblage differed at all three sites, but mummichog and Atlantic silverside dominated at all three sites.

In 1999, no clear trends were seen in overall abundance between restored and reference small marsh creeks. Browns Run demonstrated the highest abundance of fishes in the small marsh creeks. The treated site had the highest abundance among the Alloway Creek sites, with the *Phragmites* site and the *Spartina* site showing similar abundance values. Size differences were seen between the sites due in part to differences in fish assemblage.

In 2000, Browns Run demonstrated the greatest abundance of fishes in the small marsh creeks. Within Alloway Creek, the treated site showed the highest abundance, the *Spartina* site the lowest. Differences in the size of fish was seen between the sites, with Browns Run having larger fishes. Within Alloway Creek, the treated site had larger fish, with the size of the fishes being similar at the *Phragmites* site and the *Spartina* site.

In 2001, Browns Run had the greatest abundance of fish in the small marsh creeks. Among the Alloway Creek sites, the treated site showed the highest abundance, the *Spartina* site the lowest. Mummichog dominated at all sites but Mad Horse Creek, where Atlantic menhaden dominated. Mill Creek and the Alloway Creek sites had fewer species than the other two sites, with only five fish species and no blue crabs. The Mad Horse Creek reference site and Browns Run restoration site each had 12 species represented. Browns Run had a greater abundance of large fishes than at any other site. The size difference was not based solely on assemblage difference, mummichog were larger at Browns Run than at all other sites.

According to the 2002 annual report, both the Browns Run site and the Mill Creek site had higher abundance, mean size and species richness than the reference site at Mad Horse Creek. Within Alloway Creek, the treated site had the highest abundance, with similar size of fishes to both the *Spartina* site and the untreated site. The untreated *Phragmites* site had the highest species richness.

Tables 5-13 through 5-18 show the numbers of fish collected at the small marsh creeks. Figures 5-34 through 5-40 compare the numbers of each of the target species collected in the large creeks and the reference sites from 1996-2002. Figures 5-41 through 5-46 compare the numbers of each of the target species within each individual site.

5.2.3 Supplemental Studies Conducted by PSE&G

Supplemental studies were conducted by PSE&G to compare fish species composition, size and growth in restored and reference marshes. The analyses included assessment of marsh functions such as reproduction, feeding and growth for selected species.

5.2.3.1 Fish Assemblage

These supplemental studies concluded that fish assemblages were similar in the restored sites and the reference marshes including size composition, seasonal patterns of occurrence, and species composition. Considerable annual variation was seen. Prior to treatment, the abundance of fish at Browns Run was lower than that of the reference marsh at Mad Horse Creek and Mill Creek fish abundance was occasionally greater than the reference site throughout the sampling season in 1996. After treatment, fish abundance was variable at the treated marshes, with time periods showing greater abundance in the treated marshes at Browns Run and Mill Creek and other periods showing fewer fish utilizing the treated marshes.

5.2.3.2 Reproduction

The two species of fish, mummichog and Atlantic silverside, that typically reproduce in marsh creeks in the Delaware Estuary were determined to reproduce in both Brown's Run and the reference marsh at Mad Horse Creek. No evidence of reproduction of Atlantic silverside was seen at Mills Creek, although evidence of mummichog reproduction was seen at this site. Reproduction of mummichog was seen at Brown's Run and Mill Creek both prior to and after treatment. Some evidence of reproduction of Atlantic silverside was also seen at Brown's Run both prior to and after treatment.

5.2.3.3 Food Habits

Food habits were assessed to determine whether the restored and reference marsh provide equivalent habitat for fish foraging. Bay anchovy, spot and white perch were shown to eat similar prey at the Browns Run site and the Mad Horse Creek reference site. In 1998, several differences were seen in the food habits of the species using the Mill Creek site as compared to the Mad Horse Creek reference site. For bay anchovy, the diets were similar between the two sites, while weakfish had higher per capita prey consumption at Mad Horse Creek although the types of prey consumed were similar. White perch was shown to have a more diverse and different diet at Mill Creek as compared to the reference site.

Studies of mummichog indicate that they utilize *Phragmites* as a food source within *Phragmites* dominated marshes.

5.2.3.4 Feeding and Growth

Mummichog and silverside were determined to have similar feeding and growth rates in the treated and reference marshes. Adequate foraging habitat for white perch, bay anchovy, spot and weakfish was available in the treated marshes and the reference marshes. Similar growth rates of young of the year mummichog and Atlantic silverside were seen before and after treatments began.

5.3 Conclusions

Fish response to the restoration of the salt hay farms has been positive. Young of the year fish assemblages were similar between the restored salt hay farms and the references marshes including size composition, seasonal patterns of occurrence and species composition. Predator species such as striped bass and white fish were also found to be utilizing the restored salt hay farms, with a higher diversity of species and a higher density of predator fish as compared to the reference marshes. Forage studies indicated that food habits of the fish were similar between the restored salt marshes and the reference marshes. Data indicates that at least two species of fish (mummichog and Atlantic silverside) were utilizing the restored marshes for reproduction. Growth rates of young of the year fish were similar between the reference sites and the restored marshes.

The data does not support a conclusion that the restoration of the Phragmites dominated sites is increasing fish utilization of those areas. Monitoring at Alloway Creek includes several sites dominated by *Phragmites*, *Spartina* or under treatment for *Phragmites* removal. The 2000 monitoring showed that within Alloway Creek large marsh creeks, fish abundance was similar at all three sites. In 2002, no apparent trend was reported by PSE&G. Within Alloway Creek large marsh sites, the *Phragmites* site had the highest abundance of fish, while the treated and *Spartina* sites had similar abundances. Evidence of reproduction of mummichog and Atlantic silverside was seen, with reproduction occurring in the *Phragmites* dominated sites both prior to and following the treatment of *Phragmites*. Growth patterns were seen to be similar for mummichog and Atlantic silverside both pre and post treatment as well. Studies also indicate that mummichog are able to use *Phragmites* as a food source in *Phragmites* dominated sites. These results do not demonstrate that *Phragmites* eradication is resulting in increased utilization of the sites and increased fish production.

6.0 Evaluation of Fish Ladders

As part of the special conditions of the 1994 permit, PSE&G is required to "eliminate impediments to fish migration." River herring (alewife and blueback herring) serve as an important forage fish for striped bass and weakfish in Delaware Bay. Dams and other barriers that have been constructed over the past century have kept river herring from migrating back up tributaries to their natal spawning grounds. One solution to this problem is building fish ladders. These ladders act as a series of small steps, enabling the fish to "climb" the height of the dam gradually.

Eight sites were selected for fish ladder installation: Sunset Lake (on Cohansey River), Cooper River, Silver Lake, McGinnis Pond, McColley Pond, Coursey's Pond, Garrisons Lake and Moores Lake. Figure 1-1 shows the locations of the fish ladder sites. The McGinnis Pond, Silver Land and McColley Pond fish ladders have been in operation since 1996; the Coursey's Pond and Sunset Lake ladder have been operational since 1997, Cooper River since 1998 , and Moores and Garrison lakes since 1999.

To successfully establish river herring usage of the constructed fish ladders, it is often necessary to stock the area upstream of the impoundment with fish as the original native stock of fish would have been destroyed or reduced by the construction of the impediment. This way, when the next generation of fish is born, they will instinctually return to their natal waters, and thus are more likely to use the ladders. No increases in returning adult river herring resulting from fish ladder construction are expected for at least three to four years after the stocking efforts when the juvenile fish which were spawned upstream of the dam mature to reproductive age. PSE&G began stocking the ponds upstream of the fish ladders in 1996 and has continued stocking efforts since that time to establish a target abundance rate of 5 fish per acre.

To determine the success of the fish ladder project, PSE&G has been conducting annual monitoring including quantifying the adult river herring use of the fish ladders, monitoring river herring spawning success by sampling for river herring eggs and larvae in the impoundments and feeder tributaries, and documenting year-class development by sampling for juveniles.

6.1 Monitoring Programs

PSE&G is required to demonstrate the adult river herring passage up the ladders, the adult river herring spawning in the impoundments, and the juvenile herring development and emigration from the impoundments. The use of the fish ladders by adults is gauged by trapping the herring as they exit the ladders. The adult's spawning is tracked by collecting eggs and larvae from the bottom of the impoundments with nets. This is a difficult way to obtain data; it does not provide an accurate assessment of the amount of spawning, but only illustrates whether there is any spawning at all. According to PSE&G, no quantitative analysis can be conducted based upon the egg, larvae and juvenile collection efforts.

6.1.2 Garrison Lake

The Garrison Lake fish ladder became operational in 1998 and this site has been stocked every year from 1998 to 2002. Continued stocking of this lake with 432 spawners in 2002 resulted in the lake reaching its target goal of 430. However, it does not appear that much success has been achieved at this fish ladder site. Since construction, only 116 fish (39, 70, 4 and 3 (dead) in 1999, 2000, 2001 and 2002, respectively) have been observed utilizing the ladder. In addition, 1999 was the only year in which juveniles or larvae were collected at Garrison Lake with only one larvae and 67 juveniles collected. No juveniles were collected during the 2000 monitoring period. No sampling was conducted for juveniles or larvae in 2001 and 2002. Table 6-1 summarizes fish stocking efforts through 2002. Table 6-1 summarizes fish passage through 2002. Figure 6-1 depicts stocking and the adult river passage through the Garrison Lake fish ladder through 2002. Table 6-3 and Figures 6-2 and 6-3 depict eggs, larvae and juveniles collected.

6.1.2 Silver Lake

The Silver Lake fish ladder was installed in 1996. Relatively few adult herring were observed utilizing the fish ladder in the first two years after construction (1 in 1996 and 7 in 1998). Use of a fish diversion curtain beginning in 1998 increased the passage of fish through the ladder. Stocking at this site began in 1998 and continued through 2002 to reach 98.5% of the goal of 1,000 spawning fish in the lake. Table 6-1 summarizes fish stocking efforts through 2002. Table 6-2 summarizes fish passage through 2002. Figure 6-4 depicts stocking and the adult river passage through 2002.

Very few larvae and juveniles have been collected at this site since 1996. Table 6-3 and Figures 6-5 and 6-6 depict eggs, larvae and juveniles collected.

6.1.3 Moores Lake

Operation of the fish ladder at Moores Lake commenced in 1999. In 2001, a concrete diversion flume was constructed to guide spawning fish from a wooden weir at the exit of the spill pool. Since that time, adult fish passage through the fish ladder has been successful, exceeding the target goal of 135 fish. Fish stocking occurred in 1999 and 2000. Table 6-1 summarizes fish stocking efforts through 2002. Table 6-2 summarizes fish passage through 2002. Figure 6-7 depicts stocking and the adult river passage through 2002.

Sampling for fish larvae and juveniles has shown the spawning is occurring in Moores Lake. Table 6-3 and Figures 6-8 and 6-9 depict eggs, larvae and juveniles collected through 2002.

6.1.4 McGinnis Pond

The McGinnis Pond fish ladder was installed in 1996. This site was stocked from 1998 through 2001. No additional stocking was conducted in 2002. Initially, fish passage was hindered by velocities within the structure and the entrance configuration. Modifications to the ladder were completed in 1999, which allowed increased passage of adult fish through the ladder. Adult fish usage of the ladder has increased steadily since 1999. In 2002, 773 adult herring were observed passing through the ladder, with 513 allowed to pass into the pond, exceeding the target goal of 157 spawners. Table 7-1 summarizes fish stocking efforts through 2002. Table 6-2 summarizes fish passage through 2002. Figure 6-10 depicts stocking and the adult river passage through 2002.

Sampling for fish larvae and juveniles has shown the spawning is occurring. Table 6-3 and Figures 6-11 and 6-12 depict eggs, larvae and juveniles collected through 2002.

6.1.5 Coursey's Pond

Adult fish passage at this site has been successful since 1998, the year after installation was complete. Since 1998, increasing numbers of fish have been observed utilizing the fish ladder. Limited stocking of this site has been conducted, with only one stocking event in 1998. In 2002, 964 fish passed into the pond, exceeding the target goal of 291 spawners. Table 6-1 summarizes fish stocking efforts through 2002. Table 6-2 summarizes fish passage through 2002. Figure 6-13 depicts stocking and the adult river passage through 2002.

Sampling for fish larvae and juveniles has shown that spawning is occurring. Table 6-3 and Figures 6-14 and 6-15 depict eggs, larvae and juveniles collected through 2002.

6.1.6 McColley Pond

Adult fish passage at this site has been successful since installation in 1996. In 2002, 932 fish were counted passing through the fish ladder and 528 reached the pond, exceeding the target goal of 245 spawning adults. Table 6-1 summarizes fish stocking efforts through 2002. Table 6-2 summarizes fish passage through 2002. Figure 6-16 depict stocking and the adult river passage through 2002.

Sampling for fish larvae and juveniles has shown that spawning is occurring. Table 6-3 and Figures 6-17 and 6-18 depict eggs, larvae and juveniles collected through 2002.

6.1.7 Cooper River Lake

Very limited usage of the fish ladder at Cooper River Lake has been observed since completion in 1998, with only 21 fish total between 1998 and 2002. Fish stocking at this site commenced in 1998 and has continued through 2002. Even with the addition of the stocked fish, the target goal of 1,000 was not yet reached in 2002. Table 6-1 summarizes fish stocking efforts through 2002. Table 6-3 summarizes fish passage through 2002. Figure 6-19 depicts stocking and the adult river passage through 2002.

Sampling for fish larvae and juveniles has shown that spawning is occurring. Table 6-3 and Figures 6-20 and 6-21 depict eggs, larvae and juveniles collected through 2002.

6.1.8 Sunset Lake

Sunset Lake became operational in 1997 and engineering changes to reduce velocities within the fish ladder were initiated in 1998 and completed in 1999. Since 1999, adult fish passage through the ladder has increased. Stocking of this site commenced in 1998 and continued through 2002. The target goal of 1,000 spawning fish was reached in 2002 when considering both the fish utilizing the fish ladder and the stocked fish. Table 6-1 summarizes fish stocking efforts through 2002. Table 6-2 summarizes fish passage through 2002. Figure 6-22 depict stocking and the adult river passage through 2002.

Sampling for fish larvae and juveniles has shown that spawning is occurring. Table 6-3 and Figures 6-23 and 6-24 depict eggs, larvae and juveniles collected through 2002.

6.2 Conclusion

Four of the eight ladders (McColley Pond, Coursey's Pond, McGinnis Pond, and Moores Lake) are working well with large numbers of adult fish utilizing the fish ladder with limited stocking. The fish ladders at Sunset Lake and Silver Lake are also supporting adult fish passage, with the numbers of fish utilizing the Sunset Lake ladder increasing since engineering changes were complete. Although fish passage was observed at Garrison Lake in 2000, very little usage of that fish ladder has been seen in 2001 and 2002. The fish ladder at Coopers Lake does not appear to be supporting fish passage based upon the low numbers of fish observed utilizing that site since construction was complete.

Evidence of spawning was seen in all sites except Garrison Lake. It does not appear that the stocking efforts have been successful in establishing the return of offspring to the fish ladder sites. Three of the four sites with large numbers of fish utilizing the ladders received limited stocking, indicating that the fish utilizing the fish ladders are most likely pioneers, rather than either returning stocked fish or offspring of stocked fish. The sites that have received the largest numbers of stocked fish continue to show limited use of the fish ladders by adults.

7.0 Analysis of Baywide Fish Data

A number of fish abundance studies have been conducted within the Delaware Estuary including studies conducted by the Delaware Department of Natural Resources and Environmental Control (DNREC) Division of Fish and Wildlife, PSE&G, and the New Jersey Department of Environmental Protection (NJDEP).

PSE&G conducted an extensive analysis of the population of fish in the Delaware Estuary based upon a variety of studies including DNREC surveys for 1980-1998, the NJDEP Beach Seine Survey data for 1986-1998, and the PSE&G Nearfield Bottom Trawl Survey data for 1979-1982 and 1988-1994. Discrepancies in the depth, speed, and direction of the sampling among the different studies prohibit the PSE&G Nearfield Bottom Trawl Survey from the 1970's to be compared to information gathered later. In 1995, another procedural change took place making it difficult to compare the 1995-1998 data to data collected previously. Similarly, the DNREC Large Trawl Survey has gone through many procedural changes making comparisons difficult. The only survey that was consistent over an extended time period was the DNREC Juvenile Trawl.

PSE&G's analysis included manipulation of the raw data and trend analyses. However, inadequate information was provided in the application to recreate the analysis. No information has been provided regarding in which regions the fish were caught and in what volumes, making it impossible to verify PSE&G's calculated average catches-per-haul. Without the information that went into the averages, it is impossible to know whether PSE&G's results are accurate.

However, CEA was able to obtain data from DNREC for a young of the year and juvenile trawl data for additional analysis of abundance trends within the Estuary. We analyzed the RIS and Atlantic silverside. Mummichog was not analyzed due to its limited presence in the Juvenile Trawl data (if caught, only one individual was caught, so no analysis was possible). Our analysis took into account the fact that the Salem facility was shut down for maintenance from May-June 1995 through April 1998. Therefore, we compared data from 1991-1994 and data from 1998-2002 (each study year begins in April and extends to March of the following year). Table 7-1 and Figures 7-1 through 7-9 show the DNREC data from 1991-2001. The statistical analysis is contained in Attachment 1.

Below is a summary of the trends seen by PSE&G through 1999, with a supplemental analysis of the DNREC data pre and post restoration to determine if the marsh restoration program is having a noticeable impact on the fish populations within the Delaware Estuary as a whole.

7.1 Weakfish

PSE&G findings: PSE&G concluded that DNREC data show that juvenile weakfish have increased in the Estuary since 1980.

CEA findings: DNREC data from 1991 through 2001 show an increase between 1991 and 1997, however, the data shows a decline in weakfish abundance after 1997. Statistical analysis of weakfish data from 1991-1994 and data from 1998-2001 shows no statistically significant difference. Figure 7-1 shows the weakfish abundance data from 1991 through 2001.

7.2 Striped Bass

PSE&G findings: PSE&G concluded that the striped bass population has increased in the Delaware Estuary from 1986 to 1998 based upon the NJDEP Beach Seine Survey. PSE&G further stated that peak years correlated with peak years of the striped bass population in Chesapeake Bay (striped bass travel from Chesapeake Bay to the Delaware Estuary through the C&D canal).

CEA findings: DNREC juvenile trawl data from 1991 through 2001 show peaks in the striped bass population in 1996 and 2000. Overall, the striped bass population remained steady through 1999, with a sharp increase in 2000, and a slight decline in 2001. Statistical analysis of striped bass data from 1991-1994 and data from 1998-2001 shows no statistically significant difference in striped bass abundance. The striped bass abundance numbers from 1991 through 2001 is shown on Figure 7-2.

7.3 White Perch

PSE&G findings: According to PSE&G's analysis, white perch abundance has increased in the Estuary since the mid-1980s.

CEA findings: DNREC data from 1991 through 2001 shows that the white perch population is variable, with a peak year followed by a decrease in numbers. Overall, an increase in the white perch abundance was seen between 1991 and 1997, with a decline in the population from 1997 to 2001. Statistical analysis of white perch population data from 1991-1994 and data from 1998-2001 shows no statistically significant difference in white perch population. Figure 7-3 depicts the white perch abundance data from 1991 through 2001.

7.4 Spot

PSE&G findings: Based upon PSE&G's analysis, data on spot abundance within the Delaware Estuary show wide fluctuations with no clear trends. Both the NJDEP Beach Seine survey and the DNREC juvenile trawl survey show statistically significant declines in spot abundance from 1980 to 1998 according to PSE&G analysis.

CEA findings: DNREC data from 1991 through 2001 indicates that the spot population within the Delaware Estuary was variable, with a peak year followed by a decrease in numbers. Over the time period evaluated, spot numbers peaked in 1994. Overall, spot numbers appear to have declined from 1991 to 2001. Statistical analysis of spot abundance data from 1991-1994 and data from 1998-2001 shows no statistically significant difference in spot abundance. Spot abundance data from 1991 through 2001 is shown on Figure 7-4.

7.5 Atlantic Croaker

PSE&G findings: Data analyzed by PSE&G shows significant increase in abundance of Atlantic croaker in the Delaware Estuary through 1998.

CEA findings: DNREC data from 1991 through 2001 indicates that the Atlantic Croaker population within the Delaware Estuary is variable, with a peak year followed by a decrease in numbers. Overall, the Atlantic croaker appears to have held steady throughout 1991-2001, with the peak years showing approximately the same levels of Atlantic croaker. Statistical analysis of Atlantic croaker abundance data from 1991-1994 and data from 1998-2001 shows no statistically significant difference in Atlantic croaker. Figure 7-5 shows the Atlantic croaker abundance data from 1991 through 2001.

7.6 American Shad

PSE&G findings: PSE&G determined, based upon the NJDEP Beach Seine Survey, that from 1987 to 1997, the American shad abundance has increased in the Delaware Estuary.

CEA findings: DNREC juvenile trawl data from 1991 through 2001 shows a decline in the American shad population. Statistical analysis of American shad abundance data from 1991-1994 and data from 1998-2001 shows that this decline is statistically significant. American shad abundance data from 1991 through 2001 is shown on Figure 7-6.

7.7 River Herring (Alewife and Blueback Herring)

PSE&G findings: The three surveys examined by PSE&G showed no clear abundance trends for these species.

CEA findings: DNREC Juvenile Trawl data shows a peak in the alewife population in 1995, with a low in 1998. Since 1998, alewife numbers appear to be increasing. Statistical analysis of alewife abundance data from 1991-1994 and data from 1998-2001 shows that this increase is not statistically significant. Alewife abundance data from 1991 through 2001 is shown on Figure 7-7.

PSE&G findings: Blueback herring showed declines in abundance as measured by the NJDEP Beach Seine Survey and DNREC Juvenile Trawl Survey as analyzed by PSE&G.

CEA findings: DNREC Juvenile Trawl data from 1991 through 2001 shows that the blueback herring population is variable, with peak years followed by steep declines. Overall it appears that the blueback herring population has increased in the Delaware Estuary during the 1991 through 2001 time period. Statistical analysis of blueback herring abundance data from 1991-1994 and data from 1998-2001 shows that this increase is not statistically significant. Blueback herring abundance data from 1991 through 2001 is shown on Figure 7-8.

7.8 Bay Anchovy

PSE&G findings: The NJDEP Beach Seine survey data showed an increase in bay anchovy abundance, and the DNREC Juvenile Trawl survey suggested an increase which was not statistically significant according to PSE&G analysis. However, a statistically significant decrease in bay anchovy abundance was shown based upon data from the PSE&G Nearfield Bottom Trawl according to PSE&G analysis.

CEA findings: DNREC Juvenile Trawl data from 1991 through 2001 indicates that bay anchovy peaked 1991 and again in 1995, hitting a low in 1994. Overall, it appears that bay anchovy abundance has declined during the 1991 to 2001 time period. Statistical analysis of bay anchovy abundance data from 1991-1994 and data from 1998-2001 shows that this decline is not statistically significant. Figure 7-9 shows bay anchovy abundance data from 1991 to 2001.

7.9 Atlantic Silverside

PSE&G findings: PSE&G did not conduct an analysis of Atlantic silverside abundance.

CEA findings: Our analysis included Atlantic silverside due to its strong presence in the restored marshes. According to DNREC Juvenile Trawl data from 1991 through 2001, the Atlantic silverside population peaked in 1993 and again in 1996. A smaller peak was also seen in 2000. Overall, the population declined from 1994 to 1999. A slight increase in abundance has been seen since 1999. Statistical analysis of Atlantic silverside abundance data from 1991-1994 and data from 1998-2001 shows no significant difference. Figure 7-10 shows Atlantic silverside abundance data from 1991 to 2001.

7.10 Conclusions

Based upon the limited data available, there does not appear to be an increase in baywide abundance of fishes since PSE&G completed the marsh restoration and fish ladder installation. Weakfish and white perch declined in numbers after 1997. A decline was also seen for spot, bay anchovy, Atlantic silverside (1994-2001), and American shad, with the decline being statistically significant for American shad when comparing 1991-1994 data to 1997-2001 data. Increases have been seen in blueback herring, although these increases are not statistically significant. Striped bass data is difficult to interpret as the abundance numbers in the Delaware are apparently linked to abundance in Chesapeake Bay. Overall, it appears that striped bass has increased.

8.0 Evaluation of Success of Special Conditions

CEA's evaluation of the effectiveness of the wetland restoration project in increasing fish production has shown mixed results. The salt marsh restoration program is showing signs of success in terms of vegetative coverage and the return of tidal flow to the former salt hay farms. The *Phragmites* eradication program has reduced *Phragmites* coverage. Of the three salt hay farm sites, only Commercial Township has not reached the interim goal of 45% coverage, although a few more years of monitoring are necessary to reach a conclusion regarding success at this site. The Dennis and Maurice Township sites have also achieved the 12-year goals of desired plant coverage and *Phragmites* coverage. All of the Phragmites dominated sites have achieved the interim goal *Spartina* coverage except Mill Creek. However, this goal was met at Alloway Creek only because PSE&G no longer considered 1,000 acres of *Phragmites* dominated land as part of the restoration program. The Cohansey, Lang and Woodland sites achieved the 12-year goal for *Spartina* coverage. The Lang Tract has also achieved the 12-year goal for *Phragmites* coverage. However, the sustainability of the Phragmites reduction appears to be dependent on annual herbicide treatment and associated interventions such as the burn program. The true success of the *Phragmites* control program cannot be determined until herbicide treatment has been discontinued.

Fish response to the restoration of the salt hay farms has been positive. Young of the year fish assemblages were similar between the restored salt marshes and the references marshes including size composition, seasonal patterns of occurrence and species composition. Predator species such as striped bass and white fish were also found to be utilizing the restored salt hay farm marshes, with a higher diversity of species and a higher density of predator fish as compared to the reference marshes. Forage studies indicated that food habits of the fish were similar between the restored salt marshes and the reference marshes. Data indicate that at least two species of fish (mummichog and Atlantic silverside) were utilizing the restored marshes for reproduction. Growth rates of young of the year fish were similar between the reference sites and the restored marshes.

It has not been demonstrated that the restoration of the Phragmites dominated sites is increasing fish utilization of those areas. Monitoring at Alloway Creek includes several sites dominated by *Phragmites*, *Spartina* or under treatment for *Phragmites* removal. The 2000 monitoring showed that within Alloway Creek large marsh creeks, fish abundance was similar at all three sites. In 2002, the *Phragmites* site had the highest abundance of fish, while the treated and *Spartina* sites had lower abundances. While 2002 data showed larger abundance in the treated Alloway site, it also demonstrated that the untreated *Phragmites* site had the highest species richness. Reproduction of mummichog and Atlantic silverside was seen in the *Phragmites* dominated sites both prior to and following the treatment of *Phragmites* and growth patterns were seen to be similar for mummichog and Atlantic silverside both pre and post treatment as well. Studies also indicate that mummichog are able to use *Phragmites* as a food source in *Phragmites* dominated sites. These results indicate that

Phragmites eradication has not been proven to increase utilization of the site and increased fish production.

Fish ladders were installed to provide adult river herring passage; adult herring spawning in impoundments and tributaries; and juvenile herring development in, and emigration from the impoundments. CEA evaluated existing data in an attempt to determine whether successful spawning runs of herring have been or can be established as a result of fish ladder installation and whether the increase in population of river herring have or will provide additional forage for the predator populations. Four of the eight ladders (McColley Pond, Coursey's Pond, McGinnis Pond, and Moores Lake) are working well with large numbers of adult fish utilizing the fish ladder with limited stocking. The fish ladders at Sunset Lake and Silver Lake are also supporting adult fish passage. Although fish passage was observed at Garrison Lake in 2000, very little usage of that fish ladder has been seen in 2001 and 2002. The fish ladder at Coopers Lake does not appear to be supporting fish passage based upon the low numbers of fish observed utilizing that site since construction was complete. Evidence of spawning was seen in all sites except Garrison Lake. It does not appear that the stocking efforts have been successful in establishing the return of offspring to the fish ladder sites. Three of the four sites with large numbers of fish utilizing the ladders received limited stocking, indicating that the fish utilizing the fish ladders are most likely pioneers, rather than either returning stocked fish or offspring of stocked fish. The sites that have received the largest numbers of stocked fish continue to show limited use of the fish ladders by adults.

Despite successes of the wetlands program and the fish ladder installation program, no results have been realized in baywide abundance values of the representative important species or Atlantic silverside. Striped bass data is difficult to interpret as the abundance numbers in the Delaware are apparently linked to abundance in Chesapeake Bay. Overall, it appears that striped bass has increased, although this increase is not statistically significant. Weakfish and white perch declined in numbers after 1997, although the decline was not statistically significant. A decline was also seen for spot, bay anchovy, Atlantic silverside (1994-2001), and American shad, with the decline being statistically significant for American shad when comparing 1991-1994 data to 1997-2001 data. Increases have been seen in blueback herring, although these increases are not statistically significant. Thus, the data to date demonstrates that the goal of increasing fish populations in the Delaware Estuary as a result of the wetlands and fish ladder efforts has not been realized.

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TABLES

Table 3-1: 1998 PSE&G Loss Estimates

	Impingement*	Entrainment**	Total
Alewife	8,037	14,480,142	14,488,179
American Shad	2,214	0	2,214
Atlantic Croaker	2,370,135	132,129,651	134,499,786
Bay Anchovy	1,104,126	2,003,681,602	2,004,785,728
Blueback herring	57,267	59,282,494	59,339,761
Spot	2,654	20,054	22,708
Striped Bass	10,660	448,563,394	448,574,054
Weakfish	1,572,811	76,343,394	77,916,205
White perch	124,351	412,839,168	412,963,519
TOTAL	5,252,255	3,147,339,899	3,152,592,154

TABLE 3-2: COMPARISON OF BAYWIDE ABUNDANCE TO IMPINGEMENT AND ENTRAINMENT LOSSES

Species	Baywide Abundance	Impingement/ Entrainment Loss	% of Population lost due to Salem Facility
Weakfish (1981-1982)	3 million	340,000	11%
Weakfish (1996* & 1998)	1.9 million	170,000	8.9 %
Striped Bass (1989)	19 million	1.1 million	5.8%
Striped Bass (1993)	40 million	1.9 million	4.75%
White Perch (1980)	4.1 million	316,000	7.7
White Perch (1996*)	19.2 million	464,000	2.4
Alewife (1996)	84,000,000	Negligible	Negligible
Spot (1981-1982)	39 million	1.5million/5.8 million	3.8/14.8**
Spot (1996 and 1998)	240,000	5000/0	2/0
Atlantic Croaker (since 1989)	NA	5 million per year	NA
Bay anchovy (1981)	9.1 billion	1.0 billion	10
Bay anchovy (1982)	33.2 billion	5.6 billion	16.8
Bay anchovy (1996*)	1 billion	0.02 billion	2
Bay anchovy (1998)	2.5 billion	0.7 billion	28

* In 1996 Salem was undergoing maintenance and did not operate at full capacity. Only one pump out of 12 was operating and there was no power generation in 1996.

** % population calculations based upon average baywide abundance value over 1981 and 1982.

Table 4-1: *Phragmites* percent land coverage								
	1995	1996	1997	1998	1999	2000	2001	2002
Moores Beach- Reference	ND	0.3	0.2	0.3	0.2	0.2	6.2	6.2
Commercial Township	ND	42.6	26.3	19.1	8.4	7.7	7.1	5.3
Maurice River	ND	7.0	4.4	0.5	0.5	2.6	2.5	2.3
Dennis Township	16.3	7.1	6.2	6.0	4.6	3.0	2.3	ND
Mad Horse Creek - Reference	ND	3.2	3.1	4.0	3.6	3.8	3.9	3.9
Alloway Creek Watershed	ND	71.5	35.8	16.8	37.4	47.1	43.3	21.4
Mill Creek	ND	82.1	34.7	15.4	48.2	57.9	56.3	ND
Cohansey River Watershed	ND	42.7	38.5	9.0	10.1	9.3	10.5	8.5
Silver Run	85.5	60.9	20.0	15.1	ND	ND	ND	ND
Lang Tract	90.6	54.3	0.0	0.2	ND	ND	ND	ND
The Rocks	87.1	27.8	13.3	8.2	11.1	7.9	33.1	22.9
Woodland Beach	33.1	31.6	18.6	9.6	ND	ND	ND	ND
Cedar Swamp	71.7	10.7	3.0	4.2	11.3	12.2	17.9	14.9

ND indicates not determined

Table 4-2: *Spartina* spp. and other desirable marsh vegetation percent land coverage.								
	1995	1996	1997	1998	1999	2000	2001	2002
Moores Beach - Reference	ND	88.7	91.4	89.9	88.9	87.2	84.0	84.0
Commercial	ND	7.0	5.0	6.2	9.7	12.3	24.8	30.5
Maurice River	ND	11.3	17.8	51.4	58.5	39.0	70.9	69.4
Dennis Township	65.6	56.0	74.4	78.6	78.5	80.8	86.5	ND
Mad Horse Creek- Reference	ND	82.6	83.5	82.4	81.9	81.0	81.0	81.0
Alloway Creek Watershed	ND	14.7	16.8	53.7	39.5	32.3	41.1	60.9
Mill Creek	ND	5.0	7.5	61.2	28.0	20.6	28.5	ND
Cohansey River Watershed	ND	51.4	50.1	78.9	61.7	75.3	74.0	77.6
Silver Run	0.7	8.5	55.2	58.4	ND	ND	ND	ND
Lang Tract	0.7	12.2	92.6	77.2	ND	ND	ND	ND
The Rocks	10.5	19.7	82.3	88.3	79.8	87.4	62.4	70.9
Woodland Beach	62.1	64.1	77.1	83.5	ND	ND	ND	ND
Cedar Swamp	17.8	19.2	33.1	37.0	64.0	69.2	66.6	71.7

ND indicates not determined

Table 5-1 Dennis Township Catch Per Unit Effort Large Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	5.31	15.03	81.94	11.3	66.7	45.68	56.52	40.35	5.31	81.94
Atlantic silverside	0.23	1.02	0.35	0.68	0.14	0.94	0.12	0.50	0.12	1.02
Bay anchovy	1.61	2.27	4.21	2.99	3.23	1.2	4.36	2.84	1.2	4.36
Mummichog	0.42	2.57	0.72	0.07	0.01	0.06	0.05	0.56	0.01	2.57
Spot	1	4.89	3.89	3.47	13.12	0.56	1.71	4.09	0.56	13.12
Weakfish	0.15	0.86	2.05	1.21	1.96	3.24	6.79	2.32	0.15	6.79
White Perch	0.5	0.24	0.1	0.07	0.09	0.05	0.09	0.16	0.05	0.5

Note: Breaching of dikes completed in the Summer of 1996

Table 5-2 Commercial Township Catch Per Unit Effort Large Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	5.33	5.2	27.29	7.09	0.12	8.8	21.66	10.78	0.12	27.29
Atlantic silverside	0.09	0.02	0.03	0.06	0.1	4.14	0.19	0.66	0.02	4.14
Bay anchovy	0.2	0.14	1.14	1.28	0.71	5.21	0.74	1.35	0.14	5.21
Mummichog	0	0.41	0.03	0.04	0.03	0.06	0.04	0.09	0	0.41
Spot	0.22	3.87	0.16	0.68	1.8	0.45	0.71	1.13	0.16	3.87
Weakfish	0.34	0.02	1.19	1.21	7.03	2.94	3.44	2.31	0.02	7.03
White Perch	0.94	0.1	0.08	0.16	0.12	0.04	0.06	0.21	0.04	0.94

Note: Breaching of dikes completed in the Fall of 1997.

Table 5-3 Moores Beach Reference Marsh Catch Per Unit Effort Large Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	1.93	5.56	10.23	0.81	0.78	24.17	113.48	22.42	0.78	113.48
Atlantic silverside	0.27	0.29	0.07	0.85	1.1	0.48	0.16	0.46	0.07	1.1
Bay anchovy	0.24	1.02	0.83	2.8	0.91	0.87	0.42	1.01	0.24	2.8
Mummichog	0.36	0.31	0.05	0.01	0.2	0.15	2.35	0.49	0.01	2.35
Spot	0.3	1.38	0.42	1.22	1.03	0.39	0.39	0.73	0.30	1.38
Weakfish	0.04	0.44	0.23	0.15	1.01	0.91	4.54	1.05	0.04	4.54
White Perch	0.28	0.91	0.06	0.18	0.05	0.05	0.02	0.22	0.02	0.91

Table 5-4 Dennis Township Catch Per Unit Effort Small Marsh Creeks.

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	20.75	242.75	294.44	0.19	4.75	904.71	239.29	243.84	0.19	904.71
Atlantic silverside	65.00	3875.05	2136.63	251.25	133.56	99.57	25.21	940.90	25.21	3875.05
Bay anchovy	0.00	62.55	31.25	271.94	23.19	3.14	21.36	59.06	0.00	271.94
Mummichog	11.75	2044.25	579.88	10.19	9.44	30.21	12.93	385.52	9.44	2044.25
Spot	0.00	24.70	33.06	5.88	54.38	0.00	0.00	16.86	0.00	54.38
Weakfish	0.00	0.20	0.19	1.25	8.75	1.00	29.50	5.84	0.00	29.50
White Perch	0.00	0.00	0.00	587.63	0.00	0.00	0.00	83.95	0.00	587.63

Note: Breaching of dikes completed in the Summer of 1996.

Table 5-5 Commercial Township Catch Per Unit Effort Small Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	NS	NS	6.47	4.13	2.44	3.43	18.21	6.94	2.44	18.21
Atlantic silverside	NS	NS	280.20	550.38	262.31	306.50	47.36	289.35	47.36	550.38
Bay anchovy	NS	NS	81.93	1.50	2.44	1.50	0.29	17.53	0.29	81.93
Mummichog	NS	NS	275.47	80.94	48.75	443.36	407.29	251.16	48.75	443.36
Spot	NS	NS	0.00	0.31	16.13	0.07	1.50	3.60	0.00	16.13
Weakfish	NS	NS	0.33	0.00	0.13	1.07	0.00	0.31	0.00	1.07
White Perch	NS	NS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: Breaching of dikes completed in the Fall of 1997.
NS indicates not sampled. Monitoring of small creeks began in 1998 following the breach of the dikes.

Table 5-6 Moores Beach Reference Site Catch Per Unit Effort Small Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min.	Max.
Atlantic croaker	0.38	19.15	2.00	0.19	0.19	0.07	7.58	4.22	0.07	19.15
Atlantic silverside	41.46	216.74	102.81	190.38	199.81	72.14	230.67	150.57	41.46	230.67
Bay anchovy	0.12	0.76	0.13	0.25	0.13	0.00	1.17	0.37	0.00	1.17
Mummichog	466.62	2041.40	694.81	466.81	109.50	21.79	32.67	547.66	21.79	2041.40
Spot	0.00	6.37	0.38	4.19	8.88	0.00	1.83	3.09	0.00	8.88
Weakfish	0.27	2.06	0.00	0.00	0.19	0.00	0.33	0.41	0.00	2.06
White Perch	0.19	0.10	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.19

Table 5-7 Mad Horse Creek Catch Per Unit Effort Large Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	1.49	0.31	3.28	1.6	2.78	0.65	2.43	1.79	0.31	3.28
Atlantic silverside	0.01	0.1	0.21	0.11	0.02	0.14	0.01	0.09	0.01	0.21
Bay anchovy	0.74	1.06	1.82	3.22	4.74	3.08	2.6	2.47	0.74	4.74
Mummichog	0.01	0.02	0	0.01	0.01	0.07	0.02	0.02	0	0.07
Spot	0.04	1.38	0.01	0.16	0.66	0	0.37	0.37	0	1.38
Weakfish	7.57	0.76	0.72	1.93	1.8	0.31	0.04	1.88	0.04	7.57
White Perch	2.08	2.01	1.42	1.26	0.65	0.44	0.88	1.25	0.44	2.08

Table 5-8 Mill Creek Catch Per Unit Effort Large Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	0.86	1.38	2.32	2.37	1.44	0.48	3.55	1.77	0.48	3.55
Atlantic silverside	0.03	0.03	0.21	0.21	0.02	0.37	0	0.12	0	0.37
Bay anchovy	5.7	3.15	11.02	5.84	15.92	11.48	4.28	8.20	3.15	15.92
Mummichog	0.01	0.16	0.01	0.03	0.01	0.08	0.02	0.05	0.01	0.16
Spot	0.01	10.44	0	0.21	0.45	0.01	0.08	1.60	0	10.44
Weakfish	0.03	1.53	0.47	0.21	0.67	0.82	0.05	0.54	0.03	1.53
White Perch	7.8	10.8	8.49	3.82	2.82	2.2	1.2	5.30	1.2	10.8

Table 5-9 Browns Run Catch Per Unit Effort Large Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	0.21	0.49	2.94	0.83	1.14	0.55	2.67	1.26	0.21	2.94
Atlantic silverside	0.01	0.06	0.01	0.17	0.01	0.13	0.01	0.06	0.01	0.17
Bay anchovy	0.33	1.17	2.47	5.93	1.71	2.95	1.73	2.33	0.33	5.93
Mummichog	0	0.02	0	0.02	0.01	0.01	0.01	0.01	0.00	0.02
Spot	0.06	1.27	0.05	0.09	0.58	0.04	0.08	0.31	0.04	1.27
Weakfish	0.3	0.25	0.16	0.17	0.06	0.14	0	0.15	0.00	0.3
White Perch	2.52	2.76	2.25	2.27	1.42	1.2	0.68	1.87	0.68	2.76

Table 5-10 Alloway Creek Phragmites Reference Sites Catch Per Unit Effort Large Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	0	0	0	1.44	0.09	0.1	5.39	1.00	0	5.39
Atlantic silverside	0	0	0	0	0.1	0.04	0	0.02	0	0.1
Bay anchovy	0	0	0	0.99	2.29	2.16	3.56	1.29	0	3.56
Mummichog	0	0	0	0	0.01	0	0	0.00	0	0.01
Spot	0	0	0	0.28	1.15	0.03	0.06	0.22	0	1.15
Weakfish	0	0	0	0.44	0.55	0.13	0.05	0.17	0	0.55
White Perch	0	0	0	9.34	5.5	3.77	4.19	3.26	0	9.34

Table 5-11 Alloway Creek Treated Sites Catch Per Unit Effort Large Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	0	0	0	6.41	0.31	0.01	3.33	1.44	0.00	6.41
Atlantic silverside	0	0	0	0.02	0.01	0.01	0	0.01	0.00	0.02
Bay anchovy	0	0	0	2.01	3.22	3.21	2.07	1.50	0.00	3.22
Mummichog	0	0	0	0.02	0	0.01	0	0.00	0.00	0.02
Spot	0	0	0	0.06	0.17	0	0.21	0.06	0.00	0.21
Weakfish	0	0	0	0.4	2.62	0.31	0.1	0.49	0.00	2.62
White Perch	0	0	0	5.06	2.13	1.36	4.05	1.80	0.00	5.06

Table 5-12 Alloway Creek Reference Spartina Sites Catch Per Unit Effort Large Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	0	0	0	4.73	0.11	0.05	3.67	1.22	0.00	4.73
Atlantic silverside	0	0	0	0.06	0	0	0	0.01	0.00	0.06
Bay anchovy	0	0	0	1.97	4.15	6.03	1.08	1.89	0.00	6.03
Mummichog	0	0	0	0	0	0.04	0.01	0.01	0.00	0.04
Spot	0	0	0	0.07	0.29	0.02	0.11	0.07	0.00	0.29
Weakfish	0	0	0	0.23	0.71	0.46	0.12	0.22	0.00	0.71
White Perch	0	0	0	3.07	2.45	1.67	3.21	1.49	0.00	3.21

Table 5-13 Mad Horse Creek Catch Per Unit Effort Small Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	0.61	0.15	0.00	0.00	0.00	0.00	0.21	0.14	0.00	0.61
Atlantic silverside	53.04	17.10	24.50	29.94	4.25	13.14	0.71	20.38	0.71	53.04
Bay anchovy	12.46	9.75	12.56	9.81	9.13	17.57	25.86	13.88	9.13	25.86
Mummichog	103.04	89.50	63.75	52.06	14.50	17.07	11.14	50.15	11.14	103.04
Spot	0	1.15	0.00	0.00	0.50	0.00	0.00	0.24	0.00	1.15
Weakfish	22.89	1.80	0.06	0.06	0.00	0.00	0.00	3.54	0.00	22.89
White Perch	1.18	2.01	0.94	0.06	0.25	0.14	0.43	0.72	0.06	2.01

Table 5-14 Mill Creek Catch Per Unit Effort Small Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	0.00	0.35	0.06	0.06	0.00	0.00	0.86	0.19	0.00	0.86
Atlantic silverside	0.39	1.1	2.38	192.19	2.44	0.07	1.57	28.59	0.07	192.19
Bay anchovy	1.28	3	0.19	0.56	25.13	2.93	0.86	4.85	0.19	25.13
Mummichog	16.78	56.3	277.56	149.13	34.13	77.86	1182.14	256.27	16.78	1182.14
Spot	0.00	0.7	0.00	0.00	0.06	0.00	0.07	0.12	0.00	0.70
Weakfish	0.00	0.1	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.10
White Perch	1.06	3.1	0.25	0.75	0.38	0.00	3.71	1.32	0.00	3.71

Table 5-15 Browns Run Catch Per Unit Effort Small Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	0.00	0.00	0.13	0.00	0.25	0.00	7.36	1.11	0.00	7.36
Atlantic silverside	4.20	712.65	12.25	1556.56	170.81	70.36	95.00	374.55	4.20	1556.56
Bay anchovy	0.00	0.40	0.06	15.69	14.19	1.00	50.00	11.62	0.00	50.00
Mummichog	110.70	153.30	61.50	1206.81	349.75	1063.14	2236.64	740.26	61.50	2236.64
Spot	0.00	0.55	0.00	3.13	19.63	0.00	10.29	4.80	0.00	19.63
Weakfish	0.05	0.00	0.00	0.00	0.06	0.07	0.07	0.04	0.00	0.07
White Perch	3.00	0.40	0.00	14.94	5.69	5.21	4.93	4.88	0.00	14.94

Table 5-16 Alloway Creek Phragmites Reference Sites Catch Per Unit Effort Small Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	NS	NS	NS	0.00	0.00	0.00	0.18	0.05	0.00	0.18
Atlantic silverside	NS	NS	NS	3.36	0.50	0.58	0.09	1.13	0.09	3.36
Bay anchovy	NS	NS	NS	0.07	0.13	0.25	0.18	0.16	0.07	0.25
Mummichog	NS	NS	NS	10.57	21.13	23.92	21.64	19.32	10.57	23.92
Spot	NS	NS	NS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weakfish	NS	NS	NS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White Perch	NS	NS	NS	0.14	0.06	0.08	0.18	0.12	0.06	0.18

NS indicates not sampled

Table 5-17 Alloway Creek Treated Sites Catch Per Unit Effort Small Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	NS	NS	NS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Atlantic silverside	NS	NS	NS	18.07	5.13	1.29	0.00	6.12	0.00	18.07
Bay anchovy	NS	NS	NS	1.29	6.00	0.14	0.00	1.86	0.00	6.00
Mummichog	NS	NS	NS	134.29	328.50	391.43	138.86	248.27	134.29	391.43
Spot	NS	NS	NS	0.00	0.06	0.07	0.00	0.03	0.00	0.07
Weakfish	NS	NS	NS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White Perch	NS	NS	NS	0.07	0.00	0.00	0.00	0.02	0.00	0.07

NS indicates not sampled

Table 5-18 Alloway Creek Reference Spartina Sites Catch Per Unit Effort Small Marsh Creeks

	1996	1997	1998	1999	2000	2001	2002	Ave.	Min	Max
Atlantic croaker	NS	NS	NS	0.00	0.00	0.00	0.14	0.04	0.00	0.14
Atlantic silverside	NS	NS	NS	0.57	0.31	0.21	0.00	0.27	0.00	0.57
Bay anchovy	NS	NS	NS	0.14	0.00	0.07	0.00	0.05	0.00	0.14
Mummichog	NS	NS	NS	21.00	8.81	21.14	28.57	19.88	8.81	28.57
Spot	NS	NS	NS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weakfish	NS	NS	NS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White Perch	NS	NS	NS	0.43	0.00	0.07	0.00	0.13	0.00	0.43

NS indicates not sampled

Table 6-1 Adult Passage Results								
Site	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**Total**
Silver Lake	4	7	113	163	65	151	139	642
McGinnis Pond	1	2	25	48	33	99	774	982
McColley Pond	115	177	559	1122	1250	918	932	5073
Coursey Pond	---	30	459	1102	784	1399	1531	5305
Sunset Lake	---	0	10	60	32	195	366	663
Cooper River	---	---	3	1	4	2	11	21
Garrisons Lake	---	---	---	39	70	4	3	116
Moores Lake	---	---	---	95	78	670	682	1525
Total	120	216	1169	2630	2316	3438	4438	14327

Table 6-2 Number of Fish Stocked								
Site	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**Total**
Silver Lake	0	0	547	687	419	993	865	3511
McGinnis Pond	0	0	166	171	200	241	0	778
McColley Pond	0	0	7	11	0	0	0	18
Coursey Pond	0	0	154	0	0	0	0	154
Sunset Lake	0	0	1033	895	501	1337	1010	4776
Cooper River	0	0	2623	1069	964	1071	840	6567
Garrisons Lake	0	0	0	318	48	473	432	1271
Moores Lake	0	0	0	271	70	0	0	341
Total	0	0	4530	3422	2202	4115	3147	17416

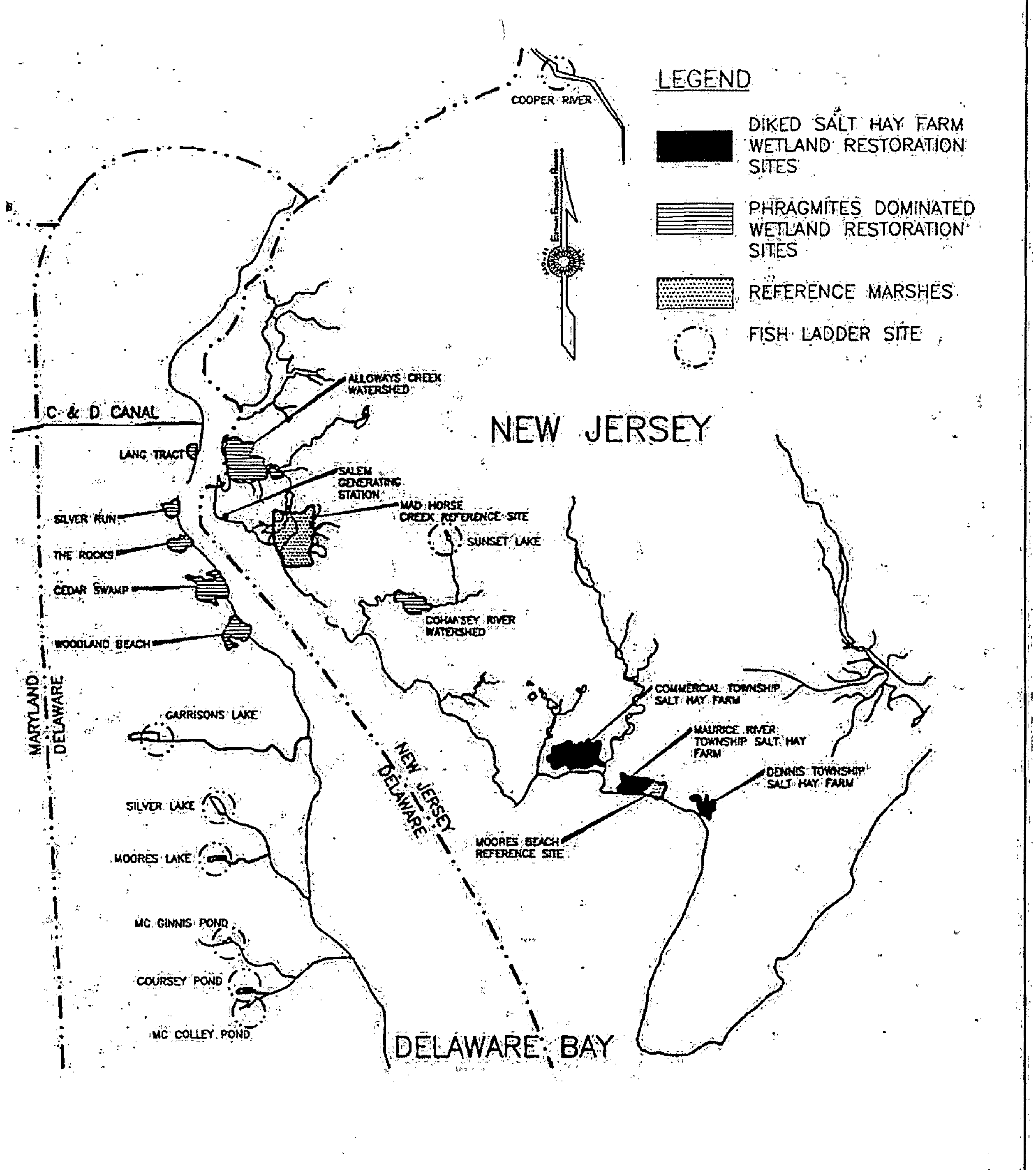
Table 6-3 Summary of Annual River Herring Monitoring Results

	Larvae							
	Sunset Lake, Since 1997	Cooper River Lake,Since 1998	Silver Land, Since 1996	McGinnis Pond, Since 1996	Coursey's Pond, Since 1997	McColley Pond, Since 1996	Garrisons Lake, Since 1999	Moores Lake, Since 1999
1996			6	6		8		
1997				5	1	4		
1998	3	41	1	2	1	6		
1999	1	62	3	5	13	28	1	5
2000	6	70	14	1	14	17		30
2001	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
2002	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	Juveniles							
	Sunset Lake, Since 1997	Cooper River Lake,Since 1998	Silver Land, Since 1996	McGinnis Pond, Since 1996	Coursey's Pond, Since 1997	McColley Pond, Since 1996	Garrisons Lake, Since 1999	Moores Lake, Since 1999
1996				20		25		
1997				114	13	133		
1998	1301	15000	5	398	144	1061		
1999	212	12394		9	89	489	67	78
2000	335	7848		718	39	715		71
2001		24327	25	244	72	92		1
2002	1683	438	3	899	129	688		
	Eggs							
	Sunset Lake, Since 1997	Cooper River Lake,Since 1998	Silver Land, Since 1996	McGinnis Pond, Since 1996	Coursey's Pond, Since 1997	McColley Pond, Since 1996	Garrisons Lake, Since 1999	Moores Lake, Since 1999
1996						4		
1997								
1998	3	41	1	61				
1999	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0
2001								
2002								

TABLE 7-1 DNREC Juvenile Trawl Data 1991-2001											
Year	Bay Anchovy	Weakfish	Atlantic Croaker	White Perch	Spot	Striped Bass	Alewife	American Shad	Atlantic Silverside	Blueback Herring
1991	233.66	31	9.72	3.17	8.39	0.32	0.18	0.12	0.044	0
1992	120.16	34.13	78.12	6.64	0.82	0.19	0.034	0.05	0.05	0.013
1993	94.24	37.17	14.72	3.73	9.15	0.72	0.079	0.063	2.57	0.0084
1994	70.85	53	20.3	12.55	34.14	1.1	0.155	0.042	0.76	0.054
1995	246.86	49.25	53.54	4.92	0.26	0.57	0.17	0	0.11	0.01
1996	158.65	57.29	73.83	10.55	0.16	2.76	0.13	0.06	1.67	0.02
1997	145.23	63.13	30.38	9.28	7.65	0.64	0.11	0.02	0.01	0.03
1998	143.53	30.42	63.45	3.47	0.5	0.95	0.02	0.0042	0.04	0.01
1999	103.21	33.8	71	6.76	1.38	0.58	0.09	0.03	0.11	0.04
2000	117.94	45.66	19.5	1.9	5.23	5.63	0.06	0.01	0.61	0.01
2001	128.39	25.62	70.22	3.9	0.2	4.74	0.14	0	0.18	0.03

All data is reported in Mean Catch per foot

FIGURES



Ref: PSEG Estuary Enhancement Program, Site Location Map, from 2001 annual report

CEA CARPENTER ENVIRONMENTAL ASSOCIATES, Inc. CEA ENGINEERS, P.C.	Site Location Map PSEG Estuary Enhancement Program Deleware Bay, DE/NJ	FIGURE 1-1	
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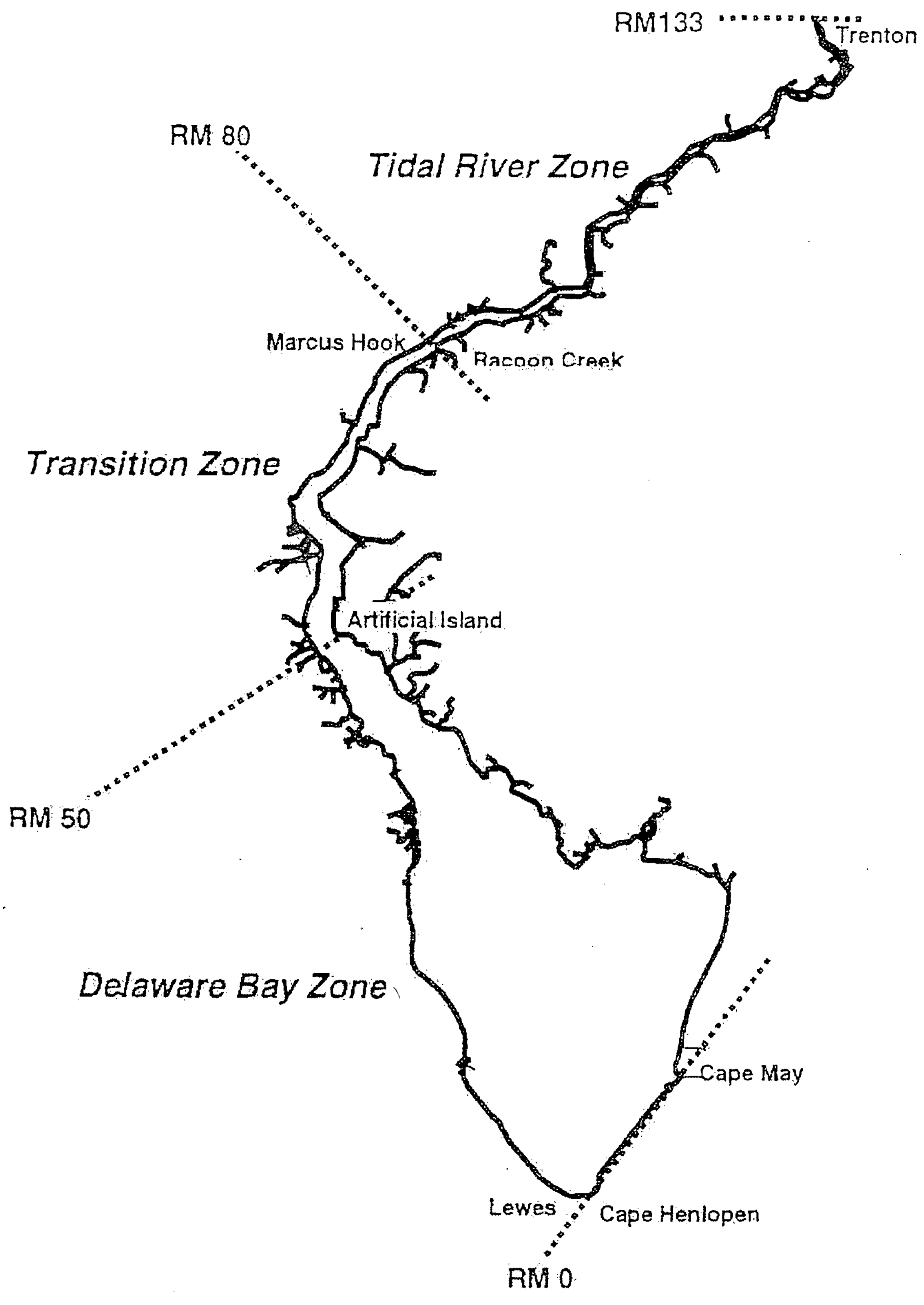


REF: Permit Renewal Application, Public Service and Gas Company Salem Generating Station, Appendix C Figure 4

CARPENTER ENVIRONMENTAL ASSOCIATES, Inc. CEA ENGINEERS, P.C.	Delaware Estuary Zones	FIGURE 2-1
		DATE: 11/24/03 / FILE: 0106701-1.dwg / SCALE: N.T.S.

Figure 4-1
Moores Beach - Reference

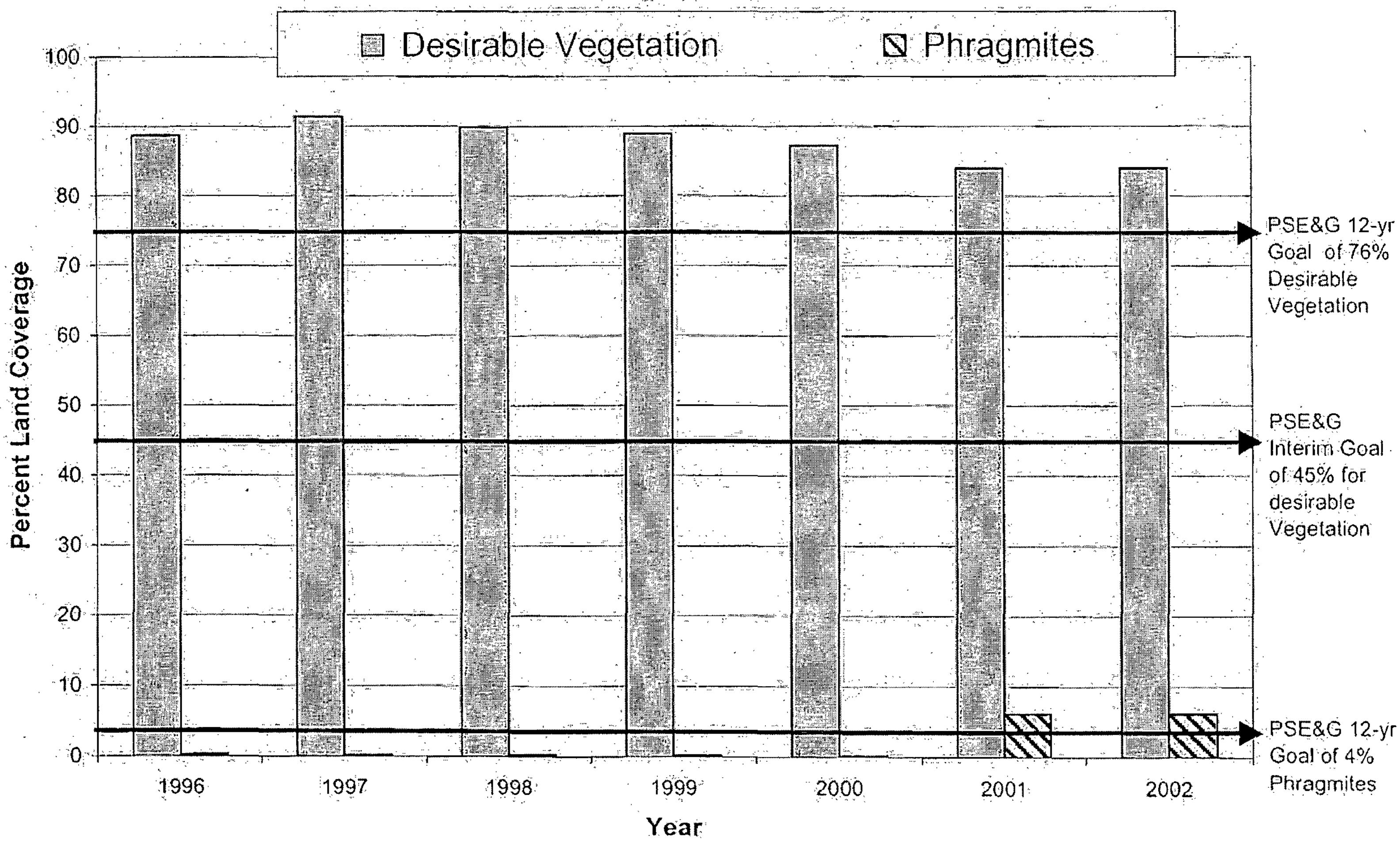


Figure 4-2
Commercial Township Results

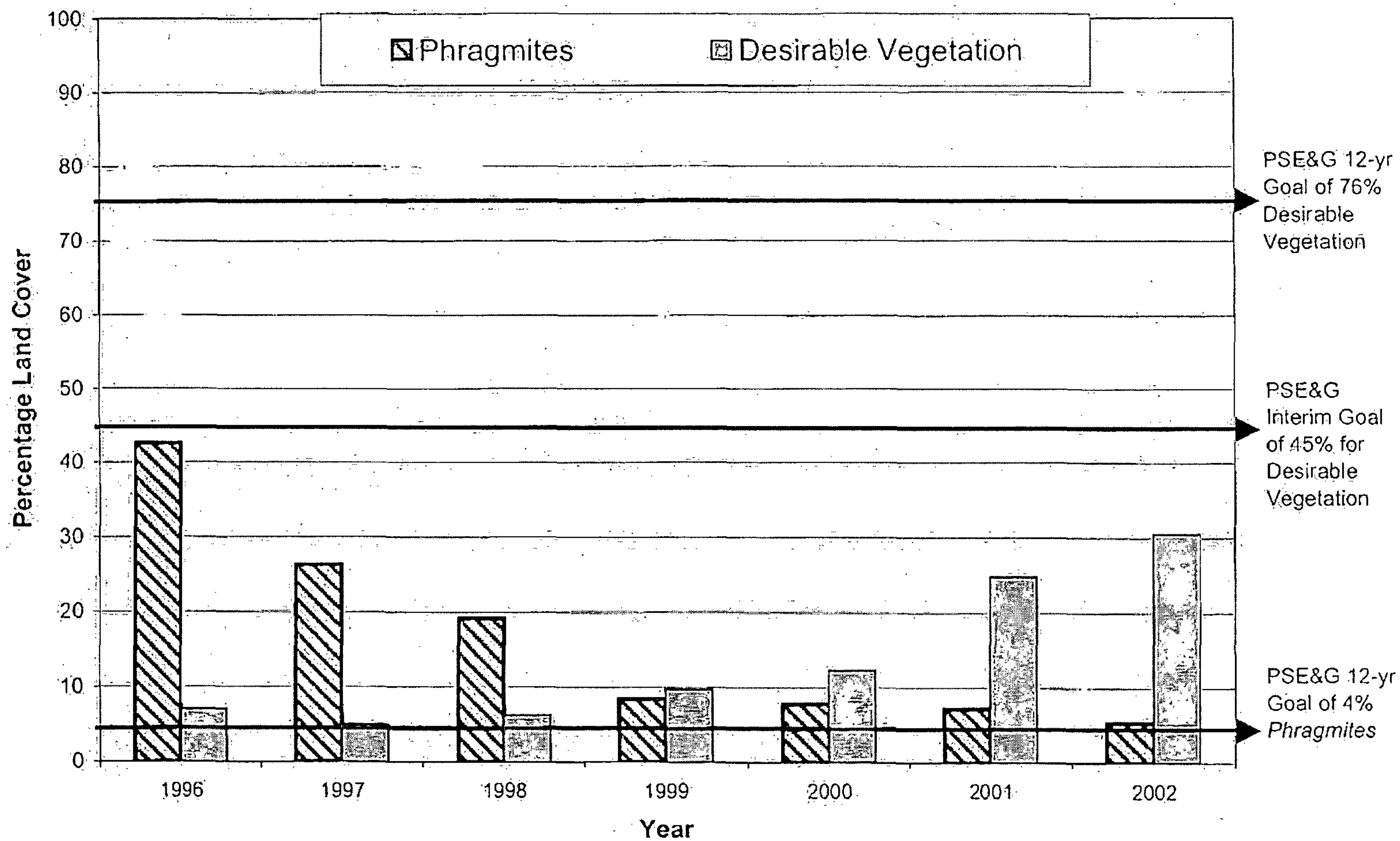


Figure 4-3
Dennis Township Results

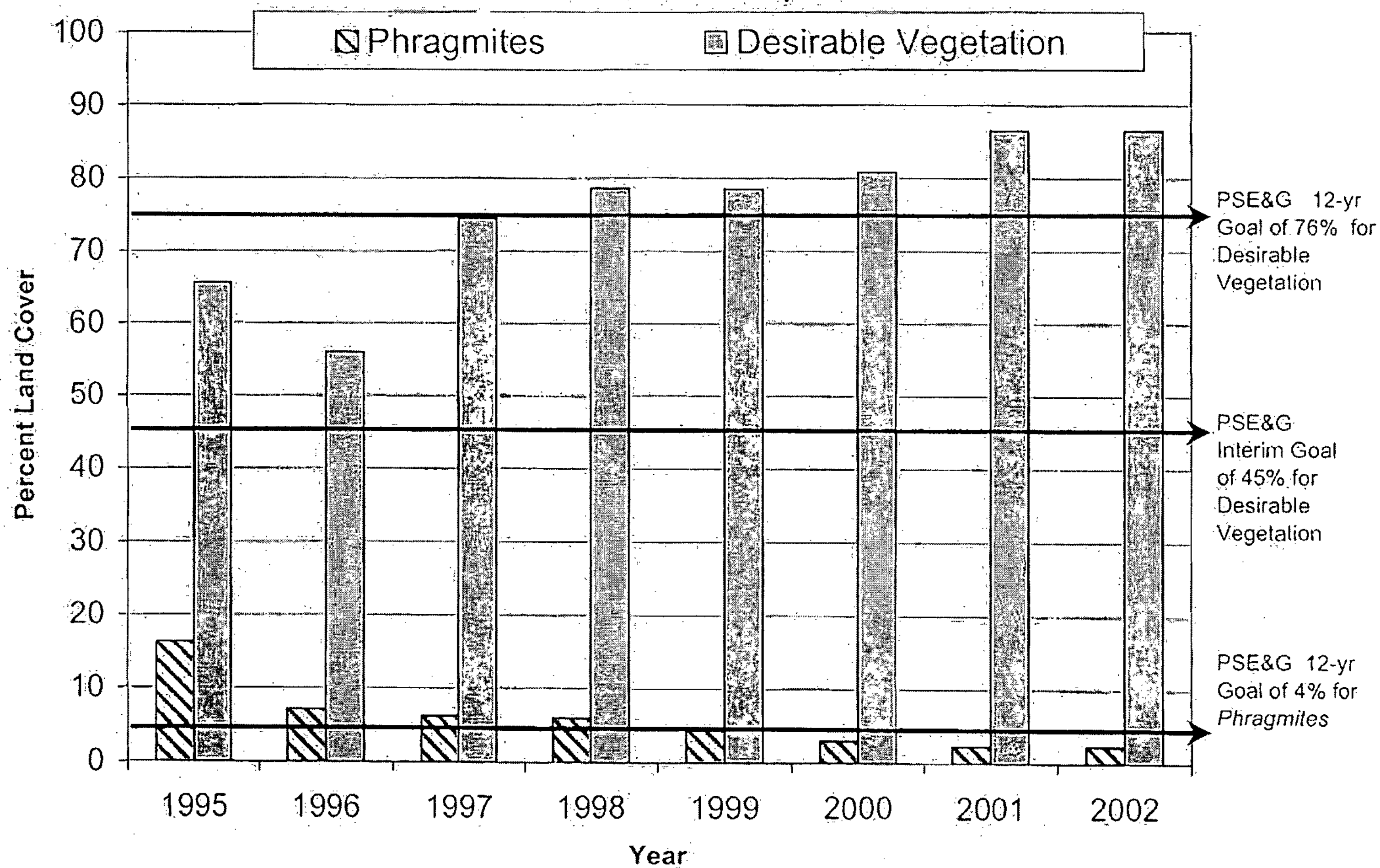


Figure 4-4
Maurice River Township

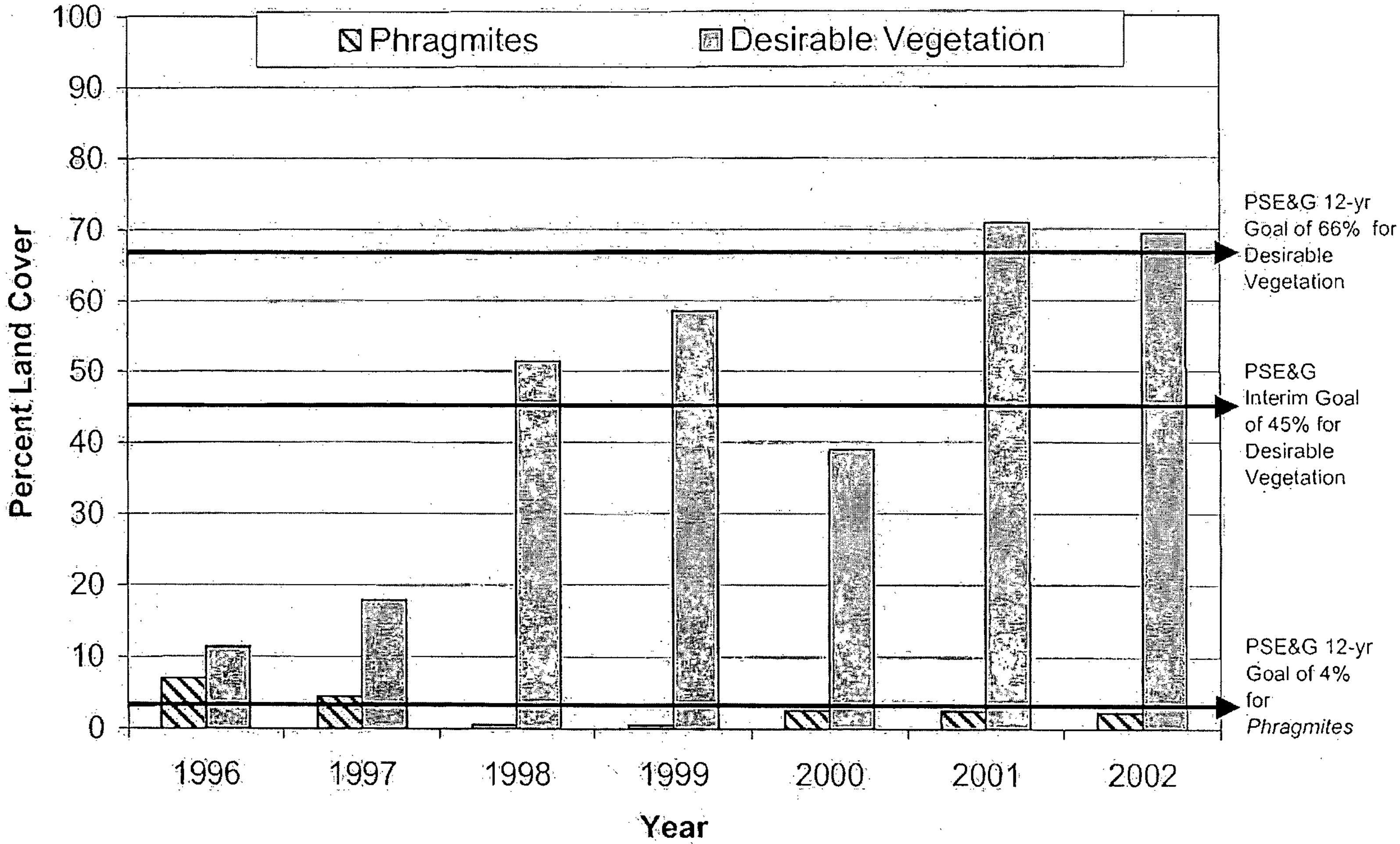


Figure 4-5
Mad Horse Creek - Reference

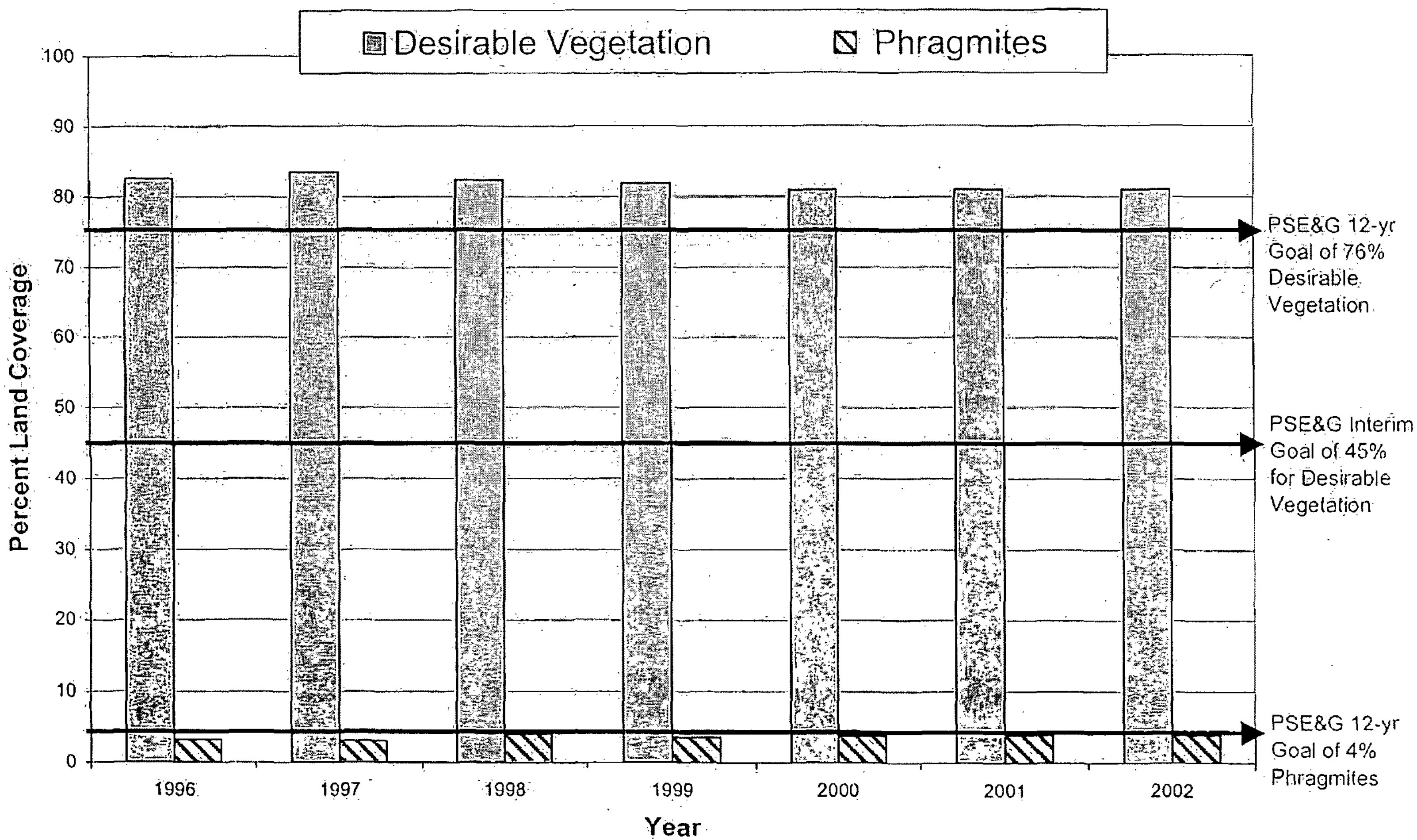


Figure 4-6
Alloway Creek Watershed

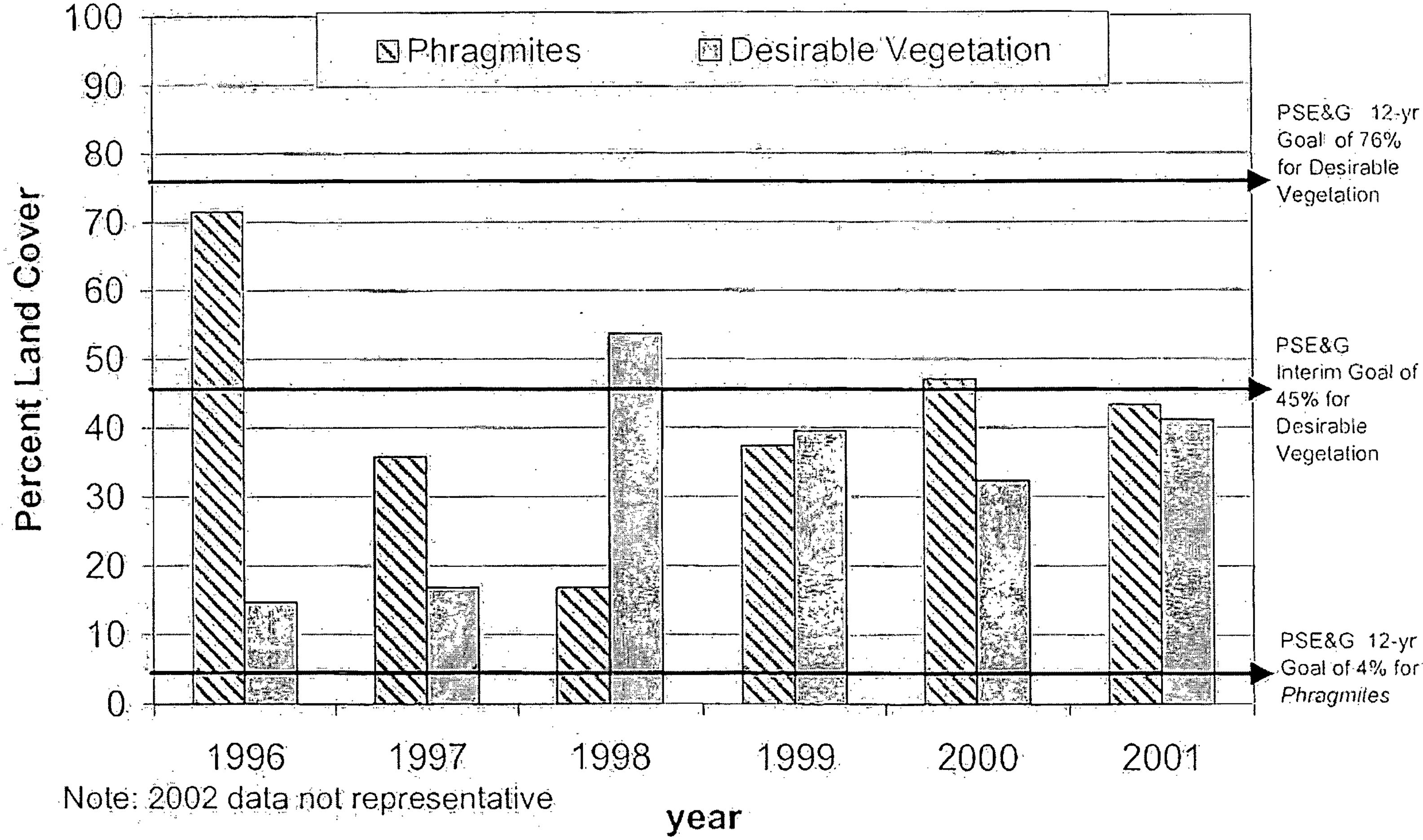


Figure 4-7
Mill Creek

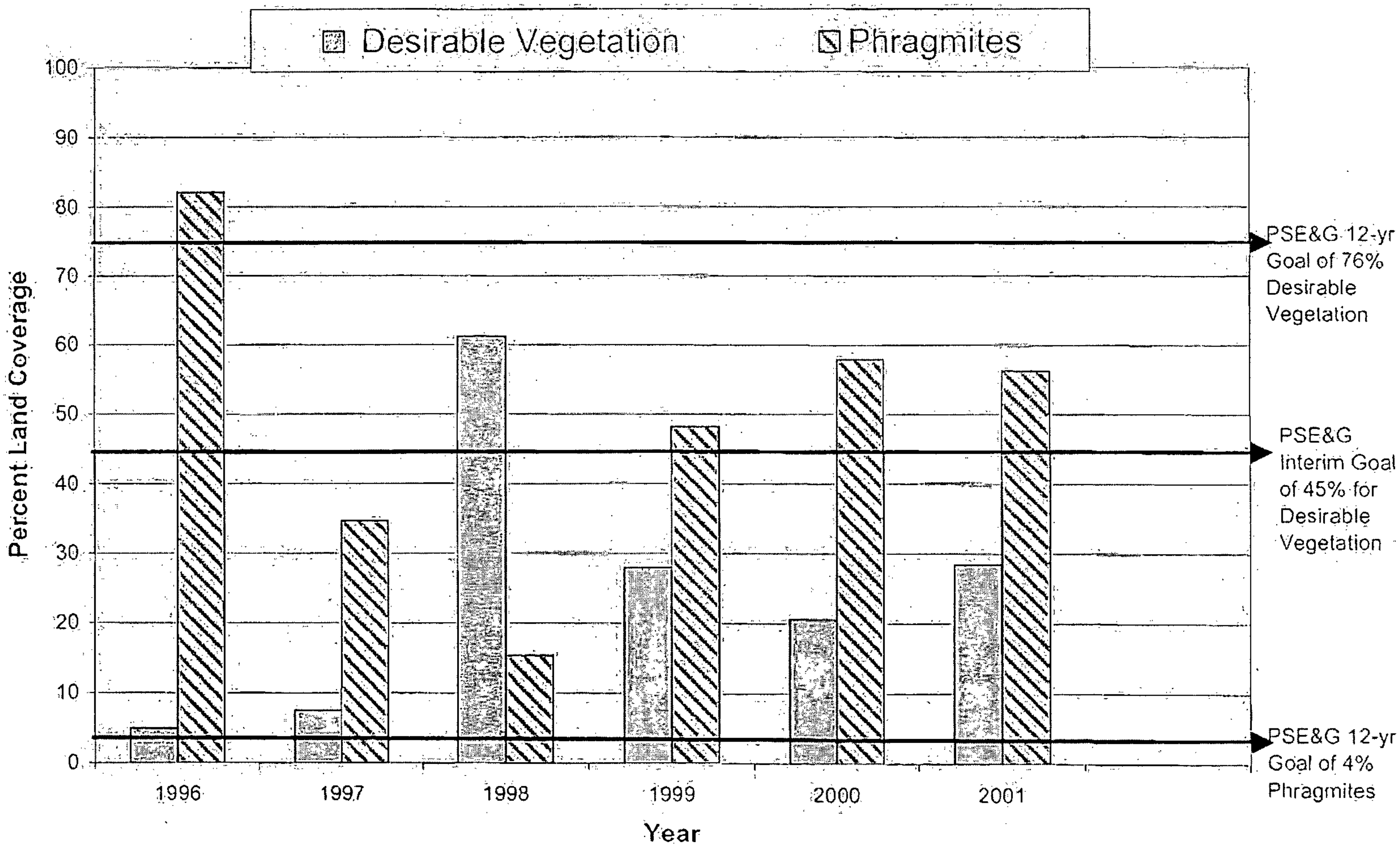


Figure 4-8
Cohansey River Watershed

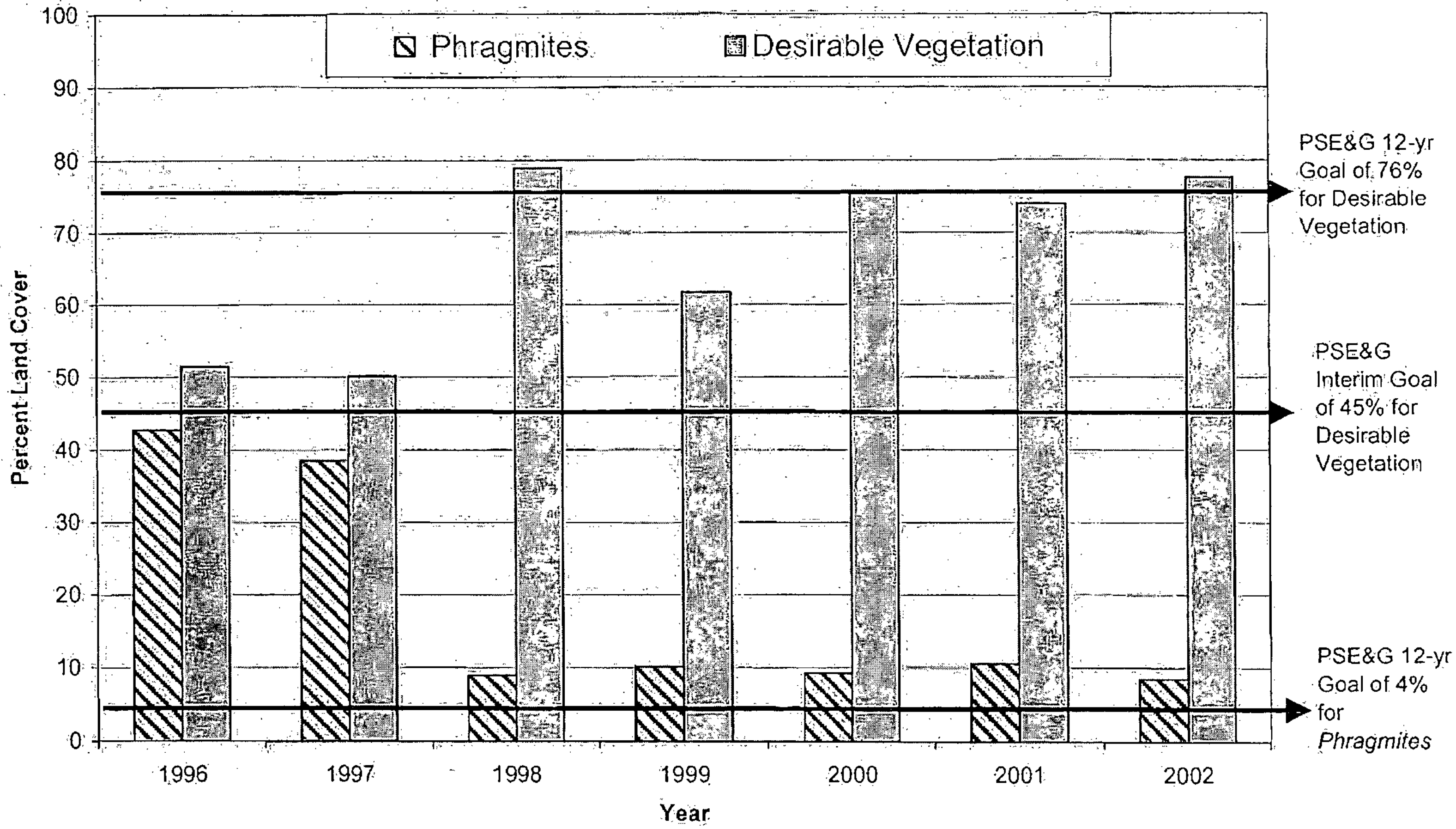


Figure 4-9
Silver Run

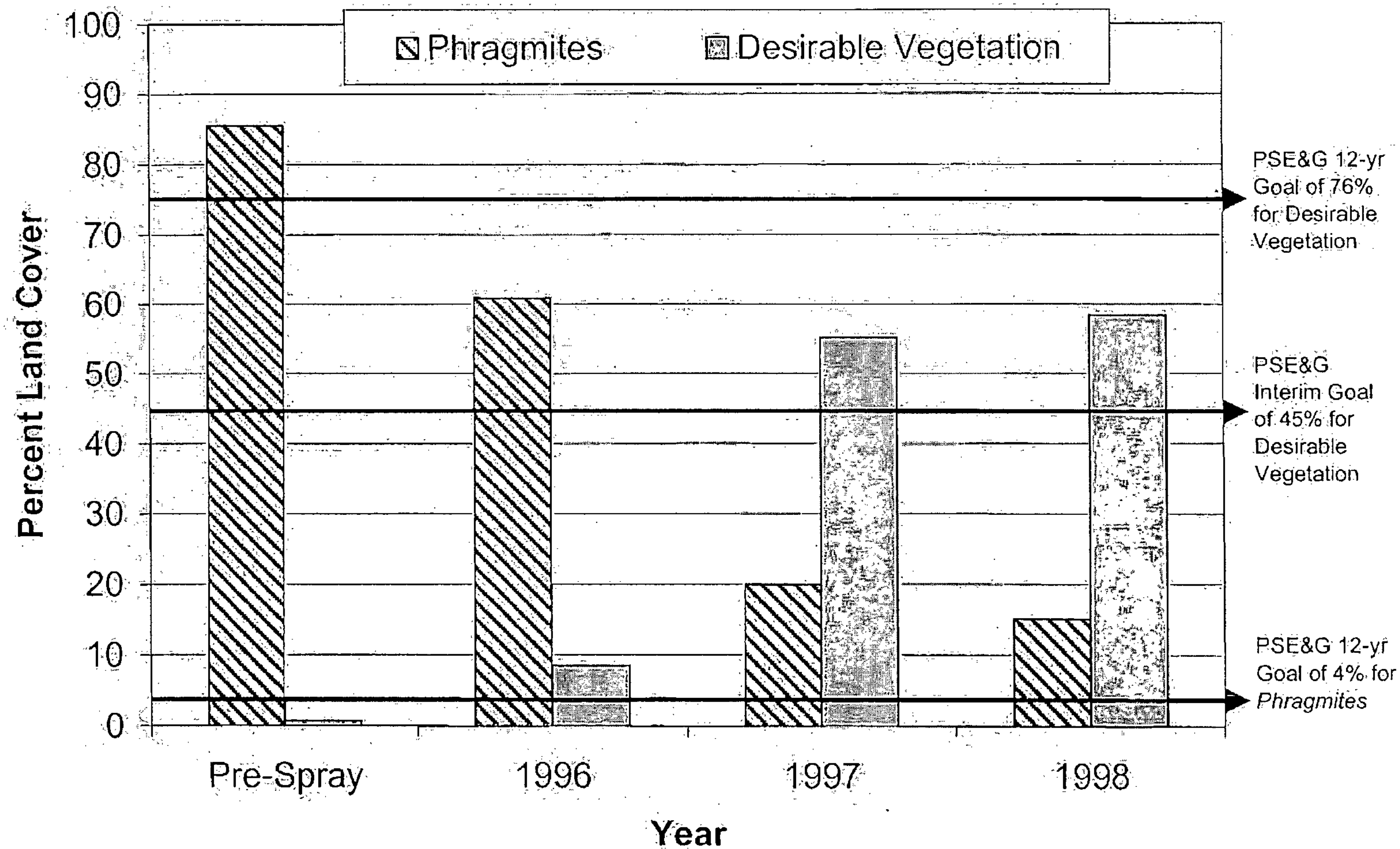


Figure 4-10
Lang Tract

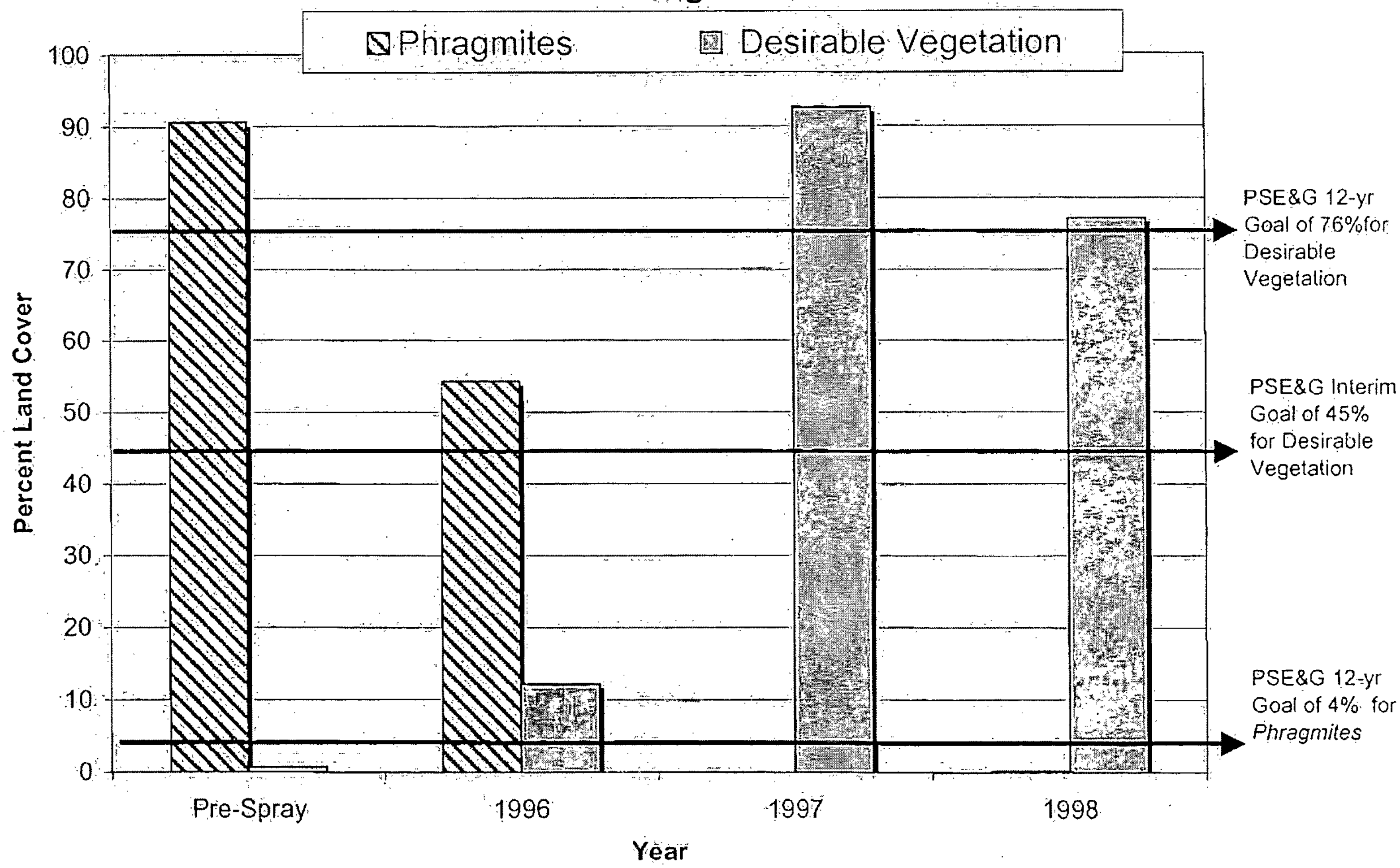


Figure 4-11
Woodland Beach

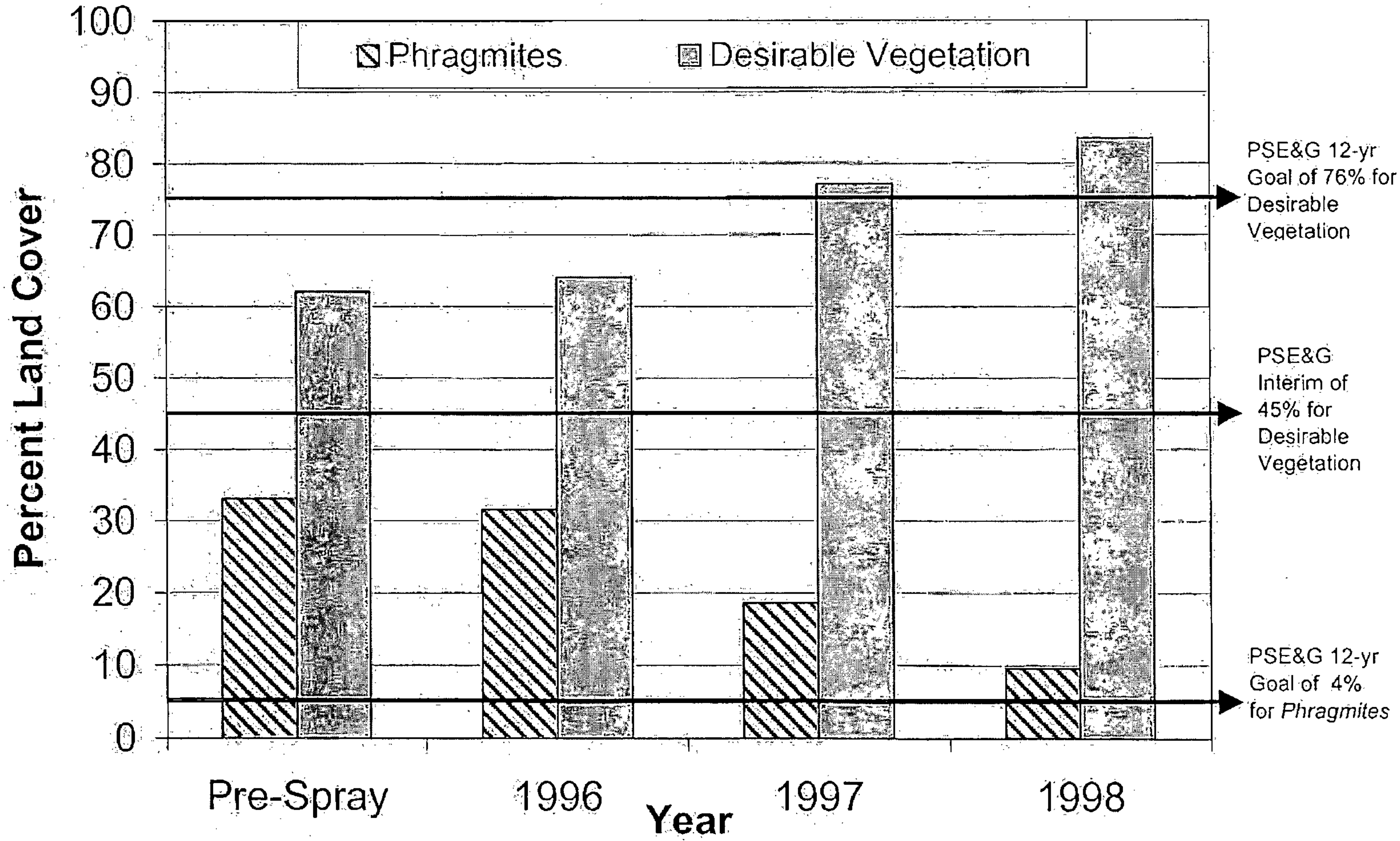


Figure 4-12
The Rocks

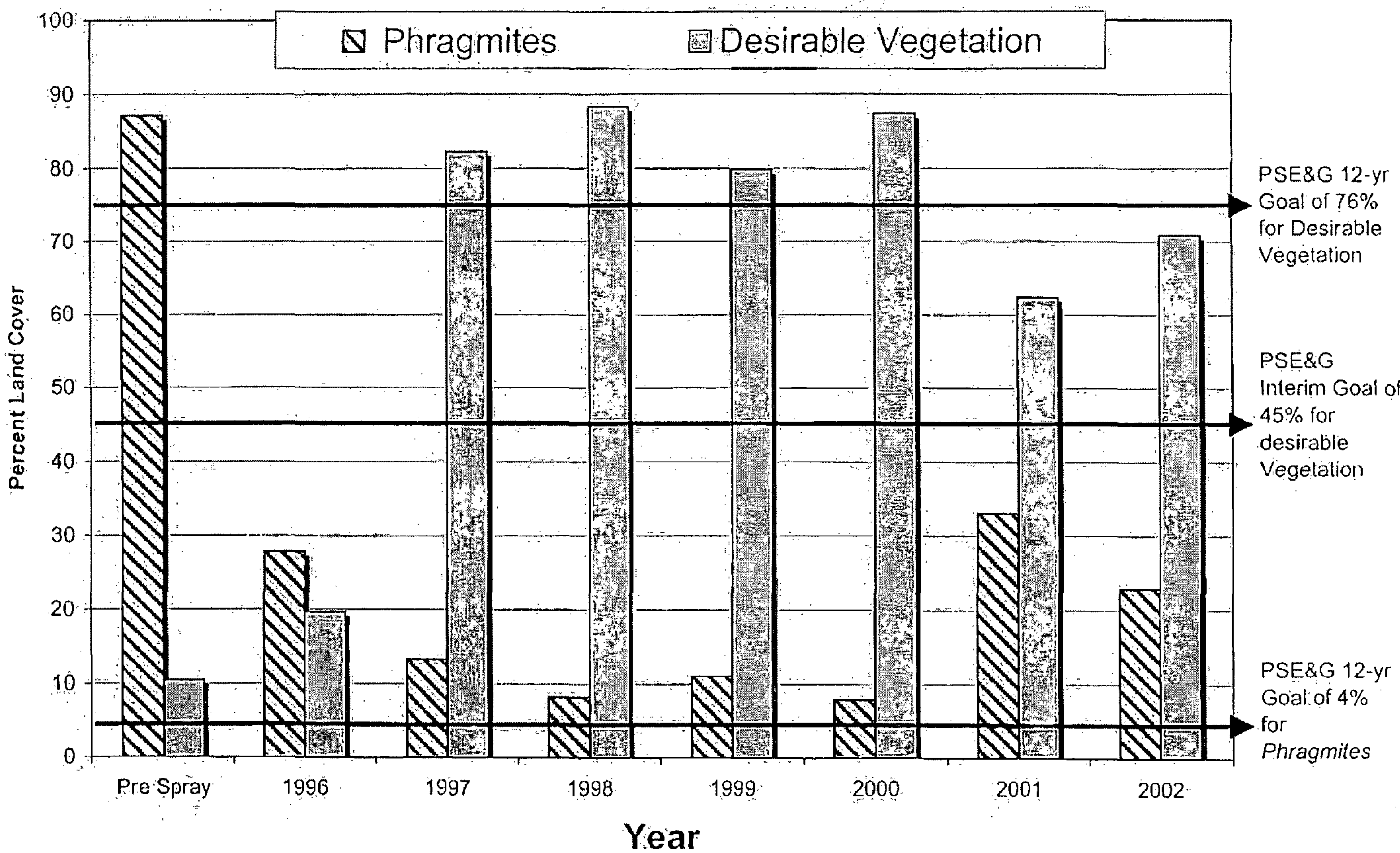


Figure 4-13
Cedar Swamp

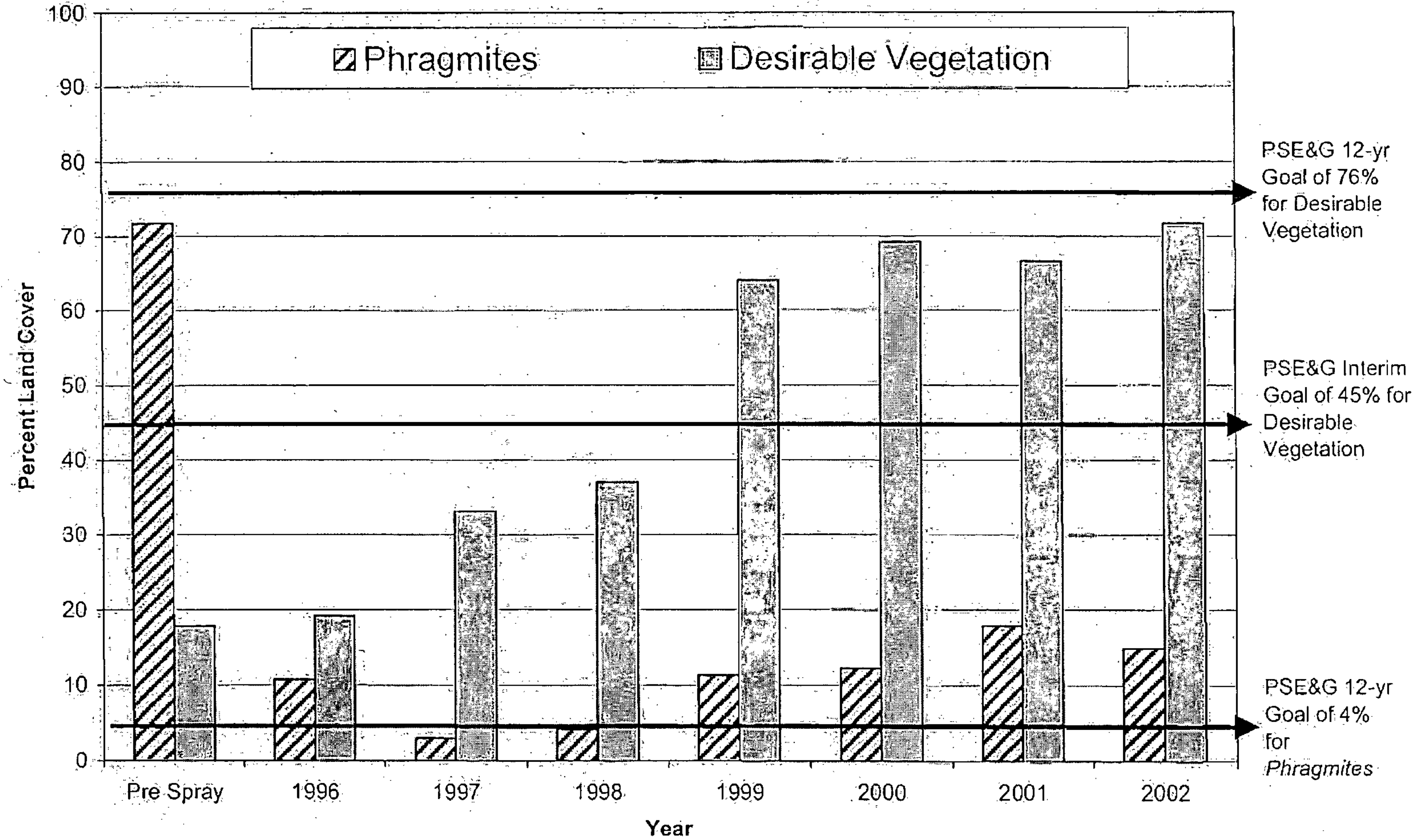
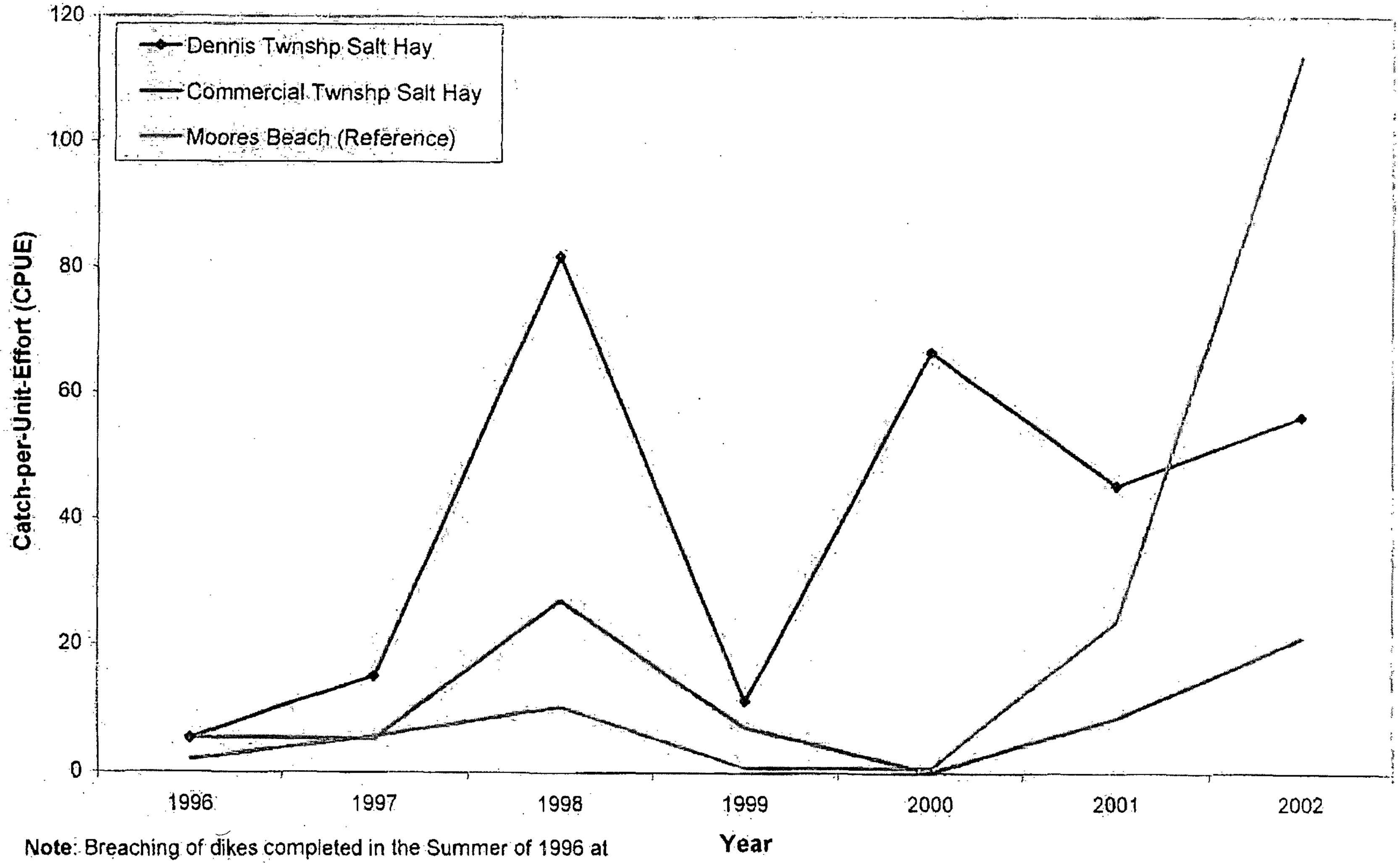
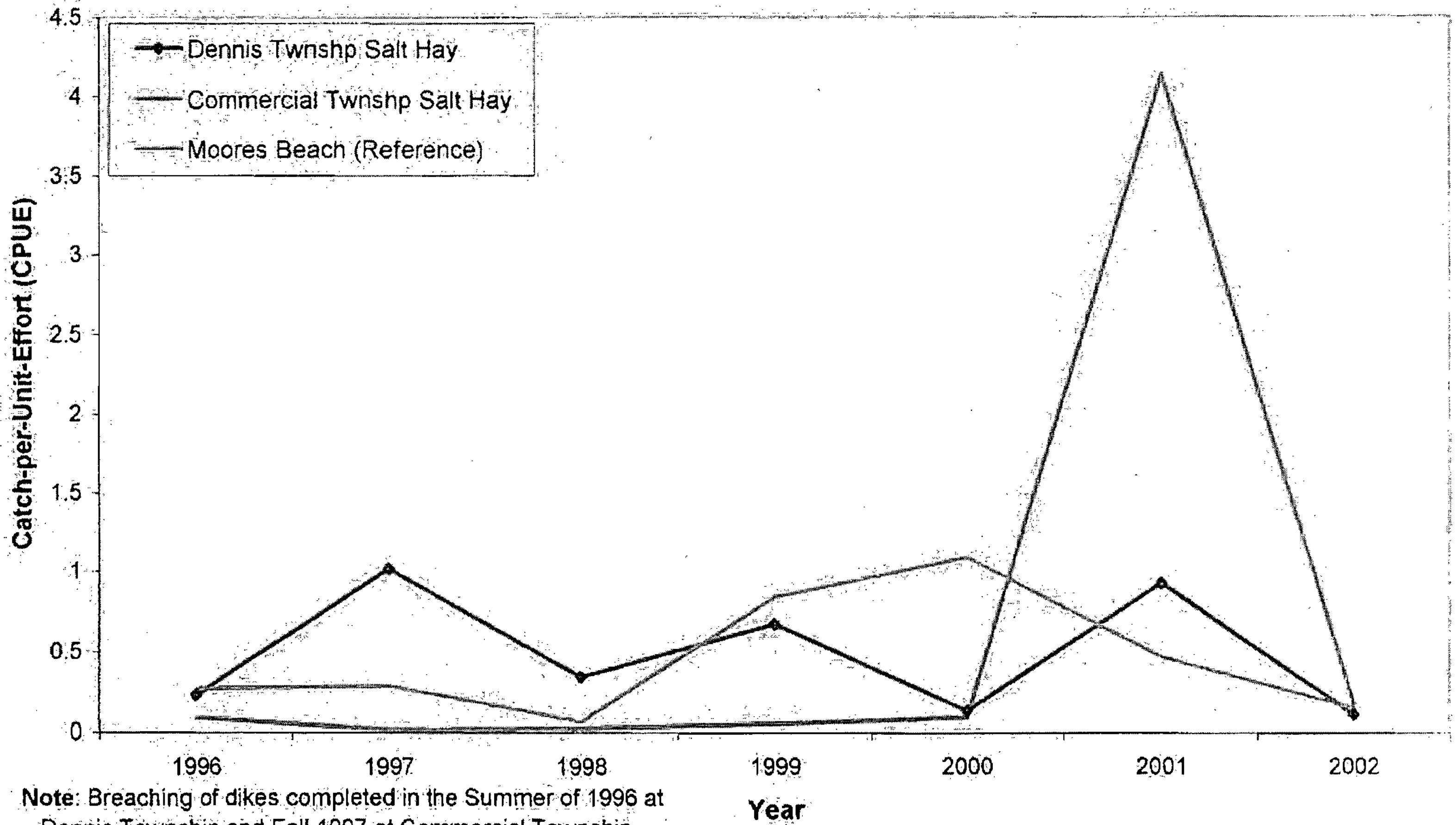


Figure 5-1 Salt Hay Farm Restoration Sites Large Marsh Creeks
Atlantic Croaker



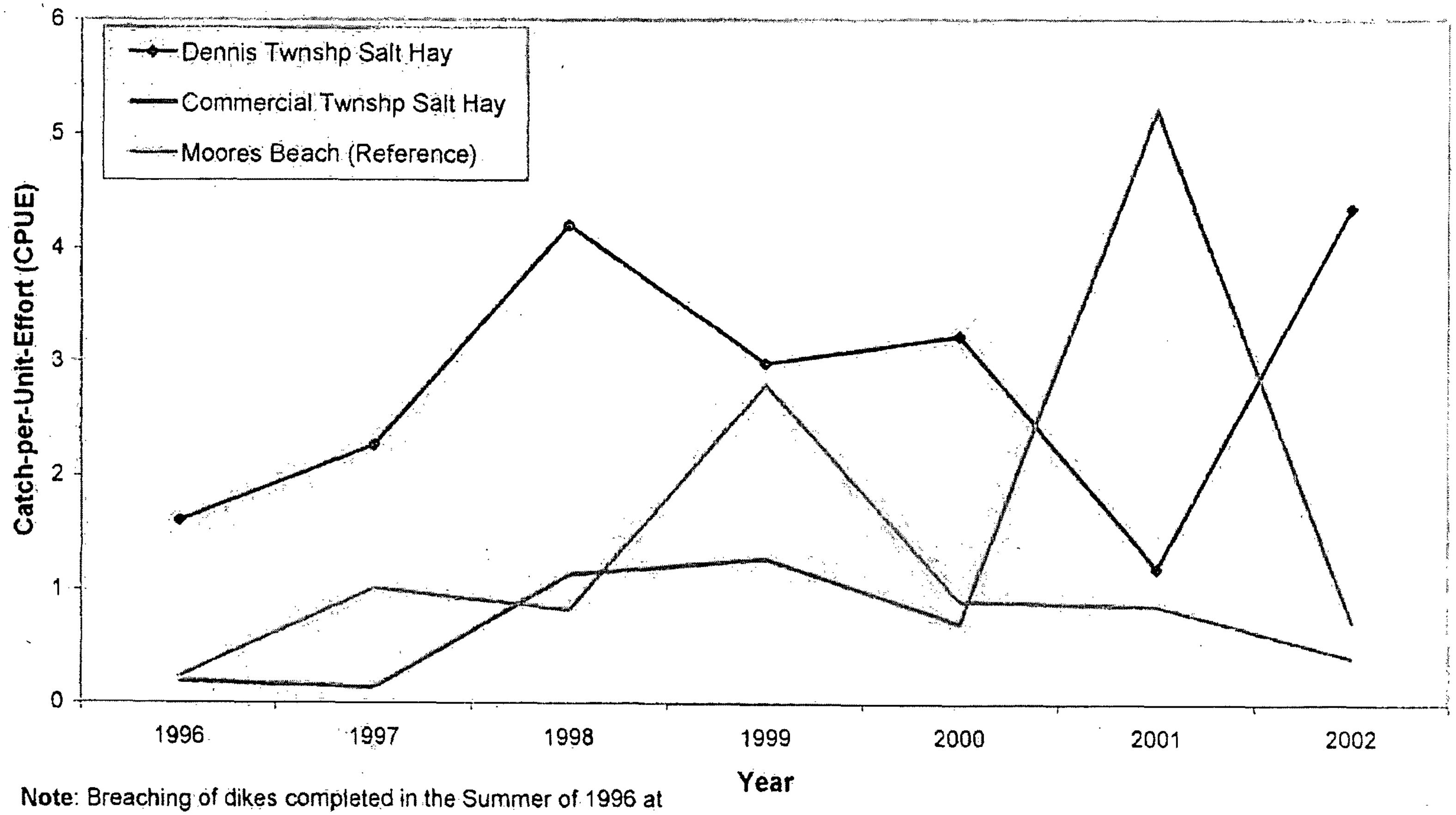
Note: Breaching of dikes completed in the Summer of 1996 at Dennis Township and Fall 1997 at Commercial Township.

Figure 5-2 Salt Hay Farm Restoration Sites Large Marsh Creeks
Atlantic Silverside



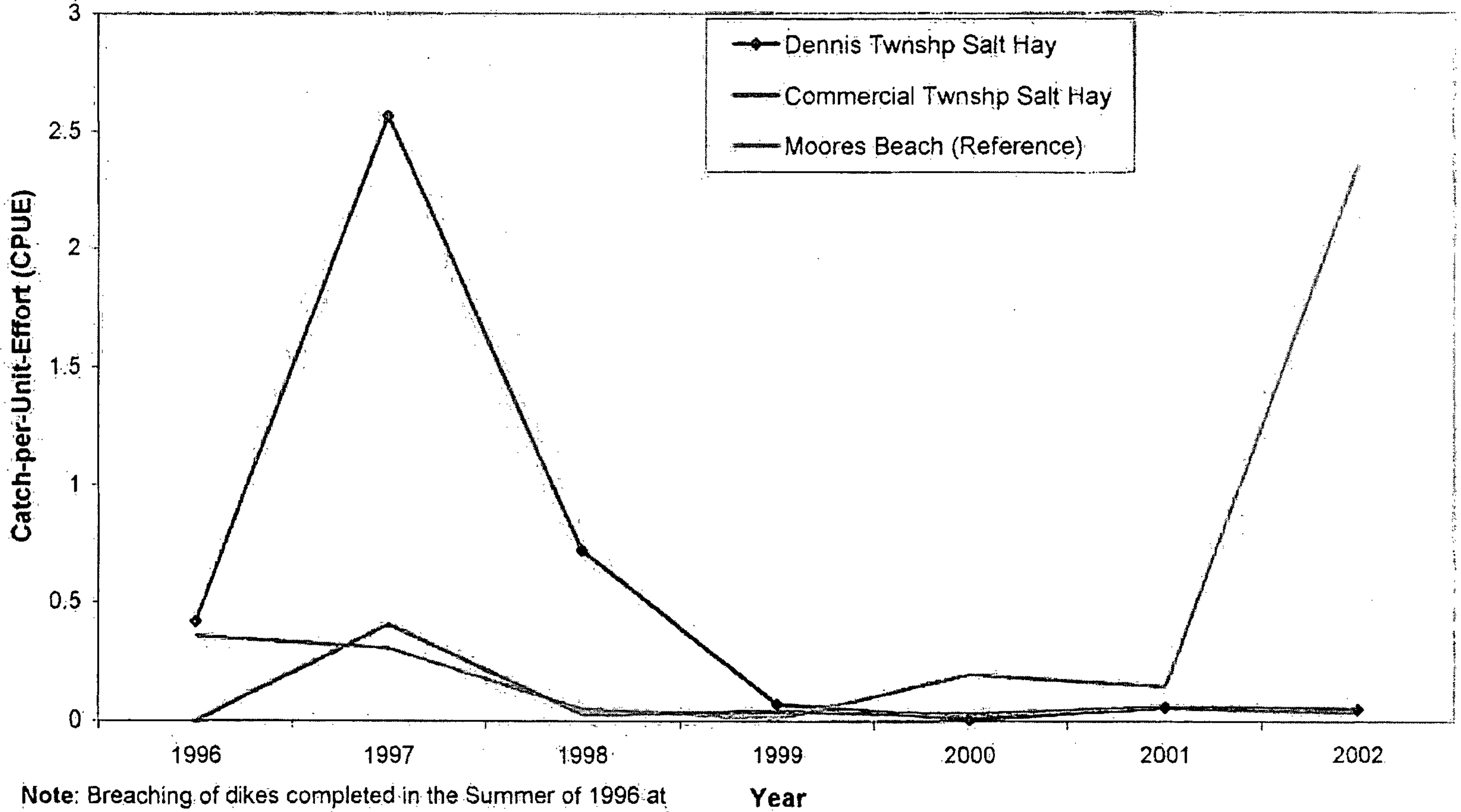
Note: Breaching of dikes completed in the Summer of 1996 at Dennis Township and Fall 1997 at Commercial Township..

Figure 5-3 Salt Hay Farm Restoration Sites Large Marsh Creeks
Bay Anchovy



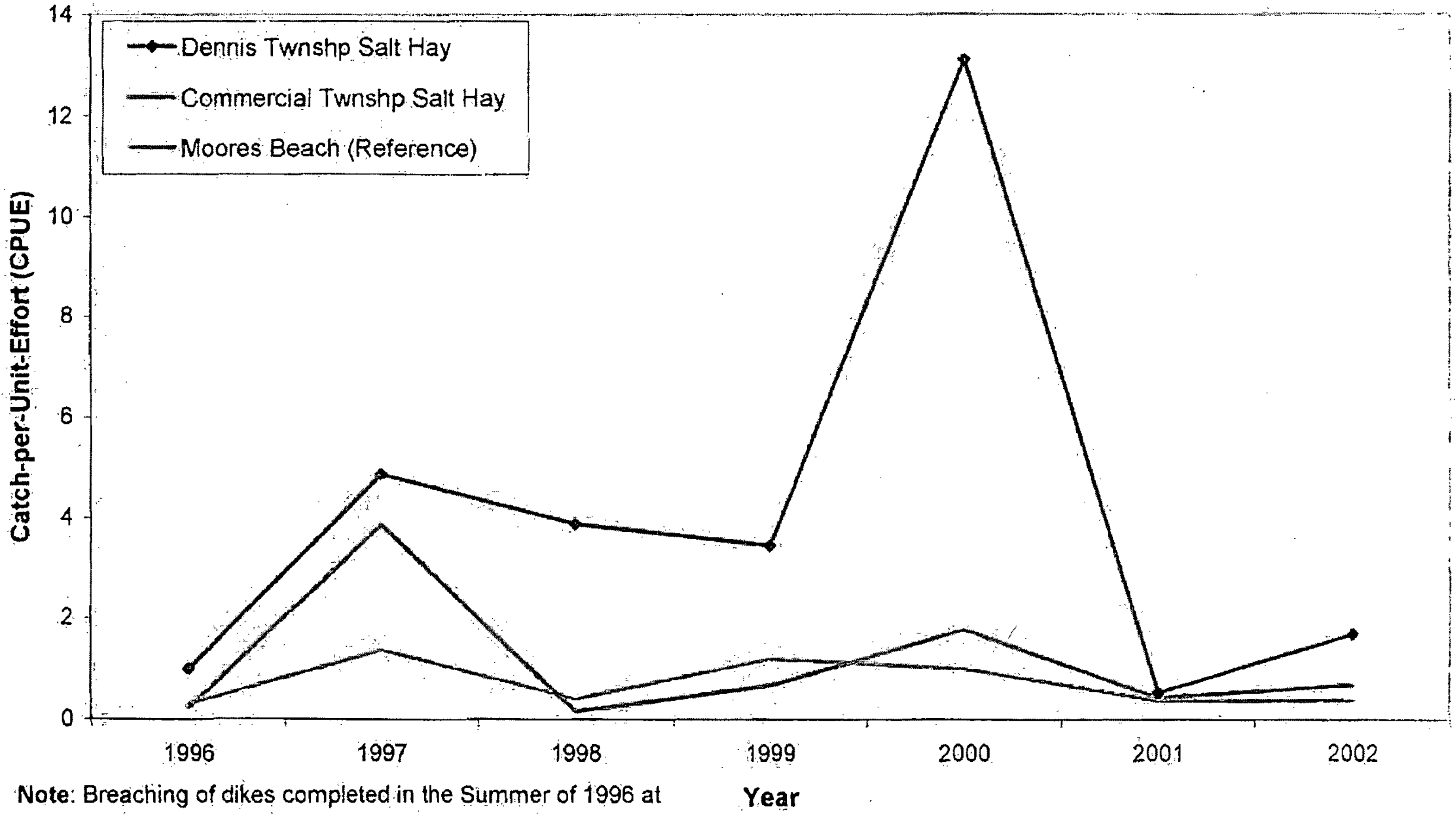
Note: Breaching of dikes completed in the Summer of 1996 at Dennis Township and Fall 1997 at Commercial Township..

Figure 5-4 Salt Hay Farm Restoration Sites Large Marsh Creeks Mummichog



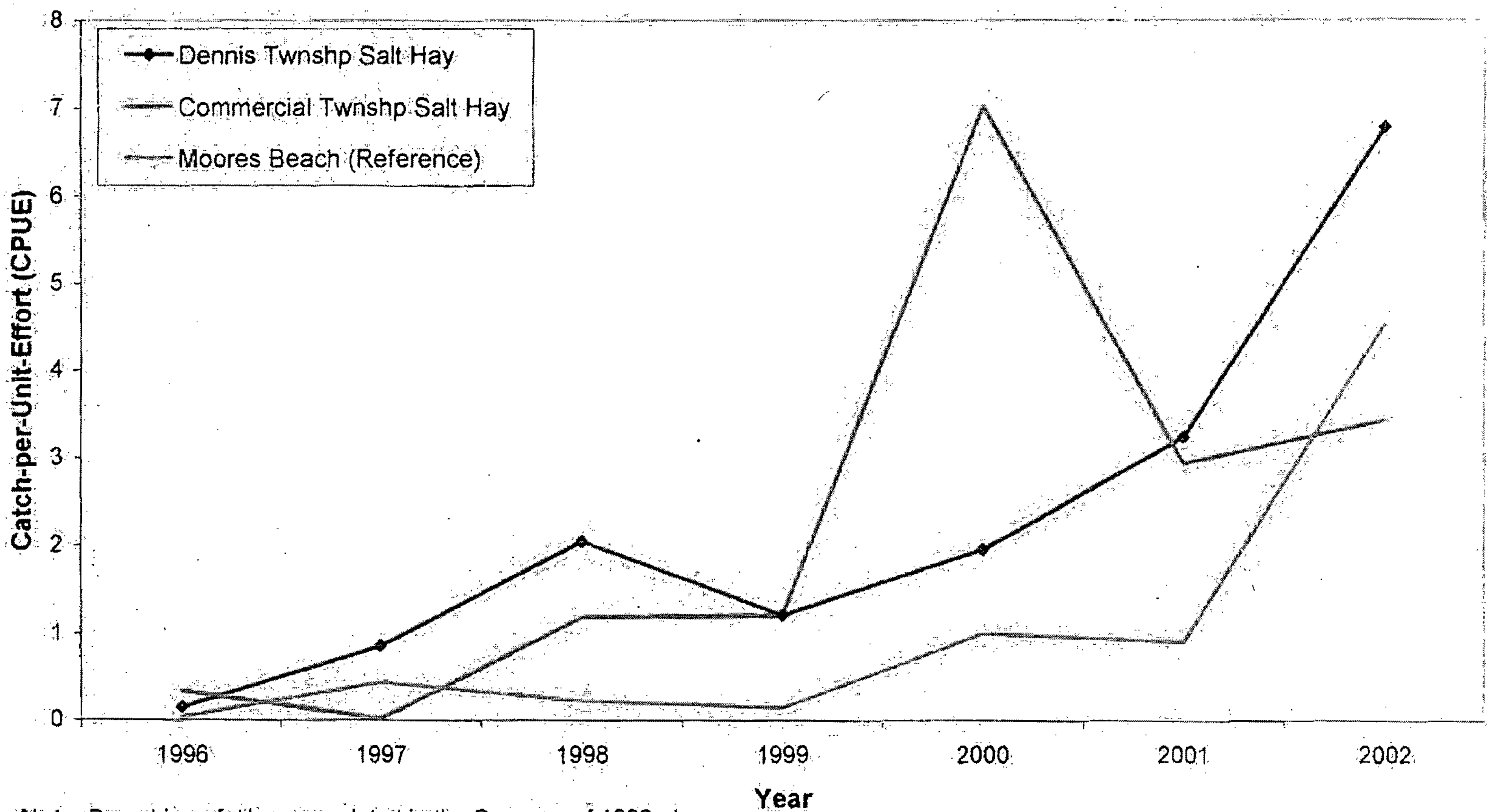
Note: Breaching of dikes completed in the Summer of 1996 at Dennis Township and fall 1997 at Commercial Township..

Figure 5-5 Salt Hay Farm Restoration Sites Large Marsh Creeks
Spot



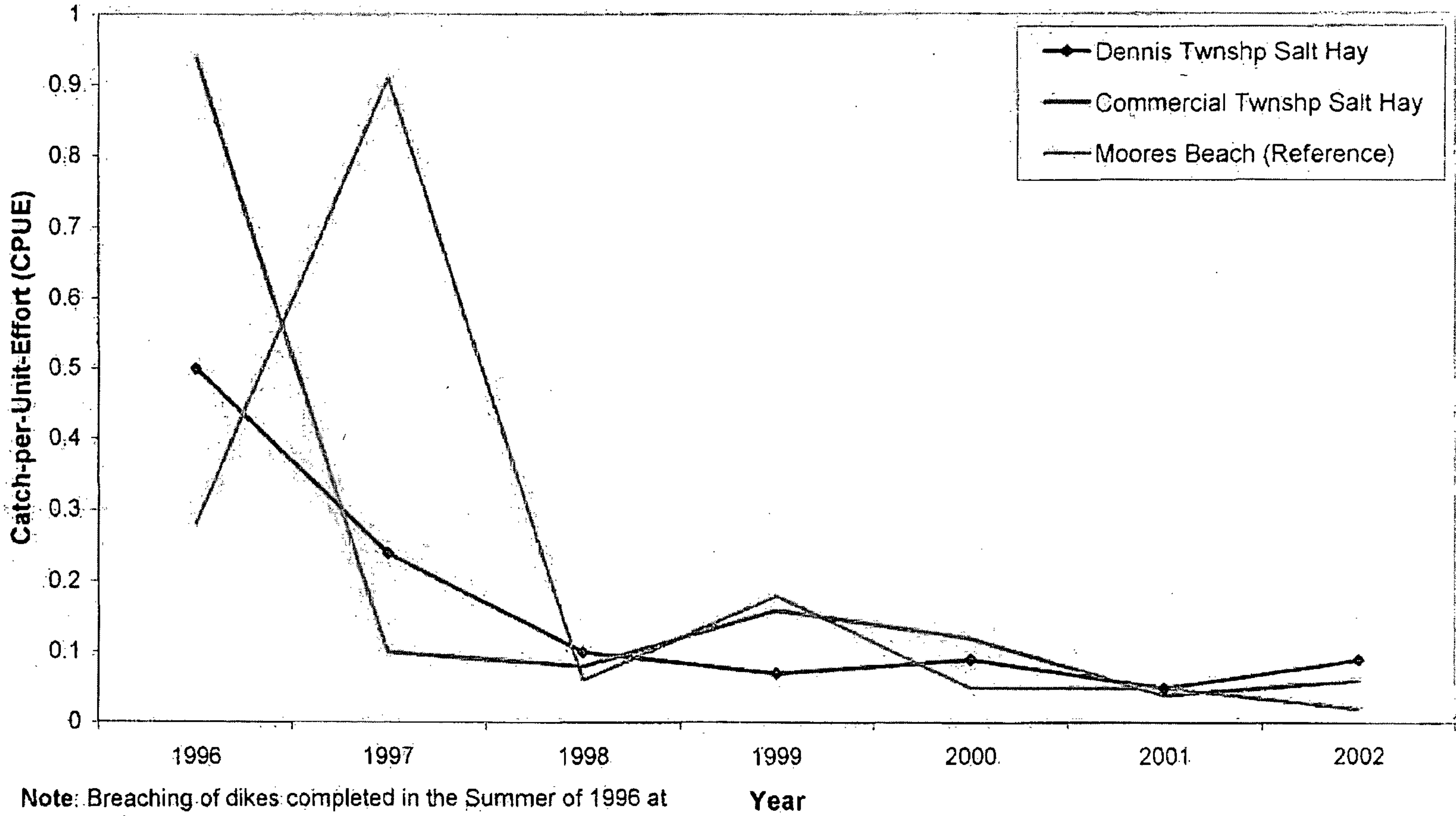
Note: Breaching of dikes completed in the Summer of 1996 at Dennis Township and Fall 1997 at Commercial Township..

Figure 5-6 Salt Hay Restoration Sites Large Marsh Creeks
Weakfish



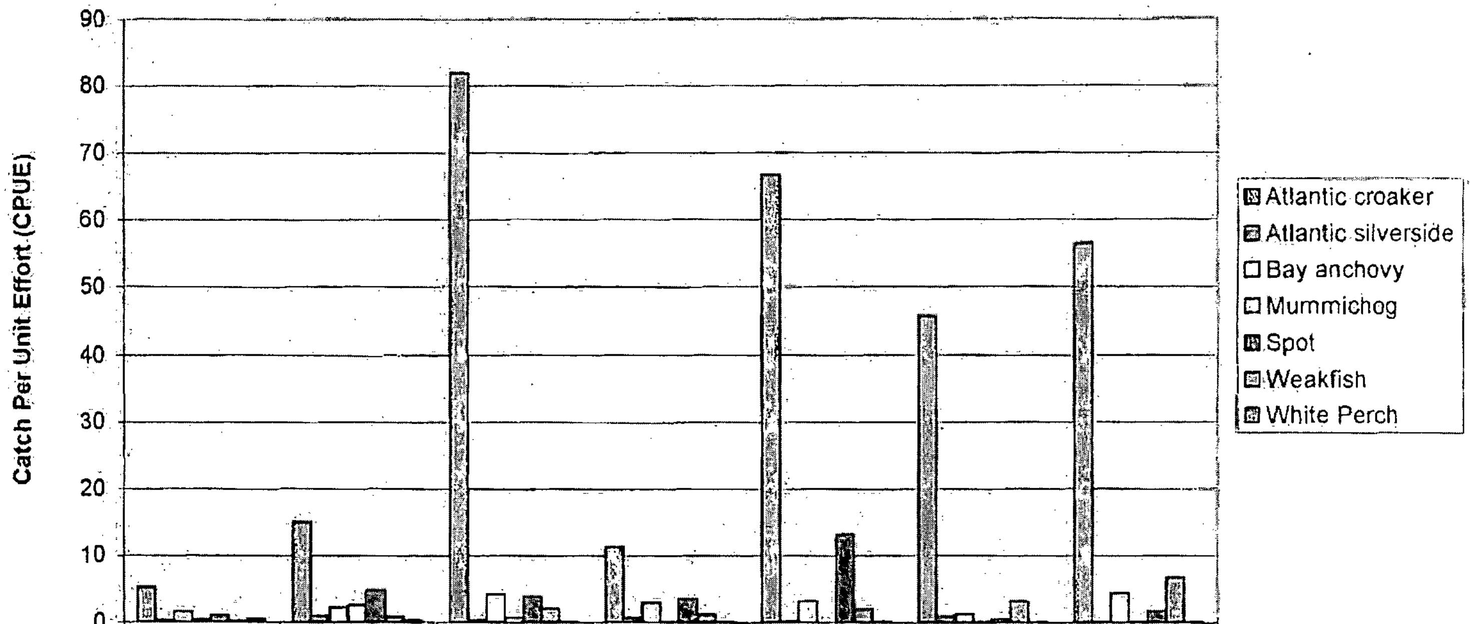
Note: Breaching of dikes completed in the Summer of 1996 at Dennis Township and Fall 1997 at Commercial Township..

Figure 5-7 Salt Hay Farm Restoration Sites Large Marsh Creeks
White Perch



Note: Breaching of dikes completed in the Summer of 1996 at Dennis Township and fall 1997 at Commercial Township..

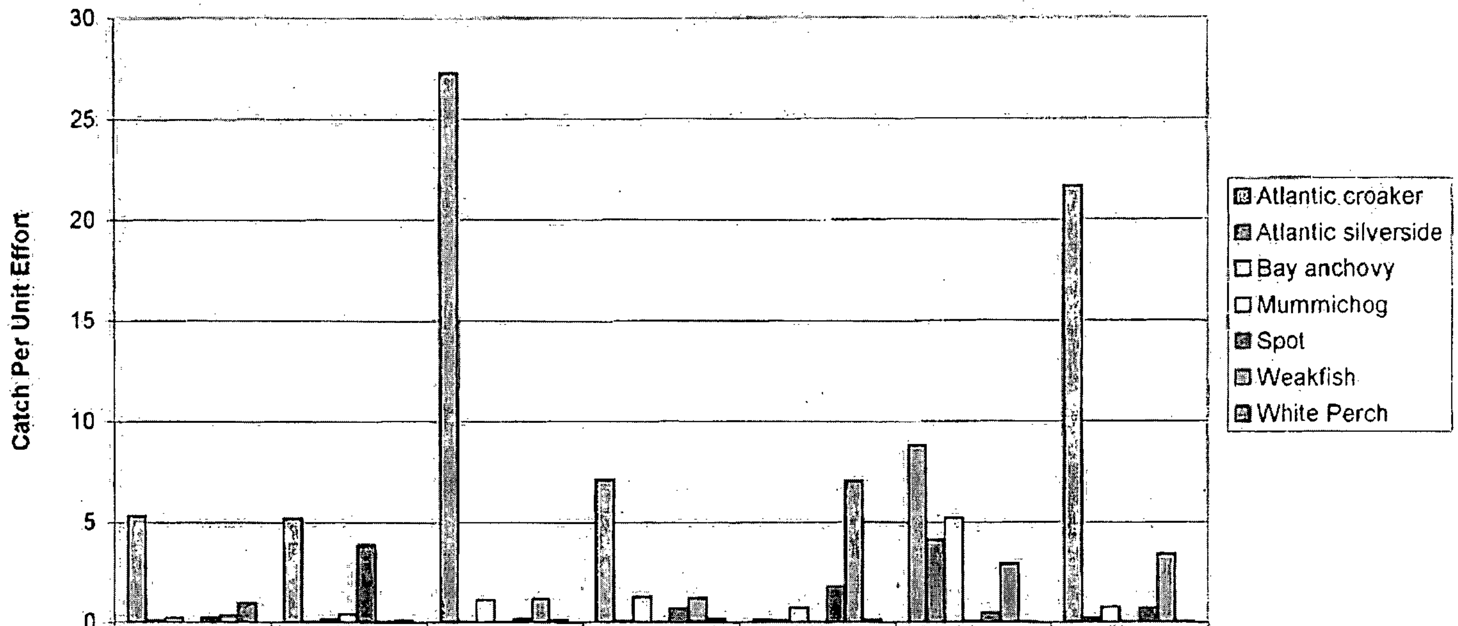
Figure 5-8 Dennis Township Large Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	5.31	15.03	81.94	11.3	66.7	45.68	56.52
Atlantic silverside	0.23	1.02	0.35	0.68	0.14	0.94	0.12
Bay anchovy	1.61	2.27	4.21	2.99	3.23	1.2	4.36
Mummichog	0.42	2.57	0.72	0.07	0.01	0.06	0.05
Spot	1	4.89	3.89	3.47	13.12	0.56	1.71
Weakfish	0.15	0.86	2.05	1.21	1.96	3.24	6.79
White Perch	0.5	0.24	0.1	0.07	0.09	0.05	0.09

Year

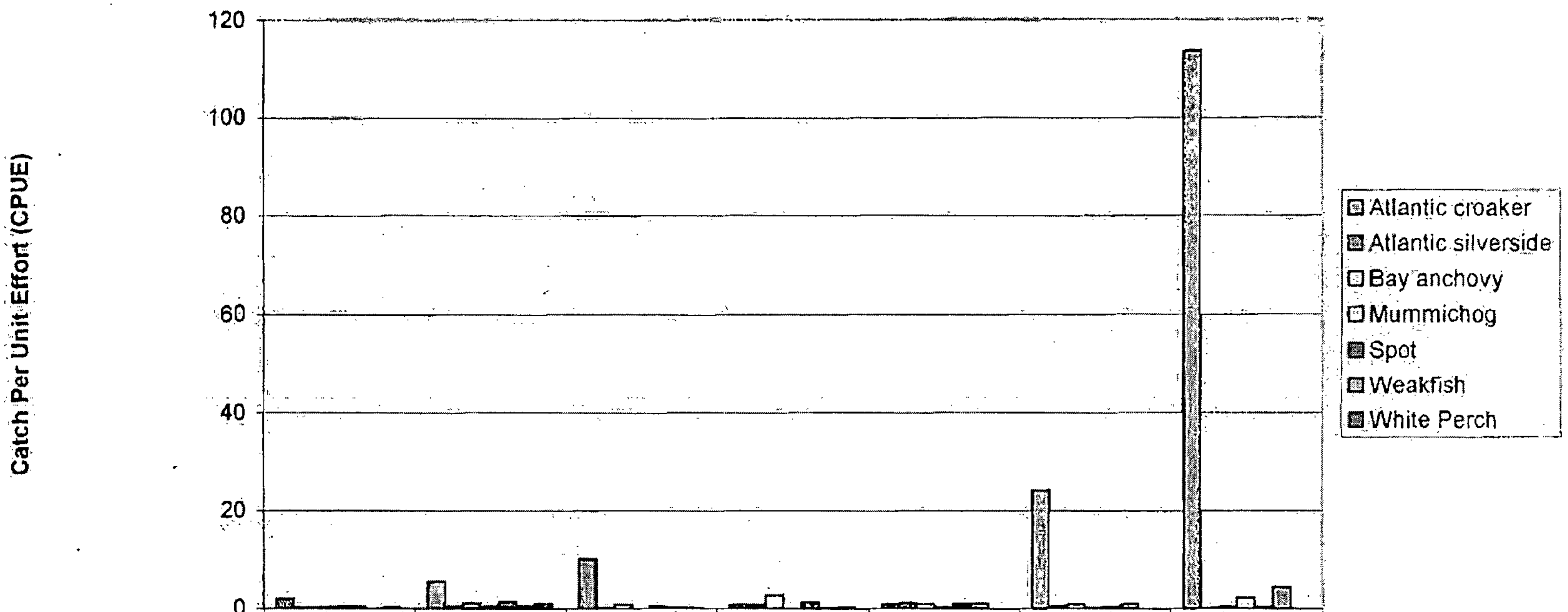
Figure 5-9 Commercial Township Large Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	5.33	5.2	27.29	7.09	0.12	8.8	21.66
Atlantic silverside	0.09	0.02	0.03	0.06	0.1	4.14	0.19
Bay anchovy	0.2	0.14	1.14	1.28	0.71	5.21	0.74
Mummichog	0	0.41	0.03	0.04	0.03	0.06	0.04
Spot	0.22	3.87	0.16	0.68	1.8	0.45	0.71
Weakfish	0.34	0.02	1.19	1.21	7.03	2.94	3.44
White Perch	0.94	0.1	0.08	0.16	0.12	0.04	0.06

Year

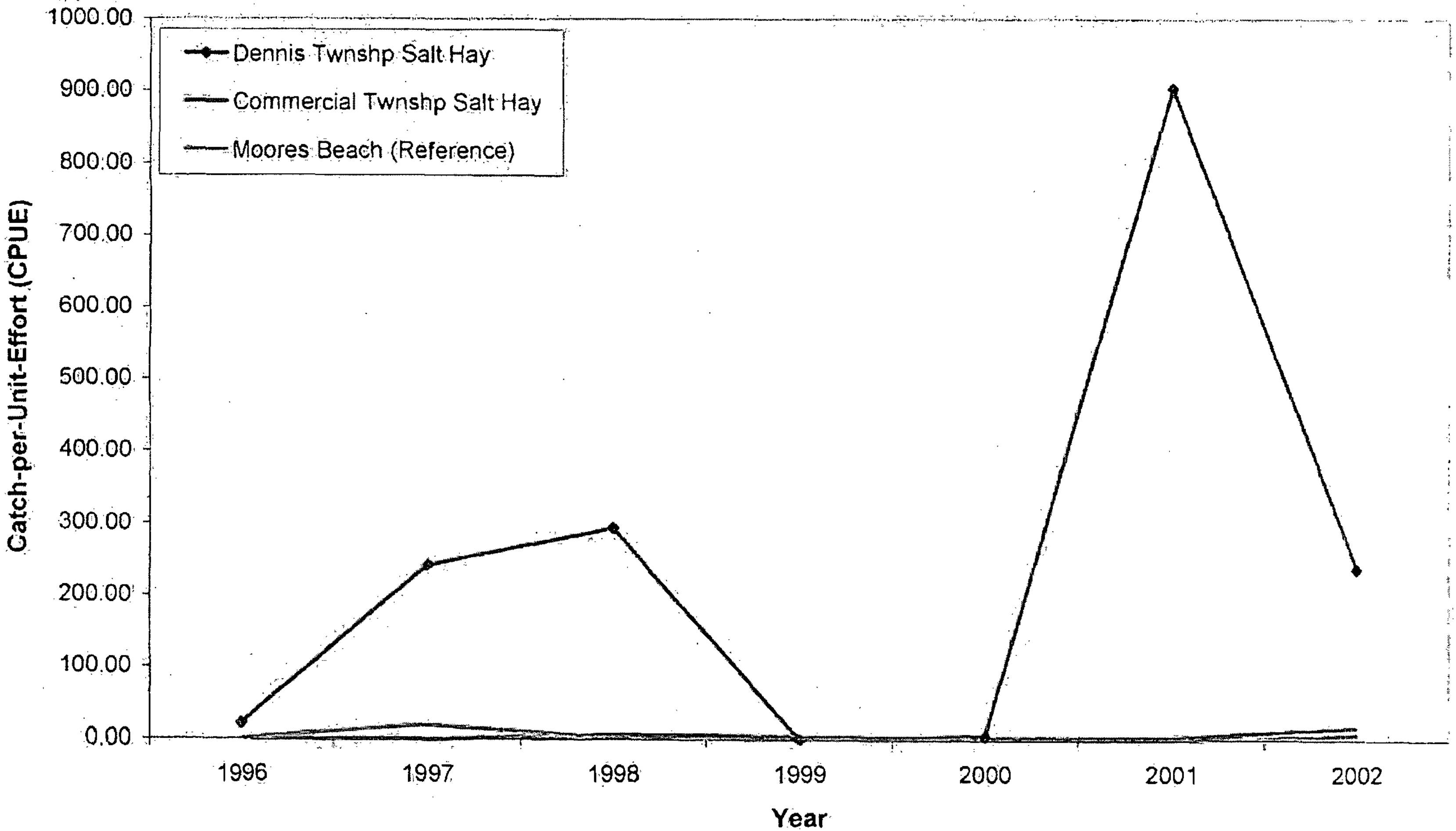
Figure 5-10 Moores Beach Reference Marsh Large Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	1.93	5.56	10.23	0.81	0.78	24.17	113.48
Atlantic silverside	0.27	0.29	0.07	0.85	1.1	0.48	0.16
Bay anchovy	0.24	1.02	0.83	2.8	0.91	0.87	0.42
Mummichog	0.36	0.31	0.05	0.01	0.2	0.15	2.35
Spot	0.3	1.38	0.42	1.22	1.03	0.39	0.39
Weakfish	0.04	0.44	0.23	0.15	1.01	0.91	4.54
White Perch	0.28	0.91	0.06	0.18	0.05	0.05	0.02

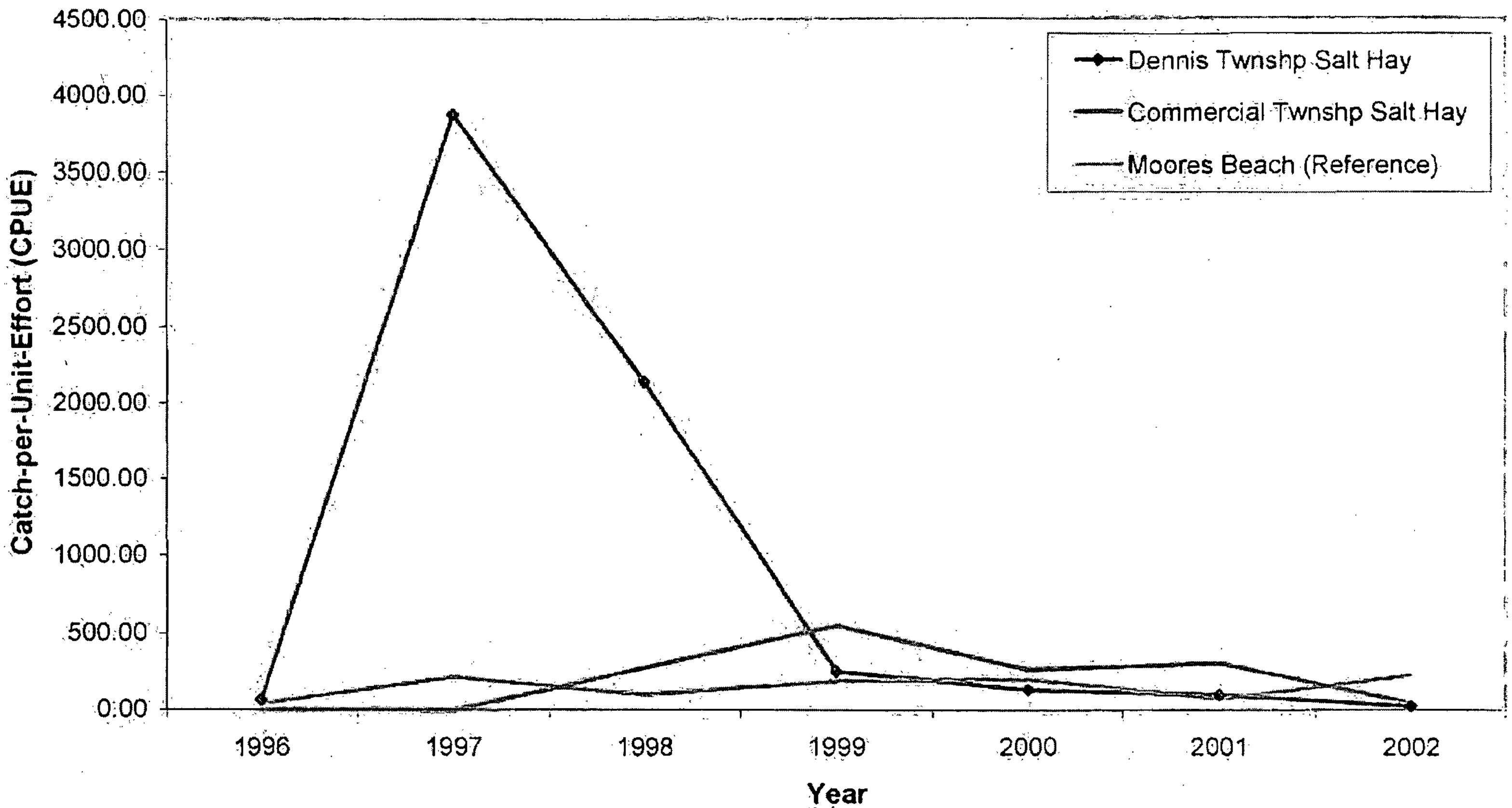
Year

Figure 5-11 Salt Hay Farm Restoration Sites Small Marsh Creeks Atlantic Croaker



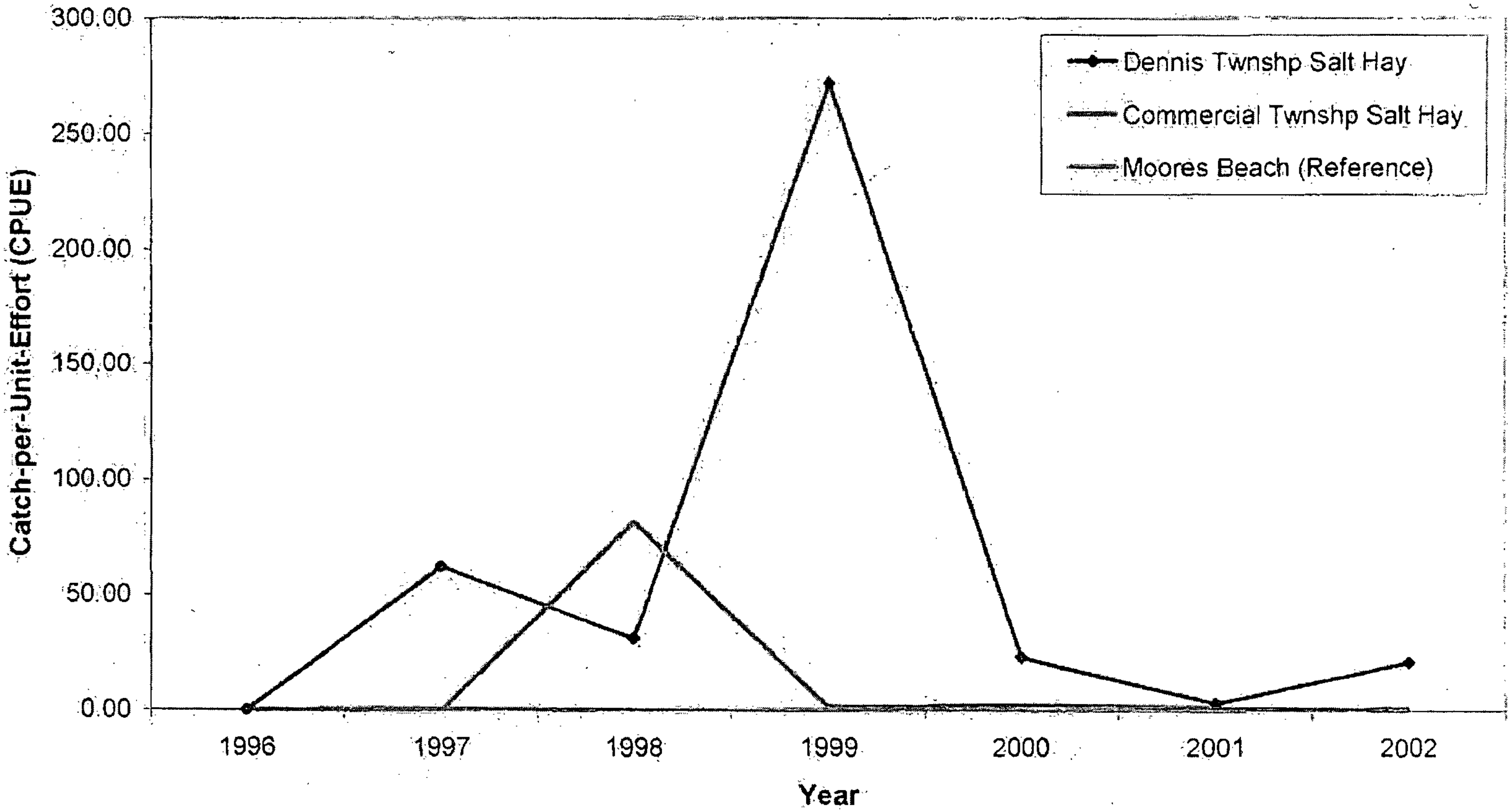
Note: Breaching of dikes completed in the Summer of 1996 at Dennis Township and Fall 1997 at Commercial Township. Monitoring of Commercial Township small creeks began in 1998 following dike breaching

Figure 5-12 Salt Hay Restoration Sites Small Marsh Creeks Atlantic Silverside



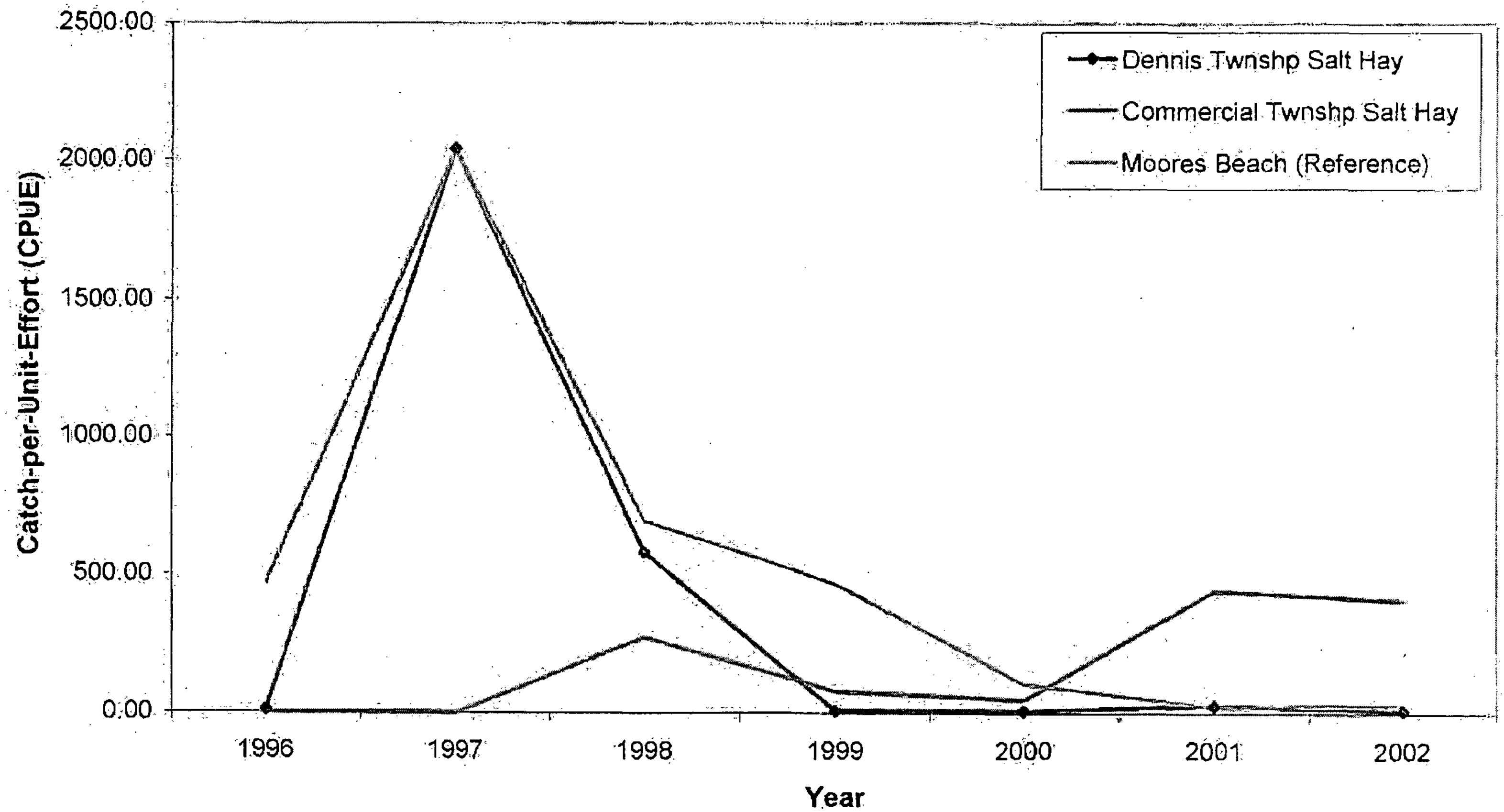
Note: Breaching of dikes completed in the Summer of 1996 at Dennis Township and fall 1997 at Commercial Township. Monitoring of Commercial Township small creeks began in 1998 following dike breaching

Figure 5-13 Salt Hay Restoration Sites Small Marsh Creeks
Bay Anchovy



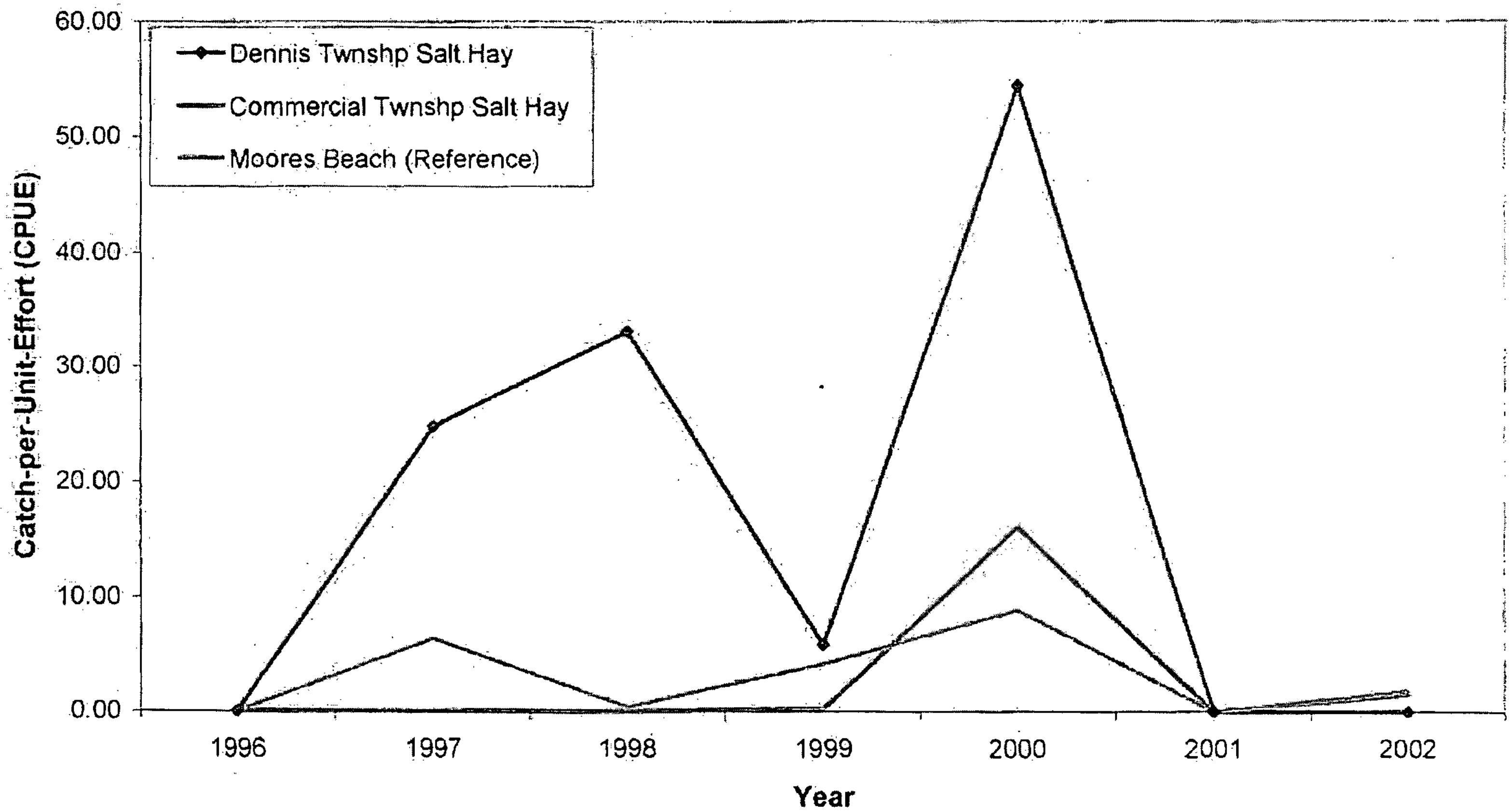
Note: Breaching of dikes completed in the Summer of 1996 at Dennis Township and Fall 1997 at Commercial Township. Monitoring of Commercial Township small creeks began in 1998 following dike breaching

Figure 5-14 Salt Hay Farm Restoration Sites Small Marsh Creeks Mummichog



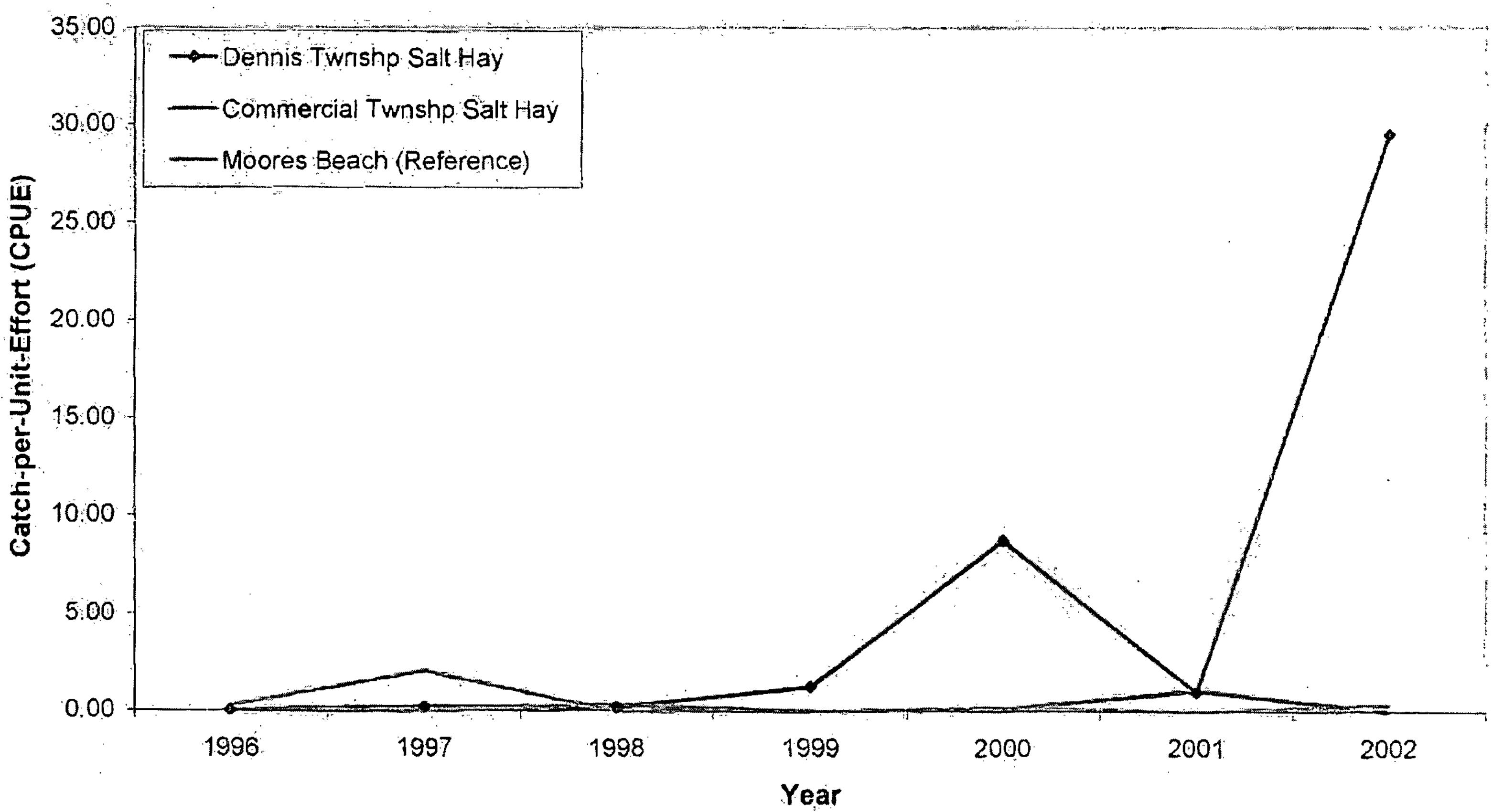
Note: Breaching of dikes completed in the Summer of 1996 at Dennis Township and fall 1997 at Commercial Township. Monitoring of Commercial Township small creeks began in 1998 following dike breaching

Figure 5-15 Salt Hay Farm Restoration Sites Small Marsh Creeks
Spot



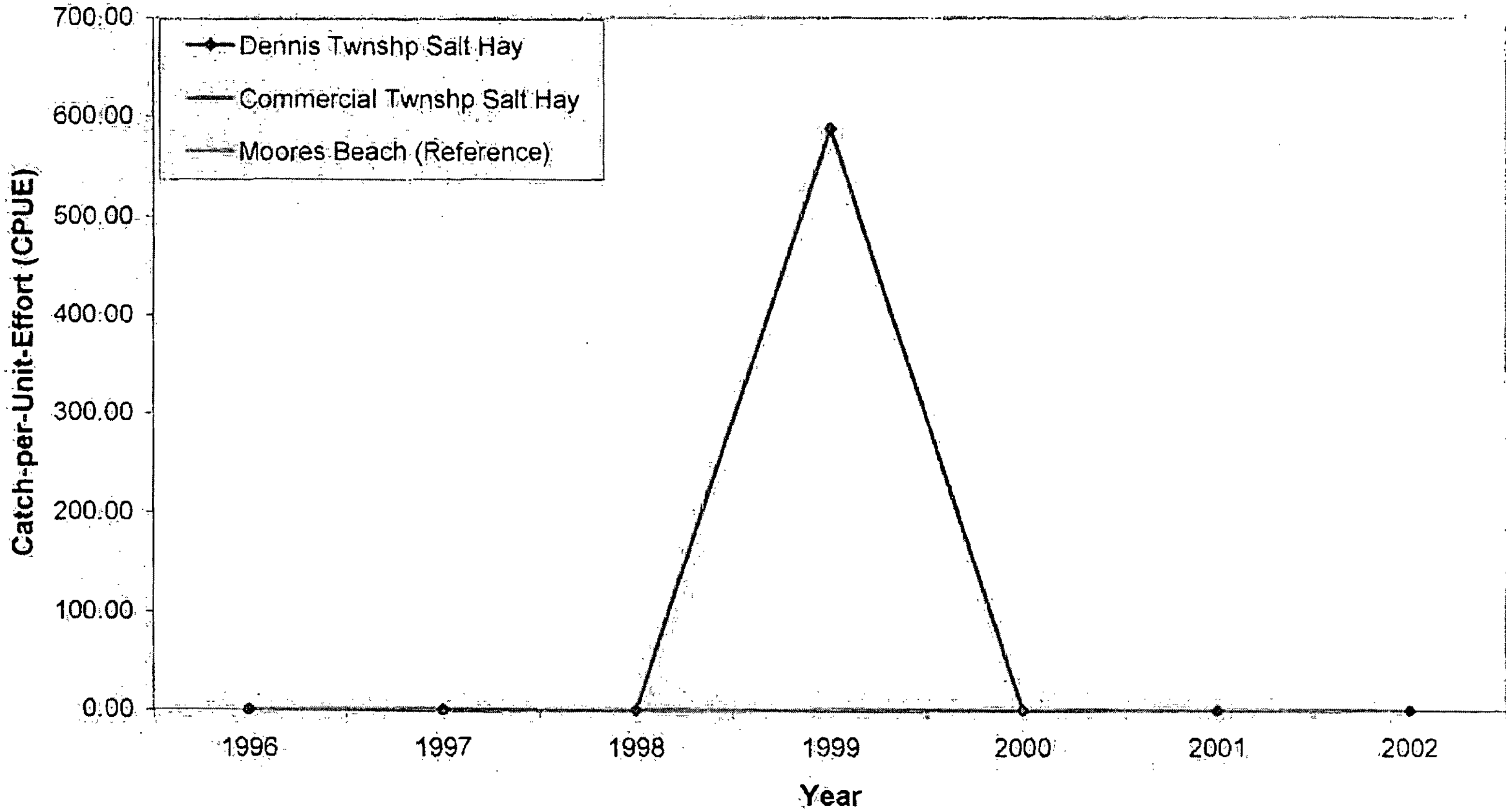
Note: Breaching of dikes completed in the Summer of 1996 at Dennis Township and Fall 1997 at Commercial Township. Monitoring of Commercial Township small creeks began in 1998 following dike breaching

Figure 5-16 Salt Hay Farm Restoration Sites Small Marsh Creeks
Weakfish



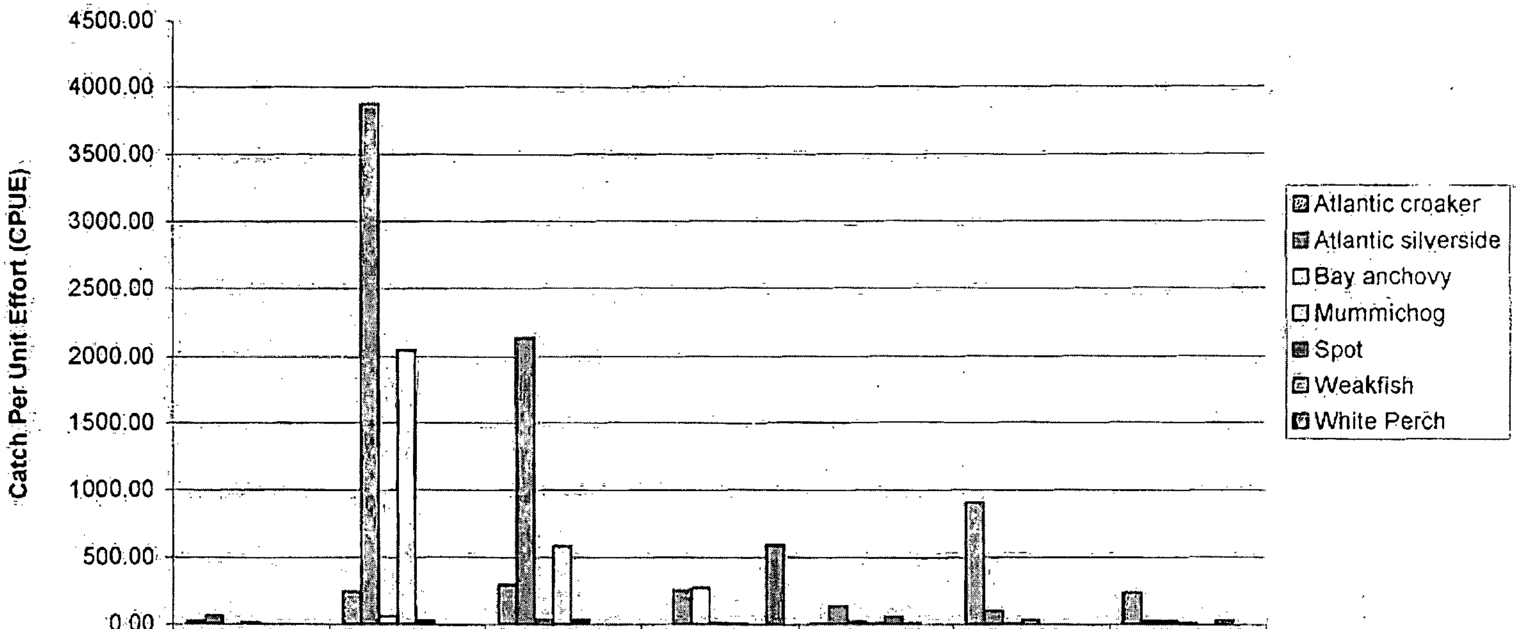
Note: Breaching of dikes completed in the Summer of 1996 at Dennis Township and Fall 1997 at Commercial Township. Monitoring of Commercial Township small creeks began in 1998 following dike breaching

Figure 5-17 Salt Hay Farm Restoration Sites Small Marsh Creeks White Perch



Note: Breaching of dikes completed in the Summer of 1996 at Dennis Township and Fall 1997 at Commercial Township. Monitoring of Commercial Township small creeks began in 1998 following dike breaching

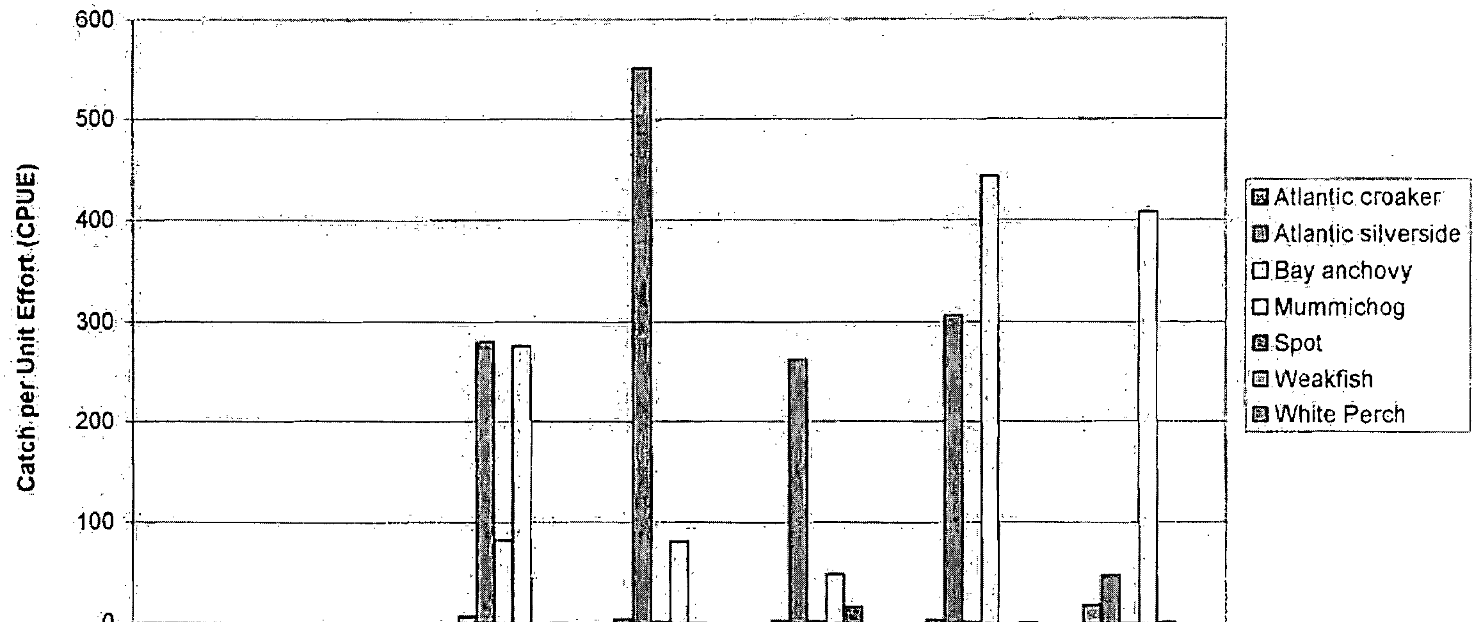
Figure 5-18 Dennis Township Small Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	20.75	242.75	294.44	0.19	4.75	904.71	239.29
Atlantic silverside	65.00	3875.05	2136.63	251.25	133.56	99.57	25.21
Bay anchovy	0.00	62.55	31.25	271.94	23.19	3.14	21.36
Mummichog	11.75	2044.25	579.88	10.19	9.44	30.21	12.93
Spot	0.00	24.70	33.06	5.88	54.38	0.00	0.00
Weakfish	0.00	0.20	0.19	1.25	8.75	1.00	29.50
White Perch	0.00	0.00	0.00	587.63	0.00	0.00	0.00

Year

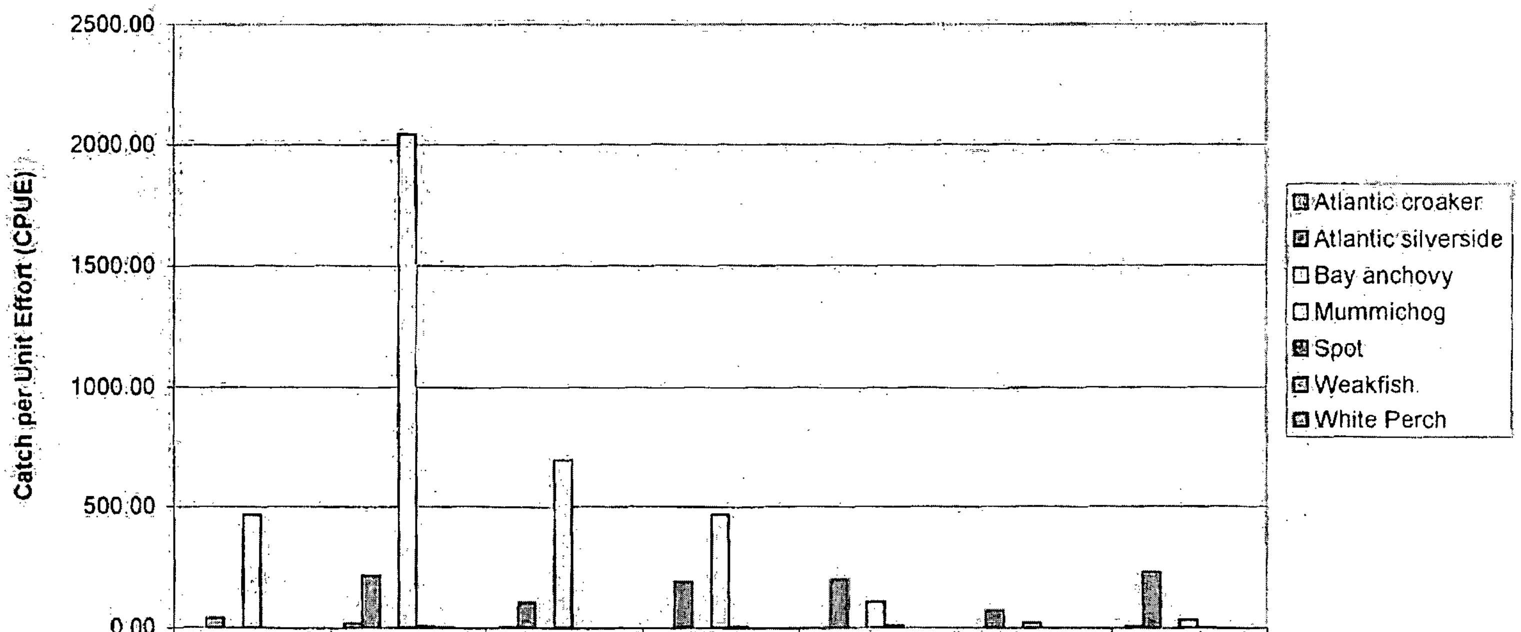
Figure 5-19 Commercial Township Small Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	0	0	6.47	4.13	2.44	3.43	18.21
Atlantic silverside	0	0	280.20	550.38	262.31	306.50	47.36
Bay anchovy	0	0	81.93	1.50	2.44	1.50	0.29
Mummichog	0	0	275.47	80.94	48.75	443.36	407.29
Spot	0	0	0.00	0.31	16.13	0.07	1.50
Weakfish	0	0	0.33	0.00	0.13	1.07	0.00
White Perch	0	0	0.00	0.00	0.00	0.00	0.00

Year

Figure 5-20 Moores Beach Reference Marsh Small Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	0.38	19.15	2.00	0.19	0.19	0.07	7.58
Atlantic silverside	41.46	216.74	102.81	190.38	199.81	72.14	230.67
Bay anchovy	0.12	0.76	0.13	0.25	0.13	0.00	1.17
Mummichog	466.62	2041.40	694.81	466.81	109.50	21.79	32.67
Spot	0.00	6.37	0.38	4.19	8.88	0.00	1.83
Weakfish	0.27	2.06	0.00	0.00	0.19	0.00	0.33
White Perch	0.19	0.10	0.00	0.00	0.00	0.00	0.00

Year

Figure 5-21 Phragmites Restoration Sites Large Marsh Creeks
Atlantic Croaker

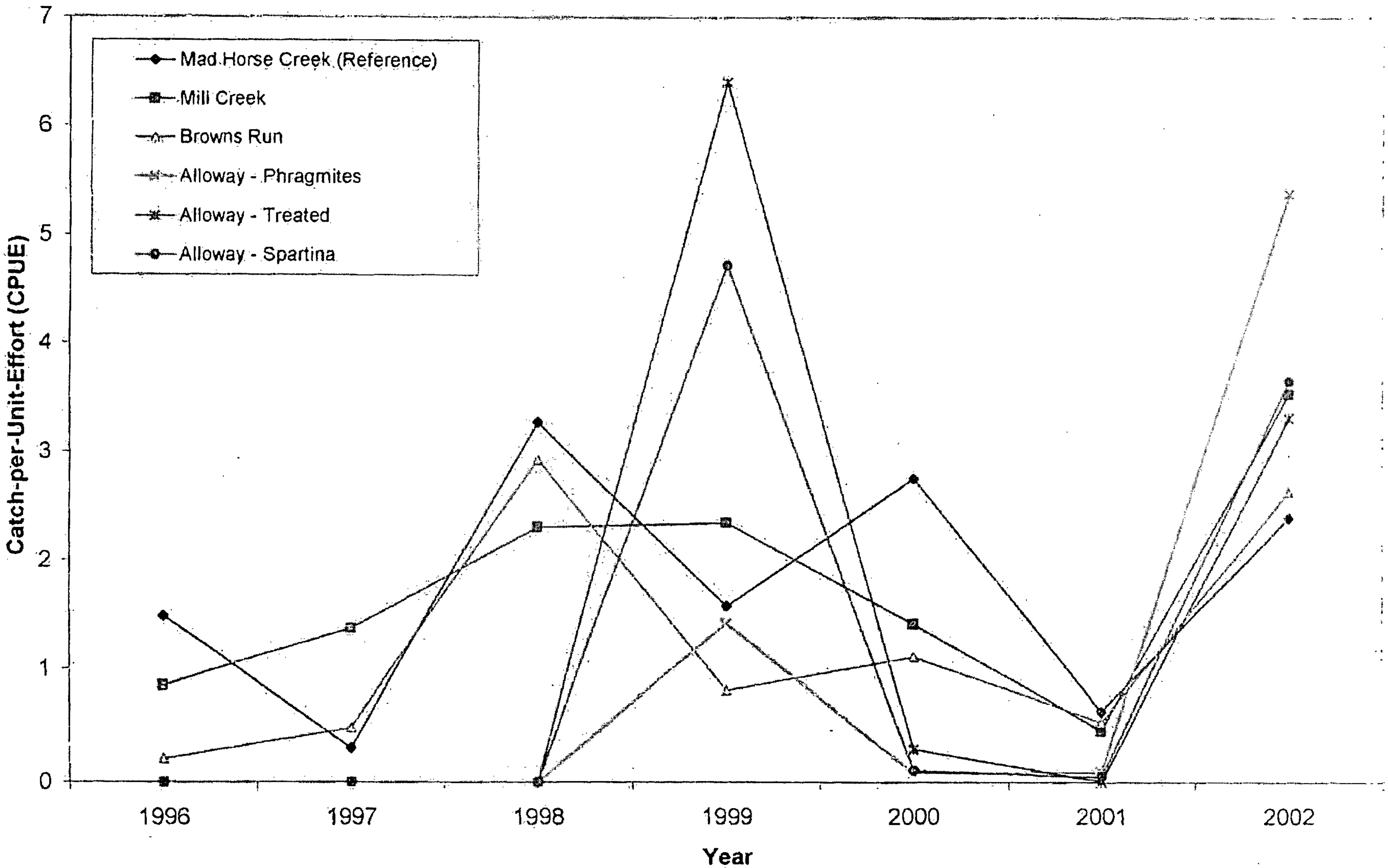


Figure 5-22 Phragmites Restoration Sites Large Marsh Creeks
Atlantic Silverside

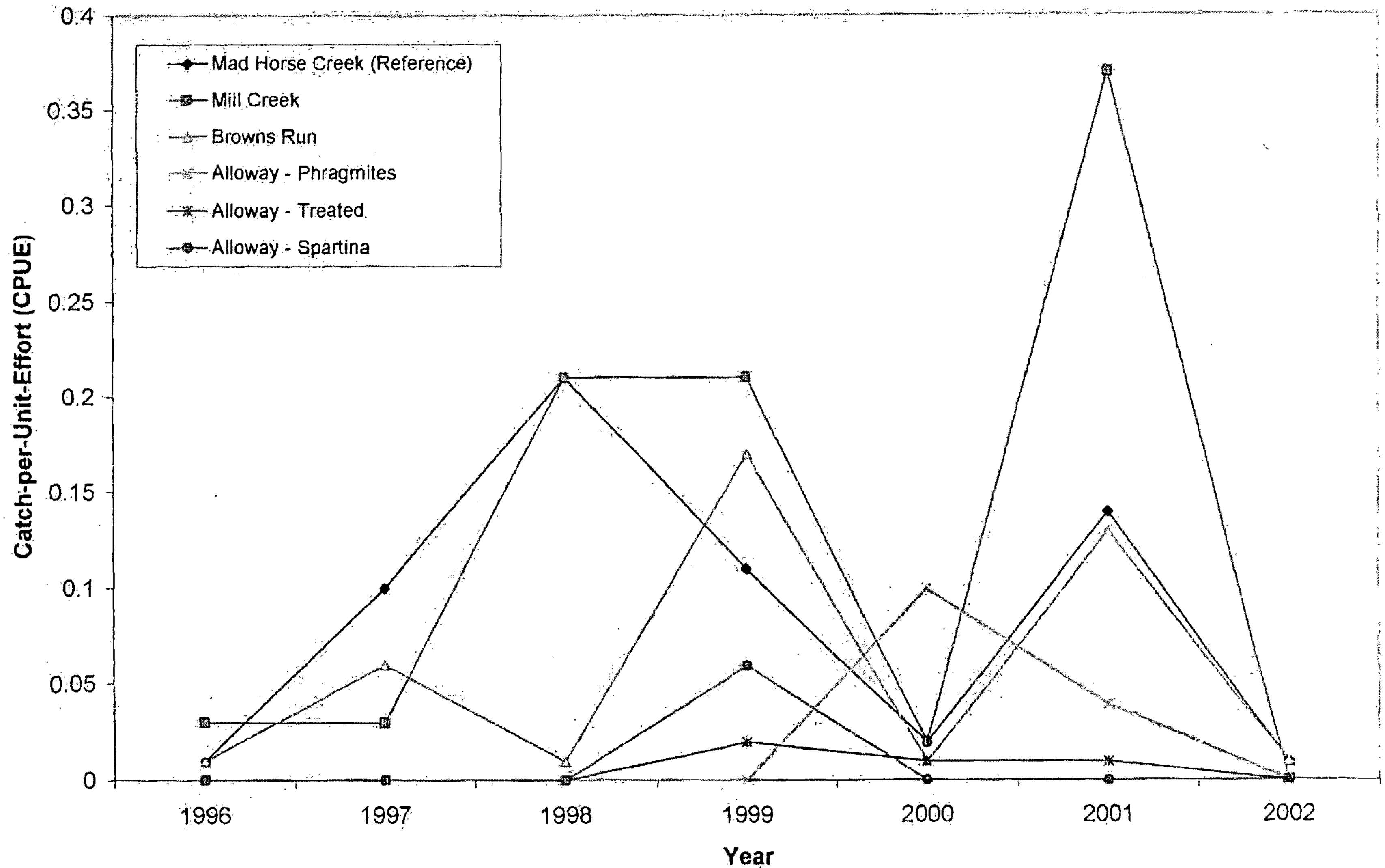


Figure 5-23 Phragmites Restoration Sites Large Marsh Creeks
Bay Anchovy

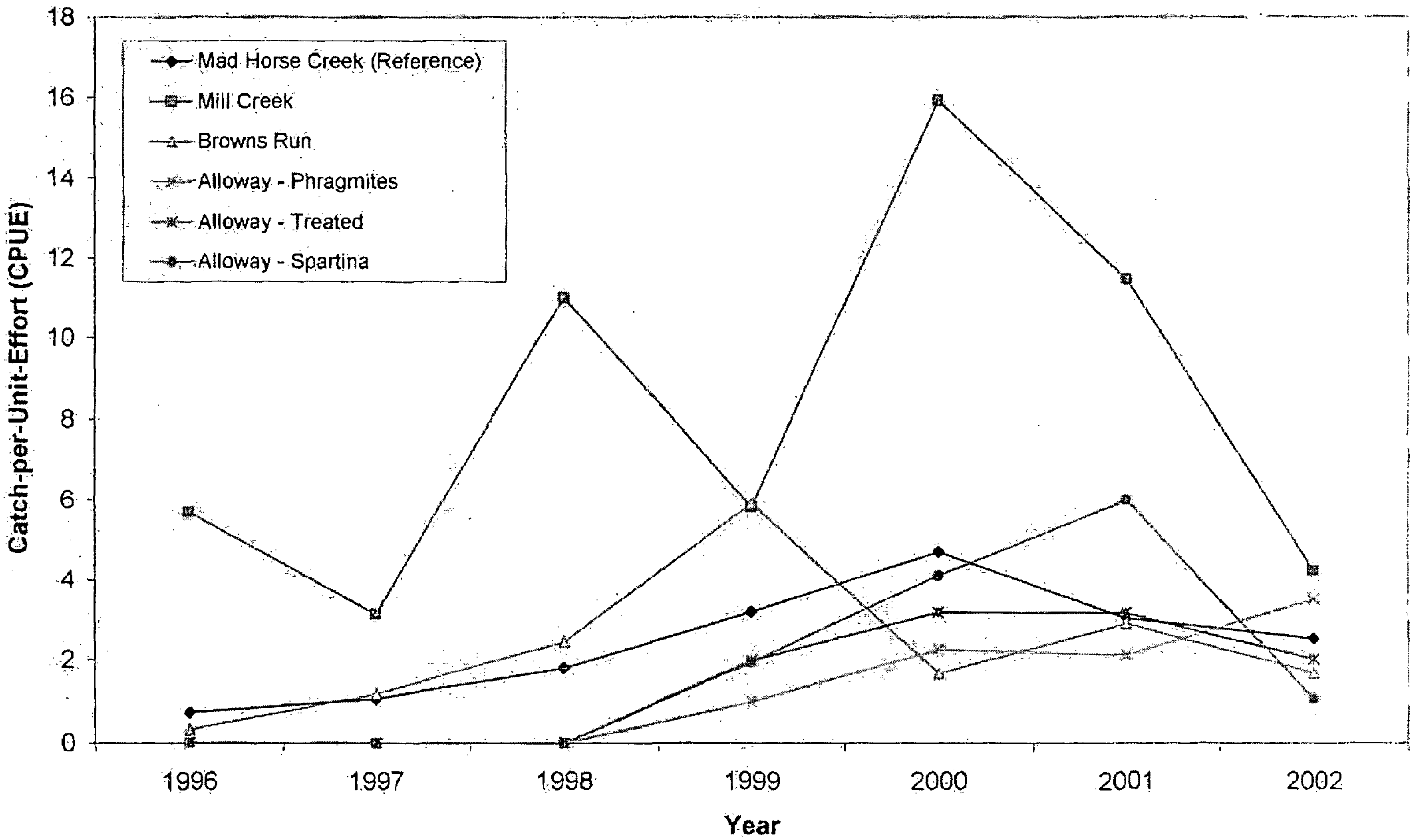


Figure 5-24 Phragmites Restoration Sites Large Marsh Creeks
Mummichog

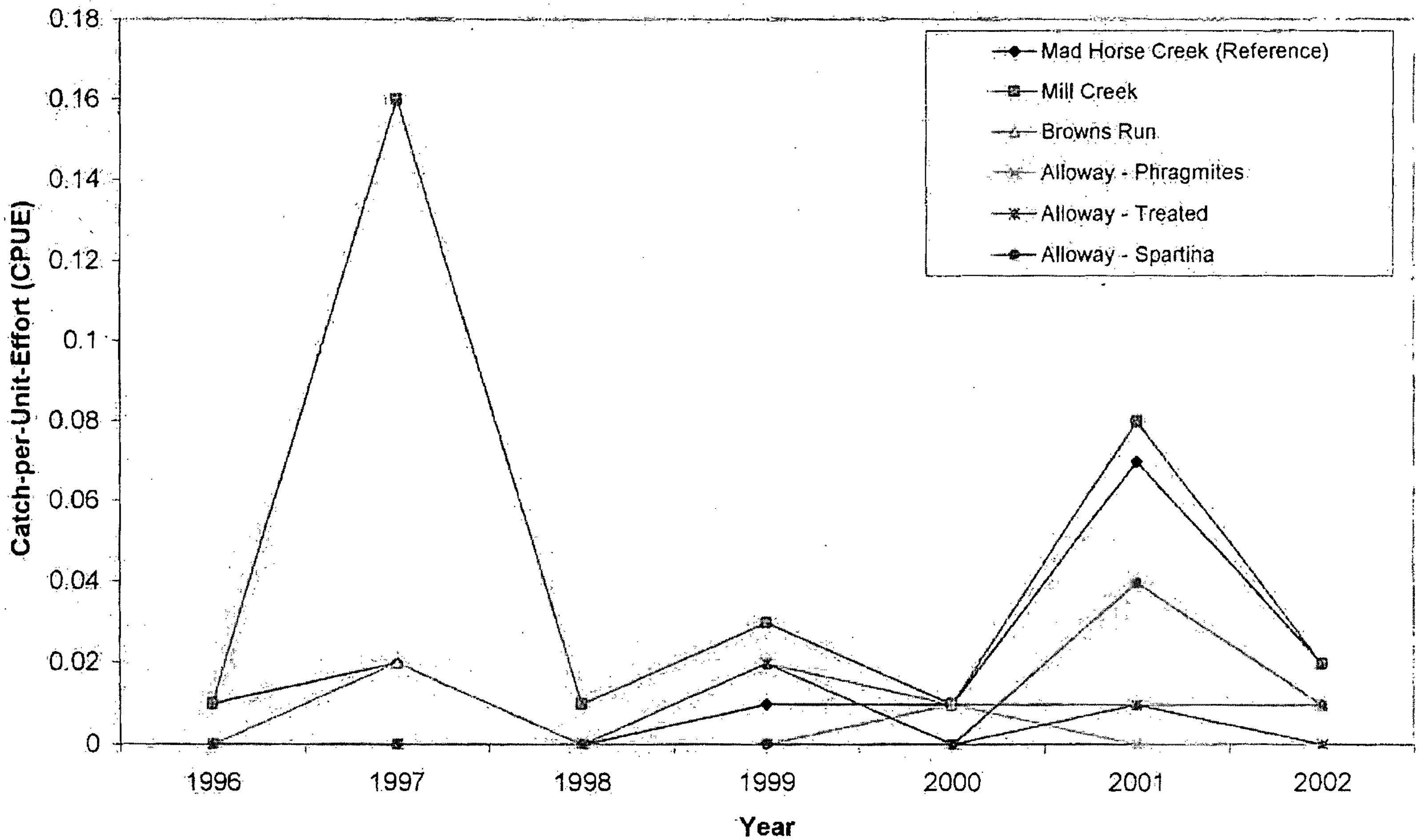


Figure 5-25 Phragmites Restoration Sites Large Marsh Creeks
Spot

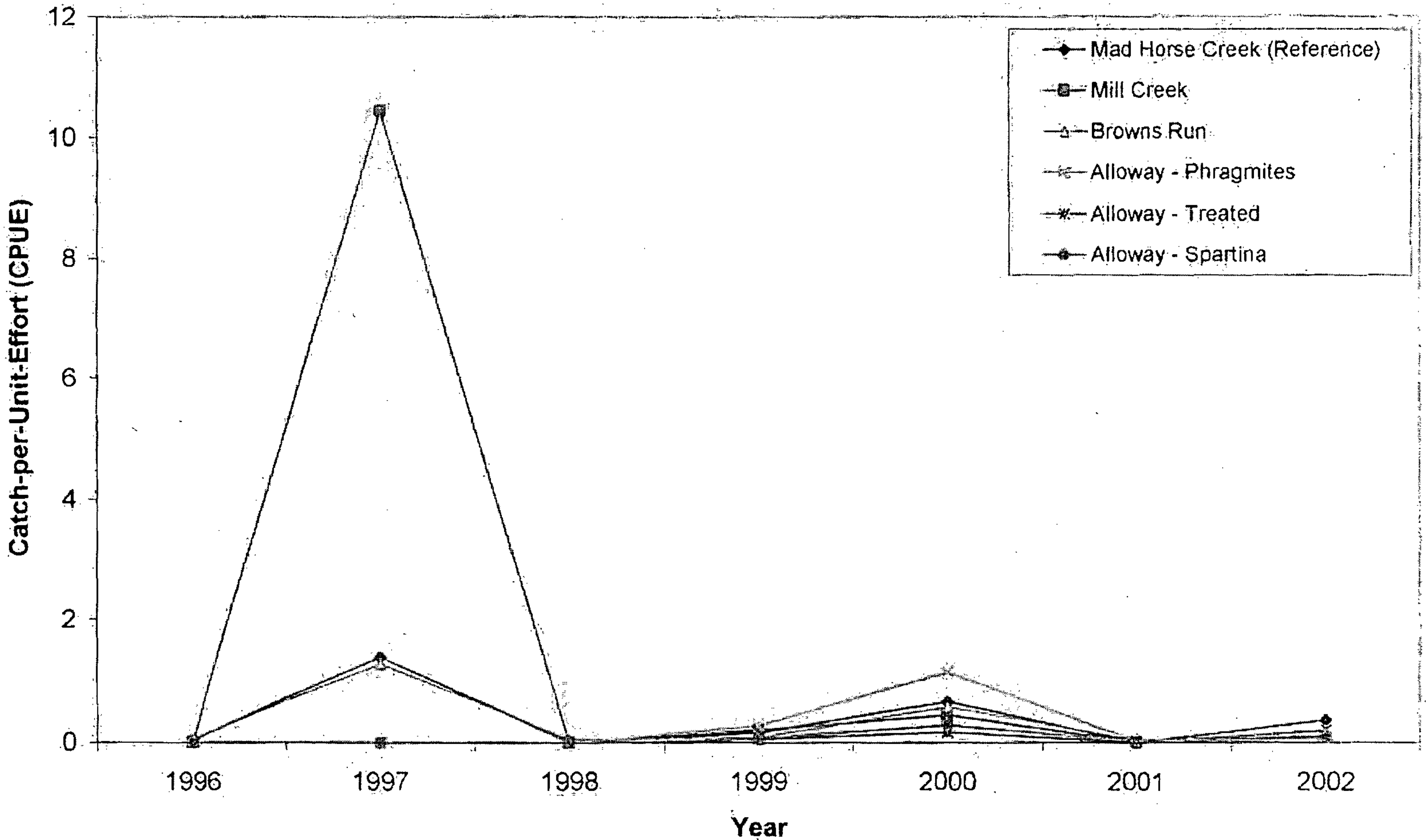


Figure 5-26 Phragmites Restoration Sites Large Marsh Creeks
Weakfish

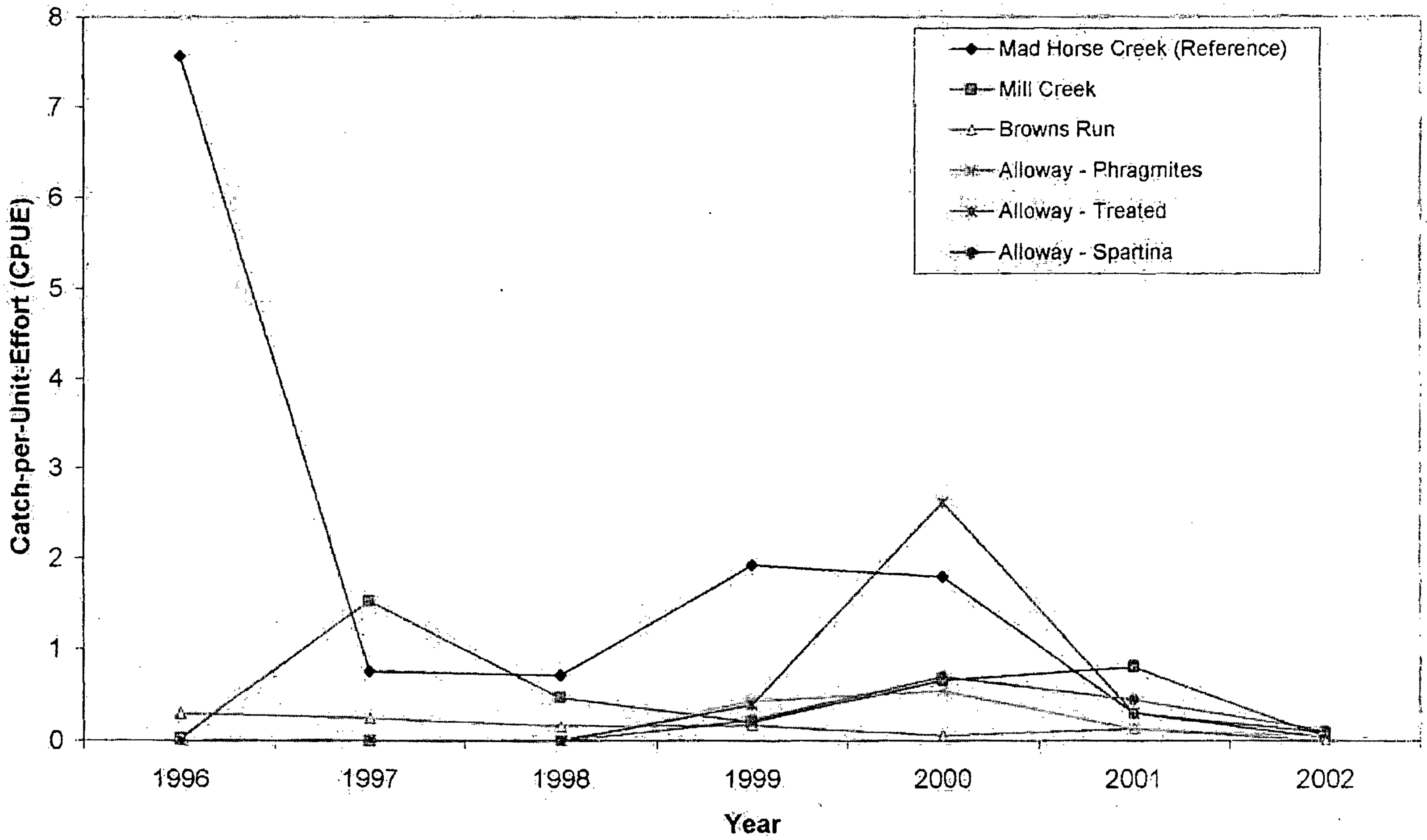


Figure 5-27 Phragmites Restoration Sites Large Marsh Creeks
White Perch

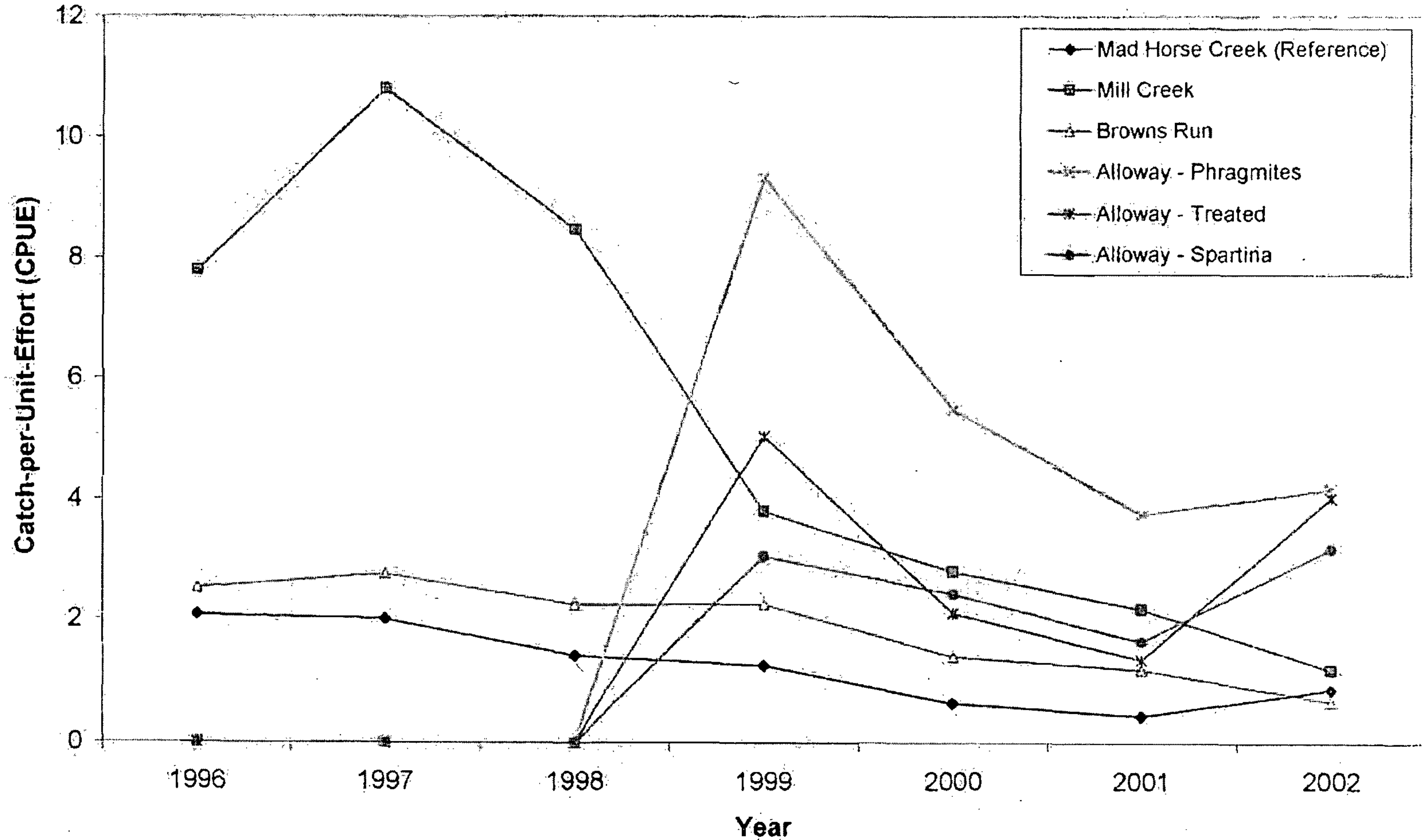
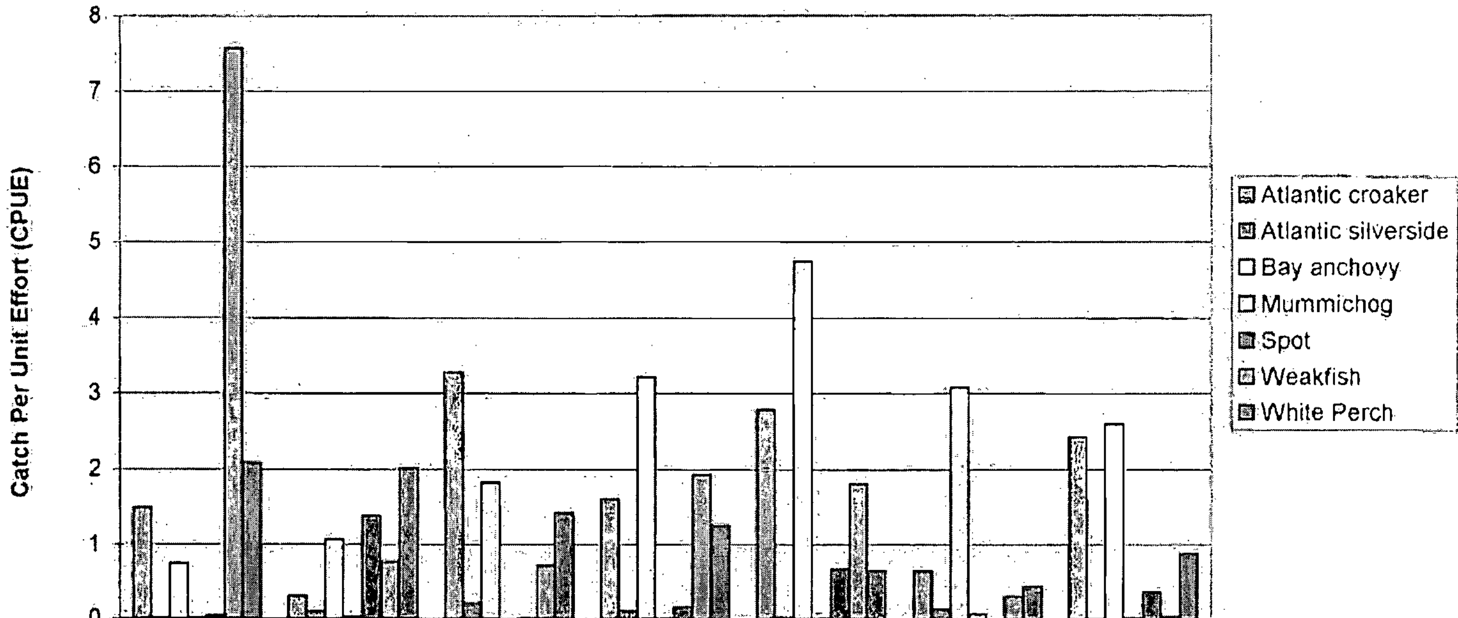


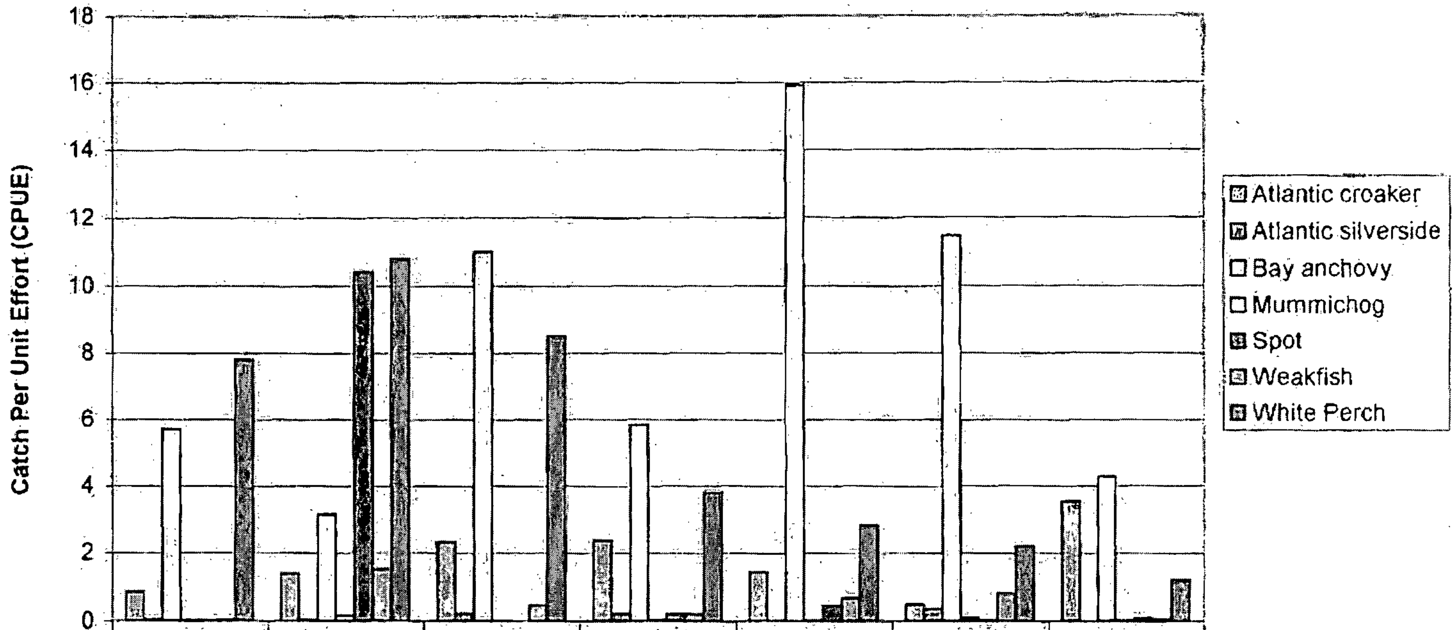
Figure 5-28 Mad Horse Creek Reference Marsh Large Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	1.49	0.31	3.28	1.6	2.78	0.65	2.43
Atlantic silverside	0.01	0.1	0.21	0.11	0.02	0.14	0.01
Bay anchovy	0.74	1.06	1.82	3.22	4.74	3.08	2.6
Mummichog	0.01	0.02	0	0.01	0.01	0.07	0.02
Spot	0.04	1.38	0.01	0.16	0.66	0	0.37
Weakfish	7.57	0.76	0.72	1.93	1.8	0.31	0.04
White Perch	2.08	2.01	1.42	1.26	0.65	0.44	0.88

Year

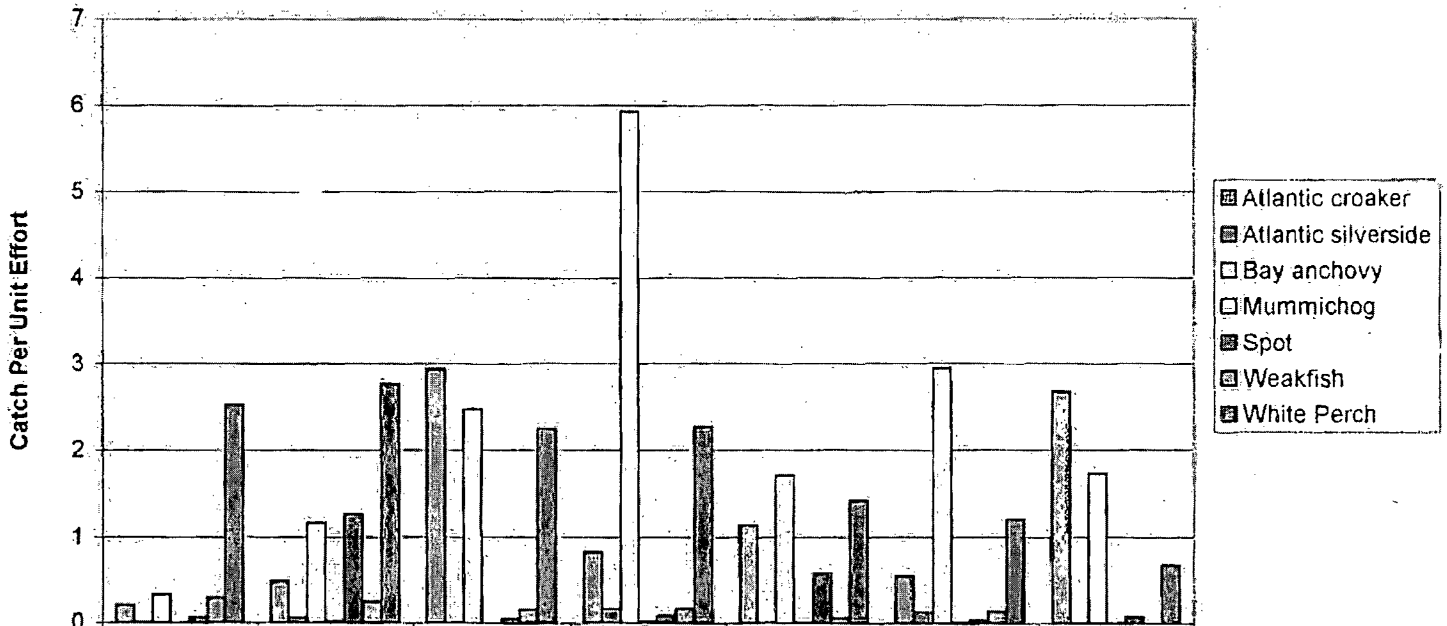
Figure 5-29 Mill Creek Large Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	0.86	1.38	2.32	2.37	1.44	0.48	3.55
Atlantic silverside	0.03	0.03	0.21	0.21	0.02	0.37	0
Bay anchovy	5.7	3.15	11.02	5.84	15.92	11.48	4.28
Mummichog	0.01	0.16	0.01	0.03	0.01	0.08	0.02
Spot	0.01	10.44	0	0.21	0.45	0.01	0.08
Weakfish	0.03	1.53	0.47	0.21	0.67	0.82	0.05
White Perch	7.8	10.8	8.49	3.82	2.82	2.2	1.2

Year

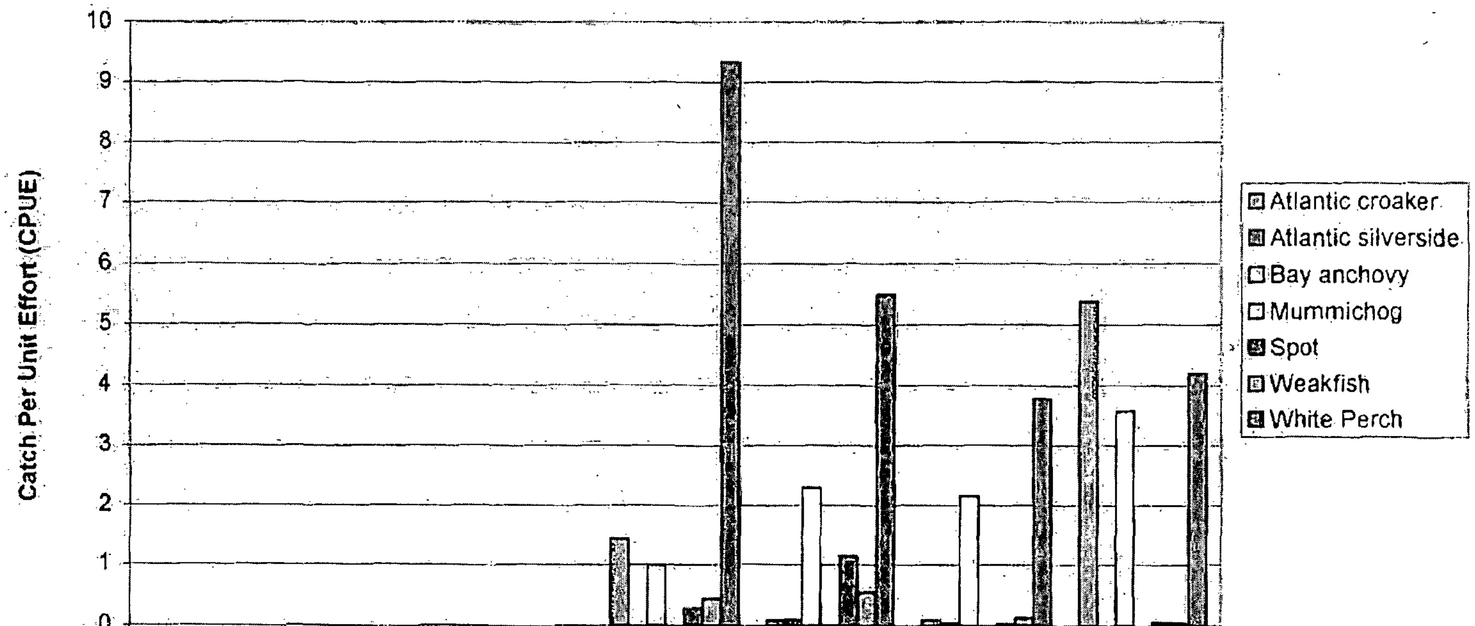
Figure 5-30 Browns Run Large Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	0.21	0.49	2.94	0.83	1.14	0.55	2.67
Atlantic silverside	0.01	0.06	0.01	0.17	0.01	0.13	0.01
Bay anchovy	0.33	1.17	2.47	5.93	1.71	2.95	1.73
Mummichog	0	0.02	0	0.02	0.01	0.01	0.01
Spot	0.06	1.27	0.05	0.09	0.58	0.04	0.08
Weakfish	0.3	0.25	0.16	0.17	0.06	0.14	0
White Perch	2.52	2.76	2.25	2.27	1.42	1.2	0.68

Year

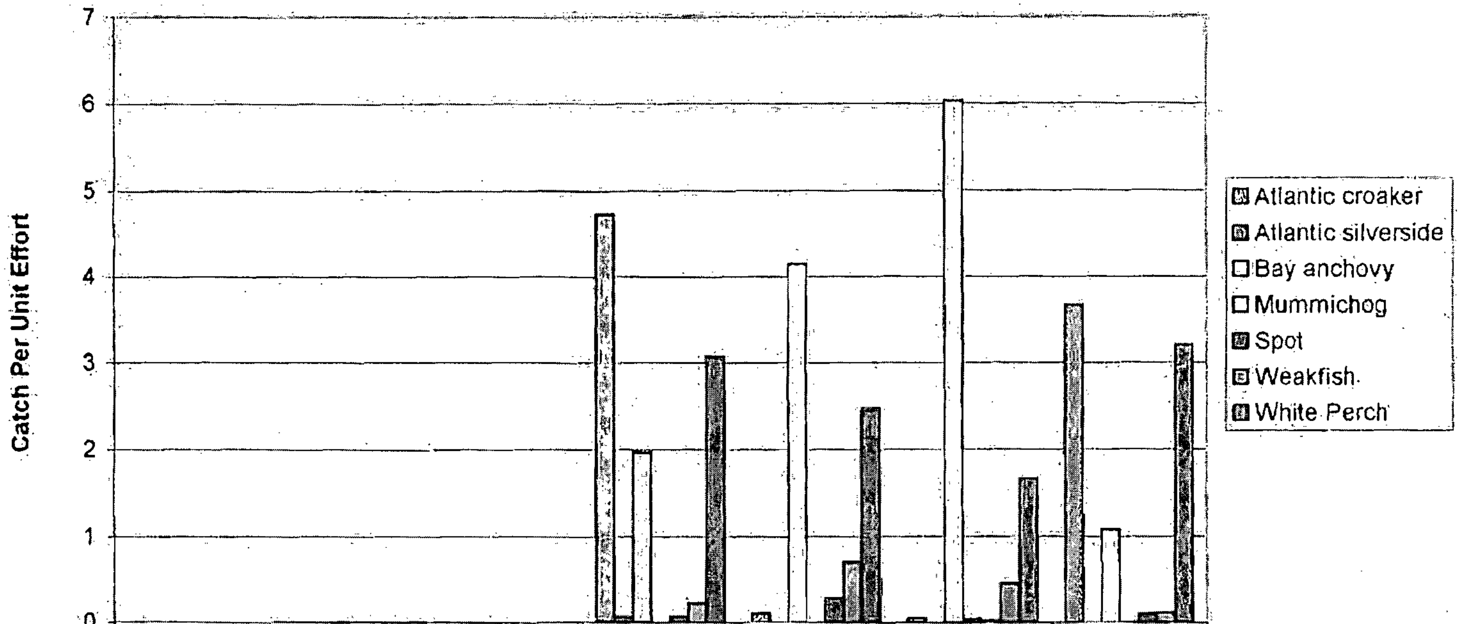
Figure 5-31 Alloway Creek Reference Phragmites Sites Large Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	0	0	0	1.44	0.09	0.1	5.39
Atlantic silverside	0	0	0	0	0.1	0.04	0
Bay anchovy	0	0	0	0.99	2.29	2.16	3.56
Mummichog	0	0	0	0	0.01	0	0
Spot	0	0	0	0.28	1.15	0.03	0.06
Weakfish	0	0	0	0.44	0.55	0.13	0.05
White Perch	0	0	0	9.34	5.5	3.77	4.19

Year

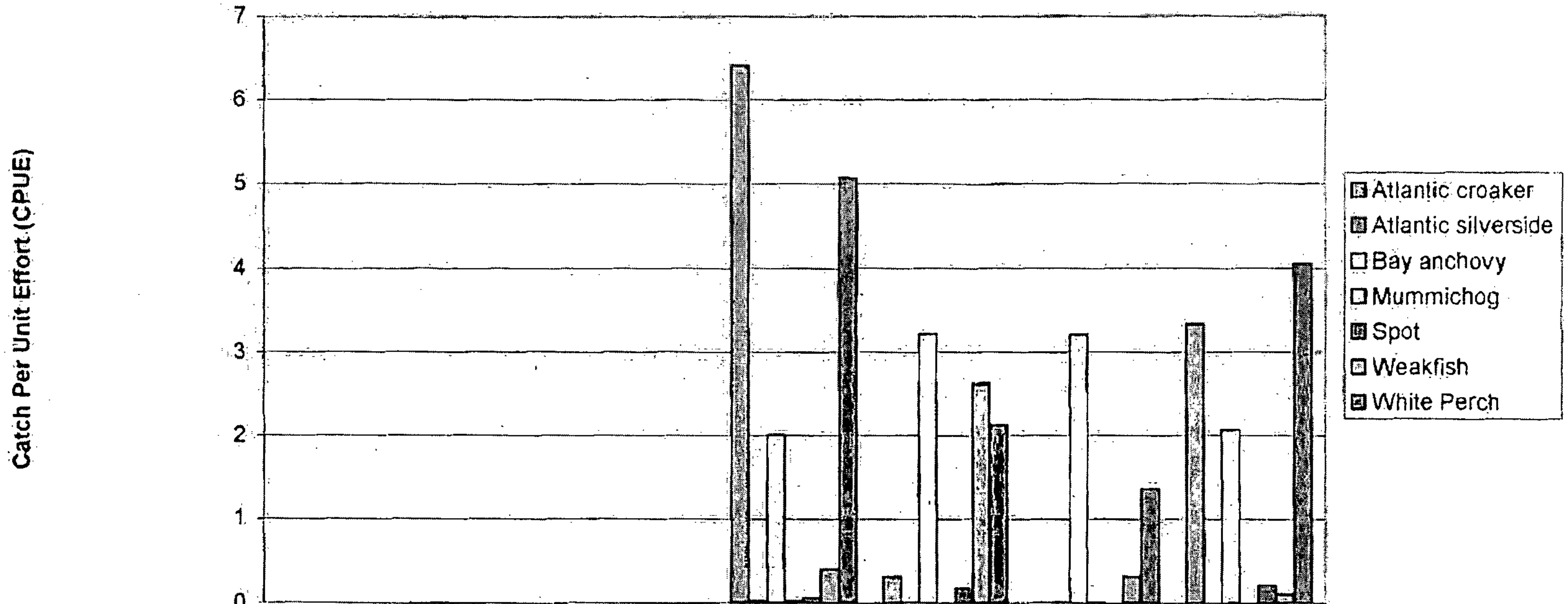
Figure 5-32 Alloway Creek Reference Spartina Sites Large Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	0	0	0	4.73	0.11	0.05	3.67
Atlantic silverside	0	0	0	0.06	0	0	0
Bay anchovy	0	0	0	1.97	4.15	6.03	1.08
Mummichog	0	0	0	0	0	0.04	0.01
Spot	0	0	0	0.07	0.29	0.02	0.11
Weakfish	0	0	0	0.23	0.71	0.46	0.12
White Perch	0	0	0	3.07	2.45	1.67	3.21

Year

Figure 5-33 Alloway Creek Treated Phragmites Sites Large Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	0	0	0	6.41	0.31	0.01	3.33
Atlantic silverside	0	0	0	0.02	0.01	0.01	0
Bay anchovy	0	0	0	2.01	3.22	3.21	2.07
Mummichog	0	0	0	0.02	0	0.01	0
Spot	0	0	0	0.06	0.17	0	0.21
Weakfish	0	0	0	0.4	2.62	0.31	0.1
White Perch	0	0	0	5.06	2.13	1.36	4.05

Year

Figure 5-34 Phragmites Restoration Sites Small Marsh Creeks
Atlantic Croaker

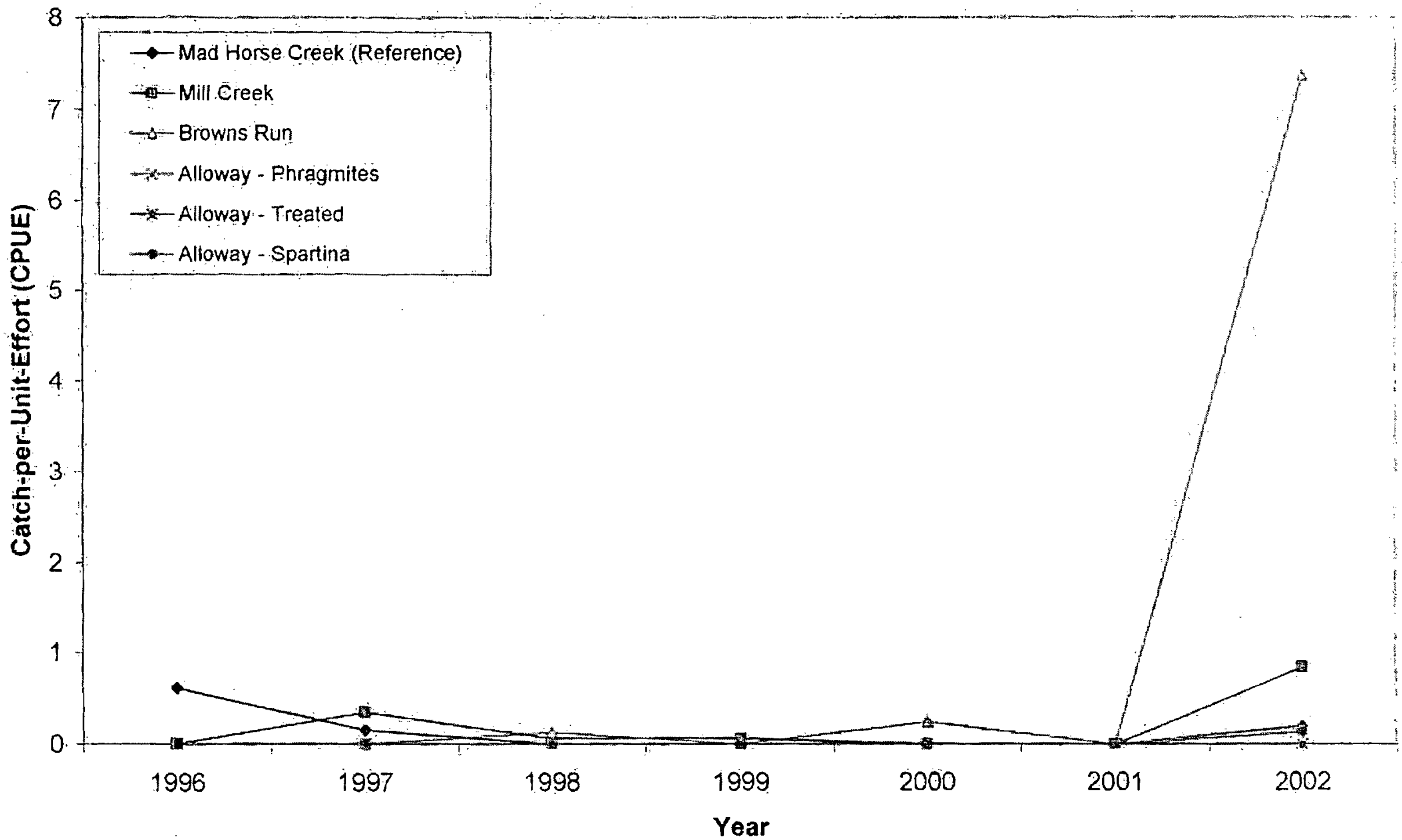


Figure 5-35 Phragmites Restoration Sites Small Marsh Creeks
Atlantic Silverside

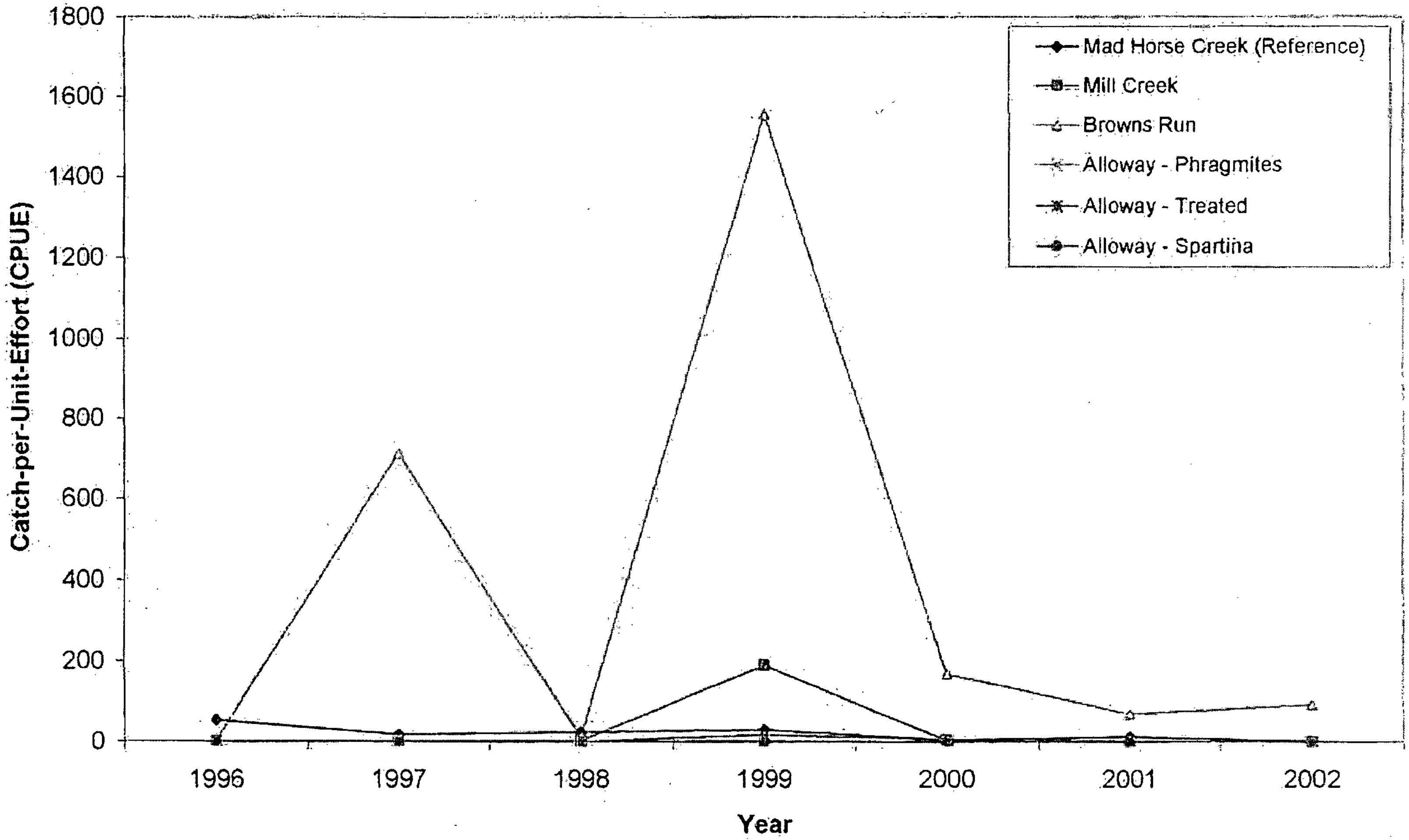


Figure 5-36 Phragmites Restoration Sites Small Marsh Creeks
Bay Anchovy

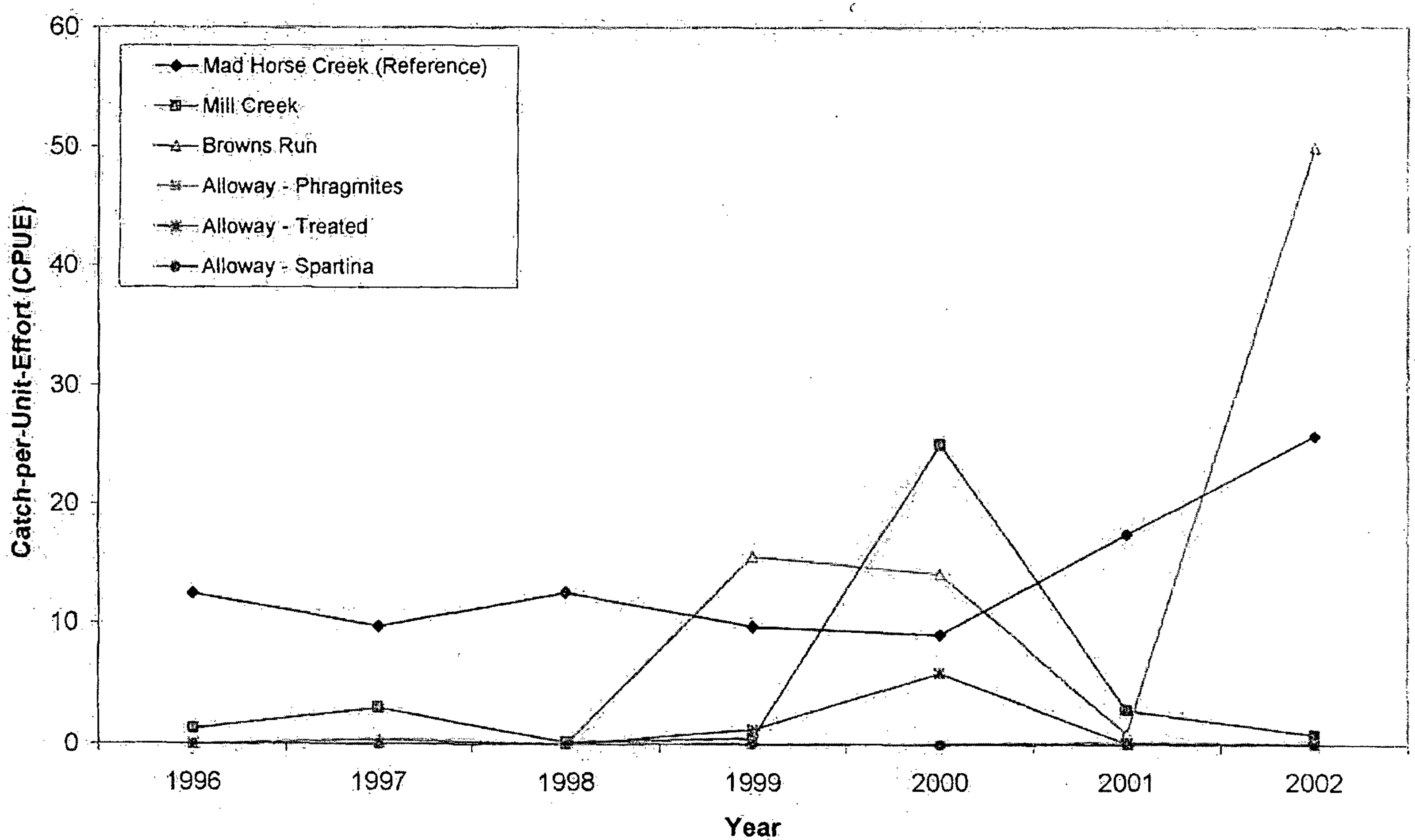


Figure 5-37 Phragmites Restoration Sites Small Marsh Creeks
Mummichog

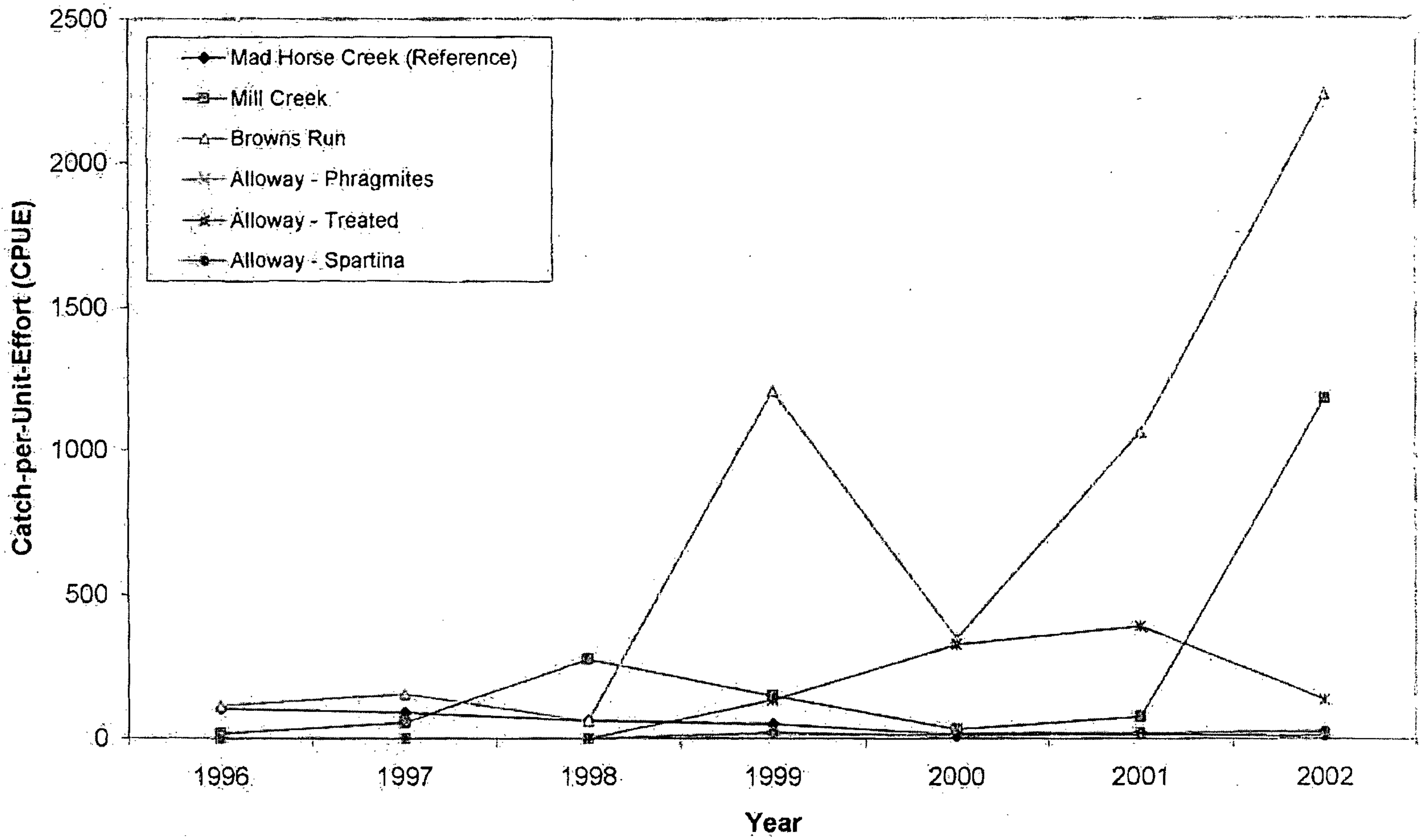


Figure 5-38 Phragmites Restoration Sites Small Marsh Creeks
Spot

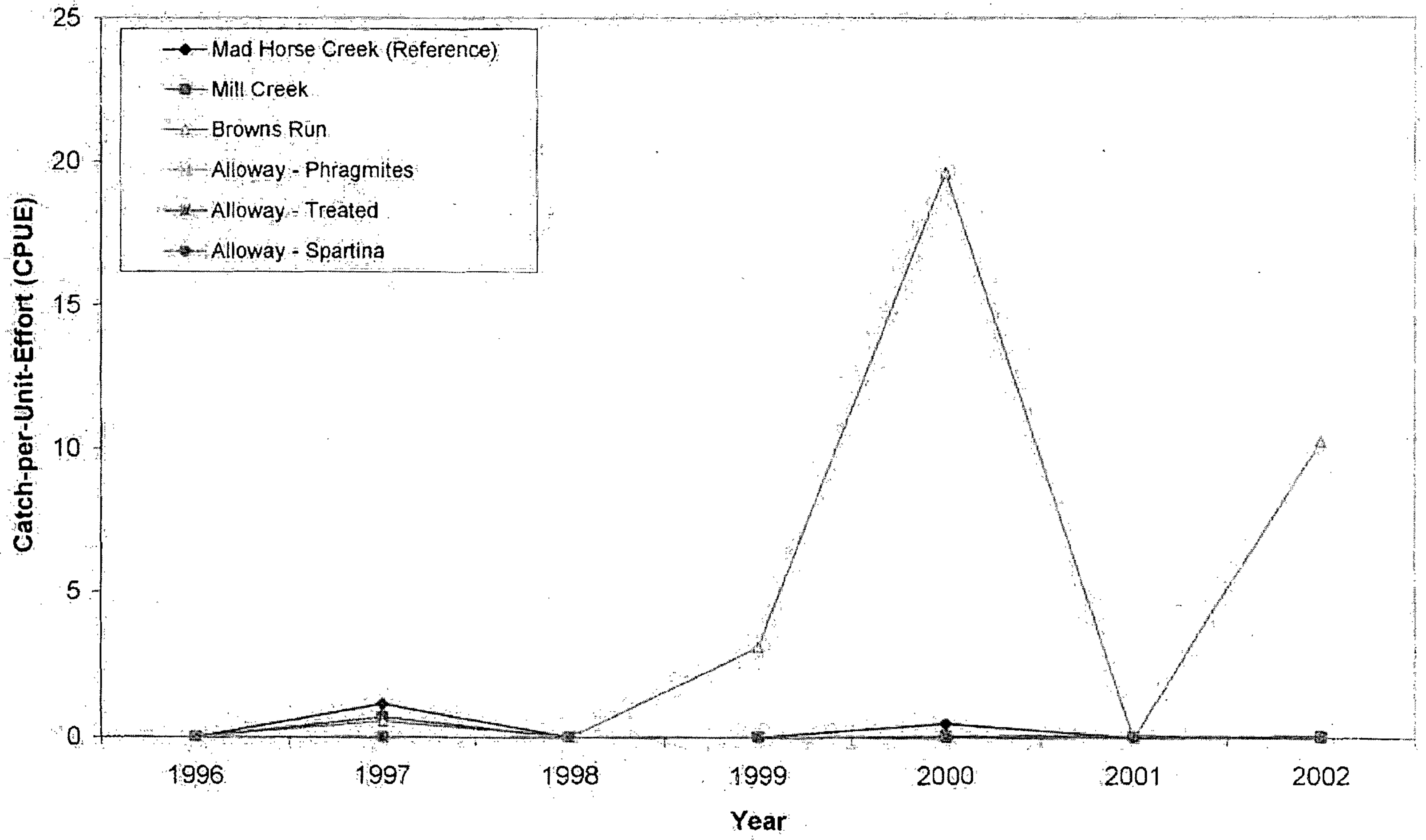


Figure 5-39 Phragmites Restoration Sites Small Marsh Creeks
Weakfish

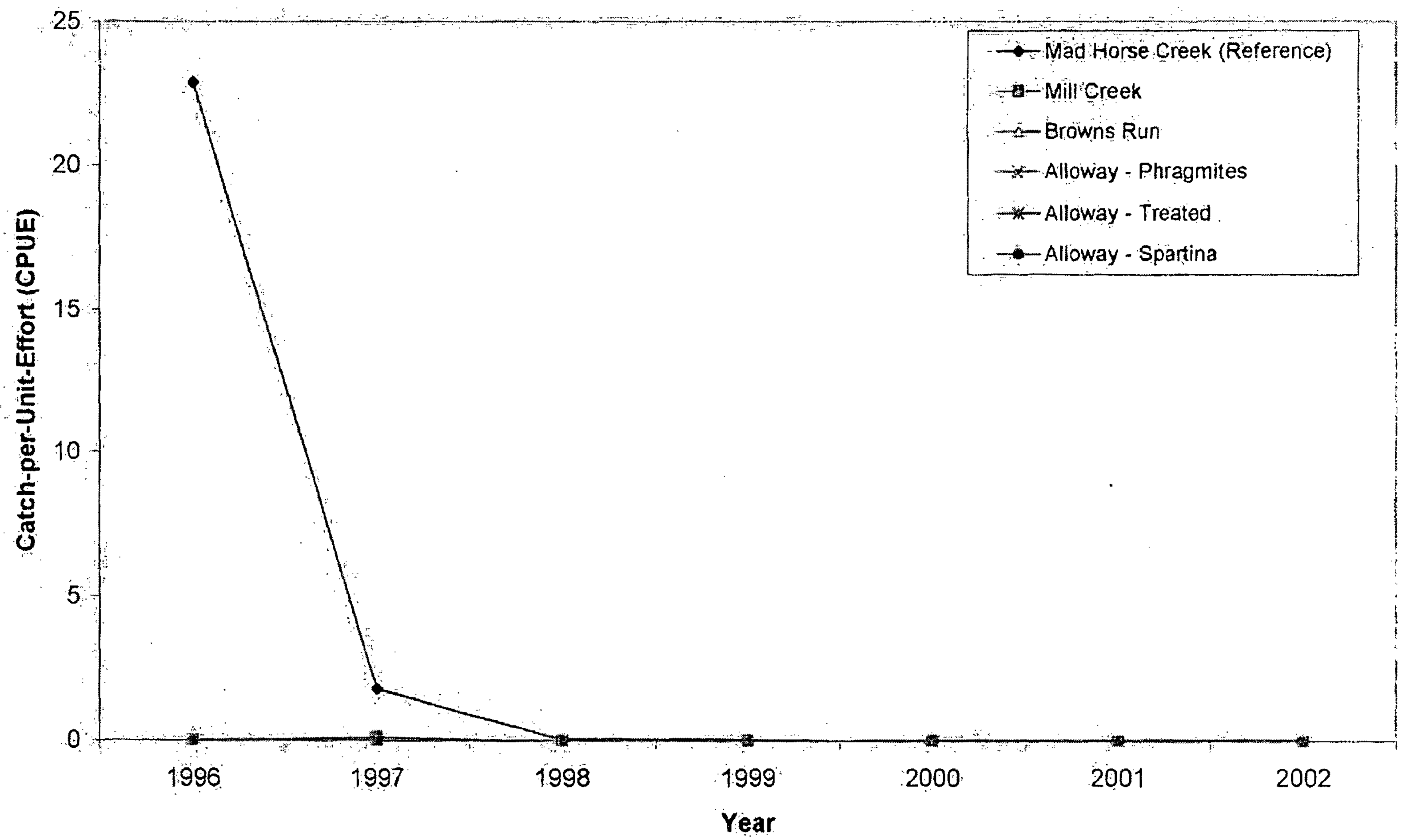


Figure 5-40 Phragmites Restoration Sites Small Marsh Creeks
White Perch

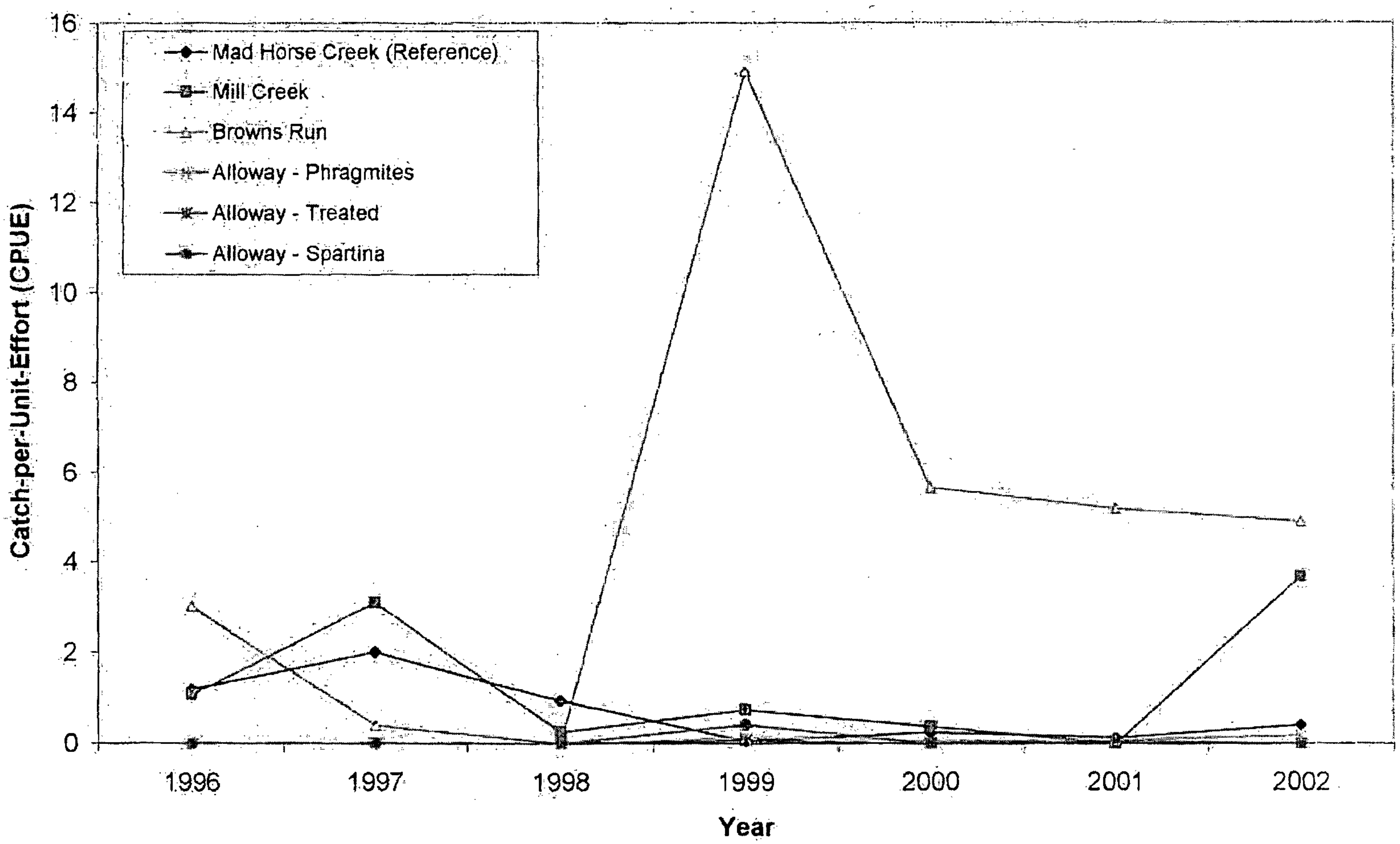
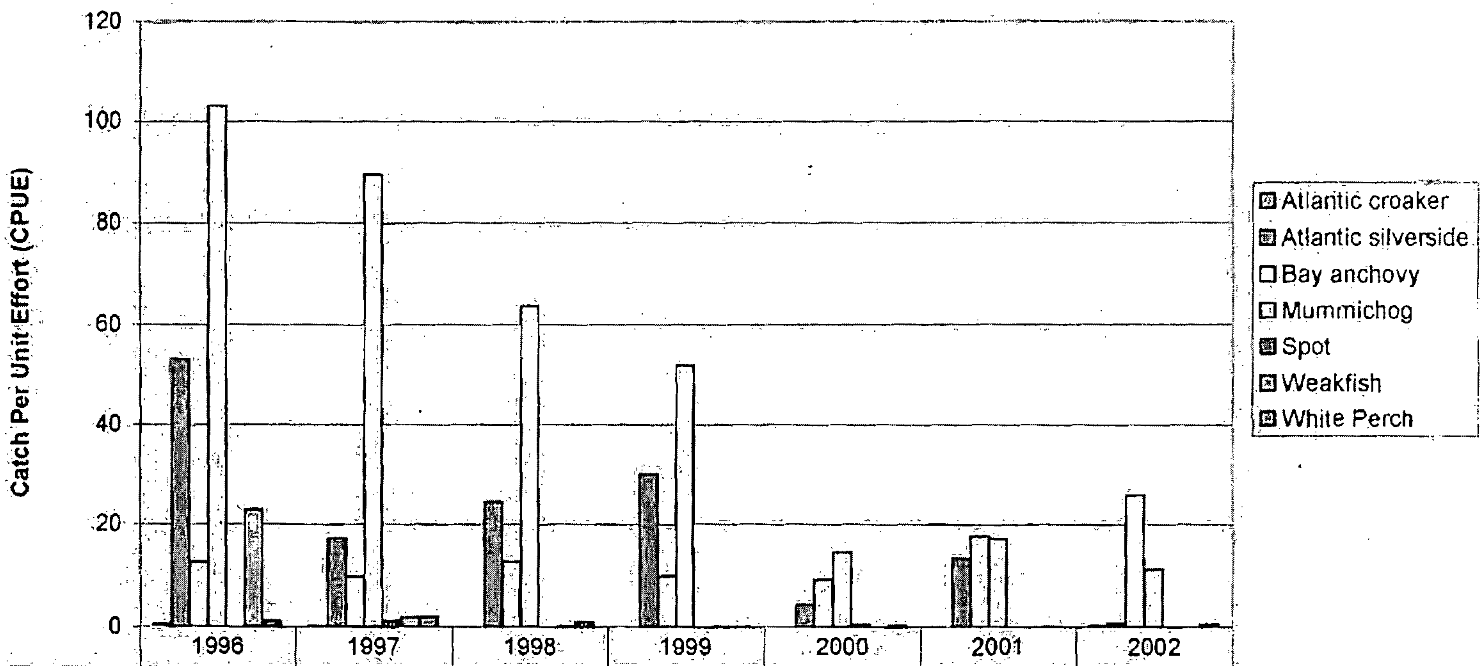


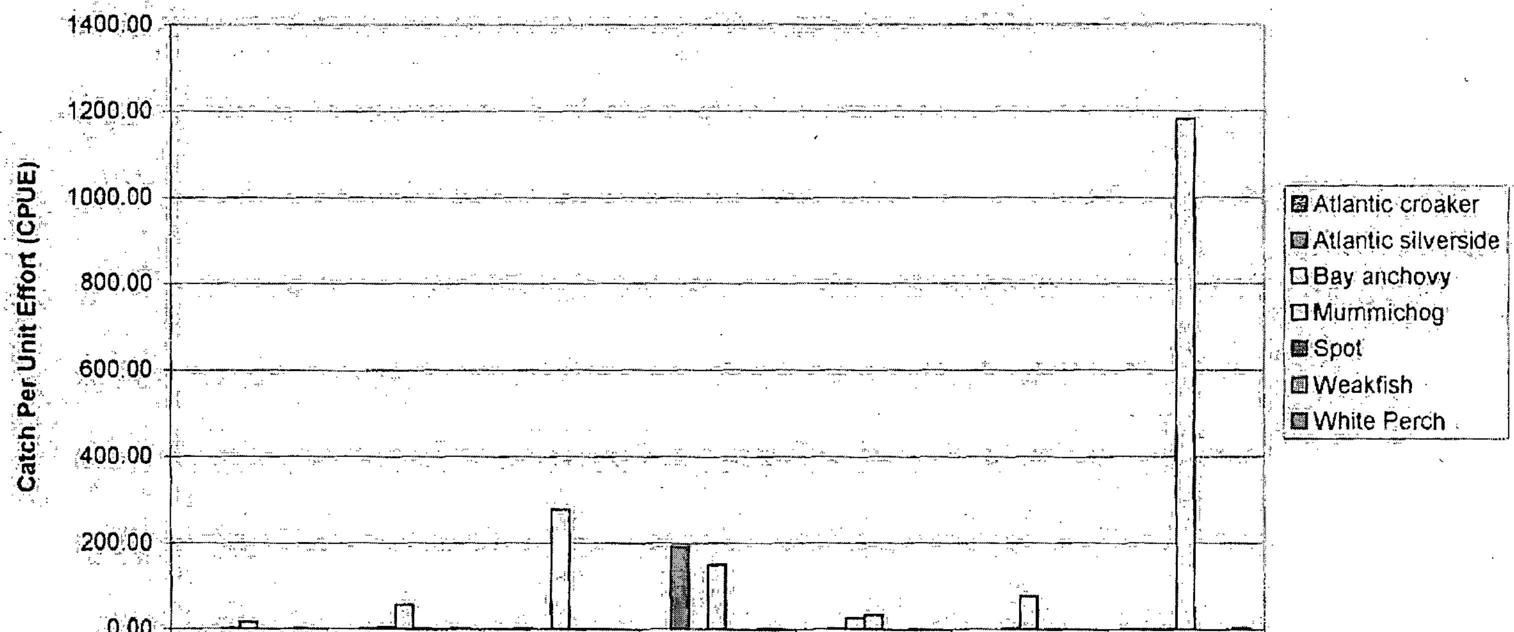
Figure 5-41 Mad Horse Creek Reference Site Small Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	0.61	0.15	0.00	0.00	0.00	0.00	0.21
Atlantic silverside	53.04	17.10	24.50	29.94	4.25	13.14	0.71
Bay anchovy	12.46	9.75	12.56	9.81	9.13	17.57	25.86
Mummichog	103.04	89.50	63.75	52.06	14.50	17.07	11.14
Spot	0	1.15	0.00	0.00	0.50	0.00	0.00
Weakfish	22.89	1.80	0.06	0.06	0.00	0.00	0.00
White Perch	1.18	2.01	0.94	0.06	0.25	0.14	0.43

Year

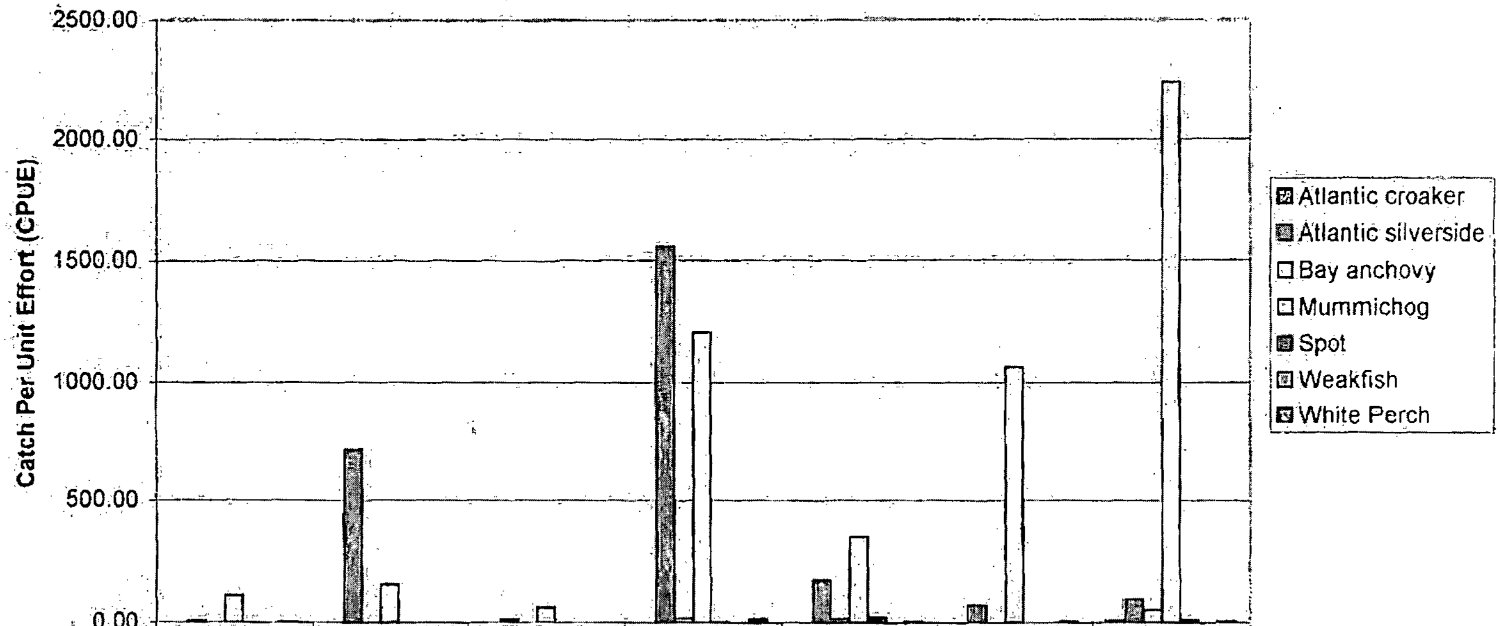
Figure 5-42 Mill Creek Small Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	0.00	0.35	0.06	0.06	0.00	0.00	0.86
Atlantic silverside	0.39	1.1	2.38	192.19	2.44	0.07	1.57
Bay anchovy	1.28	3	0.19	0.56	25.13	2.93	0.86
Mummichog	16.78	56.3	277.56	149.13	34.13	77.86	1182.14
Spot	0.00	0.7	0.00	0.00	0.06	0.00	0.07
Weakfish	0.00	0.1	0.00	0.00	0.00	0.00	0.00
White Perch	1.06	3.1	0.25	0.75	0.38	0.00	3.71

Year

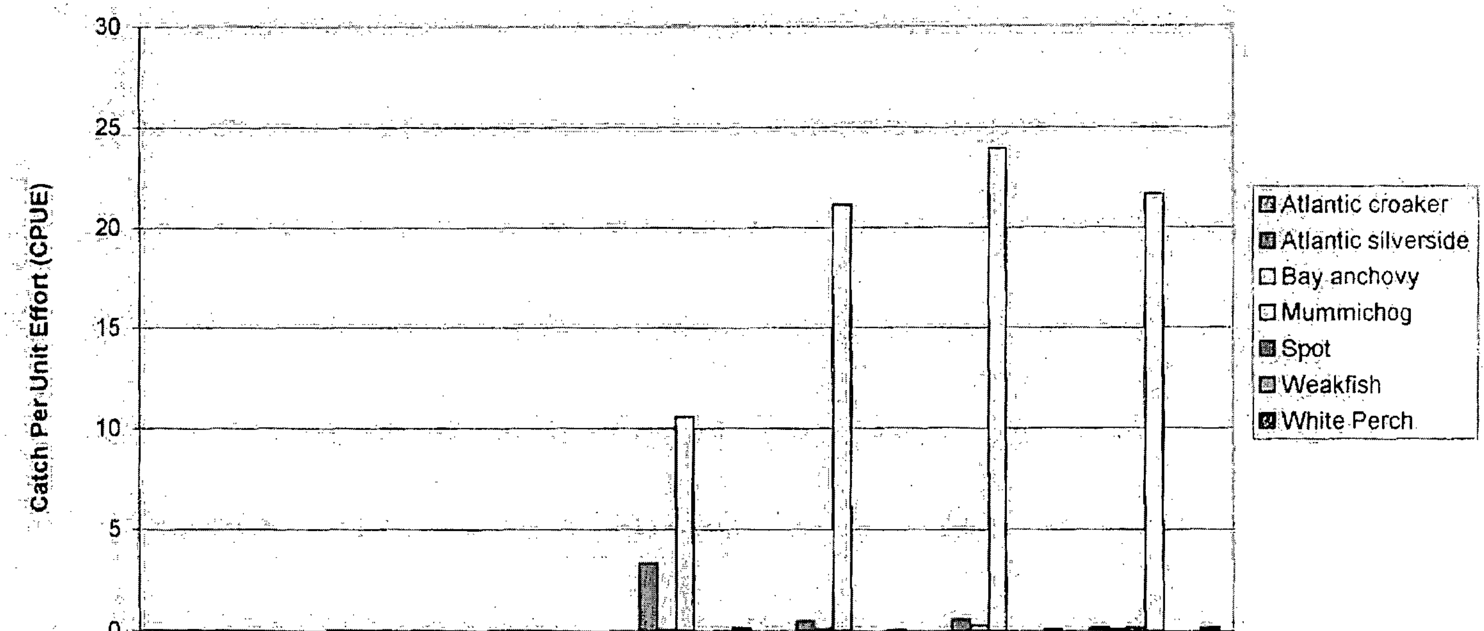
Figure 5-43 Browns Run Small Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	0.00	0.00	0.13	0.00	0.25	0.00	7.36
Atlantic silverside	4.20	712.65	12.25	1556.56	170.81	70.36	95.00
Bay anchovy	0.00	0.40	0.06	15.69	14.19	1.00	50.00
Mummichog	110.70	153.30	61.50	1206.81	349.75	1063.14	2236.64
Spot	0.00	0.55	0.00	3.13	19.63	0.00	10.29
Weakfish	0.05	0.00	0.00	0.00	0.06	0.07	0.07
White Perch	3.00	0.40	0.00	14.94	5.69	5.21	4.93

Year

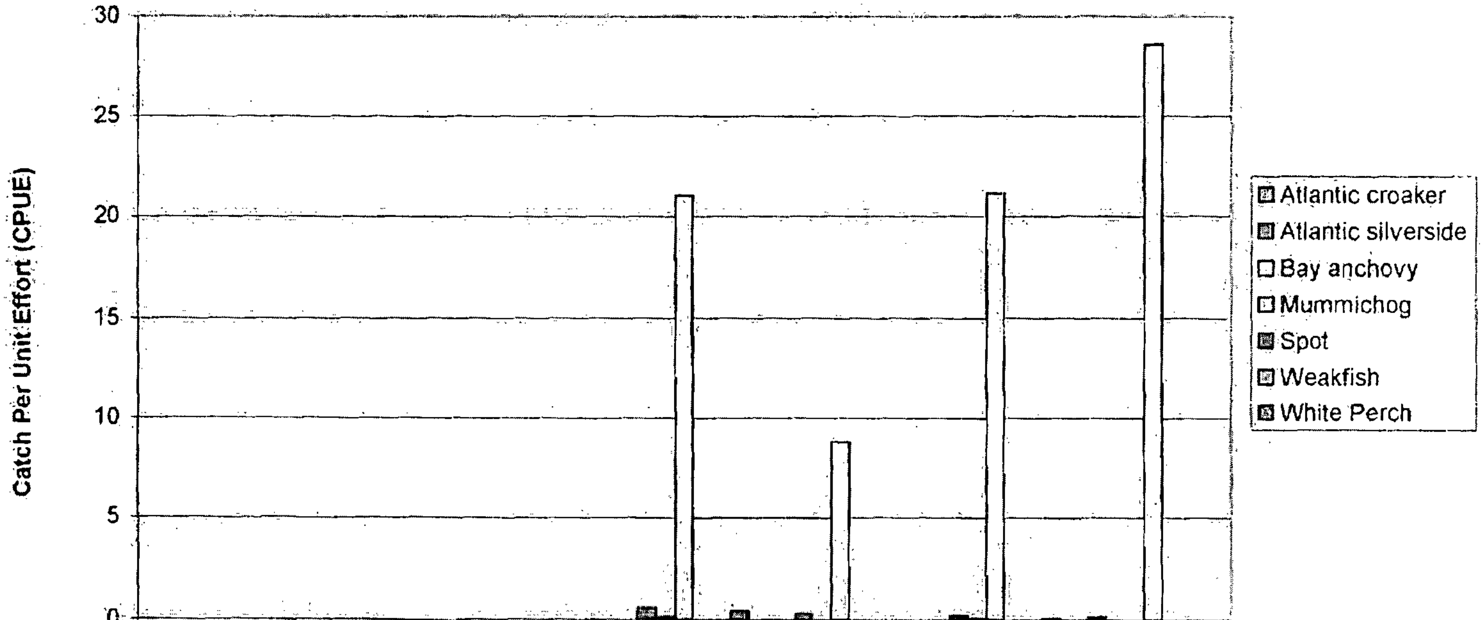
Figure 5-44 Alloway Creek Reference Phragmites Sites Small Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	0	0	0	0.00	0.00	0.00	0.18
Atlantic silverside	0	0	0	3.36	0.50	0.58	0.09
Bay anchovy	0	0	0	0.07	0.13	0.25	0.18
Mummichog	0	0	0	10.57	21.13	23.92	21.64
Spot	0	0	0	0.00	0.00	0.00	0.00
Weakfish	0	0	0	0.00	0.00	0.00	0.00
White Perch	0	0	0	0.14	0.06	0.08	0.18

Year

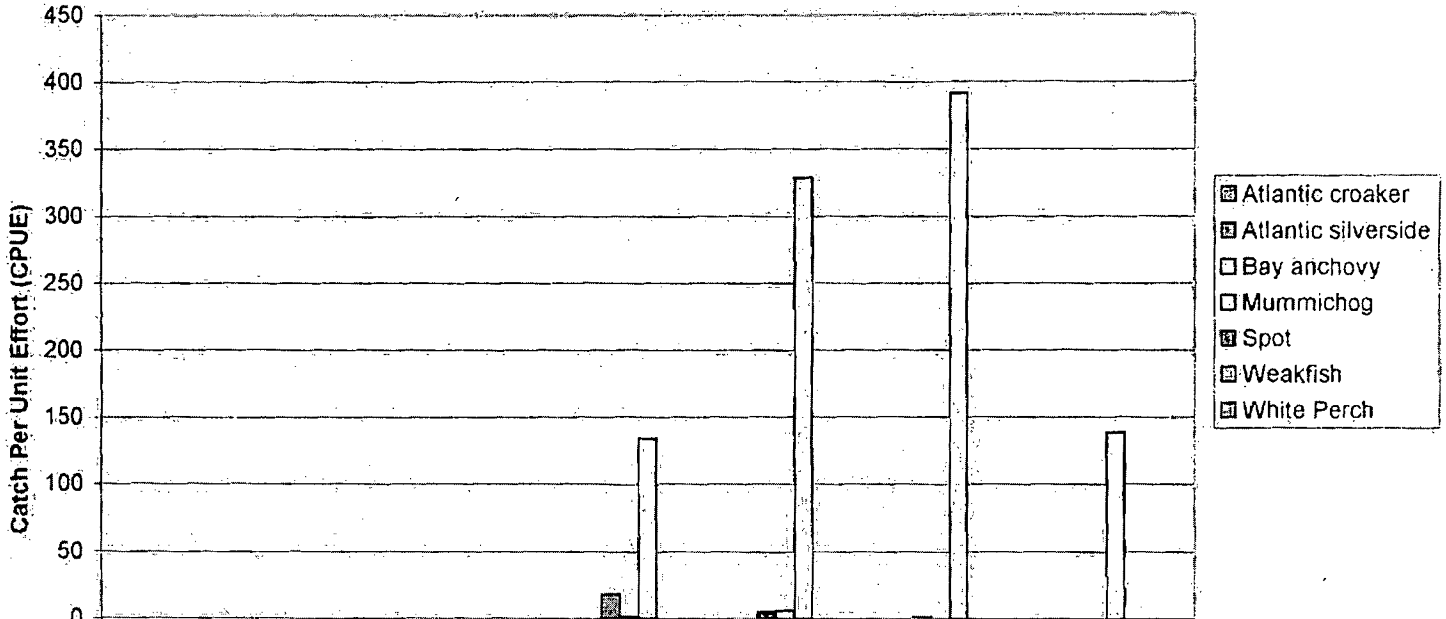
Figure 5-45 Alloway Creek Reference Spartina Sites Small Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	0	0	0	0.00	0.00	0.00	0.14
Atlantic silverside	0	0	0	0.57	0.31	0.21	0.00
Bay anchovy	0	0	0	0.14	0.00	0.07	0.00
Mummichog	0	0	0	21.00	8.81	21.14	28.57
Spot	0	0	0	0.00	0.00	0.00	0.00
Weakfish	0	0	0	0.00	0.00	0.00	0.00
White Perch	0	0	0	0.43	0.00	0.07	0.00

Year

Figure 5-46 Alloway Creek Treated Sites Small Marsh Creeks



	1996	1997	1998	1999	2000	2001	2002
Atlantic croaker	0	0	0	0.00	0.00	0.00	0.00
Atlantic silverside	0	0	0	18.07	5.13	1.29	0.00
Bay anchovy	0	0	0	1.29	6.00	0.14	0.00
Mummichog	0	0	0	134.29	328.50	391.43	138.86
Spot	0	0	0	0.00	0.06	0.07	0.00
Weakfish	0	0	0	0.00	0.00	0.00	0.00
White Perch	0	0	0	0.07	0.00	0.00	0.00

Year

Figure 6-1
Garrisons Lake Fish Ladder Adult Passage and Stocking

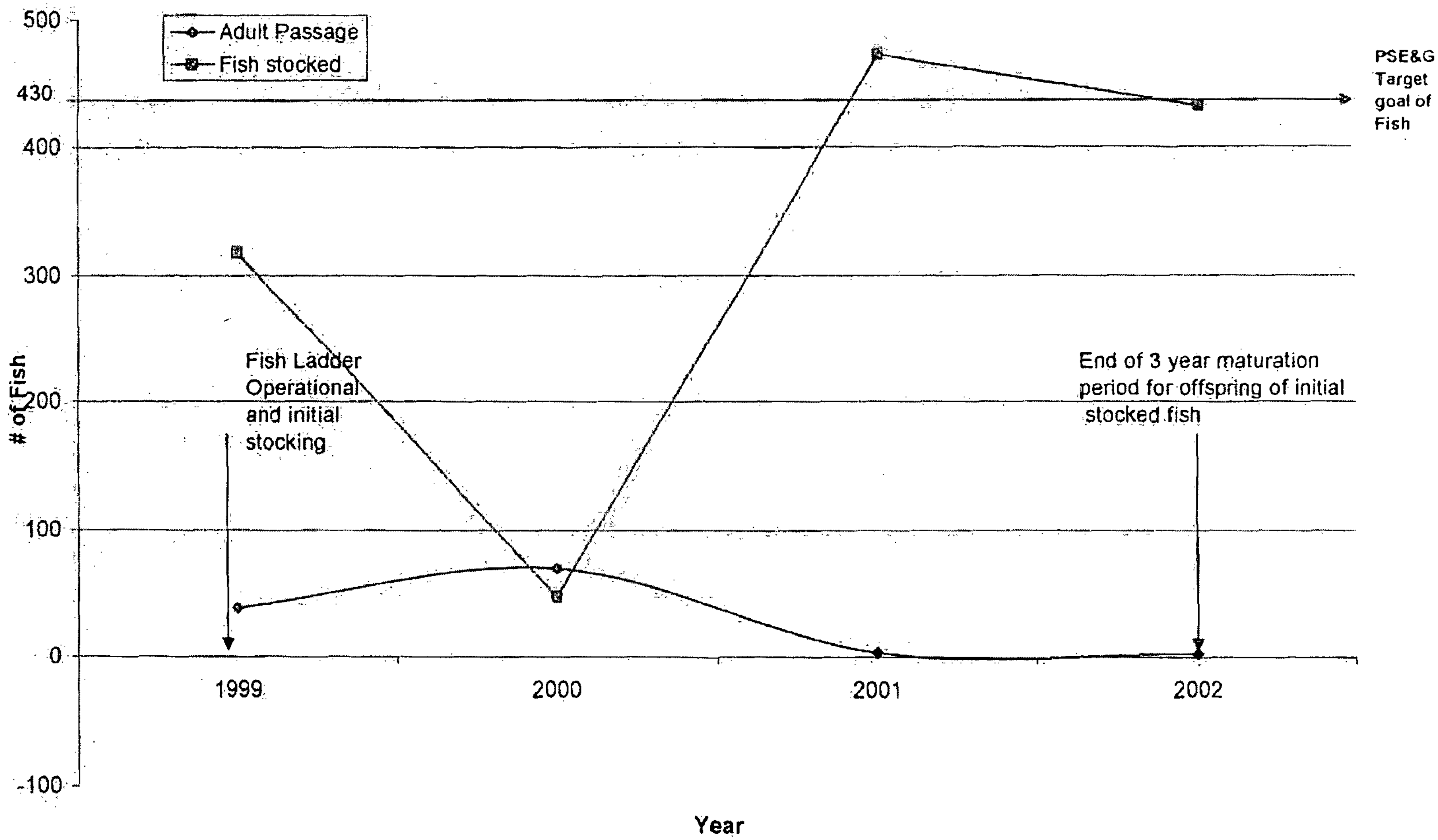


Figure 6-2
Eggs and Larvae Collection at Garrisions Lake

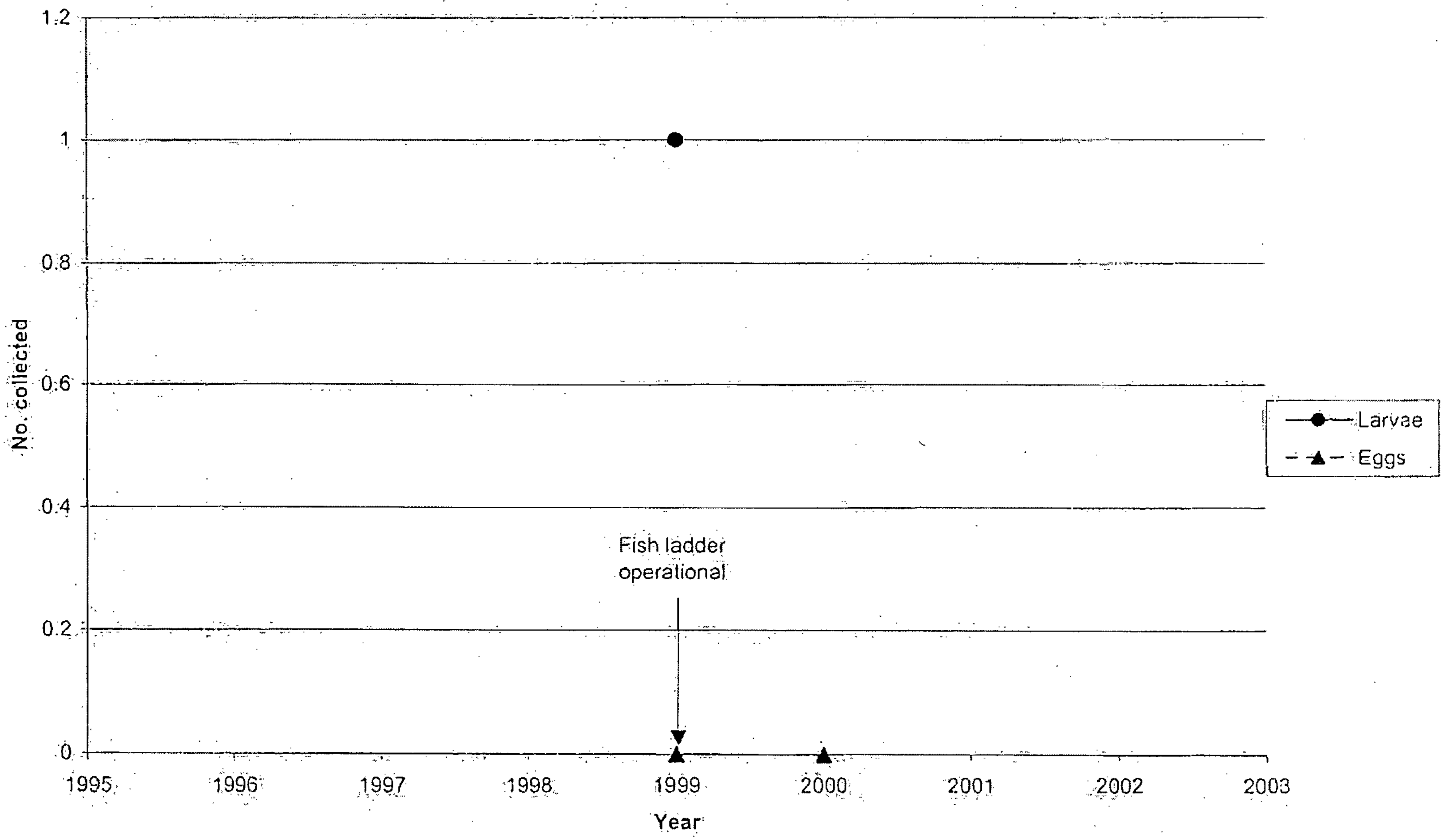


Figure 6-3
Juveniles Collection at Garrisions Lake

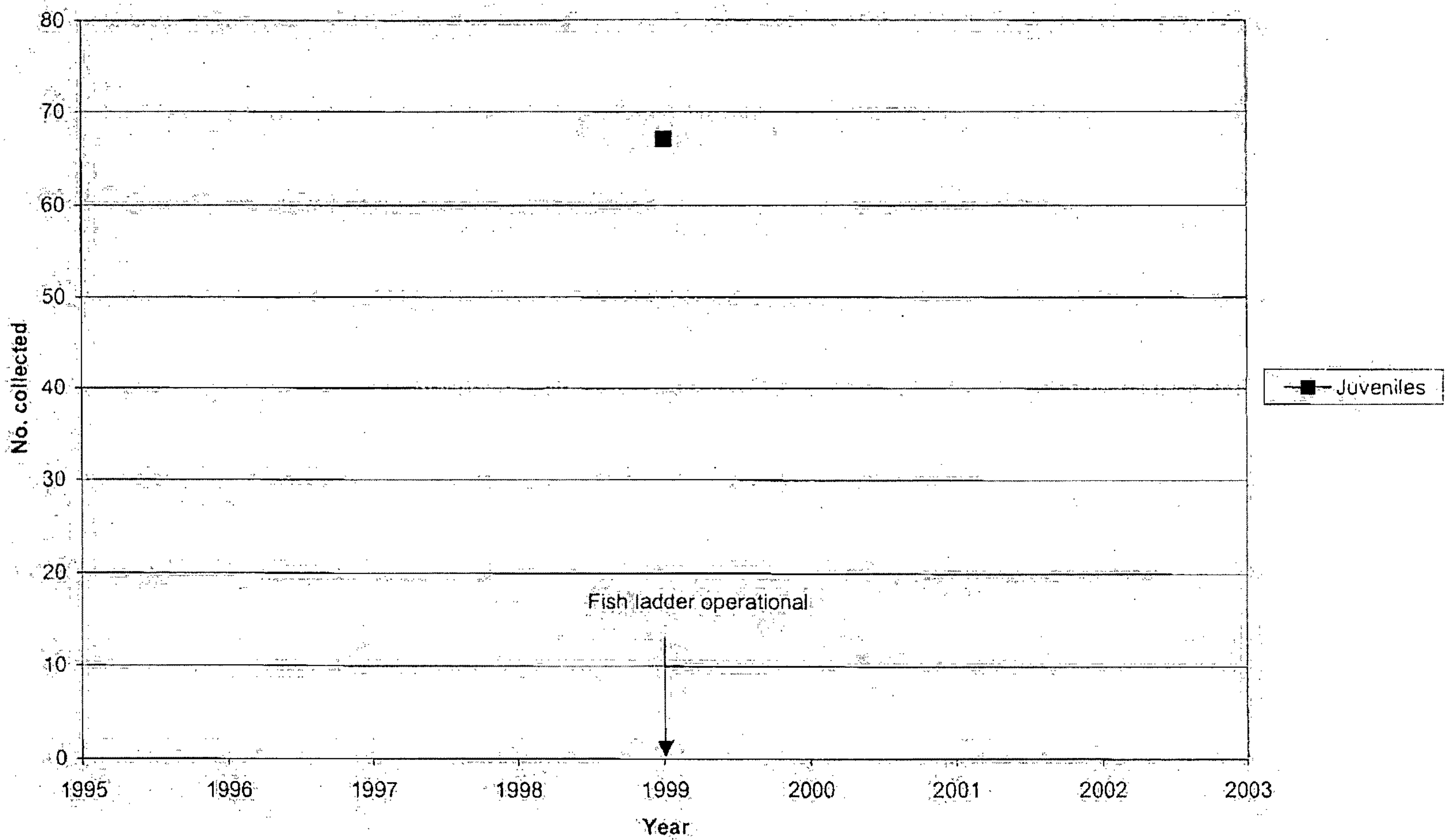


Figure 6-4
Silver Lake Fish Ladder Adult Passage and Stocking

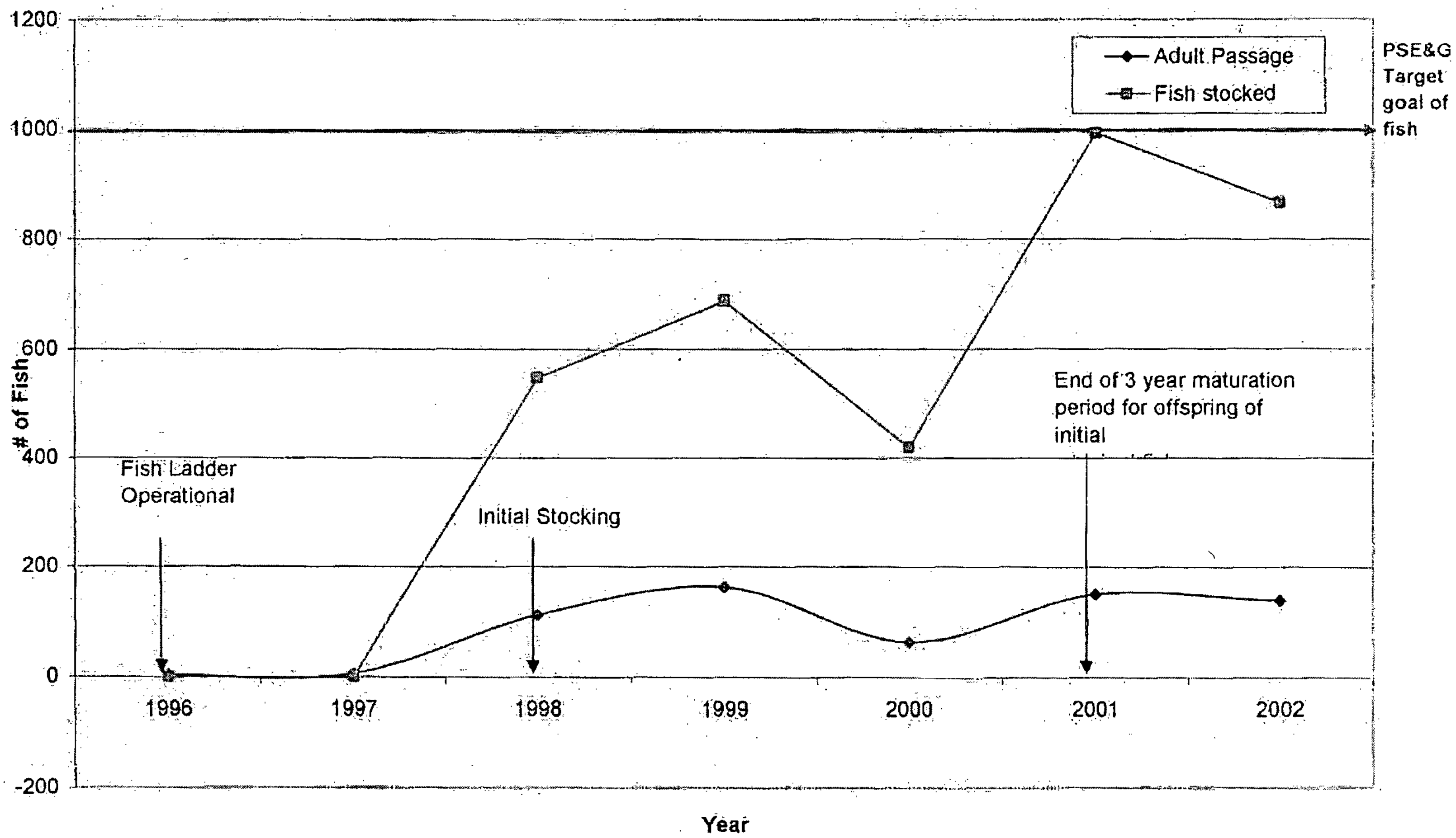


Figure 6-5
Eggs and Larvae Collection at Silver Lake

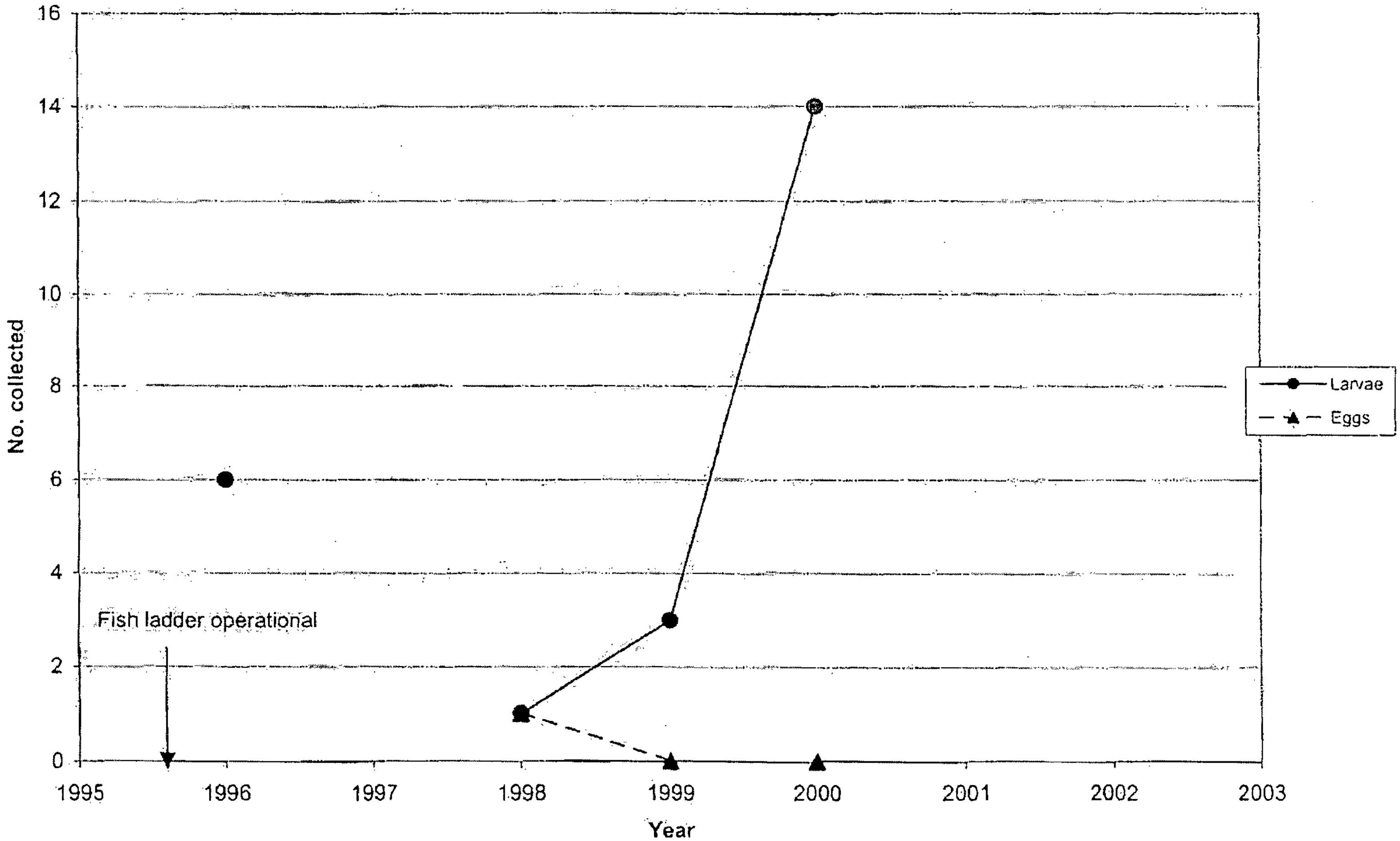


Figure 6-6
Juveniles Collection at Silver Lake

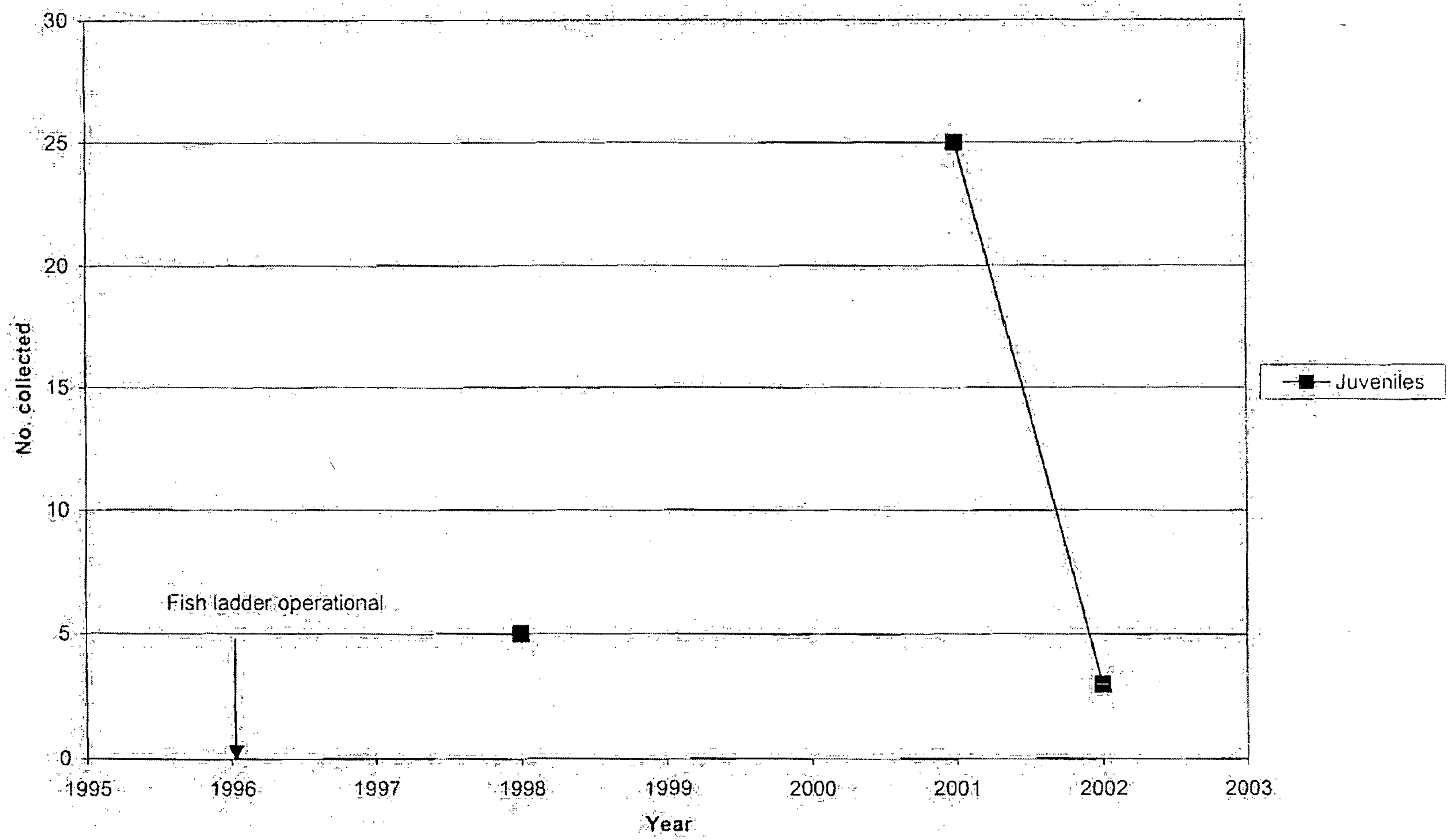


Figure 6-7
Moores Lake Fish Ladder Adult Passage and Stocking

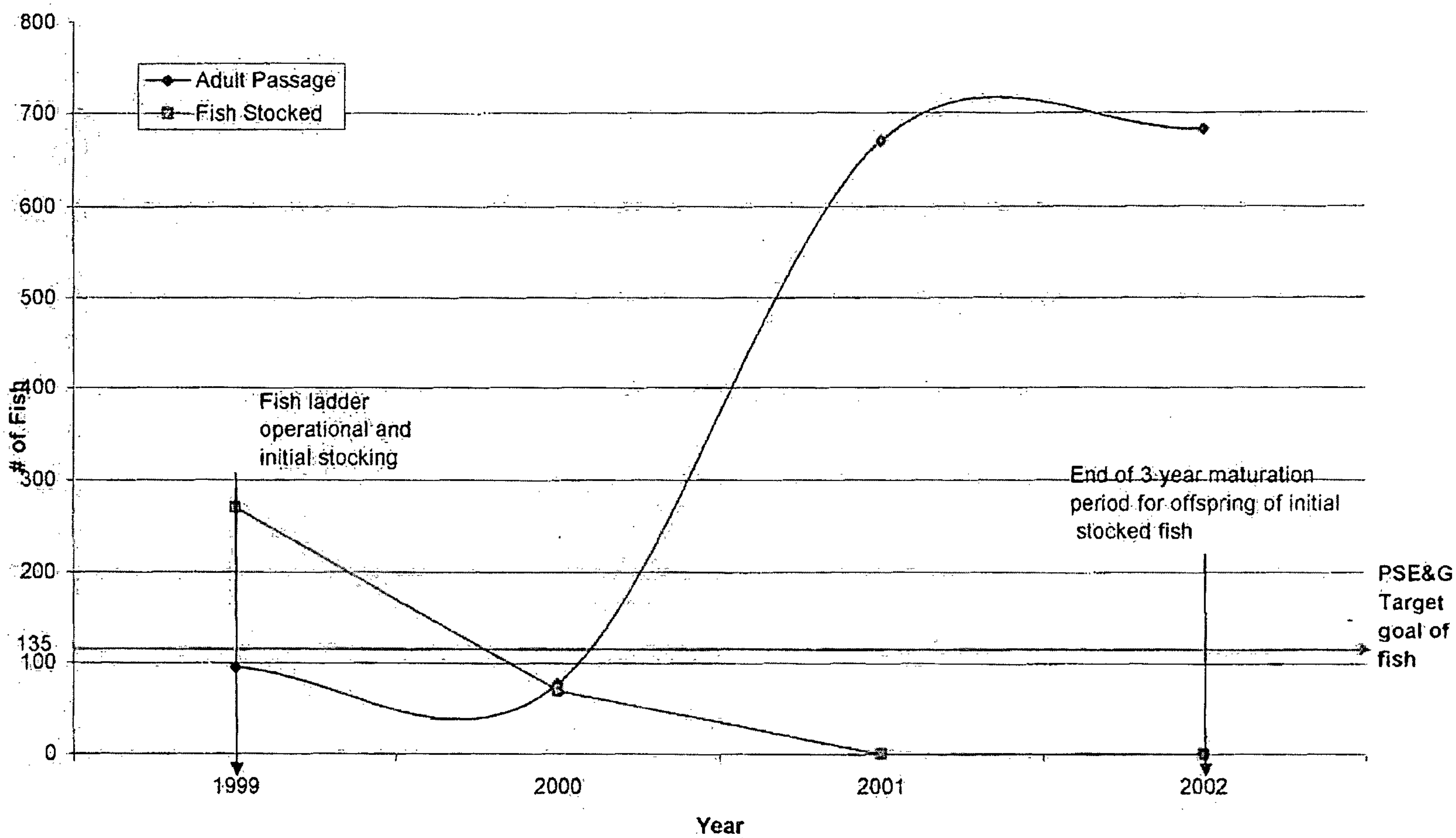


Figure 6-8
Eggs and Larvae Collection at Moores Lake

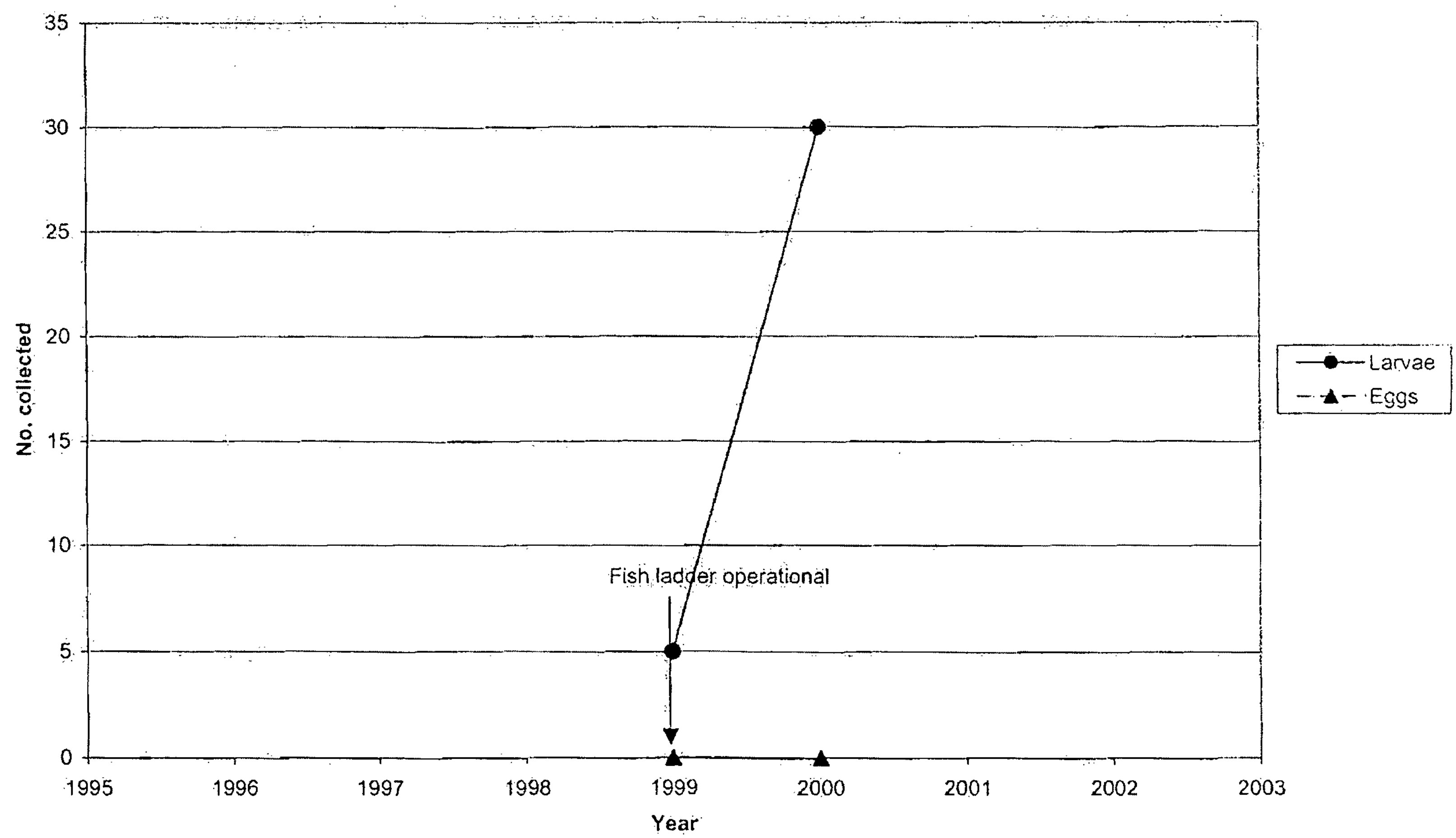


Figure 6-9
Juveniles Collection at Moores Lake

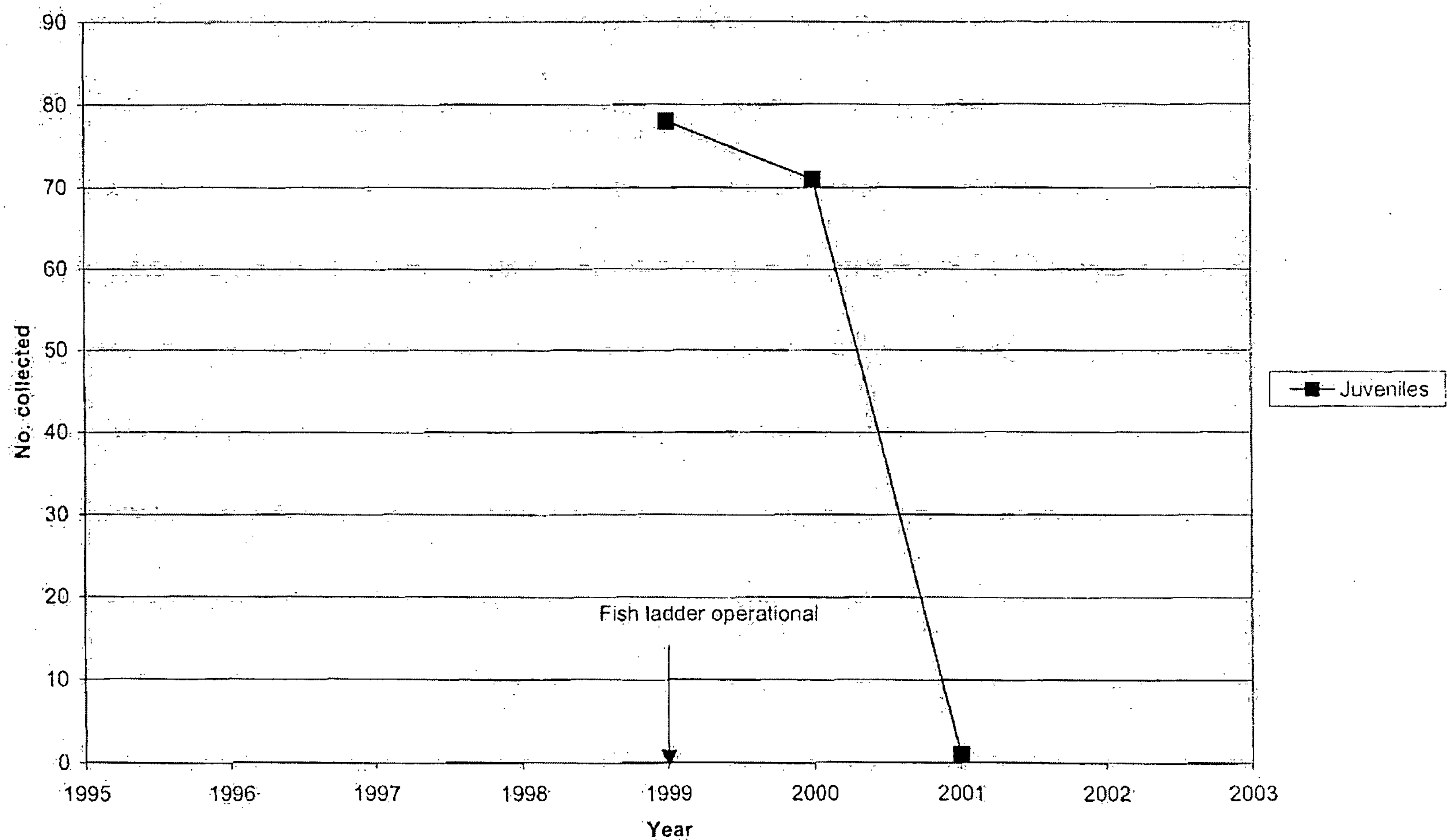


Figure 6-10
McGinnis Pond Fish Ladder Adult Passage and Stocking

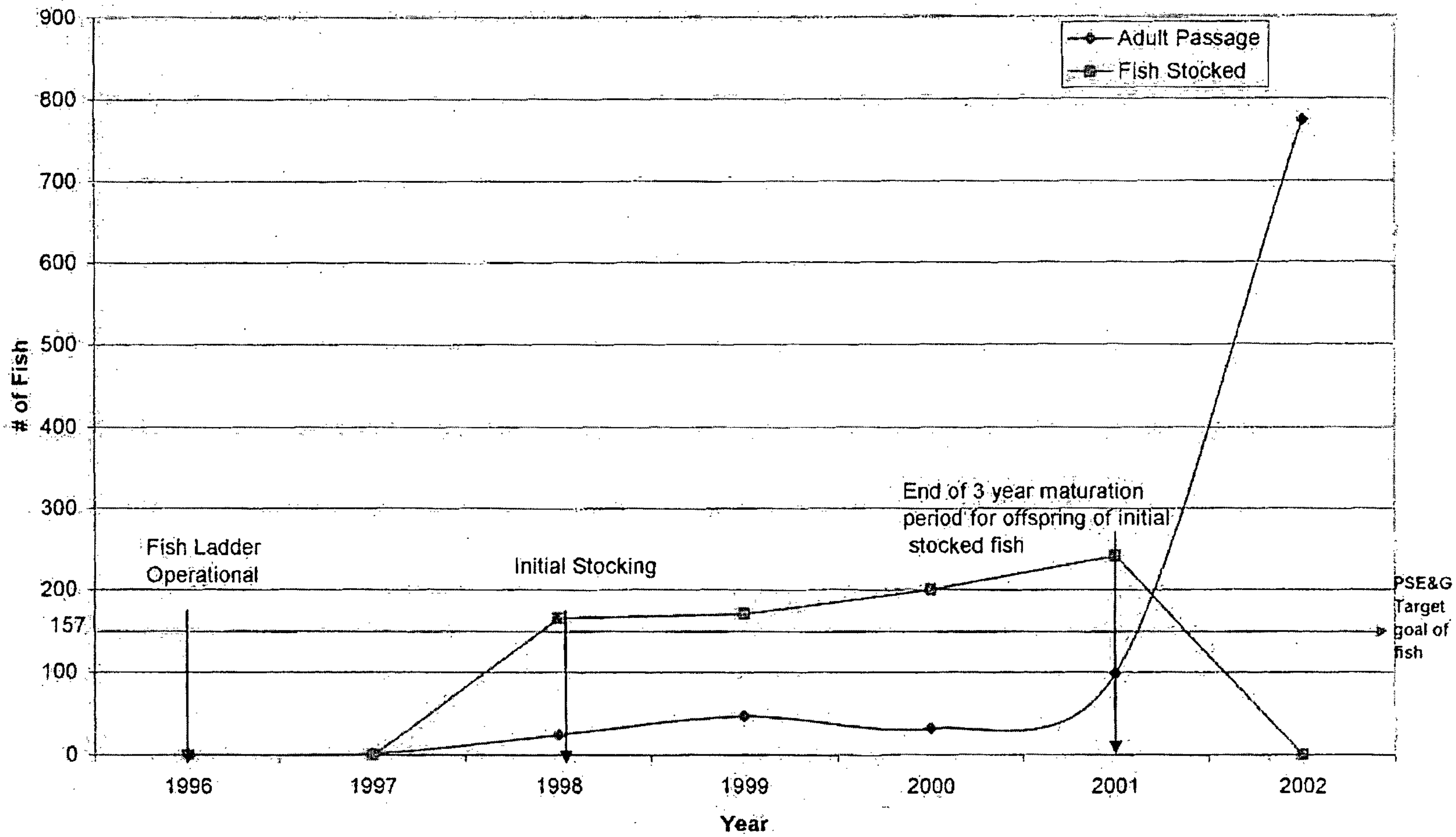


Figure 6-11
Eggs and Larvae Collection at McGinnis Pond

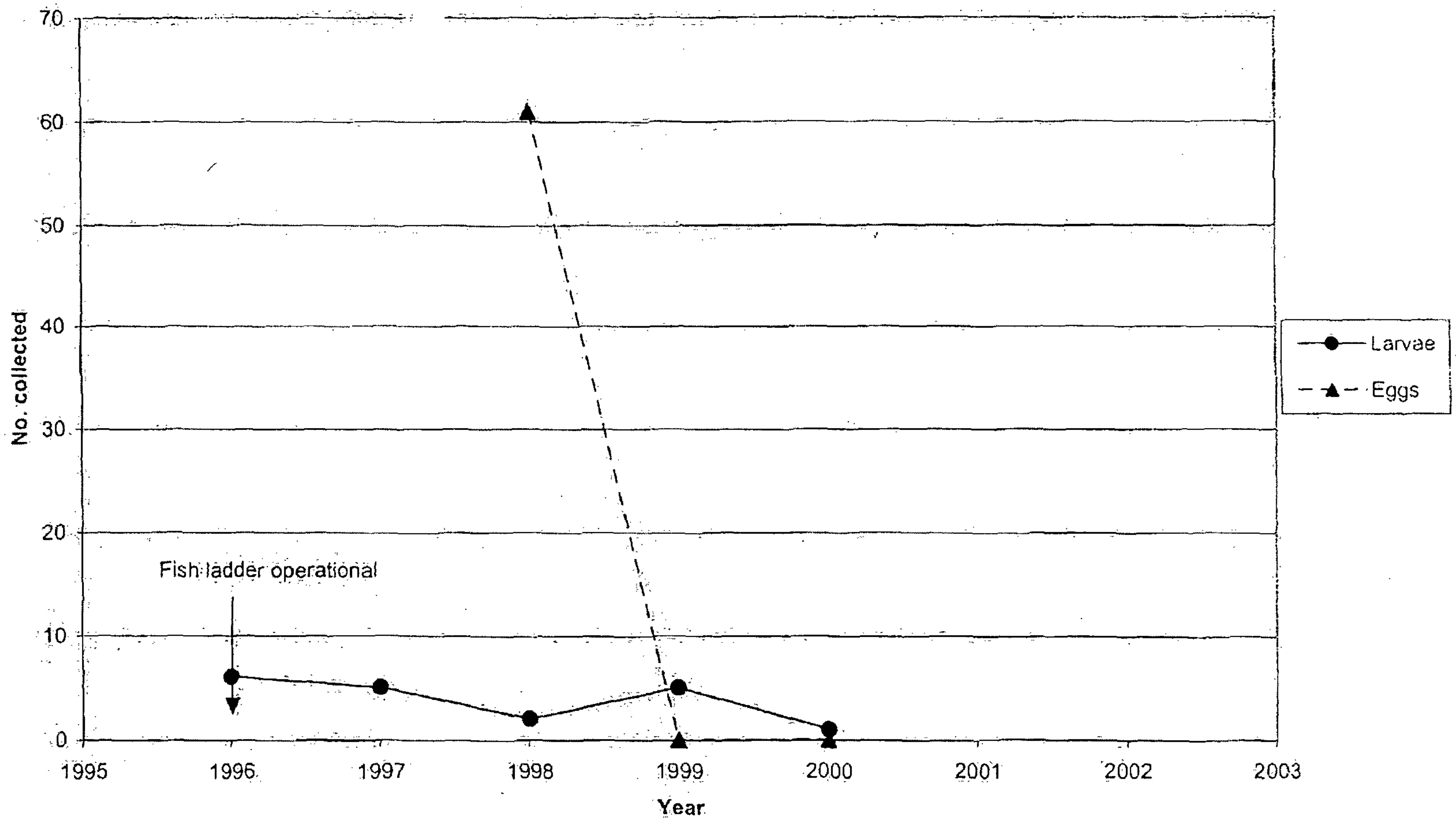


Figure 6-12
Juveniles Collection at McGinnis Pond

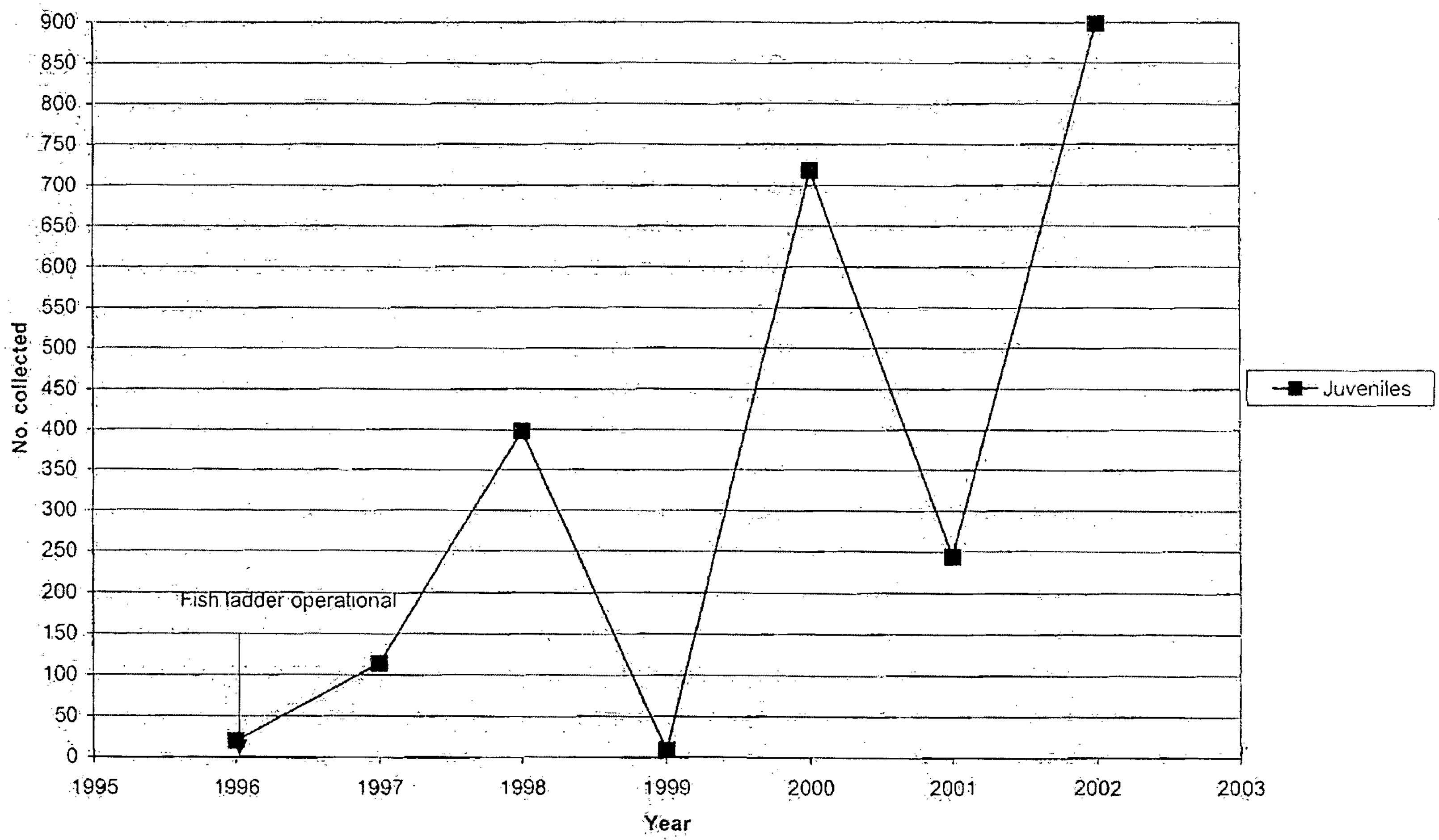


Figure 6-13
Coursey Pond Fish Ladder Adult Passage and Stocking

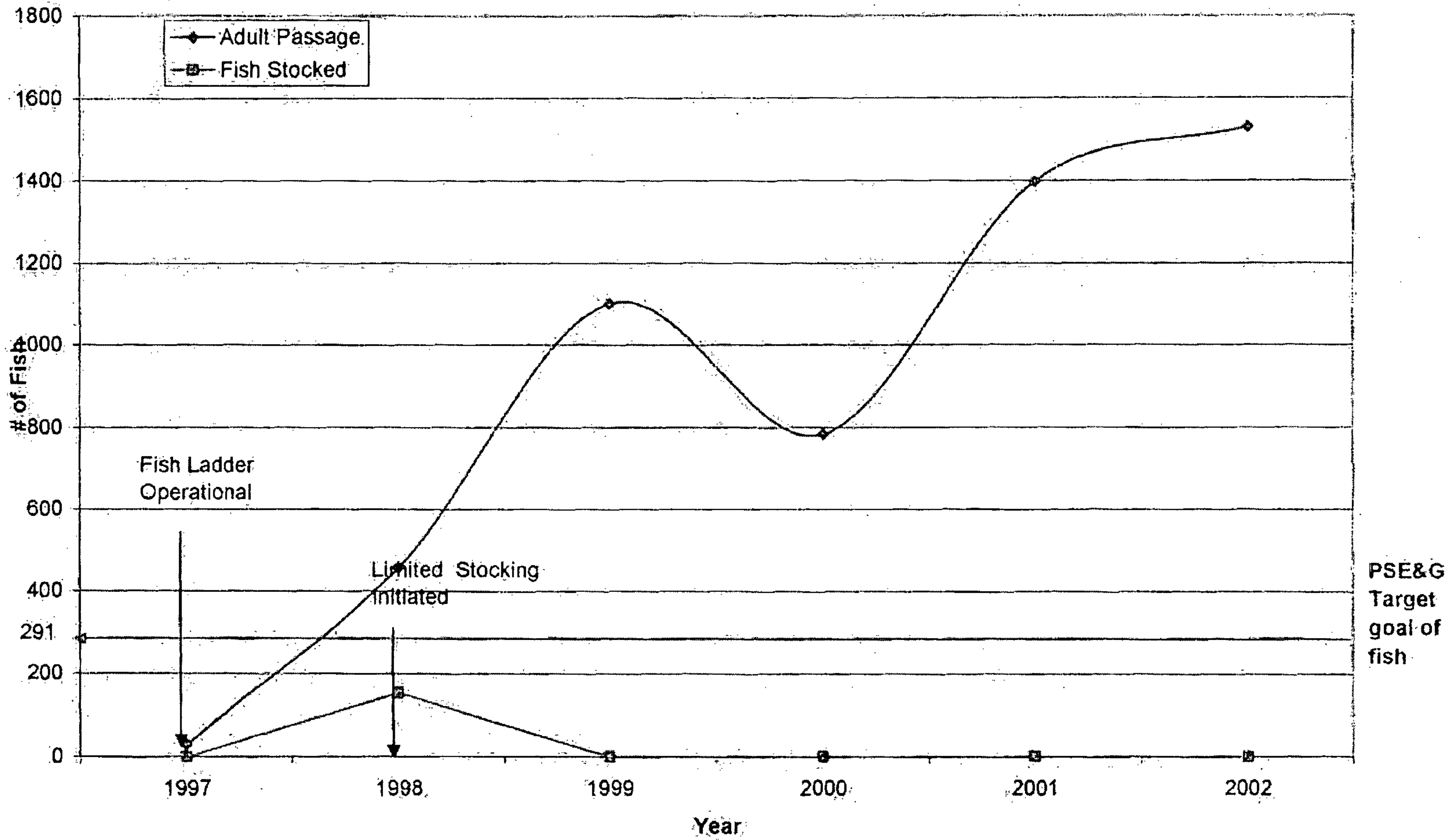


Figure 6-14
Eggs and Larvae Collection at Coursey's Pond

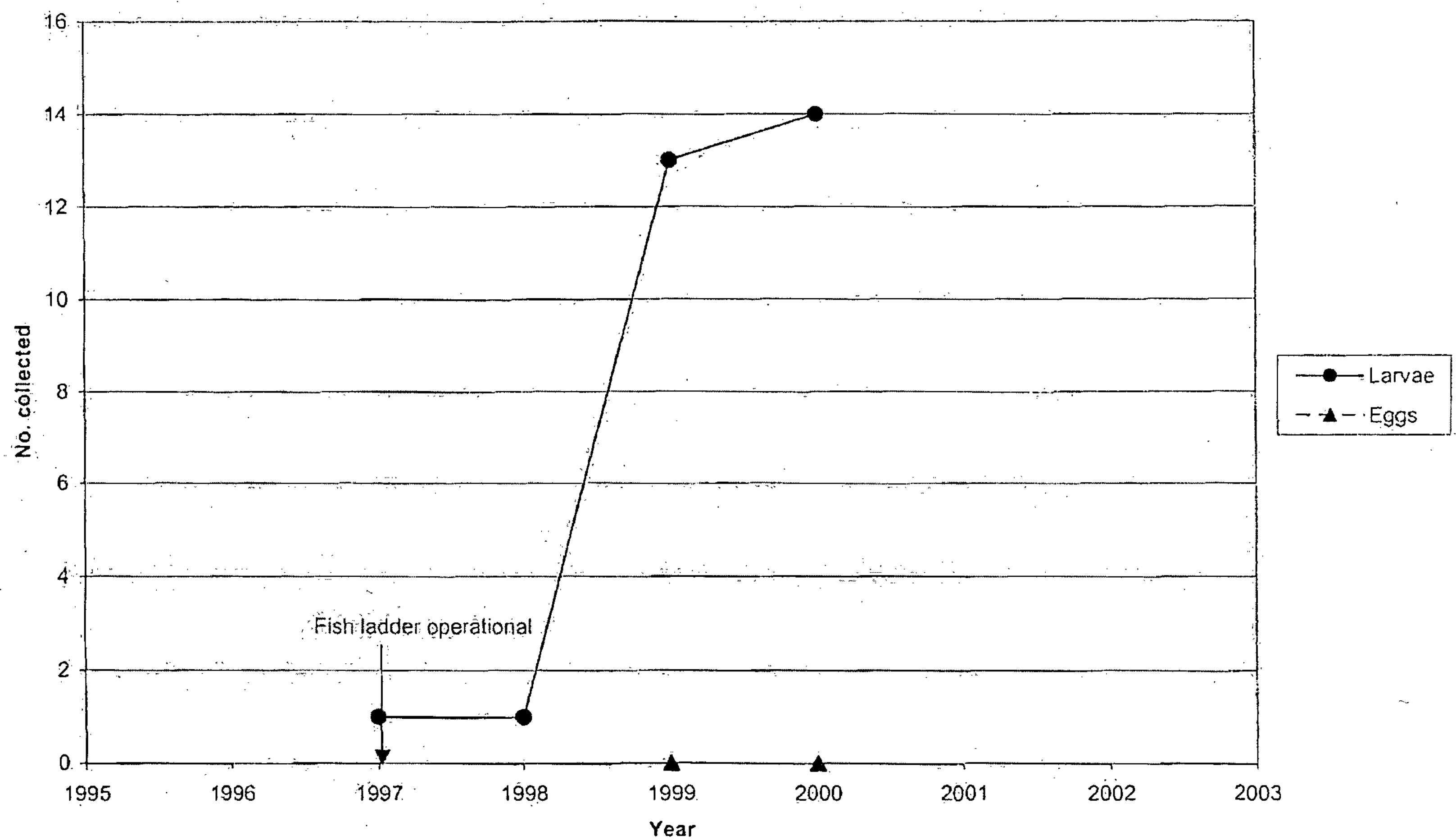


Figure 6-15
Juveniles Collection at Coursey's Pond

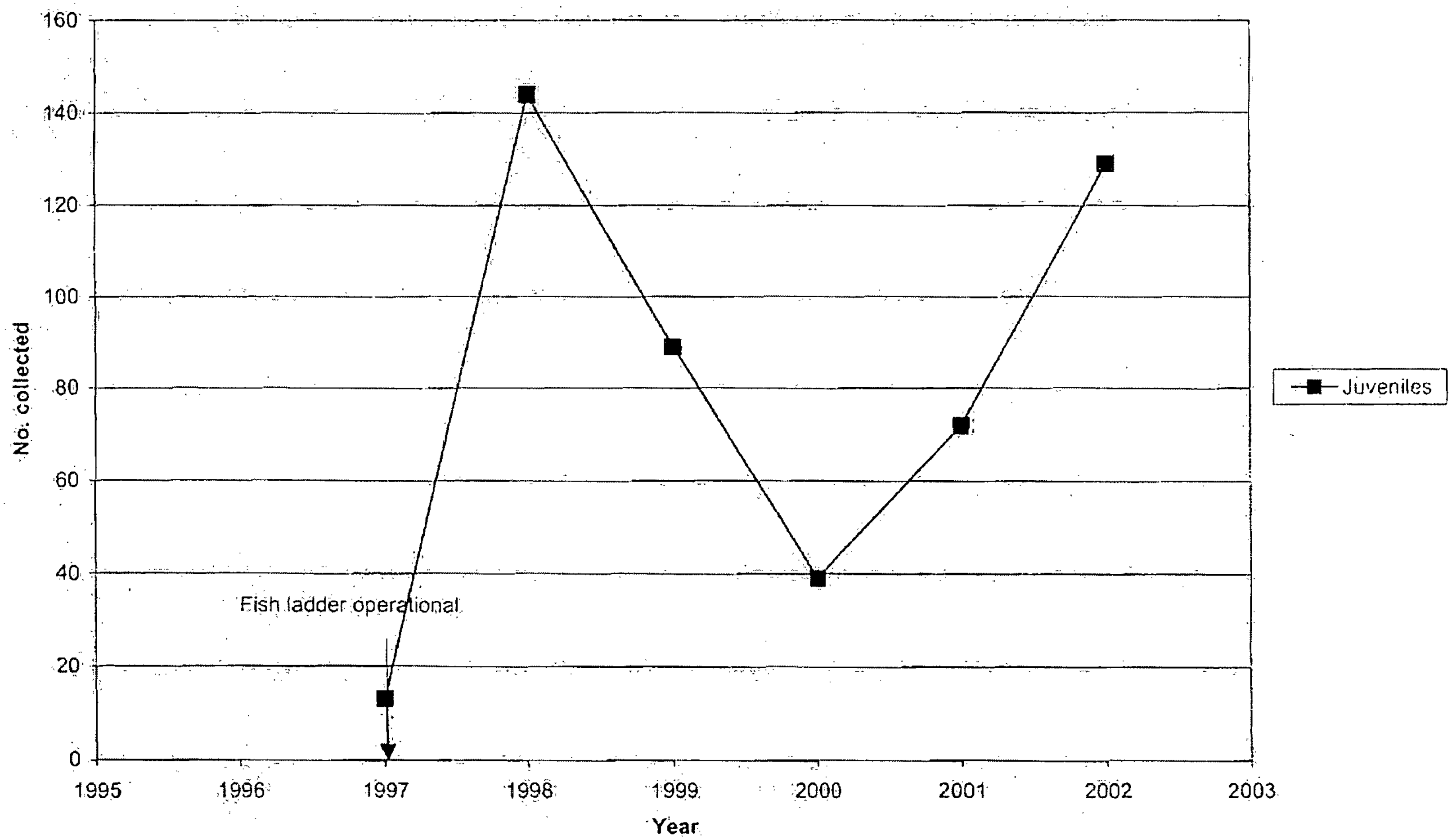


Figure 6-16
McColley Fish Ladder Adult Passage and Stocking

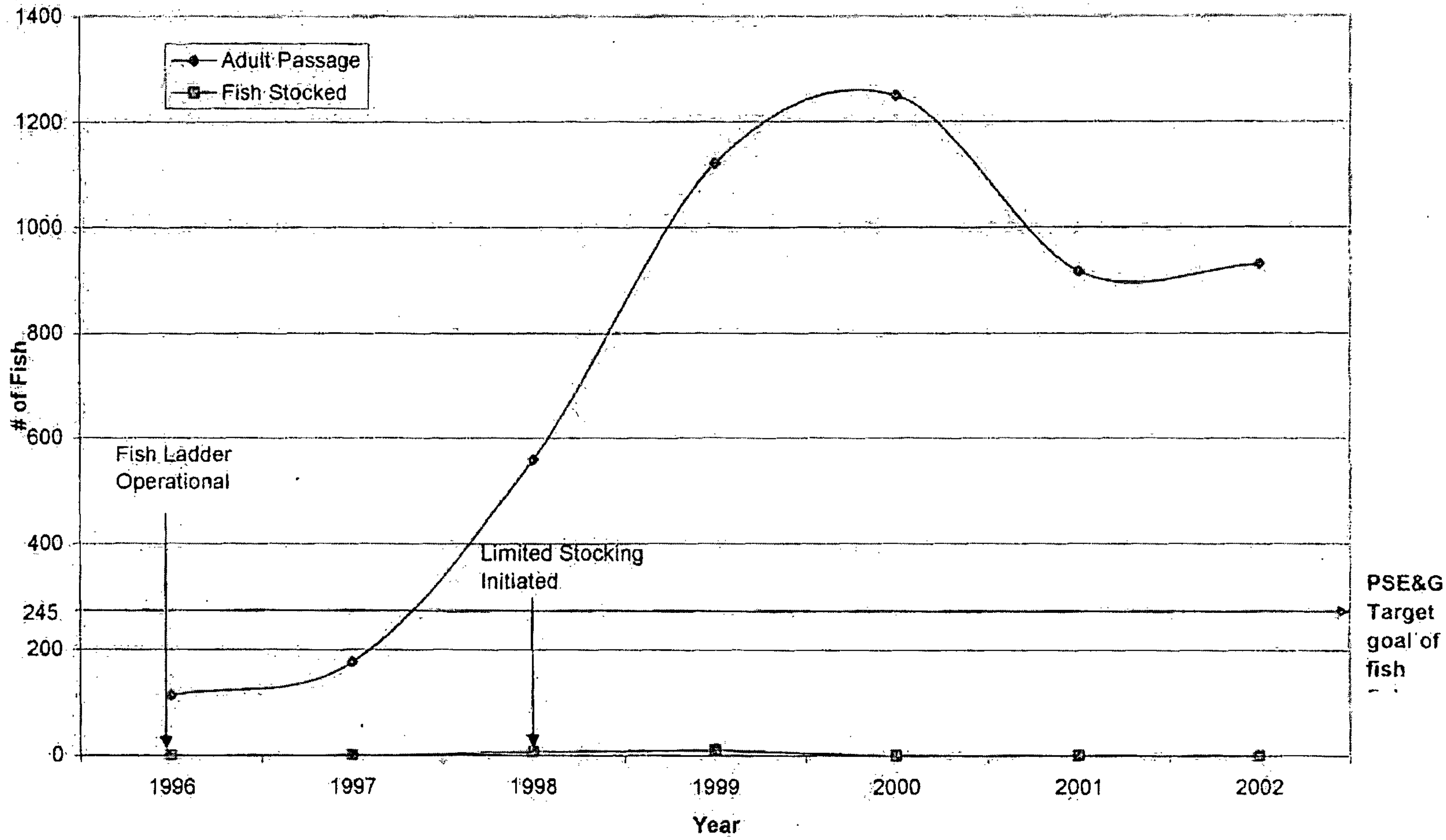


Figure 6-17
Eggs and Larvae Collection at McColley Pond

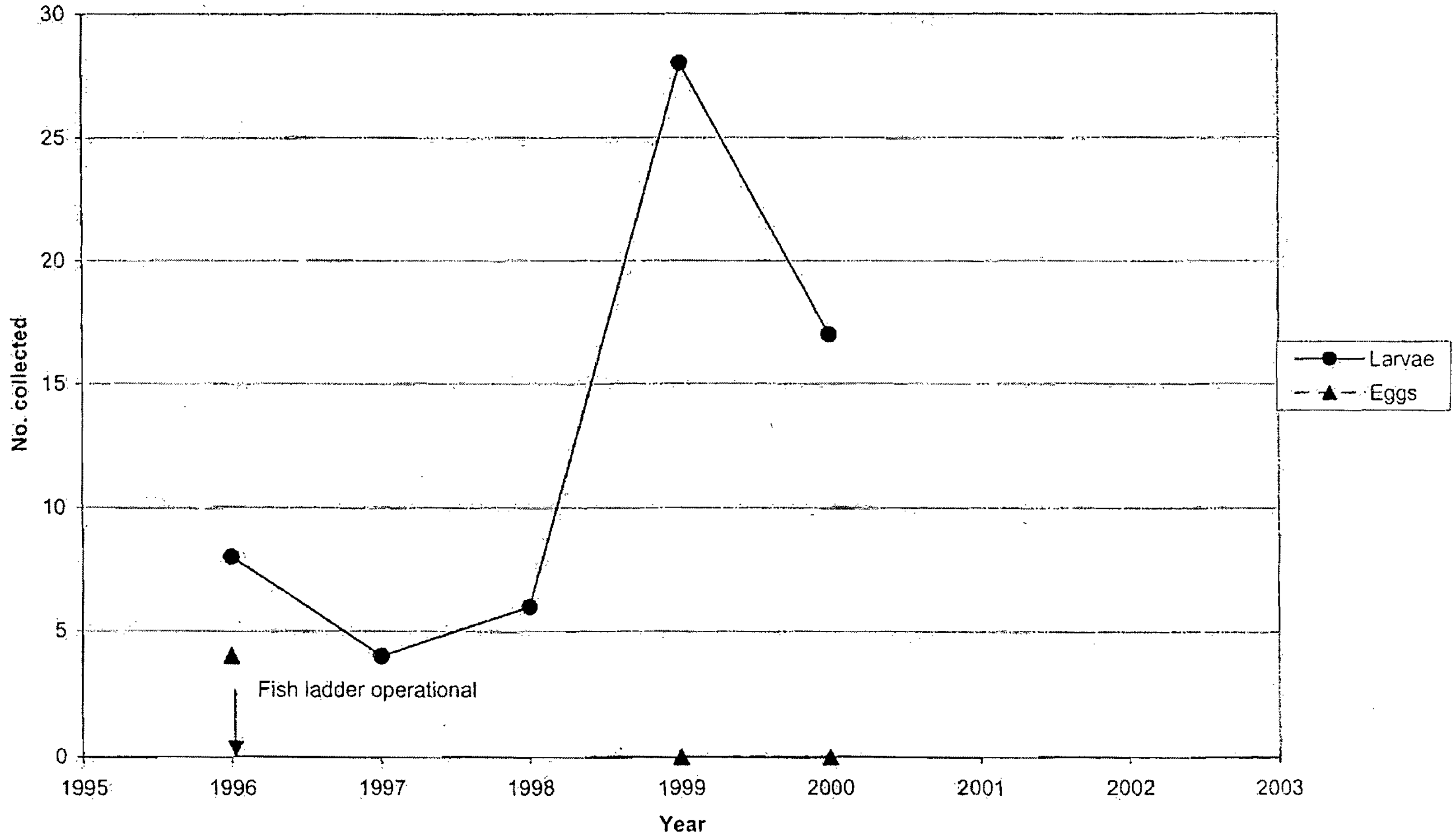


Figure 6-18
Juveniles Collection at McColley Pond

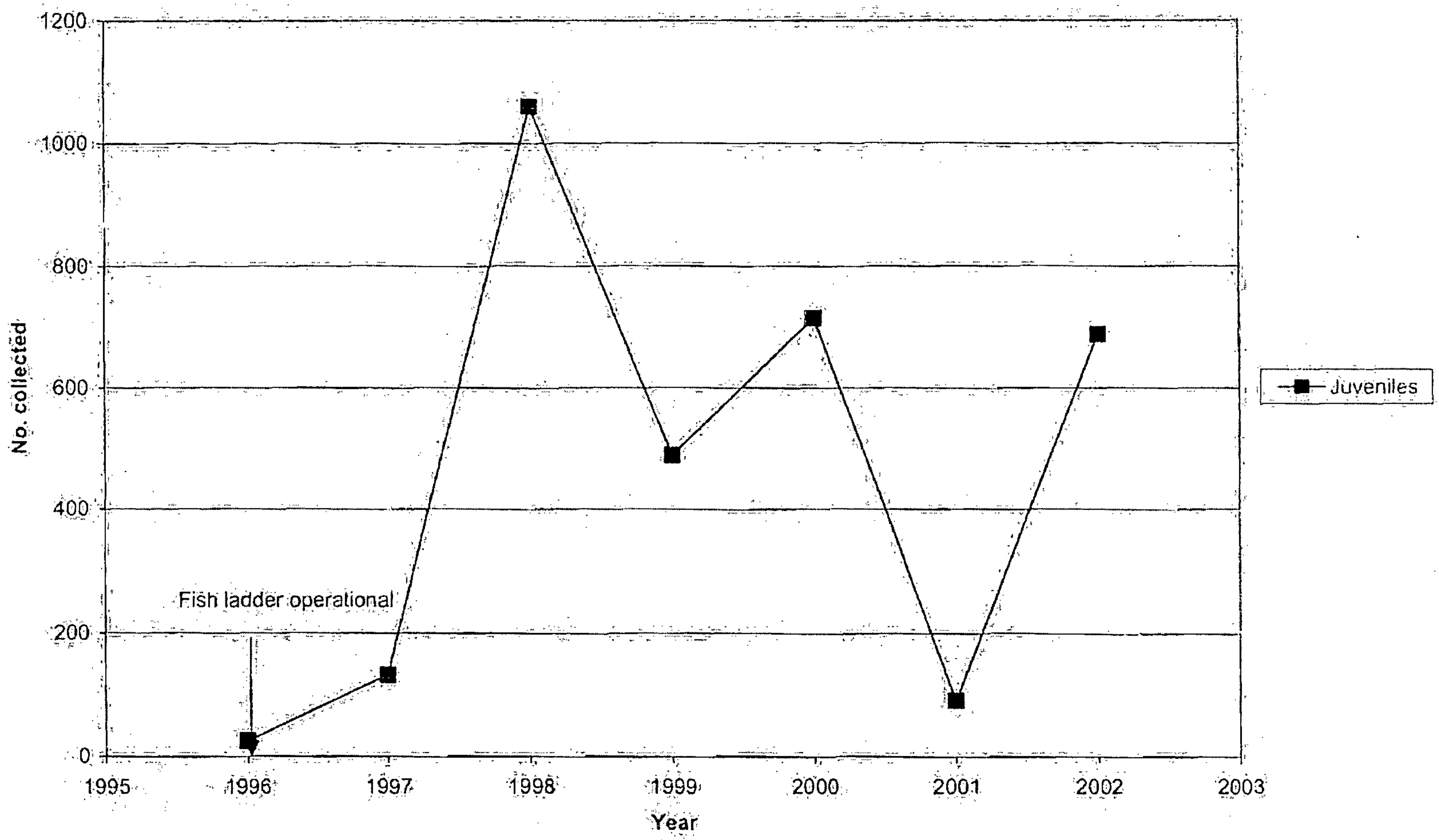


Figure 6-19
Cooper River Fish Ladder Adult Passage and Stocking

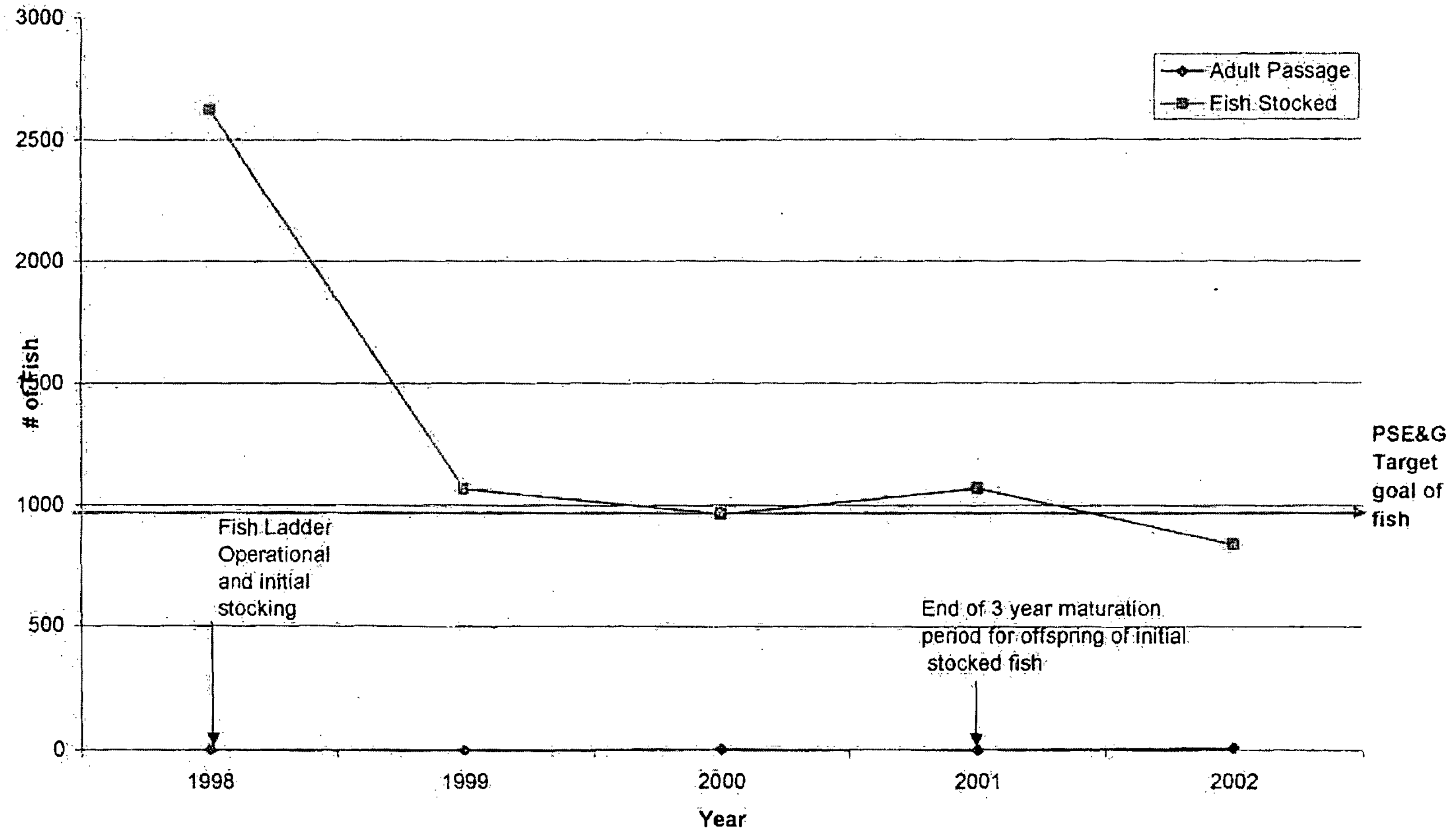


Figure 6-20
Eggs and Larvae Collection at Cooper River

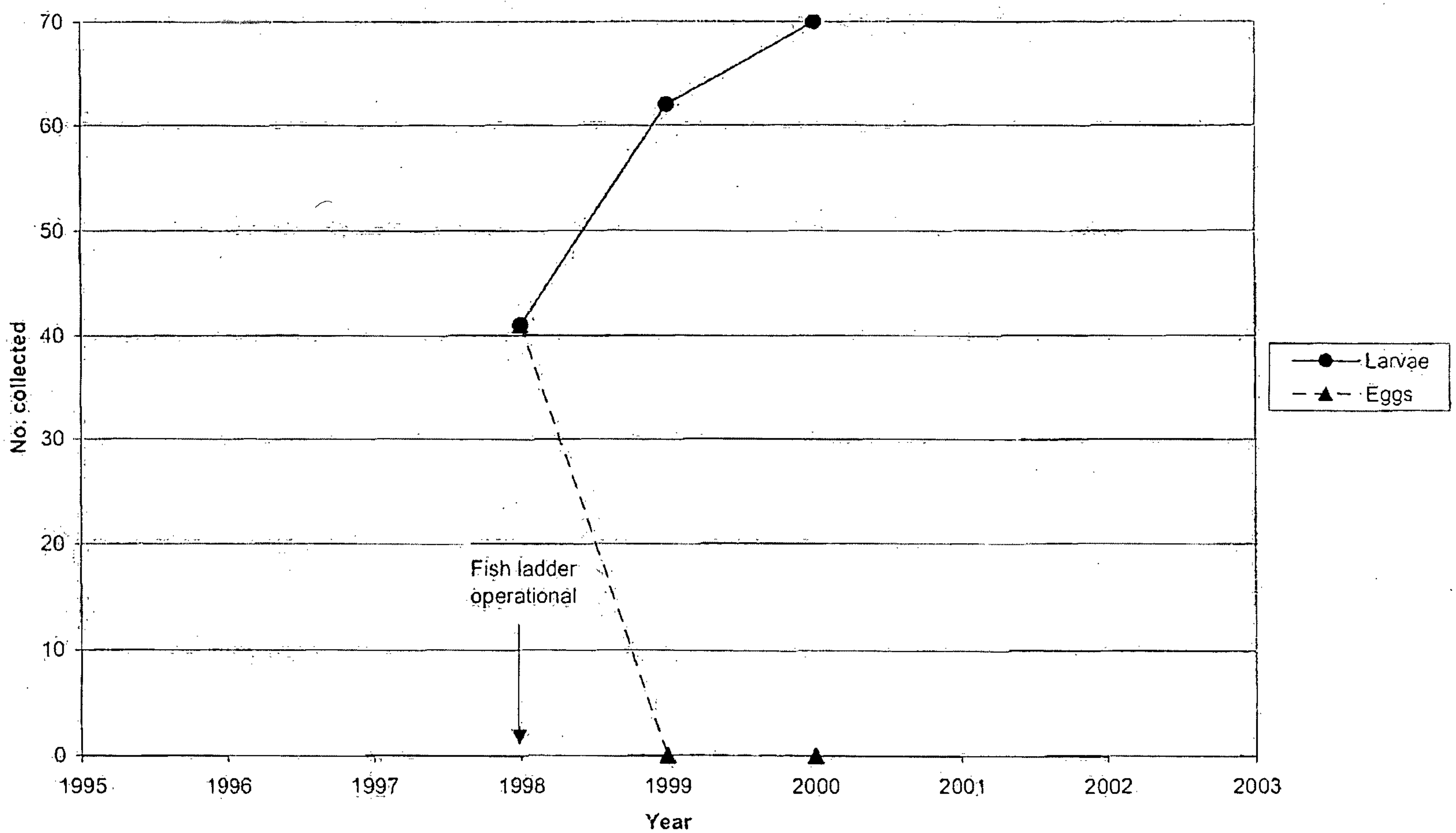


Figure 6-21
Juveniles Collection at Cooper River

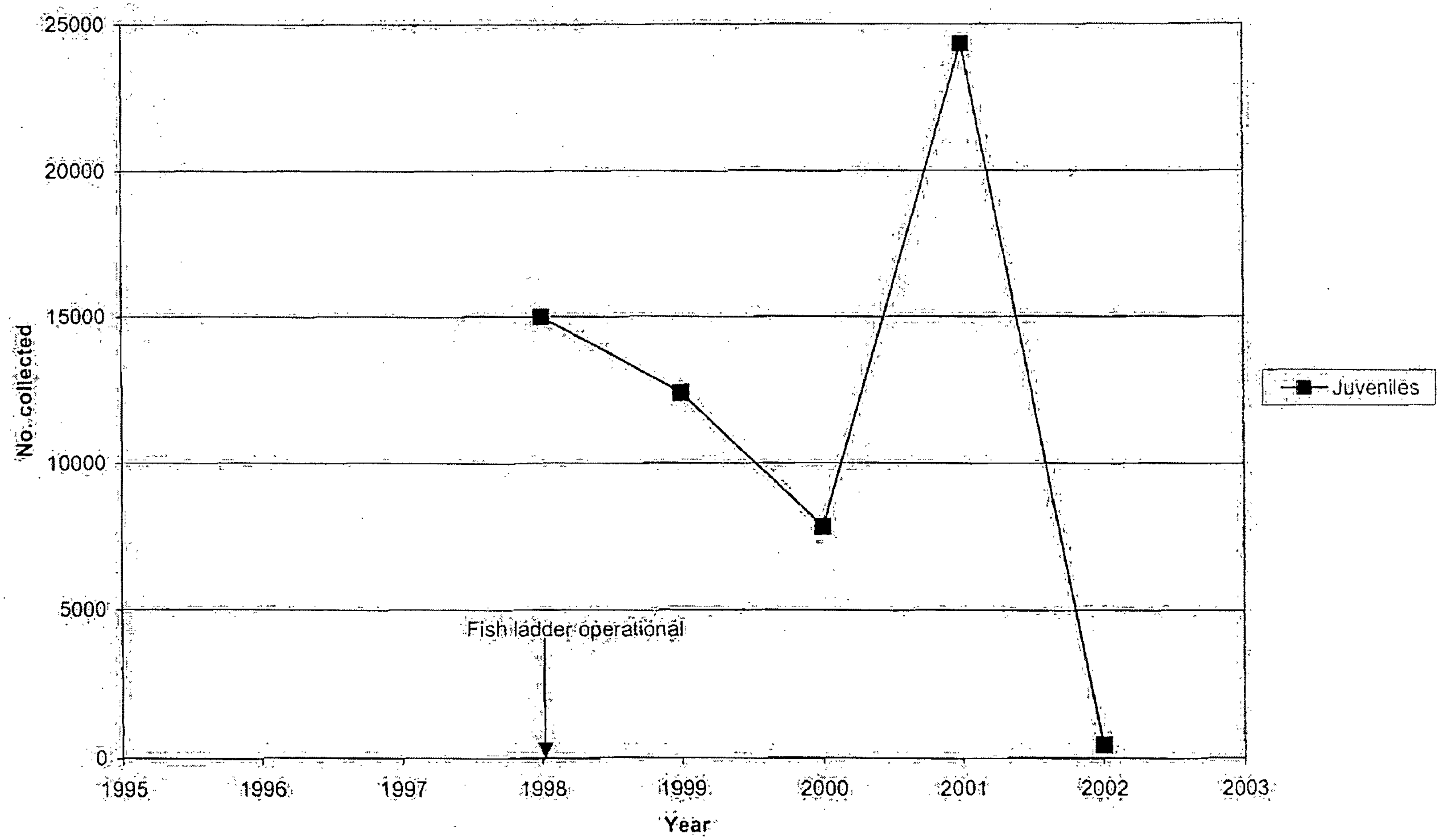


Figure 6-22
Sunset Lake Fish Ladder Adult Passage and Stocking

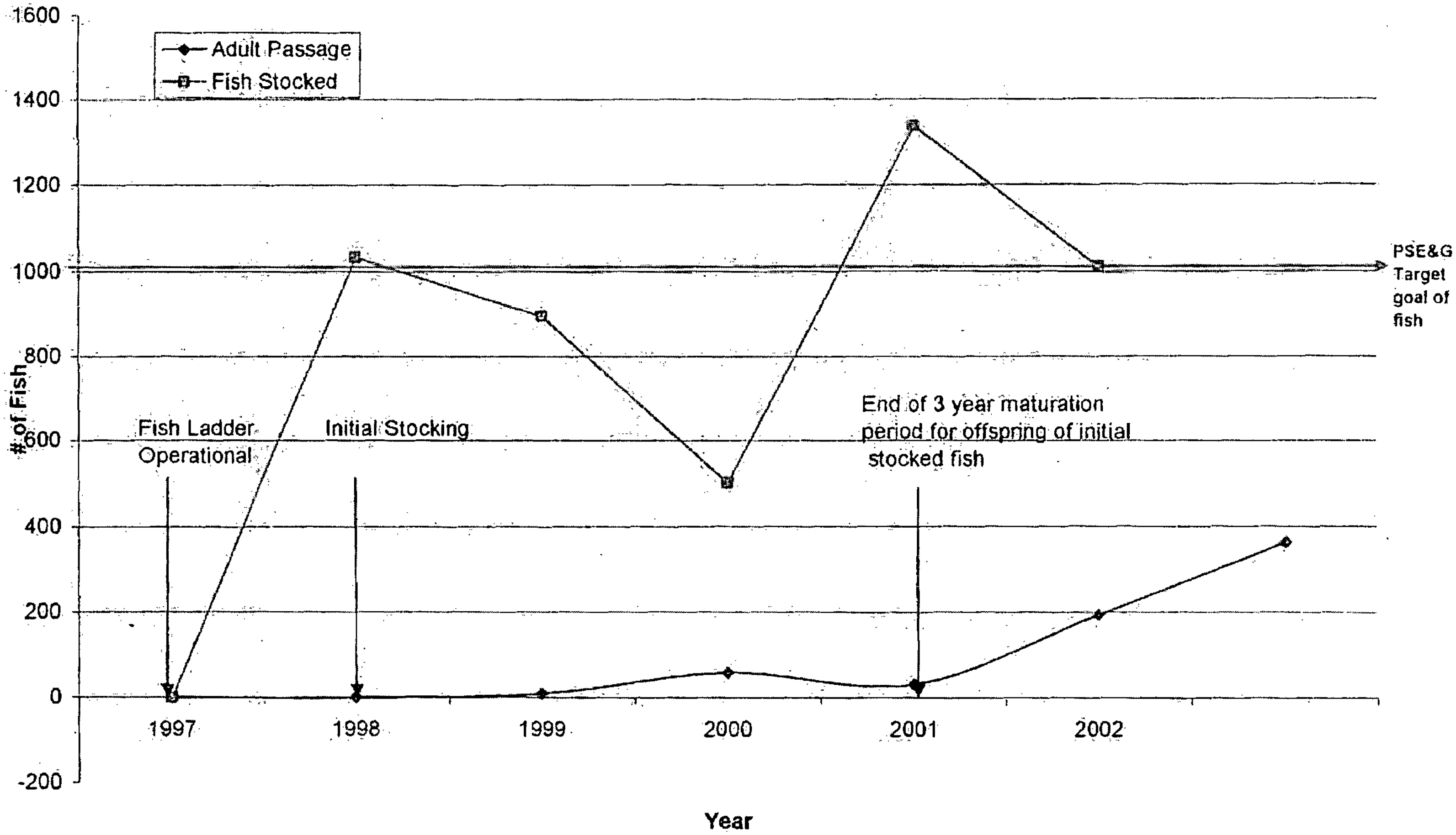


Figure 6-23
Egg and Larvae Collection at Sunset Lake

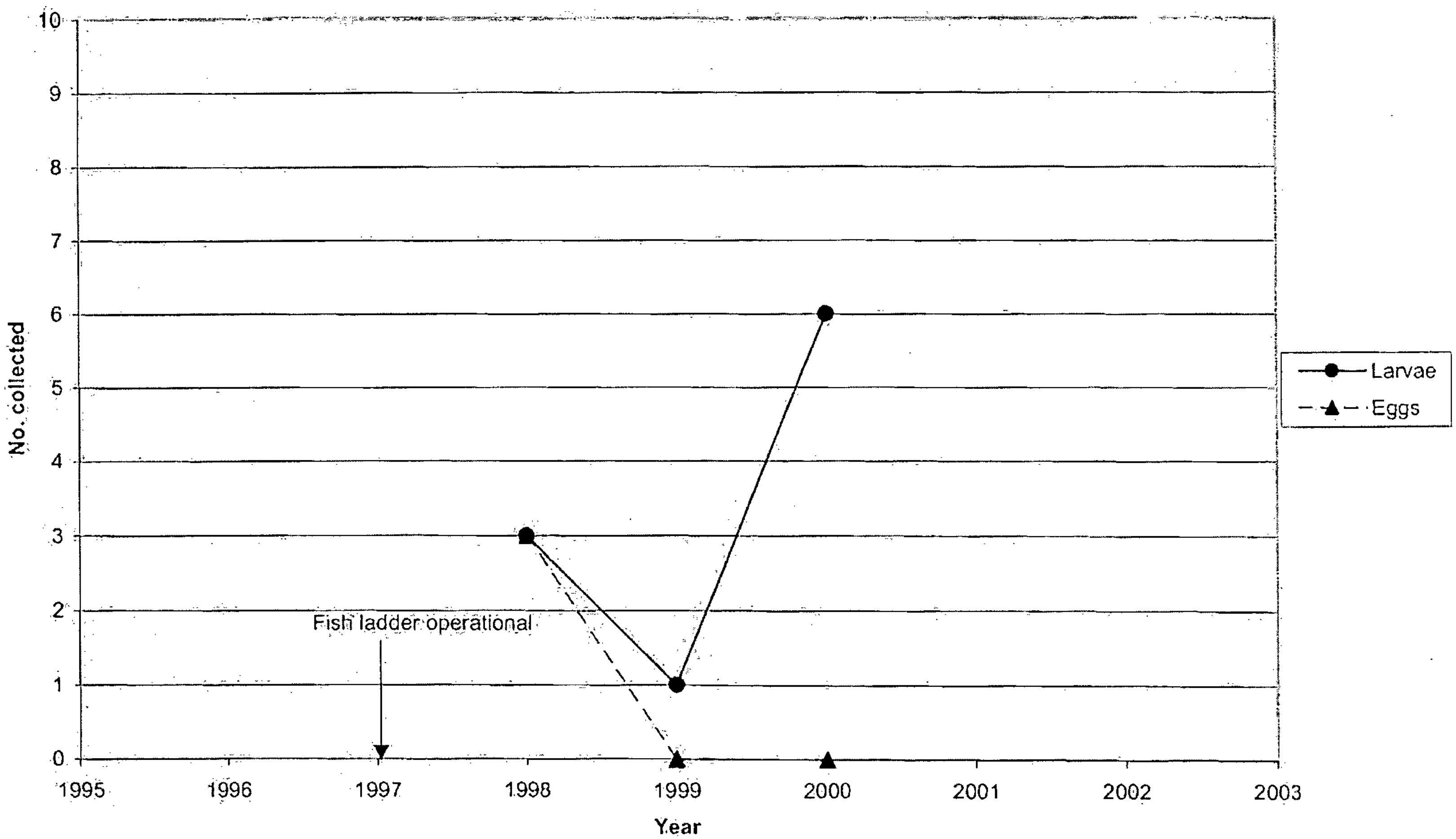


Figure 6-24
Juveniles Collection at Sunset Lake

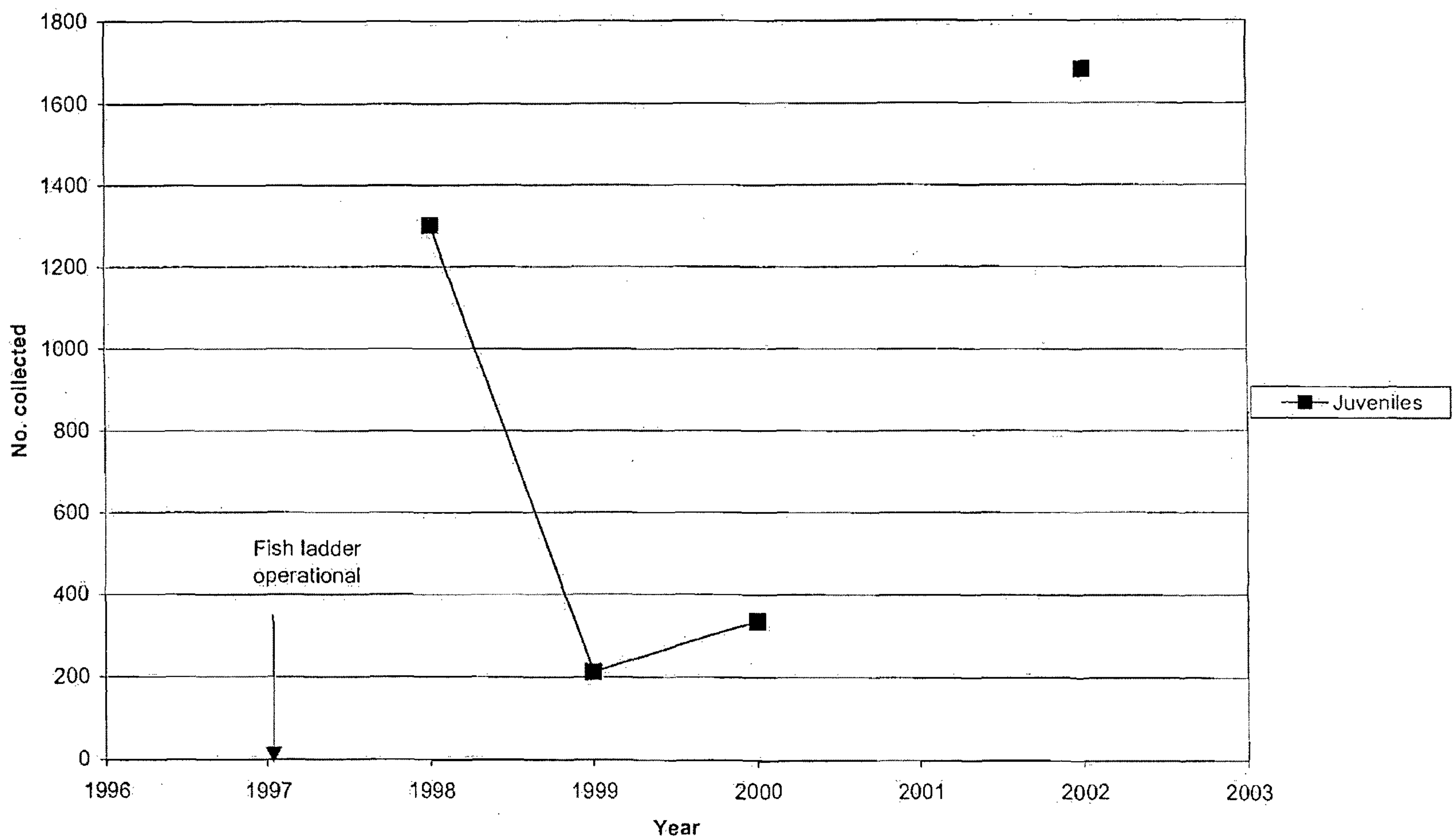


Figure 7-1 DNREC Juvenile Trawl Data 1991-2002
Weakfish

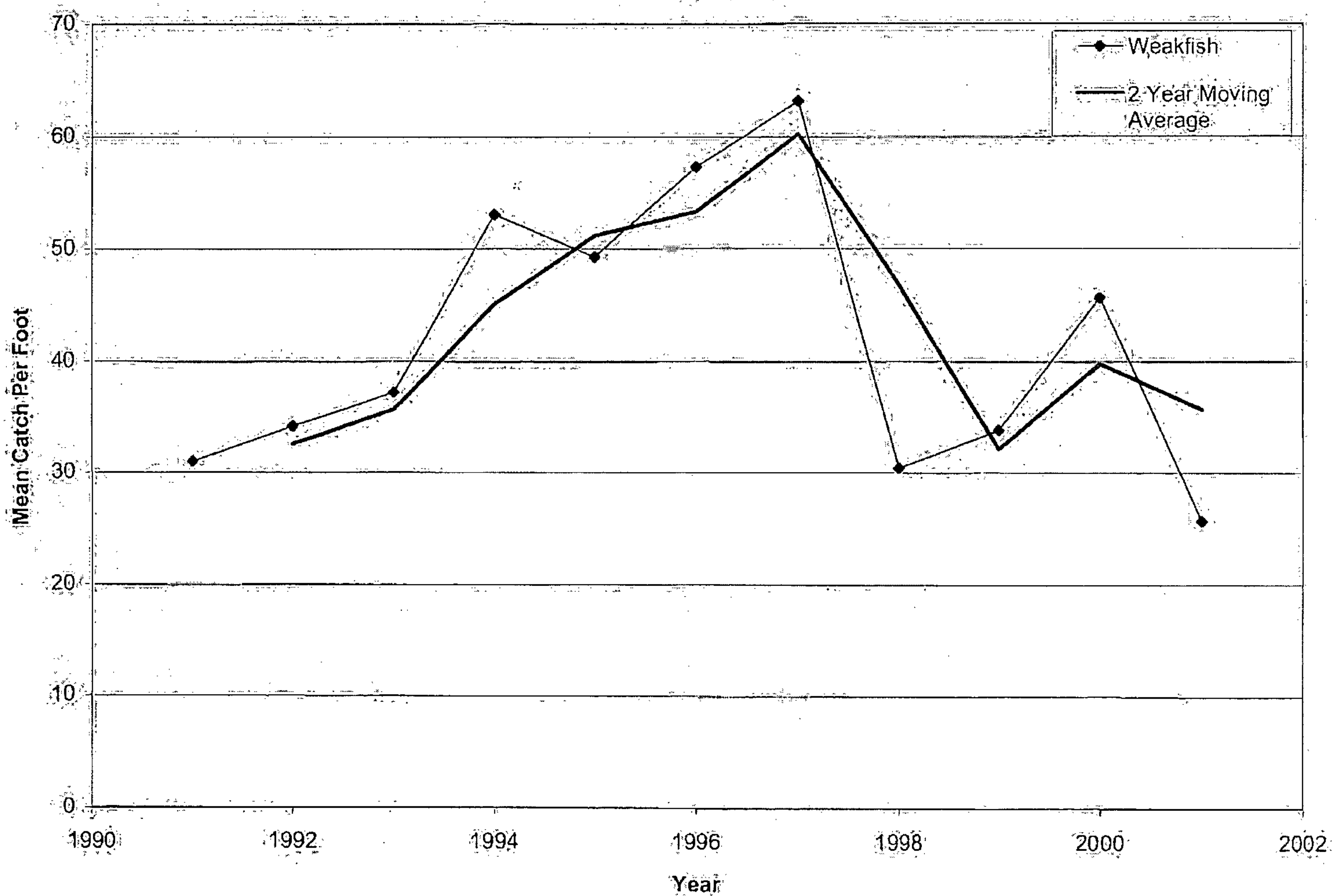


Figure 7-2 DNREC Juvenile Trawl Data 1991-2002
Striped Bass

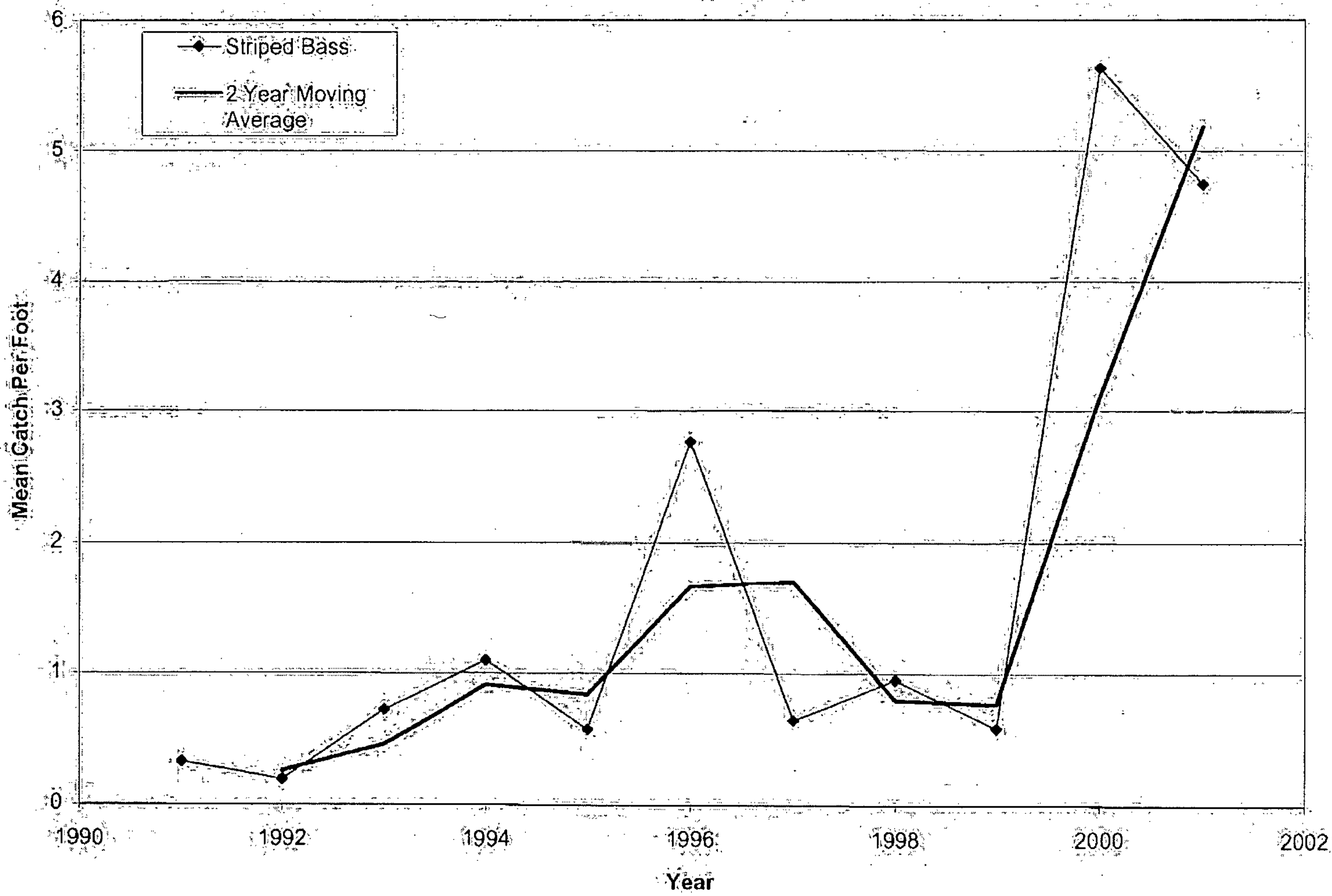


Figure 7-3 DNREC Juvenile Trawl Data 1991-2002
White Perch

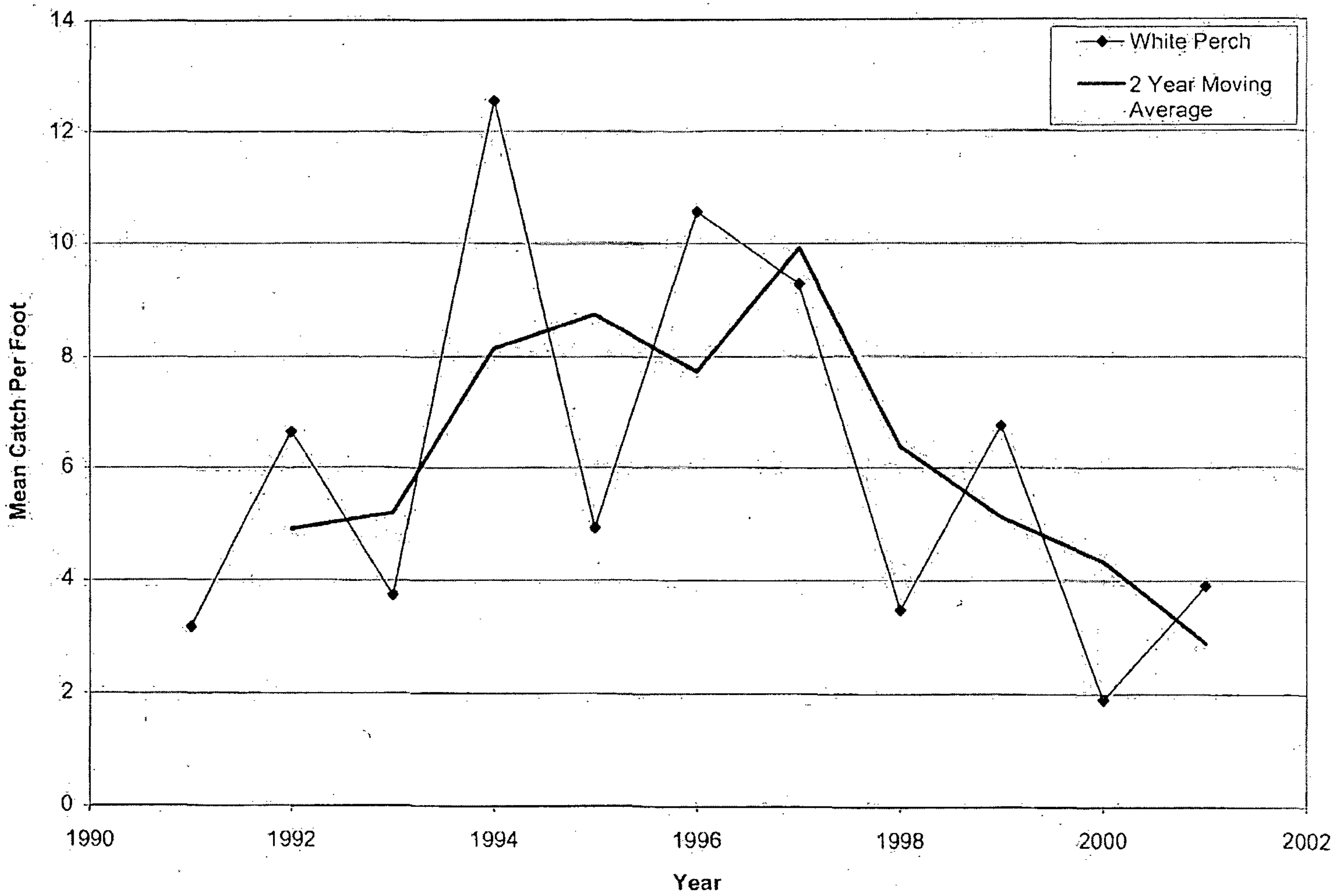


Figure 7-4 DNREC Juvenile Trawl Data 1991-2002
Spot

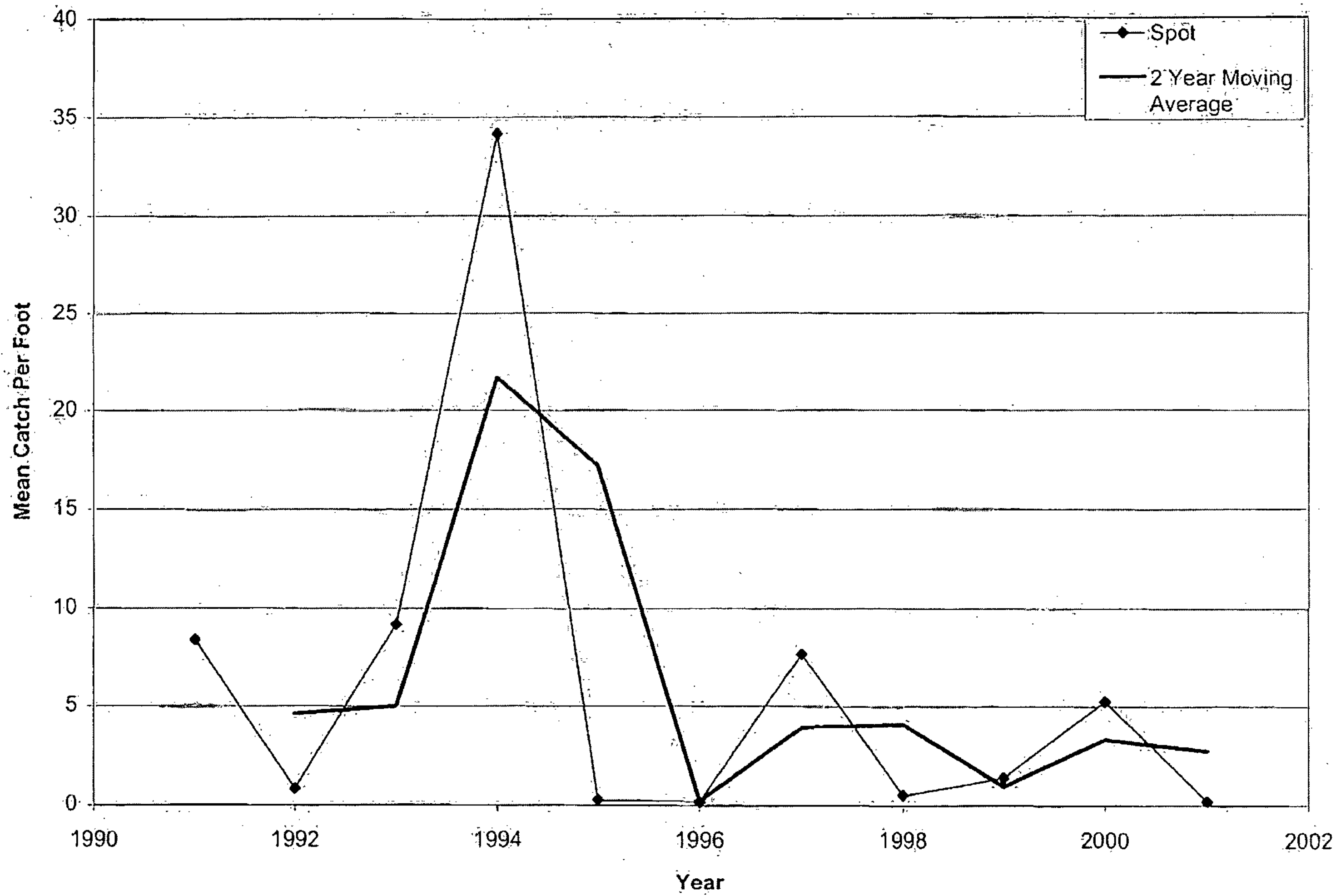


Figure 7-5 DNREC Juvenile Trawl Data 1991-2002
Atlantic Croaker

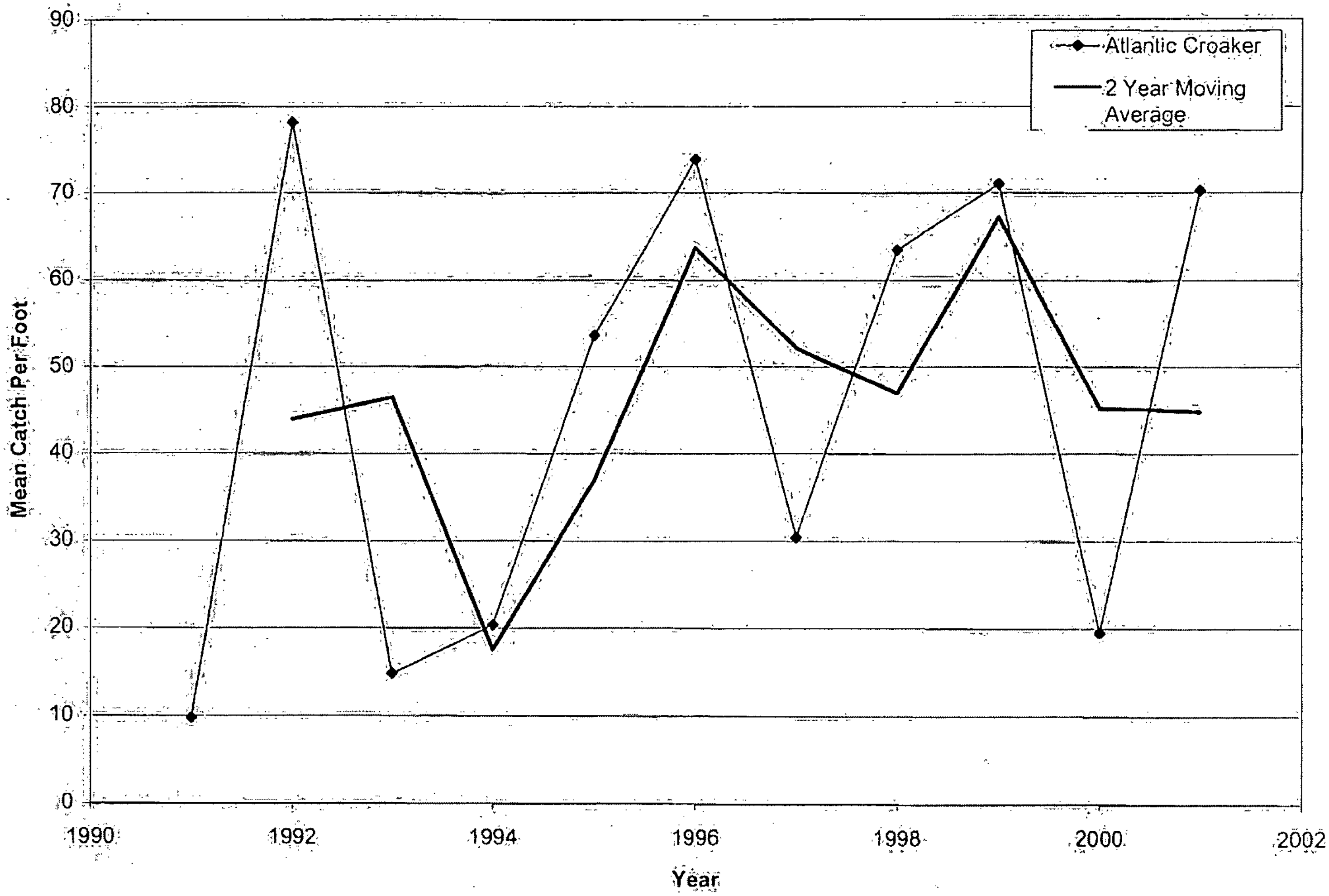


Figure 7-6 DNREC Juvenile Trawl Data 1991-2002
American Shad

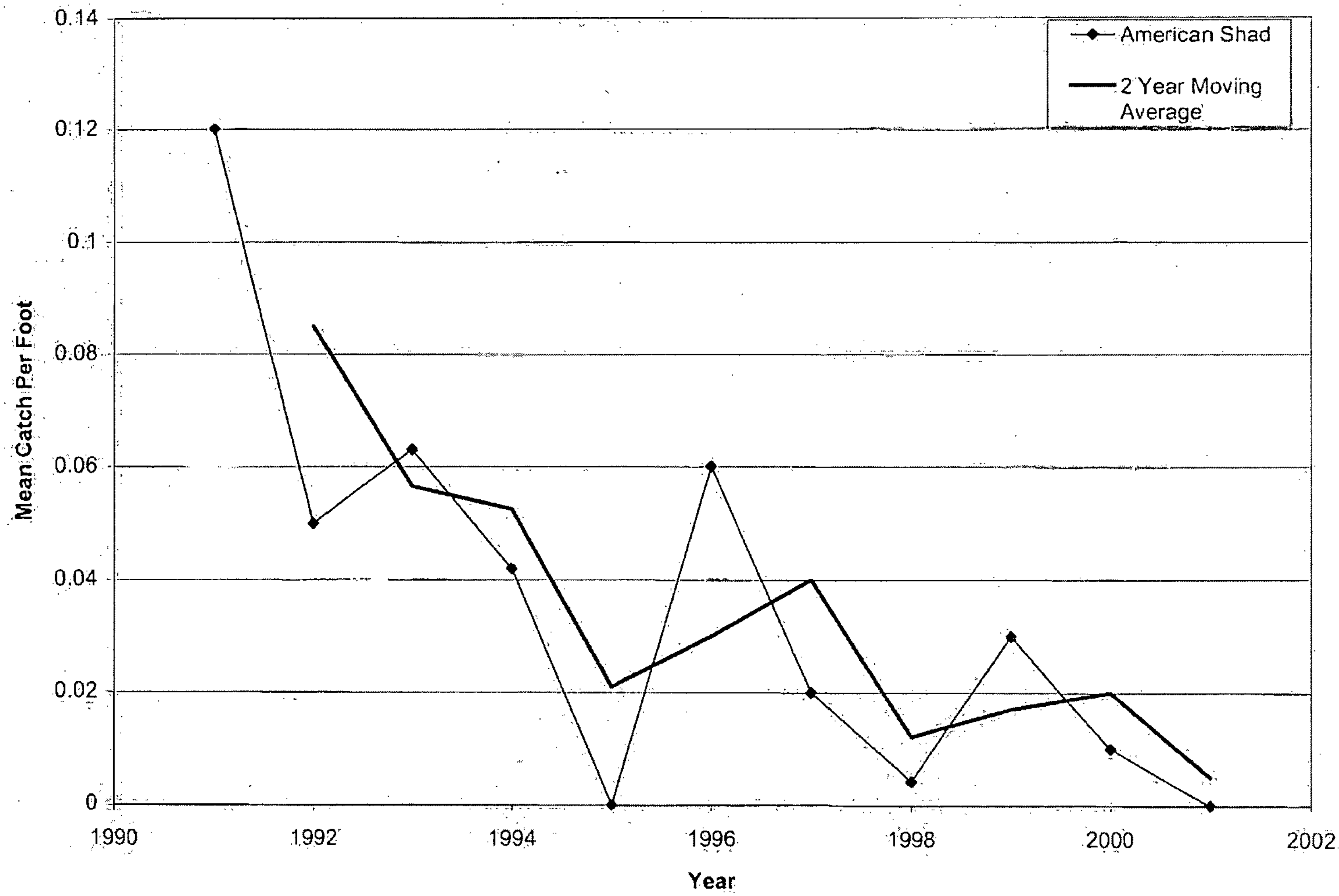


Figure 7-7 DNREC Juvenile Trawl Data 1991-2002
Alewife

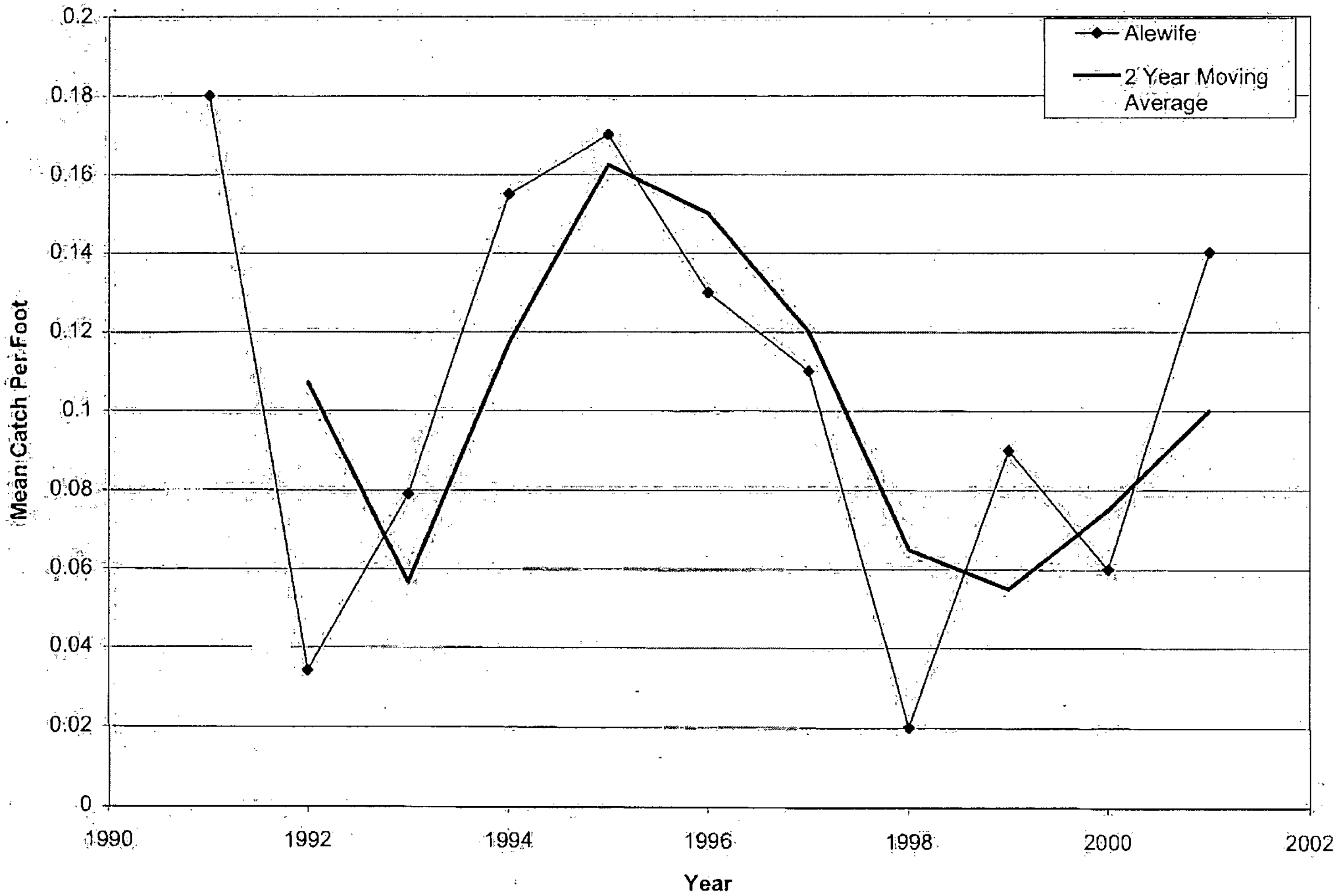


Figure 7-8 DNREC Juvenile Trawl Data 1991-2002
Blueback Herring

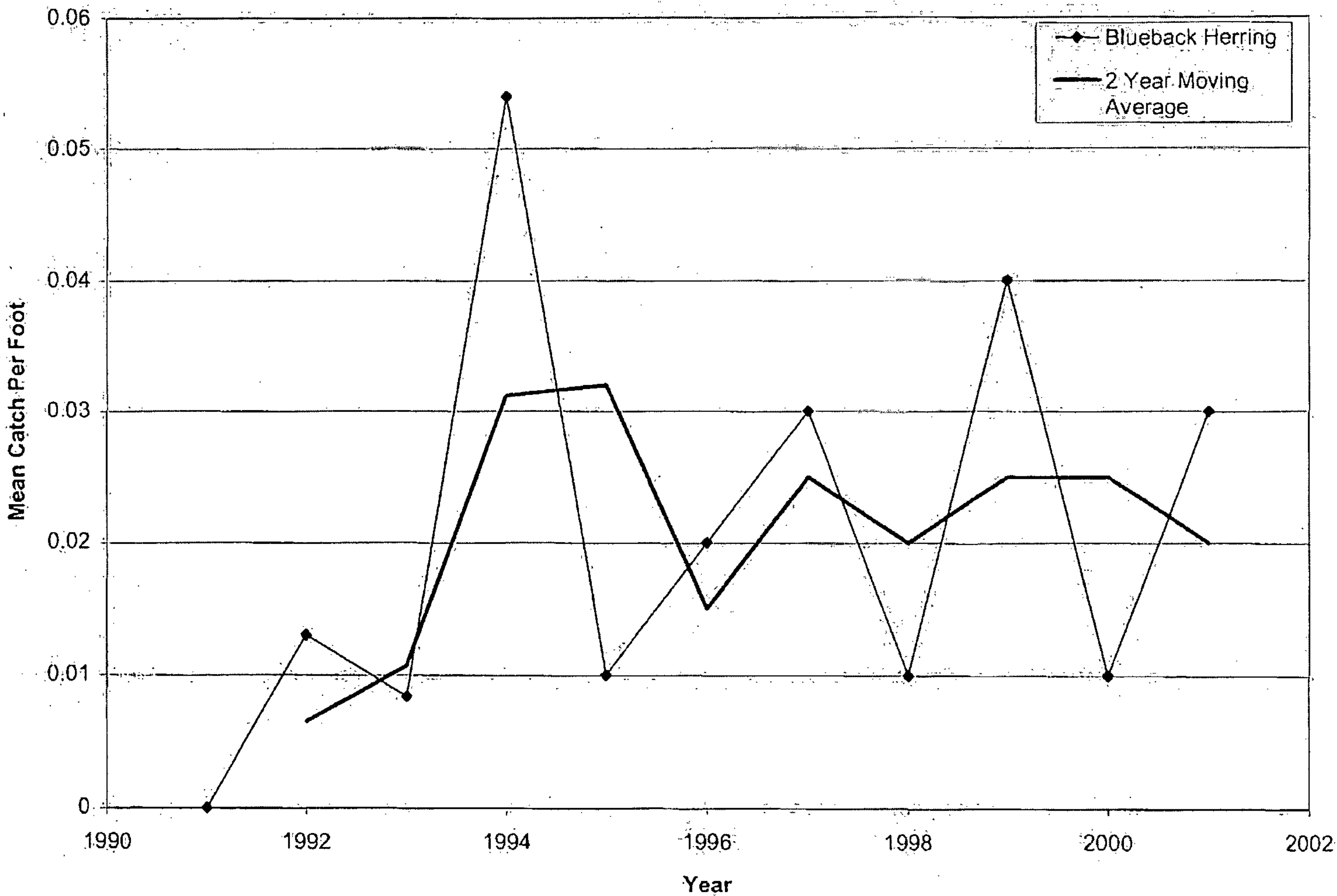


Figure 7-9 DNREC Juvenile Trawl Data 1991-2002
Bay Anchovy

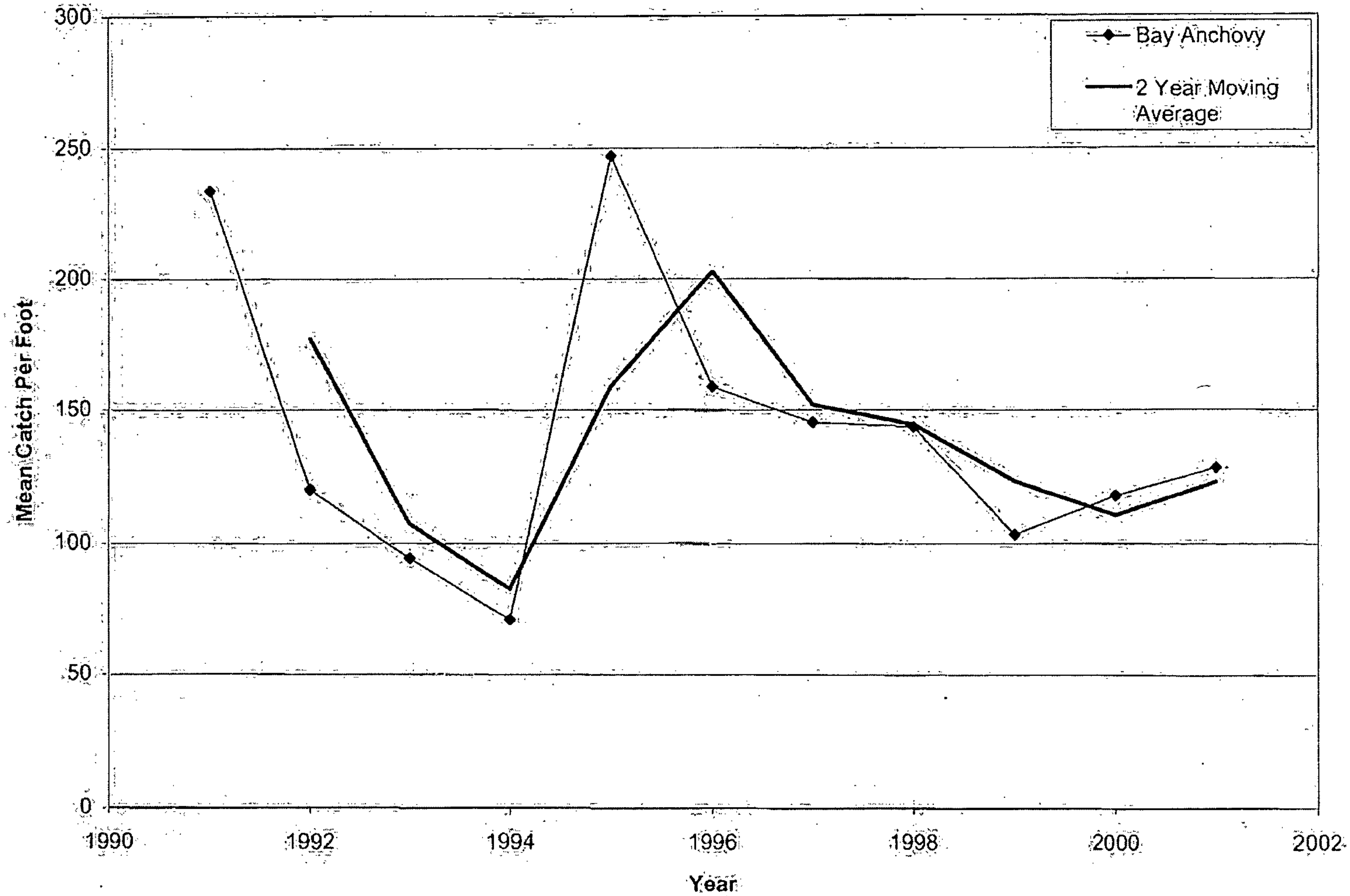
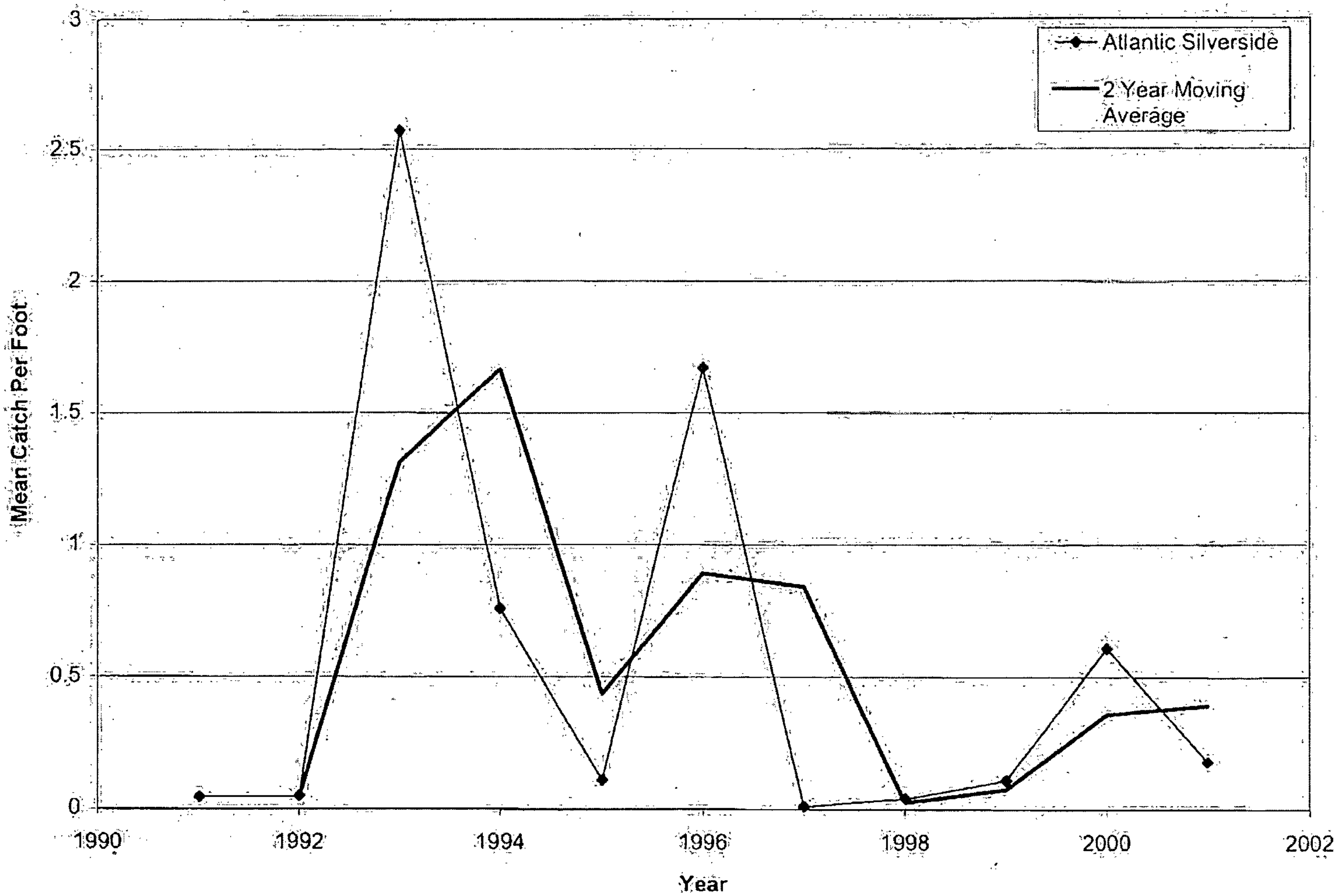


Figure 7-10 DNREC Juvenile Trawl Data 1991-2002
Atlantic Silverside



ATTACHMENT 1

Statistical Analysis of DNREC Juvenile Trawl Data Collected from the Delaware River Estuary

Date: 10/13/03
CEA No. 01067

Comparison between the mean catch per foot of fish before restorations (1991 - 1994), and after restorations were completed (1998 - 2001)

Species	Statistically significant change in numbers of fish caught by fishermen	Direction of change	Average No. of fish before the bed restoration	Average No. of fish after the bed restoration
Bay anchovy	No			
Weakfish	No			
Atlantic Croaker	No			
White Perch	No			
Spot	No			
Striped Bass	No			
Alewife	No			
American shad	Yes	Decrease	0.069	0.011
Atlantic silverside	No			
Blueback herring	No			

Comparison: Our statistical analysis compared the average number of fish caught per unit effort for the period 1991 through 1994 to the same data for the period from 1998 through 2001. The Mann-Whitney U test was used to test for any statistically significant differences between the means of these two groups of data. The FASTAT computer program was used to complete the statistical testing.

Statistical Analysis of the Number of Fish Caught Prior to (1991-1994) and After the Restorations Were Completed (1998-2001)

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KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR    8 CASES
 DEPENDENT VARIABLE IS BANCHOVY
 GROUPING VARIABLE IS     GROUP$

   GROUP       COUNT   RANK SUM

 prerest         4      16.000
 postrest        4      20.000

MANN-WHITNEY U TEST STATISTIC =        6.000
PROBABILITY IS          0.564
CHI-SQUARE APPROXIMATION =        0.333 WITH   1 DF


KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR    8 CASES
 DEPENDENT VARIABLE IS WEAKFISH
 GROUPING VARIABLE IS     GROUP$

   GROUP       COUNT   RANK SUM

 prerest         4      22.000
 postrest        4      14.000

MANN-WHITNEY U TEST STATISTIC =       12.000
PROBABILITY IS          0.248
CHI-SQUARE APPROXIMATION =        1.333 WITH   1 DF


KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR    8 CASES
 DEPENDENT VARIABLE IS ACROAKER
 GROUPING VARIABLE IS     GROUP$

   GROUP       COUNT   RANK SUM

 prerest         4      15.000
 postrest        4      21.000

MANN-WHITNEY U TEST STATISTIC =        5.000
PROBABILITY IS          0.386
CHI-SQUARE APPROXIMATION =        0.750 WITH   1 DF
```

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KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR    8 CASES
  DEPENDENT VARIABLE IS    WPERCH

  GROUPING VARIABLE IS     GROUP$

   GROUP        COUNT   RANK SUM

  prerest         4      20.000
  postrest        4      16.000

MANN-WHITNEY U TEST STATISTIC =        10.000
PROBABILITY IS          0.564
CHI-SQUARE APPROXIMATION =          0.333 WITH  1 DF


KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR    8 CASES
  DEPENDENT VARIABLE IS       SPOT
  GROUPING VARIABLE IS      GROUP$

   GROUP        COUNT   RANK SUM

  prerest         4      24.000
  postrest        4      12.000

MANN-WHITNEY U TEST STATISTIC =        14.000
PROBABILITY IS          0.083
CHI-SQUARE APPROXIMATION =          3.000 WITH  1 DF


KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR    8 CASES
  DEPENDENT VARIABLE IS STRIBASS
  GROUPING VARIABLE IS      GROUP$

   GROUP        COUNT   RANK SUM

  prerest         4      13.000
  postrest        4      23.000

MANN-WHITNEY U TEST STATISTIC =         3.000
PROBABILITY IS          0.149
CHI-SQUARE APPROXIMATION =          2.083 WITH  1 DF
```

```
KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR    8 CASES
  DEPENDENT VARIABLE IS   ALEWIFE
  GROUPING VARIABLE IS     GROUP$

    GROUP        COUNT    RANK SUM

  prerest          4       21.000
  postrest         4       15.000

MANN-WHITNEY U TEST STATISTIC =          11.000
PROBABILITY IS         0.386
CHI-SQUARE APPROXIMATION =          0.750 WITH   1 DF


KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR    8 CASES
  DEPENDENT VARIABLE IS     ASHAD
  GROUPING VARIABLE IS     GROUP$

    GROUP        COUNT    RANK SUM

  prerest          4       26.000
  postrest         4       10.000

MANN-WHITNEY U TEST STATISTIC =          16.000
PROBABILITY IS         0.021
CHI-SQUARE APPROXIMATION =          5.333 WITH   1 DF


KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR    8 CASES
  DEPENDENT VARIABLE IS   ASILVER
  GROUPING VARIABLE IS     GROUP$

    GROUP        COUNT    RANK SUM

  prerest          4       20.000
  postrest         4       16.000

MANN-WHITNEY U TEST STATISTIC =          10.000
PROBABILITY IS         0.564
CHI-SQUARE APPROXIMATION =          0.333 WITH   1 DF


KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR    8 CASES
  DEPENDENT VARIABLE IS BHERRING
  GROUPING VARIABLE IS     GROUP$

    GROUP        COUNT    RANK SUM

  prerest          4       16.000
  postrest         4       20.000

MANN-WHITNEY U TEST STATISTIC =           6.000
PROBABILITY IS         0.561
CHI-SQUARE APPROXIMATION =          0.337 WITH   1 DF
```

TABLE 7-1 DNREC Juvenile Trawl Data 1991-2001										
Year	Bay Anchovy	Weakfish	Atlantic Croaker	White Perch	Spot	Striped Bass	Alewife	American Shad	Atlantic Silverside	Blueback Herring
1991	233.66	31	9.72	3.17	8.39	0.32	0.18	0.12	0.044	0
1992	120.16	34.13	78.12	6.64	0.82	0.19	0.034	0.05	0.05	0.013
1993	94.24	37.17	14.72	3.73	9.15	0.72	0.079	0.063	2.57	0.0084
1994	70.85	53	20.3	12.55	34.14	1.1	0.155	0.042	0.76	0.054
1995	246.86	49.25	53.54	4.92	0.26	0.57	0.17	0	0.11	0.01
1996	158.65	57.29	73.83	10.55	0.16	2.76	0.13	0.06	1.67	0.02
1997	145.23	63.13	30.38	9.28	7.65	0.64	0.11	0.02	0.01	0.03
1998	143.53	30.42	63.45	3.47	0.5	0.95	0.02	0.0042	0.04	0.01
1999	103.21	33.8	71	6.76	1.38	0.58	0.09	0.03	0.11	0.04
2000	117.94	45.66	19.5	1.9	5.23	5.63	0.06	0.01	0.61	0.01
2001	128.39	25.62	70.22	3.9	0.2	4.74	0.14	0	0.18	0.03
All data is reported in Mean Catch per foot										

Results of Survey Distributed to Fishers of the Delaware Estuary

Prepared for Delaware Riverkeeper Network
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Washington Crossing, PA 18977

Prepared by Carpenter Environmental Associates, Inc.
70 Hilltop Road
Ramsey, NJ 07446

CEA Job No. 01067
December 3, 2003

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1.0 INTRODUCTION

The Public Service Electric and Gas Company (PSE&G) Salem Nuclear Generating Station (Salem facility) is located along the Delaware River Estuary at Artificial Island on the eastern shore of the Delaware River in Salem County, New Jersey. The Salem facility consists of two nuclear-powered units with once through cooling systems. Salem has a cooling water intake capacity of 3.2 billion gallons per day. Over three billion fish are killed every year due to Salem's cooling water intake. From May-June 1995 to April 1998, Salem was undergoing maintenance and did not operate at full capacity.

Carpenter Environmental Associates, Inc. (CEA) and the Delaware Riverkeeper Network (DRN) conducted a survey of local commercial and recreational fishermen to determine impacts on fishing. The intent of the survey was to compare catch from periods when the Salem facility was out of service to periods when the facility was operating. This evaluation is intended to demonstrate the long-term impact, as well as the current impact of the Salem facility on the ecosystem of the Delaware Estuary and the fishing industry. To supplement the results of the survey, CEA also evaluated data collected by the National Marine Fisheries Service.

2.0 SURVEY DEVELOPMENT

DRN and CEA developed a survey for distribution to local commercial and recreational fishers. The survey was developed, to the extent possible using previously developed and tested fisherman surveys including a previous survey prepared by DRN. No testing of the survey was conducted. The survey was peer reviewed prior to distribution by a representative of the National Marine Fisheries Service and by a target recipient (a local fisherman). Comments received were incorporated into the survey. The survey was intended to determine fishing conditions within the Delaware Estuary in the vicinity of the Salem facility prior to 1995, 1995-1997, and 1997-2002. Since recreational fishers do not typically keep detailed records, the questions were qualitative rather than quantitative in nature. The intention was to determine if fishers' perceived a change in the number and quality (weight and length) during the time period when the Salem facility was not in operation (1995-1997) as opposed to periods of operation. To prevent bias, no information regarding the intent of the survey with respect to the Salem facility was provided on the survey. A sample of the survey can be found as Attachment 1.

3.0 SURVEY DISTRIBUTION

Survey distribution was conducted by DRN through presentations at local commercial and recreational fishing organizations, the mail, and the DRN website. After initial distribution, survey follow-up was conducted including redistribution of surveys, telephone calls to clarify responses and to gather additional information. Table 1 provides information on survey distribution efforts.

4.0 SURVEY RESPONSE

A limited number of responses to the survey were received. Of the over 10,000 surveys distributed, only 43 surveys were returned, 41 of which came from recreational fishers. Due to the limited number of surveys received, no statistical analysis of the responses can be conducted. The following sections address each pertinent question raised on the survey and provide a brief narrative regarding the range of responses received.

The survey asked for information comparing fishing in the Delaware Estuary prior to 1995 to the time period 1995-1997, therefore, all surveys for which the respondent did not fish in the Delaware Estuary prior to 1995 were not included in further analysis (five surveys). One survey was rejected because it failed to provide any information in response to the questions posed. Two survey responses were rejected from analysis due to the fact that the responses were received from the same individual, yet the responses were different on each survey. One survey was rejected because the respondent did not fish the Delaware Estuary proper. One additional survey response, the only response from a commercial fisherman, was rejected because the response was to an earlier survey developed by DRN that specifically mentioned the Salem facility. A total of 33 surveys were analyzed further.

4.1 LOCATIONS

Surveys were received from recreational fishers that utilize the Delaware Estuary from the Delaware Bay north to Morrisville, PA. (Yardley not in the estuary, it just above; can we say Morrisville which is two towns down but where estuary begins?) Of the 43 surveys received, 6 failed to provide information on the locations in the Delaware Estuary that are fished. Figure 1 shows the approximate locations reported as fished.

4.2 TIME FISHED

The respondents had been fishing the Delaware Estuary between 8 and 63 years. More than 50% of the respondents had been fishing in the Delaware Estuary for 20 years or more.

On average, the respondents fished the Delaware Estuary 36 days per year, ranging from a minimum of 2 days fishing to a maximum of 200 days.

Table 2 summarizes information regarding the amount of time spent fishing by the respondents.

4.3 FISHING METHODS AND PREFERRED CATCH

Based upon the survey responses, a variety of fishing methods are utilized by recreational fishers within the Delaware Estuary, including chumming, trolling, trawling, casting, bottom fishing, drifting eels, fly fishing, netting, and lining methods.

The majority of respondents utilized casting and bottom fishing methods. Table 3 summarizes the responses regarding fishing methods.

4.4 ANALYSIS OF RESPONSES

The following sections detail the responses to the survey regarding perceived changes in numbers and size of fish during 1995-1997 and after 1997.

4.4.1 1995-1997 TIMEFRAME

The survey asked fishers to provide information regarding their experiences fishing the Delaware Estuary during the time period 1995-1997 compared to previous years. The questions pertained to perceived increases and/or decreases in the relative numbers of fish found in the Estuary as well as any changes in the relative size of fish. Tables 5 and 6 summarize the responses received.

No clear trends can be seen based upon the survey responses. More than 50% of the respondents reported increased numbers, and size (length and weight) of striped bass during this time period and 39% of the respondents reported an increase in number of Atlantic Croaker. A decrease in the number and size (length and weight) of weakfish was reported by over 35% of the respondents. For flounder, 33% of the respondents reported decreases in number and 36% and 42% noted a decrease in length and weight, respectively, during this time period. All other perceived changes in the numbers of fish within the Delaware were reported by 25% or less of the respondents (eight individuals or fewer), or approximately equal numbers of individual reported increases as reported decreases (e.g., six respondents reported an increase in bluefish and seven reported a decrease).

4.4.2 1998-2001 TIMEFRAME

The survey asked fishers to provide information regarding their experiences fishing the Delaware Estuary during the time period 1998-2001 as compared to the 1995-1997 timeframe. The questions pertained to perceived increases and/or decreases in the relative numbers of fish found in the Estuary as well as any changes in the relative size of fish. Tables 7 and 8 summarize the responses received.

Again, no clear trends can be seen based upon the survey responses. Approximately 50% of the respondents reported increased numbers and size (length and weight) of striped bass during this time period. Forty-eight percent of the respondents reported an increase in numbers of Atlantic Croaker and approximately 30% reported an increase in size (length and weight). A decrease in the number of weakfish was reported by 48% of respondents and approximately 40% of respondents reported a decrease in the size (length and weight) of weakfish. For flounder, 39% of the respondents reported decreases in number and 27% reported decreases in size (length and weight) during this time period. However, at the same time 12% reported an increase in numbers, 18% reported an increase in length and weight of flounder, 18% reported no change in numbers, and 15% reported no change in size. Approximately

25% of respondents reported a decrease in the numbers and size (length and weight) of bluefish during this time period, although 33% reported no change in either numbers or size. All other perceived changes in the numbers of fish within the Delaware were reported by 25% or less of the respondents (eight individuals or less), or approximately equal numbers of individuals reported increases as reported decreases.

5.0 NATIONAL MARINE FISHERIES SERVICE COMMERCIAL LANDINGS DATA

CEA was provided with data regarding the commercial landings of fish within the Delaware Estuary for the time period 1995-2001. The data has not been normalized to adjust for effort (time spent fishing), therefore, comparisons between years is difficult. Figures 2 through 17 show the landing information for the species of fish addressed as part of the survey. Each species is discussed below.

- Alewife: Increased landings reported in 1998. Landings in 1999-2001 are greater than in 1995-1997, but represent a sharp decline from the landings in 1998. Figure 2 shows the alewife landings between 1995-2001.
- Striped Bass: Landings have increased steadily since 1995, with a slight decline seen in 2000. Figure 3 shows striped bass landings between 1995-2001.
- Bluefish: There was a sharp increase in landings in 1996 which dropped again in 1997. Bluefish landings between 1995-2001 are shown on Figure 4.
- Carp: Carp landings declined between 1995 and 1997 and again between 1998 and 2001, with an increase seen between 1997-1998. Figure 5 depicts carp landings between 1995-2001.
- Catfish: Landings increased between 1996 and 1999, dropped in 2000 and increased again in 2001. Catfish landings are shown on Figure 6.
- Atlantic Croaker: There has been a steady increase in Atlantic croaker landings since 1995. Figure 7 shows Atlantic croaker landings.
- Drum: Landings of drum decreased between 1995-1996, with a peak in landings in 1998. Landings have declined between 1998 and 2001. Figure 8 depicts drum landings.
- American eels: American eel landings decreased between 1995 through 1998 and increased from 1999 to 2001. American eel landings are shown on Figure 9.
- Summer flounder: Landings of summer flounder were very variable, with peaks in 1996, 1998 and 2001. Figure 10 depicts summer flounder landings.
- Spanish mackeral: An increase in Spanish mackeral landings was seen in 1996, with a smaller peak in 2000. Spanish mackeral landings are shown on Figure 11.
- White perch: White perch steadily declined from 1995-1999, with an increase seen in 2000. Figure 11 shows white perch landings.
- Sea Bass: A peak in sea bass landings was seen in 1997, with landings declining from 1998 thru 2001. Sea bass landings are shown on Figure 12.
- American shad: Landings of American shad declined between 1995 and 2000. A sharp increase in landings was seen in 2001. Figure 13 depicts American shad landings.

- Sharks: Limited data was available on shark landings, however, there has been a decline in landings since 1995, with slight increases between 1996 and 1997. Shark landings are shown on Figure 14.
- Spot: A sharp increase in landings of spot was seen in 1998, with a decline back to approximate 1997 levels in 1999. Figure 15 depicts spot landings.
- Tautog: Tautog landings steeply declined in 1997. An increase was seen in 1998, with a decline from 1999-2000. Increased landings were again seen in 2001, although not to the level seen in 1995. Figure 16 depicts tautog landings.
- Weakfish: Weakfish landings peaked between 1997 and 1998, with a steady decline from 1999-2001. Weakfish landings are shown on Figure 17.

A number of species showed increases in landings during the 1996 to 1998 time frame, including alewife (1996), bluefish (1996), carp (1998), summer flounder (1996 and 1998, declines were seen in 1997), Spanish mackeral (1996), sea bass (1997), sharks (1997, limited data), spot (1998), weakfish (1997-1998). Striped bass landings and Atlantic croaker landings steadily increased over the entire time period (1995-2001).

6.0 REVIEW OF BAYWIDE DATA

CEA reviewed Delaware Department of Natural Resources and Environmental Control (DNREC) Division of Fish and Wildlife Juvenile Trawl data from 1991-2001. Table 9 shows the DNREC data.

The survey respondents' perceived increase in striped bass during the 1995-1997 time frame is supported by information available from DNREC Juvenile Trawl surveys, which showed a spike in the juvenile striped bass juvenile abundance in 1996 (Figure 19). However, a spike in the juvenile weakfish was also seen in 1997, contrary to the perception of the fishers (Figure 20). The Atlantic croaker abundance was variable, with a spike in 1996 and a decline in 1997 (Figure 21). According to the baywide abundance data, a decrease in summer flounder was seen from 1995 to 1997 as reported by the respondents (Figure 22).

The respondent's perceived increase in striped bass during the 1998-2001 time frame is supported by information available from DNREC Juvenile Trawl surveys which showed a spike in the juvenile striped bass population in 2000 (Figure 19). Declines in the juvenile weakfish population were seen in baywide data in 1998 and 2001, again supporting the perception of the fishers (Figure 20). The Atlantic croaker abundance was variable, with a spike in 1999 and a decline in 2000 with numbers increasing again in 2001 (Figure 21). For flounder, baywide abundance data shows a slight increase in numbers from 1998 and 2001, although the numbers remained below the values seen in 1995 (Figure 22), supporting the conflicting information provided by the survey respondents with 39% of the respondents reporting decreases in number, 12% of respondents reporting an increase in numbers, and 18% reporting no change. Bluefish decreased in numbers between 1997 and 1998, although 1998 values were similar to 1992-1996 values. A peak in abundance was seen in 2001 (Figure 23). Once again, this data supports the conflicting information reported by respondents, 25% of which reported a decrease in the numbers of bluefish during this time period, while 33% reported no change in either numbers or size.

We conducted a statistical analysis of the DNREC data from 1991 to 1994 to the 1995-1997 data to determine the impact, if any, of the shut down of the facility. Species evaluated included the representative important species as identified by PSE&G which are the focus of its impingement and entrainment sampling. The representative important (RIS) fish species are alewife, American shad, Atlantic Croaker, bay anchovy, blueback herring, spot, striped bass, weakfish, and white perch. Our statistical analysis did not show any statistically significant change in numbers of fish. The statistical analysis is included as Attachment 2.

7.0 CONCLUSION

The limited responses received from the distribution of the fisherman's survey did not provide sufficient information to come to a conclusion regarding the impact of the Salem facility on fishing conditions in the Delaware Estuary. For most of the species for which changes were noted (striped bass, weakfish, flounder, and Atlantic croaker) the same changes (increases or decreases) were seen during the period of shut down and after the facility resumed full operations. Analysis of commercial landings over the same time period showed increases in landings during the 1996 to 1998 time frame, including alewife (1996), bluefish (1996), carp (1998), summer flounder (1996 and 1998, declines were seen in 1997), Spanish mackeral (1996), sea bass (1997), sharks (1997, limited data), spot (1998), weakfish (1997-1998). Striped bass landings and Atlantic croaker landings steadily increased over the entire time period (1995-2001). Analysis of baywide abundance data showed no significant difference in baywide abundance values of juveniles when comparing data from 1991-1994 (facility operating at full capacity) to data from 1995-1997 (facility shut down).

8.0 REFERENCES

Permit Renewal Application, NJPDES Permit No. NJ0005622, Public Service Electric and Gas Company Salem Generating Station, March 4, 1999.

Final Report, Coastal Finfish Assessment Survey, April 1, 1998 -March 31, 1999, Delaware Department of Natural Resources and Environmental Control (DNREC) Division of Fish and Wildlife

Annual Report, Coastal Finfish Assessment Survey, April 1, 1999 -March 31, 2000, Delaware Department of Natural Resources and Environmental Control (DNREC) Division of Fish and Wildlife

Annual Report, Coastal Finfish Assessment Survey, April 1, 2000 -March 31, 2001, Delaware Department of Natural Resources and Environmental Control (DNREC) Division of Fish and Wildlife

Annual Report, Coastal Finfish Assessment Survey, April 1, 2001 -March 31, 2002, Delaware Department of Natural Resources and Environmental Control (DNREC) Division of Fish and Wildlife

Summary Tables, DNREC Juvenile Trawl Surveys 1991-1996.

National Marine Fisheries Service, Delaware River, Bay and Tributary Landings, 1995-2001.

TABLES

TABLE 1: FISH SURVEY DISTRIBUTION

12-11-2001	Sent e-mails to five fishing organizations and one press contact requesting assistance in distribution and/or help publicizing the fish survey. Made phone contact with three additional organizations.
12-11-2001	Sent e-mails to five fishing organizations and one press contact requesting assistance in distribution and/or help publicizing the fish survey. Made phone contact with three additional organizations.
1-17-2002	Mailed surveys to three individuals recommended by Dery Bennett at American Littoral Society. Two completed surveys were returned.
1-23-2002	Mailed 50 copies of the survey to the Delaware River Fisherman's Association for distribution at their January 31 meeting.
2-01-2002	Copy of survey included in DRN newsletter "River Rapids" mailed to 6,866 members and supporters. Delaware River Shad Fisherman's Association published a notice about the survey in their February 2002 newsletter. Twelve individual copies were given to a club representative for distribution.
2-06-02	Provided 300 copies of survey to Jersey Coast Anglers Association for distribution at the Atlantic City Boat Show.
3-05-2002	Copy of the survey was placed on the DRN website.
3-25-2002	Mailed 23 press releases including copies of the survey to media outlets adjacent to the estuary.
3-26-2002	Story was included in the 3-26-2002 edition of the Garden State Environews on line.
3-26-2002	Article about the survey appeared in the Philadelphia Inquirer. The article generated numerous requests for the survey and approximately 10 completed surveys were returned.
3-27-2002	A press release including a copy of the survey was mailed to the Delaware River Yachtmans League for distribution to their member groups.
4-09-2002	Press releases and copies of the survey were mailed to 6 additional press contacts.
5-01-2002	Survey mentioned in article in Garden State EnviroNet.
5-07-2002	E-mailed press release to fishing groups telling them that the survey was available on DRN website.
5-09-2002	Follow up contacts with 2 news papers.
5-14-2002	Made follow up calls to fishing groups.
5-20-2002	"Stop the Salem Fish Slaughter Campaign" published a notice about the survey. Discussed survey and sent copy with press release to newspaper.
7-01-2002	Notice about survey published in the July issue of "The River News" newsletter of the Delaware River Fisherman's association.

7-09-2002	Made follow up calls to fishing groups and discussed reasons for low response rate for the survey. Mailed press release and copy of survey to NJ Fisherman magazine.
8-15-2002	Press release and survey included on NJStriper website.
9-17-2002	Made follow up calls to individuals who had requested a copy of the survey but had not returned a completed survey.
10-28-2002	Copy of survey posted on website of South Jersey Bass Club association.
3-01-2003	Survey mailed to 2,900 DRN members living near the estuary. Approximately 25 responses received.

Table 2: Time Fished		
Survey	Number of Years	Number of Days Per Year
1	9	20
2	18	120
3	8	30
4	8	10
5	14	20
6	28	4
7	10	2
8	23	8
9	38	30
10	22	NA
11	23	40
12	23	100
13	27	60
14	13	30
15	33	15
16	58	5
17	NA	15
18	28	30
19	28	20
20	29	15
21	30	35
22	21	50
23	55	200
24	49	109
25	9	25
26	14	NA
27	21	45
28	18	10
29	33	10
30	19	4
31	61	5
32	63	15
33	28	NA
Maximum	63	200
Minimum	8	2
Average	26.91	36.07

NA Not Availabale

Table 3: Fishing Methods													
Survey #	Chumming	Trolling	Trawling	Casting	Bottom Fishing	Seining	Drifting Eels	Fly Fishing	Netting	Lining	Dredging	Other
1				1								
2	1	1		1	1		1	1	1			
3		1		1	1							
4				1								
5				1								
6		1		1	1							
7				1	1				1	1		
8	1	1		1								
9	1	1		1	1							
10	1			1	1		1					
11				1	1							
12	1				1							
13	1	1	1	1	1							
14		1		1	1		1					
15				1								
16					1							
17	1	1			1		1					
18		1		1	1							
19				1	1		1					
20					1							
21	1			1	1		1					
22					1		1					
23				1								1
24	1			1	1							
25				1	1							
26		1		1	1							
27				1								
28				1	1							
29				1	1			1				
30				1	1							
31		1		1	1		1					
32					1							
33		1			1							1
Total	9	12	1	26	26	0	8	2	2	1	0	2

Table 4: Preferred Catch and Actual Catch		
Species of fish	Preferred Catch	Actual Catch
Alewife	1	1
American Shad	10	8
American Eels	3	9
Atlantic Croaker	13	18
Bay Anchovy	0	0
Bluefish	20	19
Blueback Herring	5	5
Catfish	14	18
Drum	12	8
Killies	2	4
Mullet	3	2
Pinfish	0	0
Porgies	4	8
Shark	6	13
Silversides	2	2
Spot	7	10
Striped Bass	29	26
Tautog	8	7
Weakfish	22	23
White Perch	9	10
Flounder	21	19
Other-Large Mouth Bass	4	3
Other-Small Mouth Bass	3	3
Other-Carp	2	3
Other-Sea Bass	9	12
Other-Trout	0	0
Other-Chain Pickeral	0	0
Other-Crab	1	1
Other-Blowfish	1	1
Other-Walleye	1	1
Other-Sunfish	1	1
Other-Yellow Perch	1	1
Other-Blugill	1	1
Other-Fallfish	1	1
Other-Grass Carp	1	1
Other-Crappie Sucker	1	1
Other-Minnows		1
Other-SheepsHead		1

Table 5

The following is a list of fish commonly found in the Delaware Estuary. Please indicate, if possible, whether you experienced an increase, decrease, or no change in numbers during the period between 1995-1997 as compared to previous years. (Relative to the amount of time spent fishing) if you didn't fish for a particular species check "Not Fished For"

Fish Species	Total Increase	% Of Respondents Noting Increase	Total Decrease	% Of Respondents Noting Decrease	Total No Change	% Of Respondents Noting No Change	Total Not Fished For	% Of Respondents Not Fished For	Total No Response	% Of Respondents Providing No Response
Alewife	1	0.03	0	0.00	1	0.03	23	0.70	8	0.24
American Shad	3	0.09	3	0.09	3	0.09	20	0.61	4	0.12
American Eels	2	0.06	0	0.00	5	0.15	20	0.61	6	0.18
Atlantic Croaker	13	0.39	4	0.12	4	0.12	9	0.27	3	0.09
Bay Anchovy	0	0.00	0	0.00	1	0.03	23	0.70	9	0.27
Bluefish	6	0.18	7	0.21	9	0.27	7	0.21	4	0.12
Blueback Herring	2	0.06	0	0.00	3	0.09	20	0.61	8	0.24
Catfish	7	0.21	0	0.00	7	0.21	15	0.45	4	0.12
Drum	0	0.00	5	0.15	4	0.12	18	0.55	6	0.18
Killies	0	0.00	1	0.03	4	0.12	21	0.64	7	0.21
Mullet	0	0.00	1	0.03	2	0.06	23	0.70	7	0.21
Pinfish	0	0.00	0	0.00	1	0.03	24	0.73	8	0.24
Porgies	3	0.09	5	0.15	3	0.09	16	0.48	6	0.18
Shark	6	0.18	4	0.12	4	0.12	13	0.39	6	0.18
Silversides	1	0.03	0	0.00	2	0.06	21	0.64	9	0.27
Spot	2	0.06	3	0.09	4	0.12	16	0.48	8	0.24
Striped Bass	19	0.58	6	0.18	4	0.12	3	0.09	1	0.03
Tautog	0	0.00	4	0.12	3	0.09	16	0.48	10	0.30
Weakfish	6	0.18	12	0.36	5	0.15	6	0.18	4	0.12
White Perch	4	0.12	0	0.00	7	0.21	15	0.45	7	0.21
Flounder	5	0.15	11	0.33	7	0.21	7	0.21	3	0.09
Other-Spanish Mackeral	1	0.03	0	0.00	0	0.00	0	0.00	0	0.00
Other-Large Mouth Bass	0	0.00	1	0.03	1	0.03	0	0.00	0	0.00
Other-Small Mouth Bass	0	0.00	1	0.03	1	0.03	0	0.00	0	0.00
Other-Trigger Fish	1	0.03	0	0.00	0	0.00	0	0.00	0	0.00
Other-Carp	0	0.00	0	0.00	1	0.03	0	0.00	0	0.00
Other-Tiger Muskie	0	0.00	0	0.00	0	0.00	1	0.03	0	0.00
Other-Sea Bass	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

Table 6

For the period between 1995-1997, did you notice a change in the size (length or weight) of specific fish caught as compared to previous years? Please indicate whether there was an increase, decrease, or no change of fish weight and/or length for the species.

Fish Species	Total Length Increase	% Of Respondents Noting Length Increase	Total Weight Increase	% Of Respondents Noting Weight Increase	Total Length Decrease	% Of Respondents Noting Length Decrease	Total Weight Decrease	% Of Respondents Noting Weight Decrease	Total No Change	% Of Respondents Noting No Change	Total Not Fished For	% Of Respondents Not Fished For	Total No Response	% Of Respondents Providing No Response
Alewife	0	0.00	0	0.00	0	0.00	1	0.03	1	0.03	23	0.70	8	0.24
American Shad	2	0.06	1	0.03	0	0.00	1	0.03	4	0.12	20	0.61	6	0.18
American Eels	1	0.03	1	0.03	2	0.06	1	0.03	4	0.12	20	0.61	5	0.15
Atlantic Croaker	5	0.15	6	0.18	1	0.03	2	0.06	11	0.33	12	0.36	3	0.09
Bay Anchovy	0	0.00	0	0.00	0	0.00	1	0.03	0	0.00	22	0.67	10	0.30
Bluefish	0	0.00	0	0.00	5	0.15	7	0.21	15	0.45	7	0.21	4	0.12
Blueback Herring	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	33	1.00
Catfish	4	0.12	5	0.15	0	0.00	1	0.03	5	0.15	16	0.48	6	0.18
Drum	0	0.00	0	0.00	5	0.15	6	0.18	3	0.09	18	0.55	6	0.18
Killies	0	0.00	0	0.00	0	0.00	1	0.03	3	0.09	22	0.67	7	0.21
Mullet	0	0.00	0	0.00	0	0.00	1	0.03	1	0.03	23	0.70	8	0.24
Pinfish	0	0.00	0	0.00	0	0.00	1	0.03	0	0.00	24	0.73	8	0.24
Porgies	0	0.00	0	0.00	2	0.06	4	0.12	9	0.27	14	0.42	6	0.18
Shark	0	0.00	0	0.00	3	0.09	6	0.18	6	0.18	15	0.45	6	0.18
Silversides	0	0.00	0	0.00	0	0.00	1	0.03	2	0.06	23	0.70	7	0.21
Spot	0	0.00	0	0.00	1	0.03	2	0.06	6	0.18	16	0.48	9	0.27
Striped Bass	18	0.55	17	0.52	3	0.09	6	0.18	6	0.18	3	0.09	0	0.00
Tautog	0	0.00	0	0.00	4	0.12	5	0.15	3	0.09	17	0.52	8	0.24
Weakfish	5	0.15	5	0.15	12	0.36	13	0.39	5	0.15	6	0.18	3	0.09
White Perch	2	0.06	2	0.06	4	0.12	3	0.09	4	0.12	14	0.42	8	0.24
Flounder	4	0.12	4	0.12	12	0.36	14	0.42	3	0.09	8	0.24	5	0.15
Other-Spanish Mackeral	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.03
Other-Large Mouth Bass	0	0.00	0	0.00	0	0.00	0	0.00	1	0.03	0	0.00	2	0.06
Other-Small Mouth Bass	0	0.00	0	0.00	0	0.00	0	0.00	1	0.03	0	0.00	1	0.03
Other-Trigger Fish	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.03
Other-Carp	0	0.00	0	0.00	0	0.00	0	0.00	1	0.03	0	0.00	0	0.00
Other-Tiger Muskie	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Other-Sea Bass	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

Table 7

The following is a list of fish commonly found in the Delaware Estuary. Please indicate, if possible, whether you experienced an increase, decrease, or no change in numbers during the period between 1998-2001 as compared to the period before 1995-1997. (Relative to the amount of time spent fishing) if you didn't fish for a particular species check "Not Fished For"

Fish Species	Total Increase	% Of Respondents Noting Increase	Total Decrease	% Of Respondents Noting Decrease	Total No Change	% Of Respondents Noting No Change	Total Not Fished For	% Of Respondents Not Fished For	Total No Response	% Of Respondents Providing No Response
Alewife	0	0.00	1	0.03	1	0.03	24	0.73	7	0.21
American Shad	1	0.03	6	0.18	3	0.09	19	0.58	4	0.12
American Eels	1	0.03	2	0.06	4	0.12	21	0.64	5	0.15
Atlantic Croaker	16	0.48	2	0.06	3	0.09	9	0.27	3	0.09
Bay Anchovy	0	0.00	0	0.00	1	0.03	24	0.73	8	0.24
Bluefish	3	0.09	8	0.24	11	0.33	8	0.24	3	0.09
Blueback Herring	1	0.03	1	0.03	4	0.12	21	0.64	6	0.18
Catfish	4	0.12	2	0.06	8	0.24	16	0.48	3	0.09
Drum	1	0.03	4	0.12	5	0.15	18	0.55	5	0.15
Killies	0	0.00	0	0.00	3	0.09	23	0.70	7	0.21
Mullet	0	0.00	0	0.00	3	0.09	23	0.70	7	0.21
Pinfish	0	0.00	0	0.00	1	0.03	25	0.76	7	0.21
Porgies	2	0.06	4	0.12	5	0.15	16	0.48	6	0.18
Shark	4	0.12	3	0.09	6	0.18	14	0.42	6	0.18
Silversides	0	0.00	0	0.00	2	0.06	24	0.73	7	0.21
Spot	2	0.06	2	0.06	4	0.12	19	0.58	6	0.18
Striped Bass	17	0.52	5	0.15	8	0.24	3	0.09	0	0.00
Tautog	0	0.00	5	0.15	3	0.09	17	0.52	8	0.24
Weakfish	4	0.12	16	0.48	3	0.09	7	0.21	3	0.09
White Perch	1	0.03	2	0.06	7	0.21	13	0.39	10	0.30
Flounder	4	0.12	13	0.39	6	0.18	7	0.21	3	0.09
Other-Spanish Mackeral	0	0.00	0	0.00	0	0.00	0	0.00	1	0.03
Other-Large Mouth Bass	0	0.00	1	0.03	1	0.03	0	0.00	0	0.00
Other-Small Mouth Bass	0	0.00	1	0.03	1	0.03	0	0.00	0	0.00
Other-Trigger Fish	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Other-Carp	0	0.00	0	0.00	1	0.03	0	0.00	0	0.00
Other-Tiger Muskie	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Other-Sea Bass	0	0.00	1	0.03	0	0.00	0	0.00	0	0.00

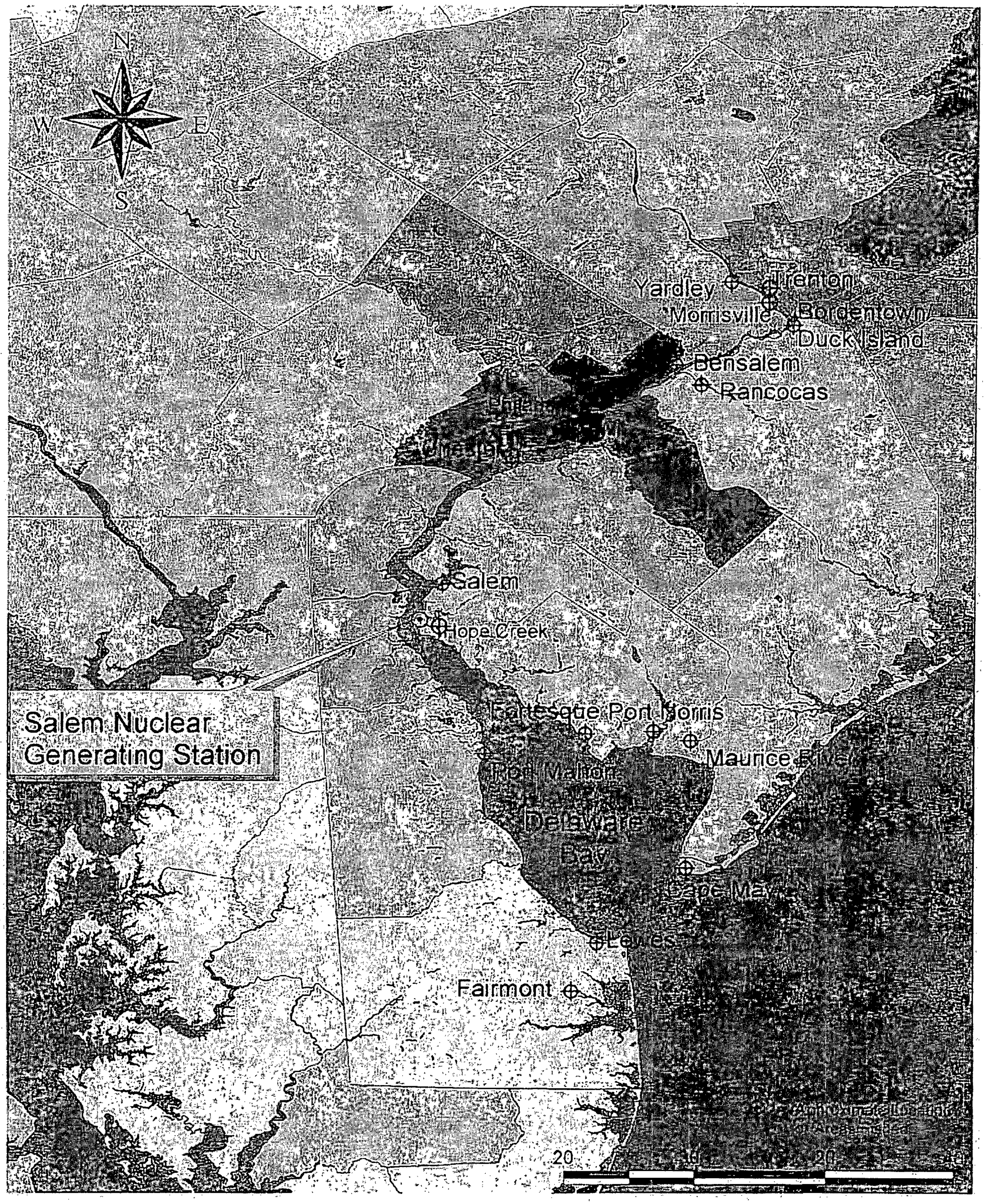
Table 8

For the period between 1998-2001, did you notice a change in the size (length or weight) of specific fish caught as compared to the period between 1995-1997? Please indicate whether there was an increase, decrease, or no change of fish weight and/or length for the species.

Fish Species	Total Length Increase	% Of Respondents Noting Length Increase	Total Weight Increase	% Of Respondents Noting Weight Increase	Total Length Decrease	% Of Respondents Noting Length Decrease	Total Weight Decrease	% Of Respondents Noting Weight Decrease	Total No Change	% Of Respondents Noting No Change	Total Not Fished For	% Of Respondents Not Fished For	Total No Response	% Of Respondents Providing No Response
Alewife	0	0.00	0	0.00	0	0.00	0	0.00	2	0.06	23	0.70	8	0.24
American Shad	1	0.03	1	0.03	2	0.06	2	0.06	6	0.18	19	0.58	5	0.15
American Eels	1	0.03	1	0.03	0	0.00	0	0.00	6	0.18	20	0.61	6	0.18
Atlantic Croaker	10	0.30	9	0.27	2	0.06	2	0.06	6	0.18	9	0.27	6	0.18
Bay Anchovy	0	0.00	0	0.00	0	0.00	0	0.00	1	0.03	22	0.67	10	0.30
Bluefish	1	0.03	1	0.03	8	0.24	9	0.27	11	0.33	7	0.21	5	0.15
Blueback Herring	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	33	1.00
Catfish	4	0.12	3	0.09	1	0.03	0	0.00	8	0.24	15	0.45	5	0.15
Drum	1	0.03	1	0.03	4	0.12	4	0.12	4	0.12	17	0.52	7	0.21
Killies	0	0.00	0	0.00	0	0.00	0	0.00	3	0.09	21	0.64	9	0.27
Mullet	0	0.00	0	0.00	0	0.00	0	0.00	2	0.06	22	0.67	9	0.27
Pinfish	0	0.00	0	0.00	0	0.00	0	0.00	1	0.03	23	0.70	9	0.27
Porgies	1	0.03	1	0.03	1	0.03	1	0.03	8	0.24	16	0.48	7	0.21
Shark	1	0.03	1	0.03	5	0.15	6	0.18	5	0.15	13	0.39	8	0.24
Silversides	0	0.00	0	0.00	0	0.00	0	0.00	2	0.06	23	0.70	8	0.24
Spot	0	0.00	0	0.00	1	0.03	1	0.03	6	0.18	19	0.58	7	0.21
Striped Bass	17	0.52	16	0.48	4	0.12	6	0.18	4	0.12	3	0.09	3	0.09
Tautog	0	0.00	0	0.00	4	0.12	4	0.12	3	0.09	16	0.48	10	0.30
Weakfish	4	0.12	4	0.12	13	0.39	14	0.42	3	0.09	6	0.18	6	0.18
White Perch	1	0.03	1	0.03	1	0.03	1	0.03	9	0.27	14	0.42	9	0.27
Flounder	6	0.18	6	0.18	9	0.27	9	0.27	5	0.15	8	0.24	5	0.15
Other-Spanish Mackeral	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.03
Other-Large Mouth Bass	0	0.00	0	0.00	1	0.03	1	0.03	1	0.03	0	0.00	0	0.00
Other-Small Mouth Bass	0	0.00	0	0.00	1	0.03	1	0.03	1	0.03	0	0.00	0	0.00
Other-Trigger Fish	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Other-Carp	0	0.00	0	0.00	0	0.00	0	0.00	1	0.03	0	0.00	0	0.00
Other-Tiger Muskie	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Other-Sea Bass	0	0.00	0	0.00	1	0.03	1	0.03	0	0.00	0	0.00	0	0.00

TABLE 9 DNREC Juvenile Trawl Data 1991-2001					
Year	Striped Bass	Weakfish	Atlantic Croaker	Summer Flounder	Bluefish
1991	0.32	31	9.72	0.29	0.15
1992	0.19	34.13	78.12	0.88	0.06
1993	0.72	37.17	14.72	0.63	0.06
1994	1.1	53	20.3	0.53	0.1
1995	0.57	49.25	53.54	0.65	0.1
1996	2.76	57.29	73.83	0.2	0.07
1997	0.64	63.13	30.38	0.23	0.19
1998	0.95	30.42	63.45	0.21	0.08
1999	0.58	33.8	71	0.21	0.11
2000	5.63	45.66	19.5	0.3	0.1
2001	4.74	25.62	70.22	0.35	0.44
All data is reported in Mean Catch per foot					

FIGURES



CARPENTER ENVIRONMENTAL ASSOCIATES, Inc.
CEA ENGINEERS, P.C.

Areas Fished

FIGURE 1
CEA No. 01067
Date: 11/17/03
Scale: As Shown
(1 : 1,250,000)

Figure 2
Delaware Bay, River and Tributary Landings, 1995-2001
Alewife

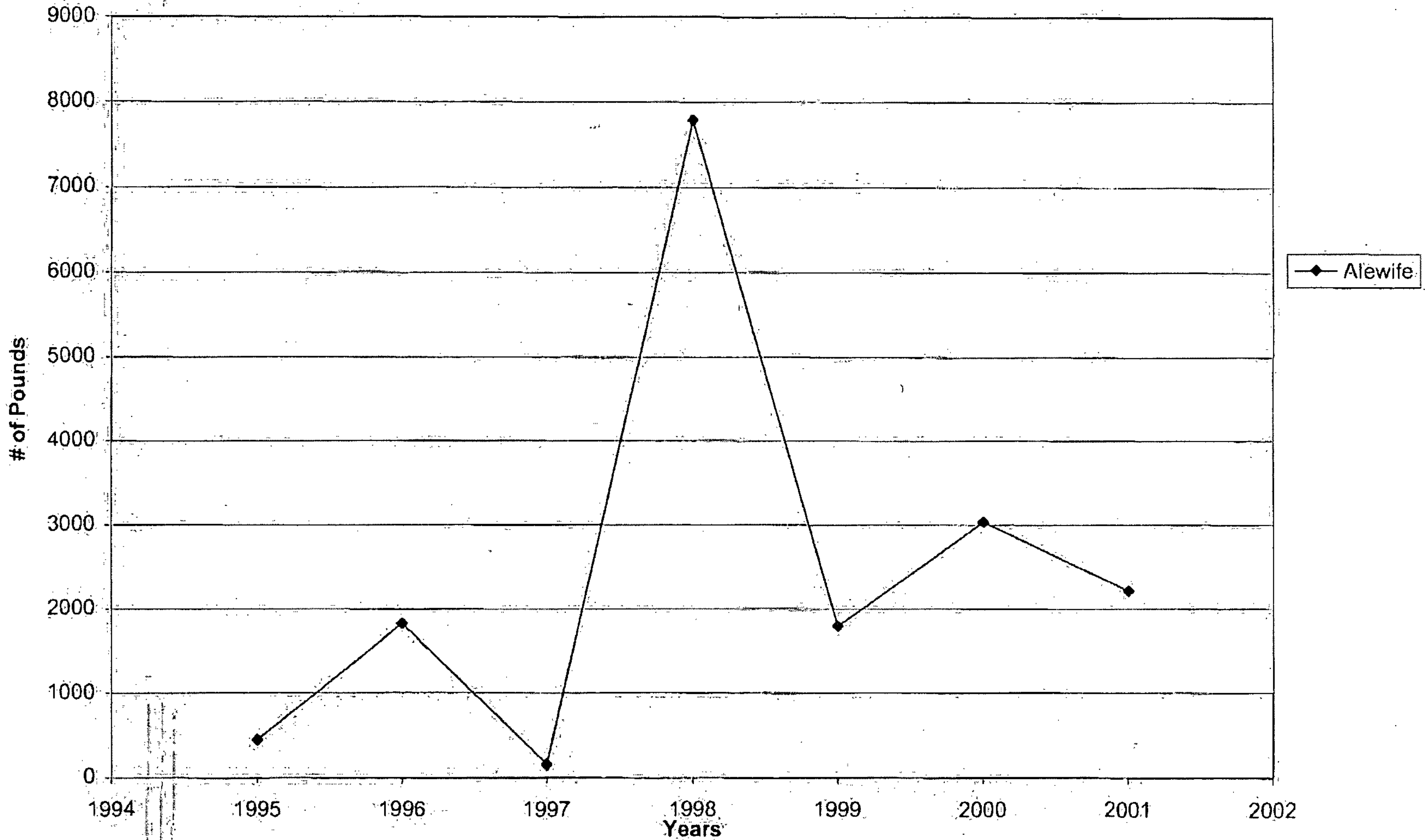


Figure 3
Delaware Bay, River and Tributary Landings, 1995-2001
Striped Bass

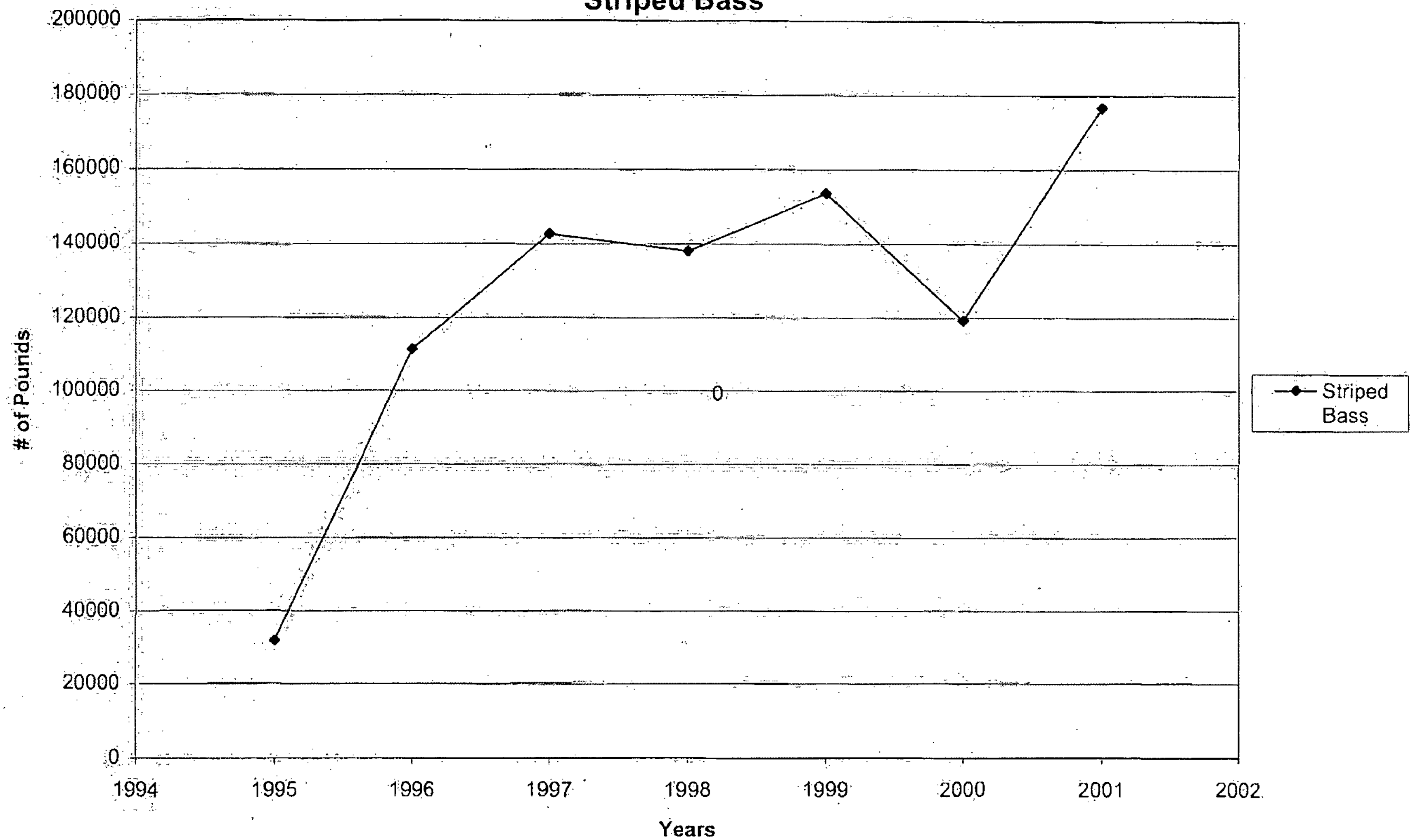
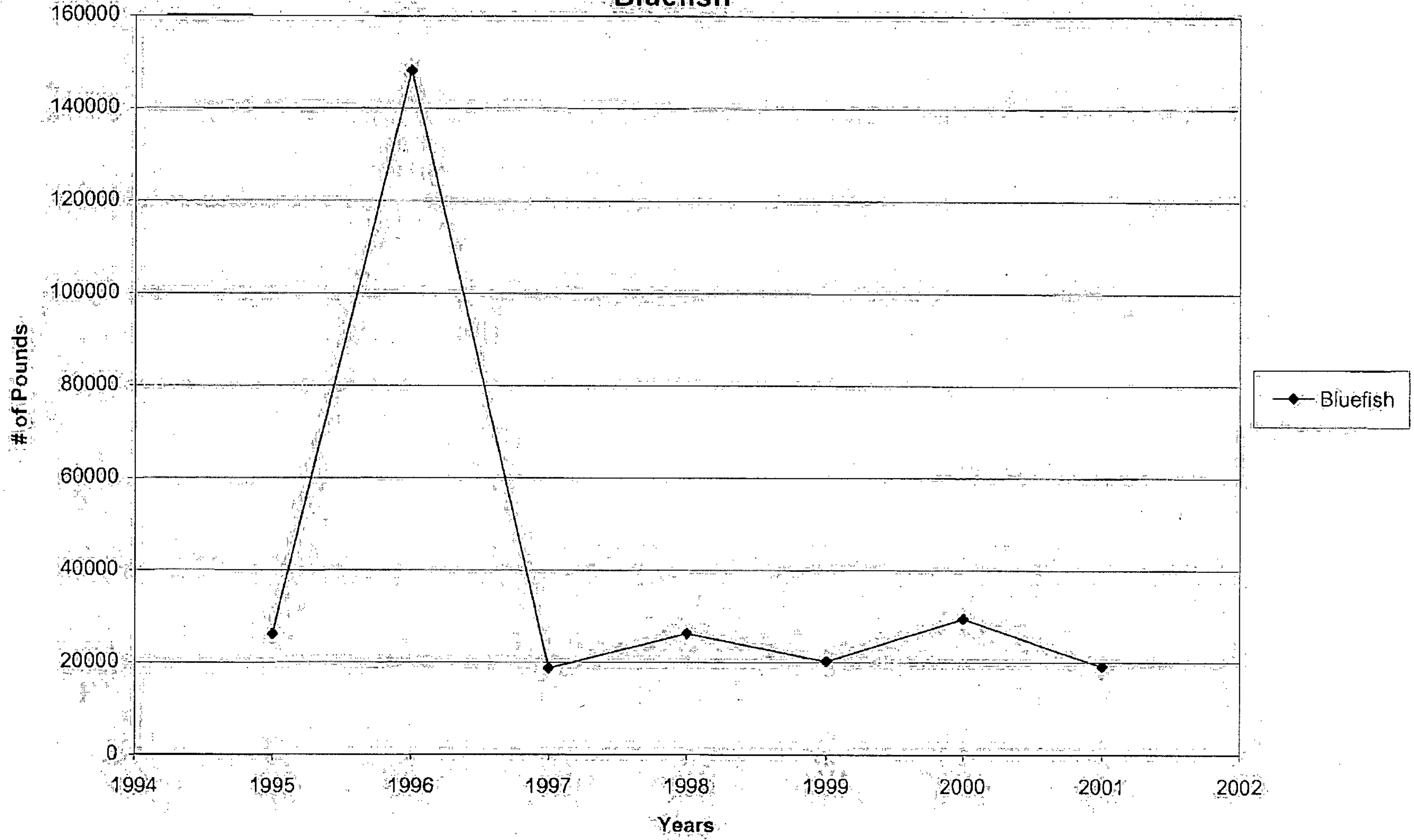


Figure 4
Delaware Bay, River and Tributary Landings, 1995-2001
Bluefish



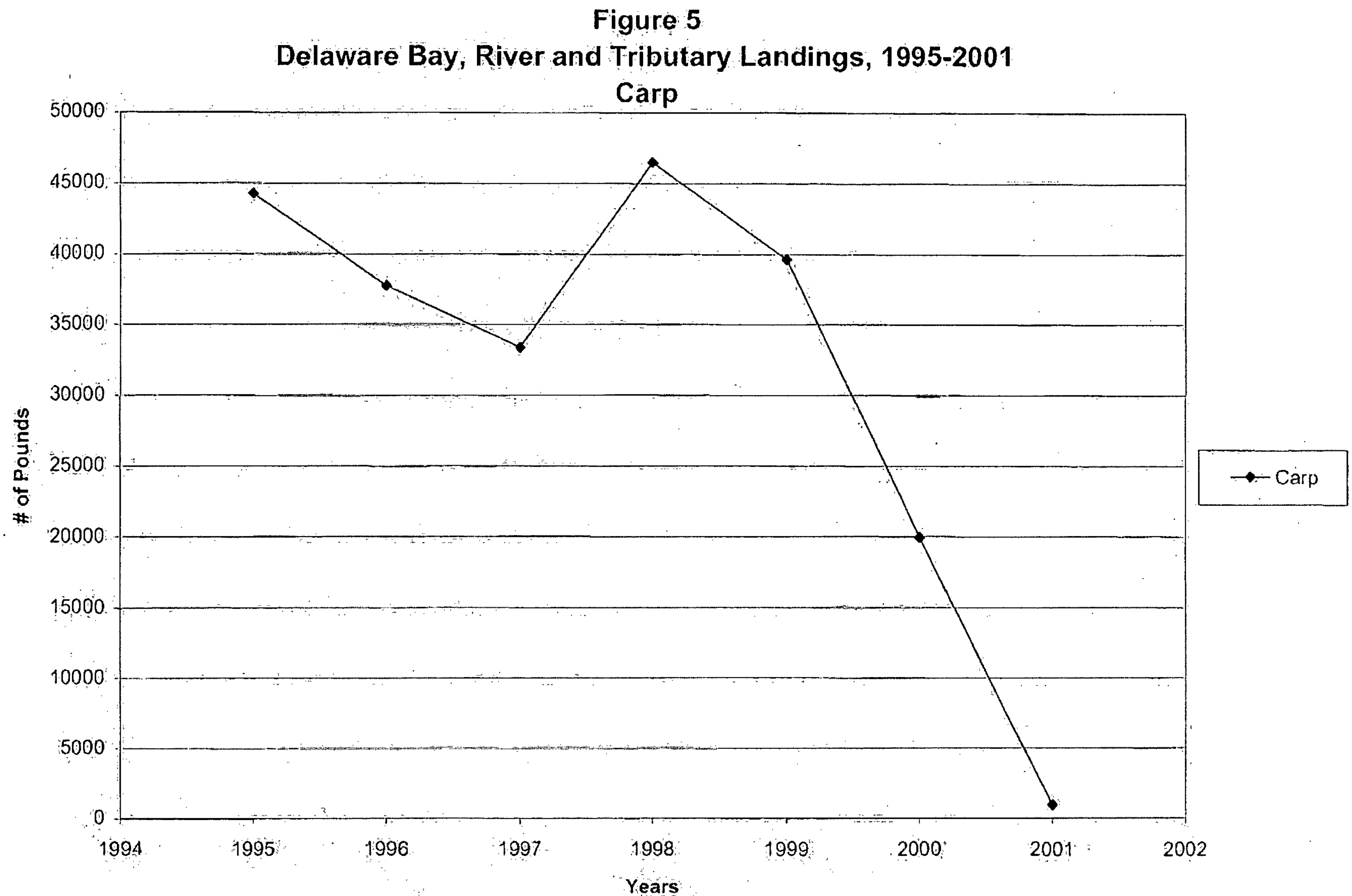


Figure 5
Delaware Bay, River and Tributary Landings, 1995-2001
Carp
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
# of Pounds
1994
1995
1996
1997
1998
1999
2000
2001
2002
Years
Carp

Figure 6
Delaware Bay, River and Tributary Landings, 1995-2001
Catfish

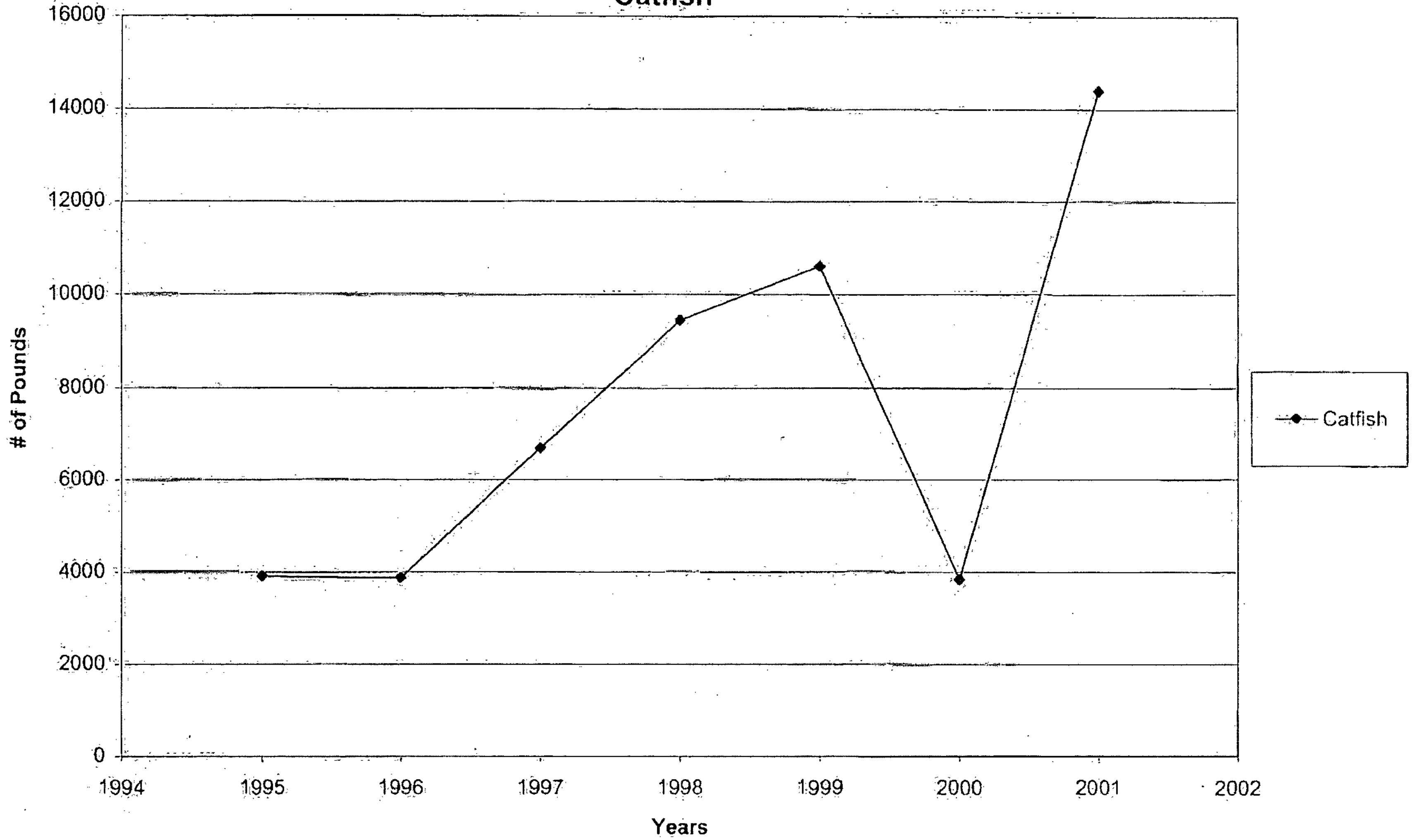


Figure 7
Delaware Bay, River and Tributary Landings, 1995-2001
Atlantic Croaker

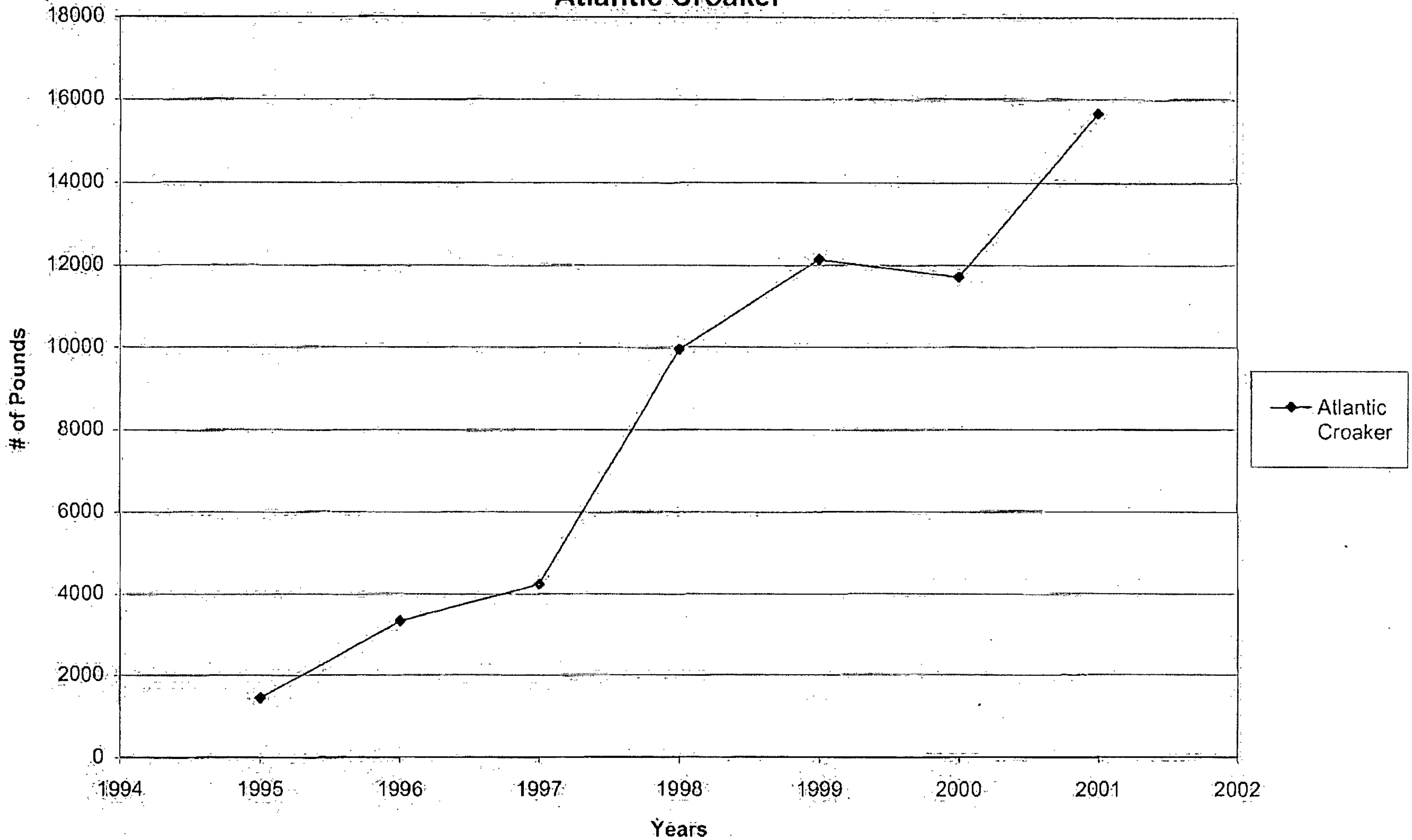


Figure 8
Delaware Bay, River and Tributary Landings, 1995-2001
Drum

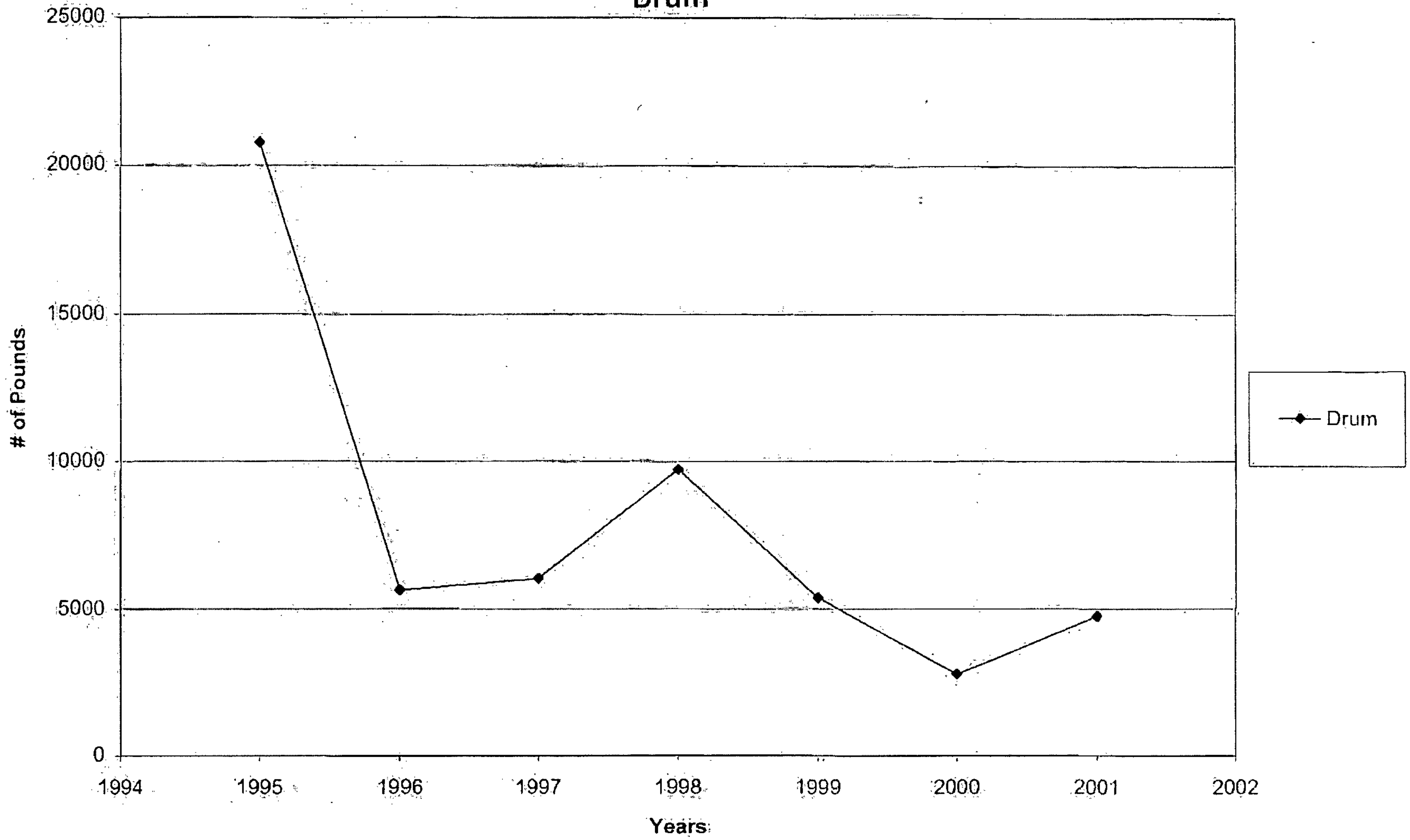


Figure 9
Delaware Bay, River and Tributary Landings, 1995-2001
American Eels

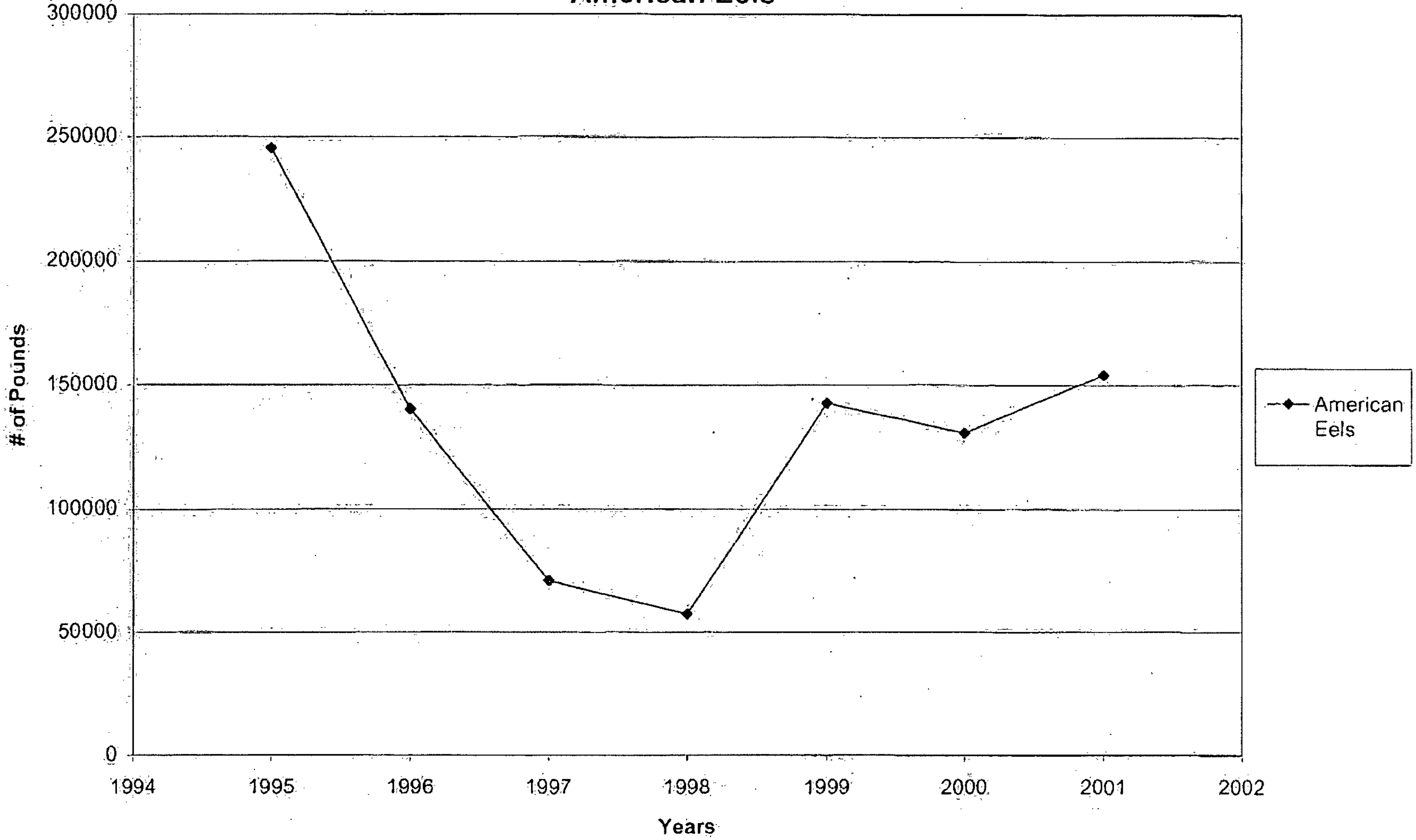


Figure 10
Delaware Bay, River and Tributary Landings, 1995-2001
Summer Flounder

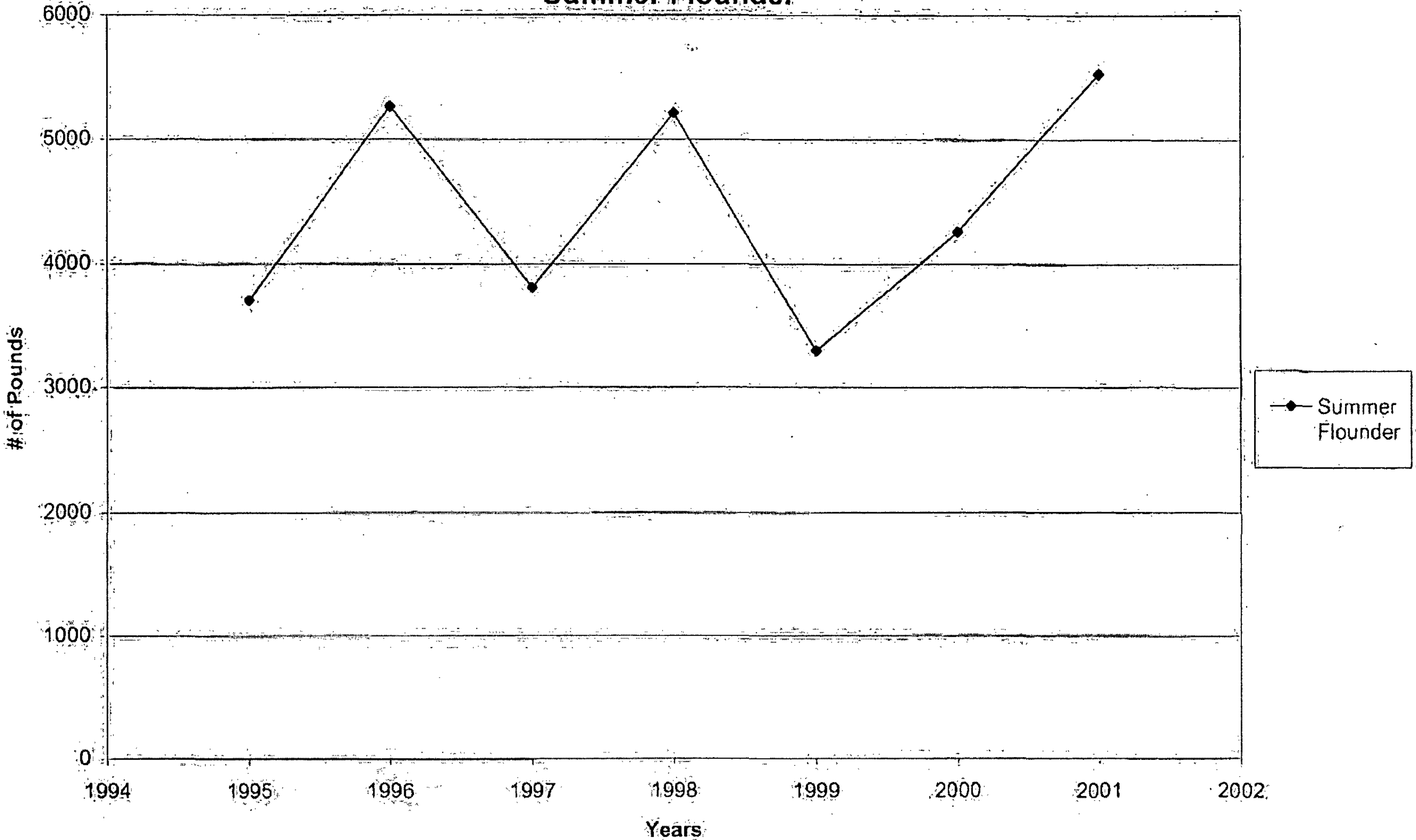


Figure 11
Delaware Bay, River and Tributary Landings, 1995-2001
Spanish Mackeral

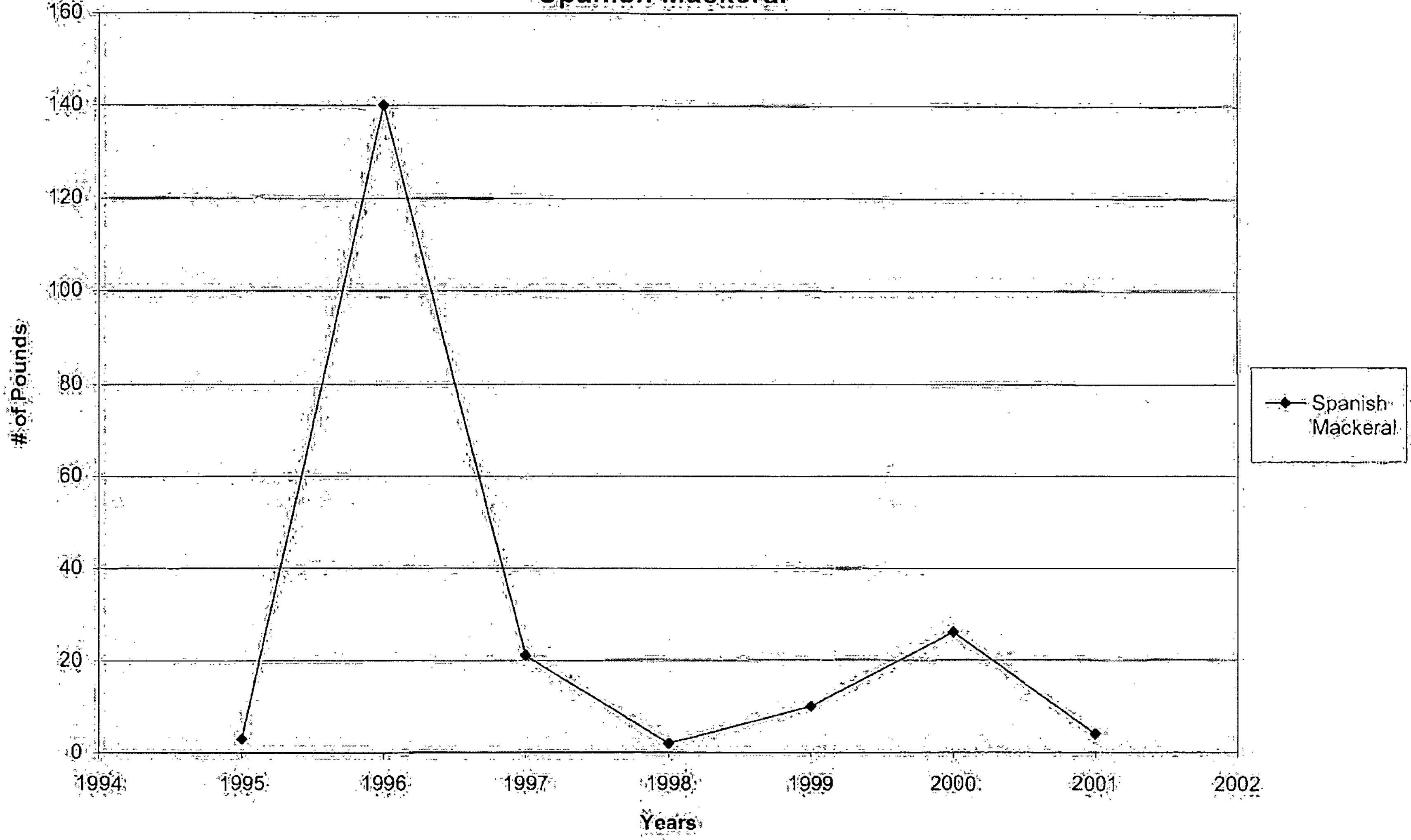


Figure 12
Delaware Bay, River and Tributary Landings, 1995-2001
White Perch

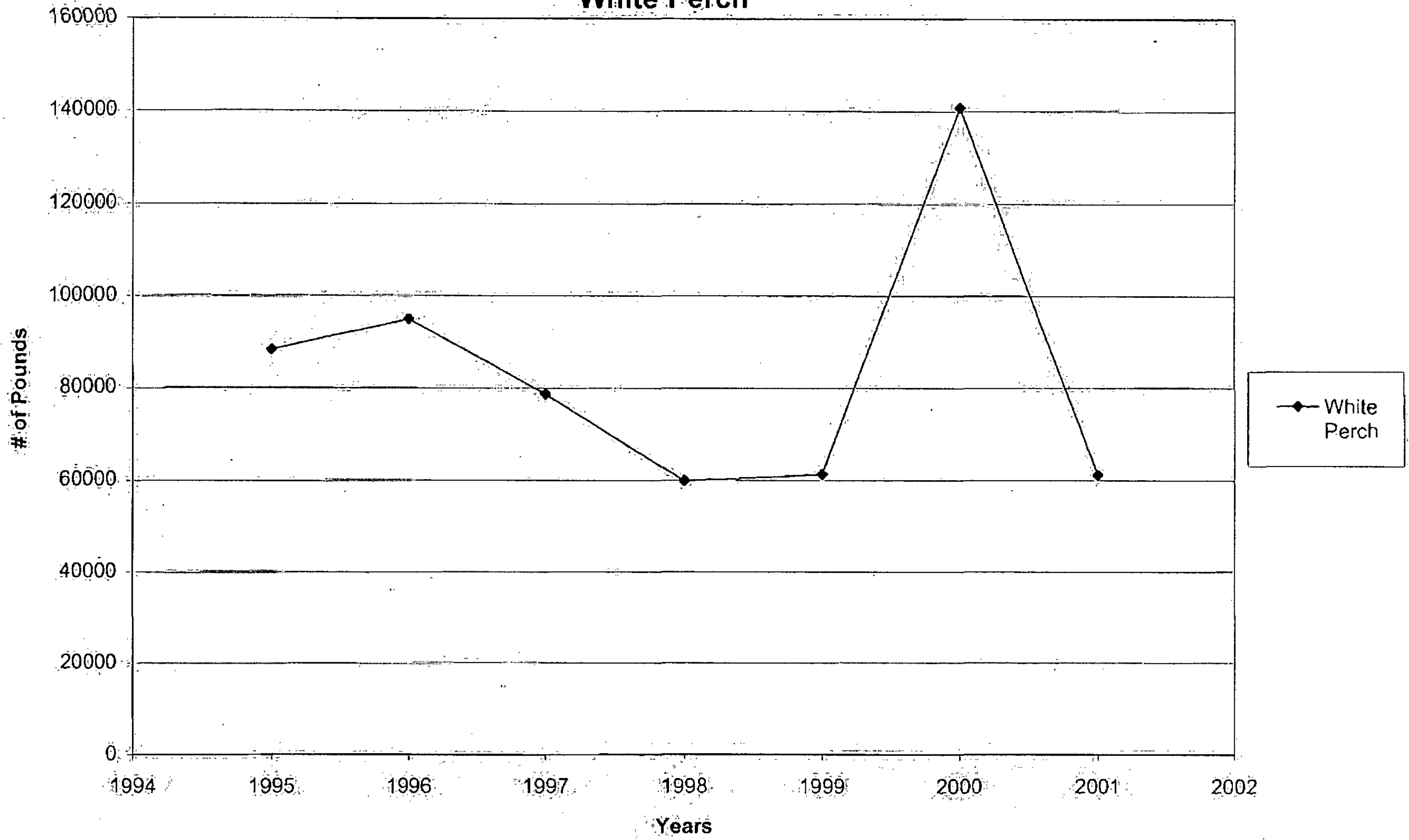


Figure 13
Delaware Bay, River and Tributary Landings, 1995-2001
Sea Bass

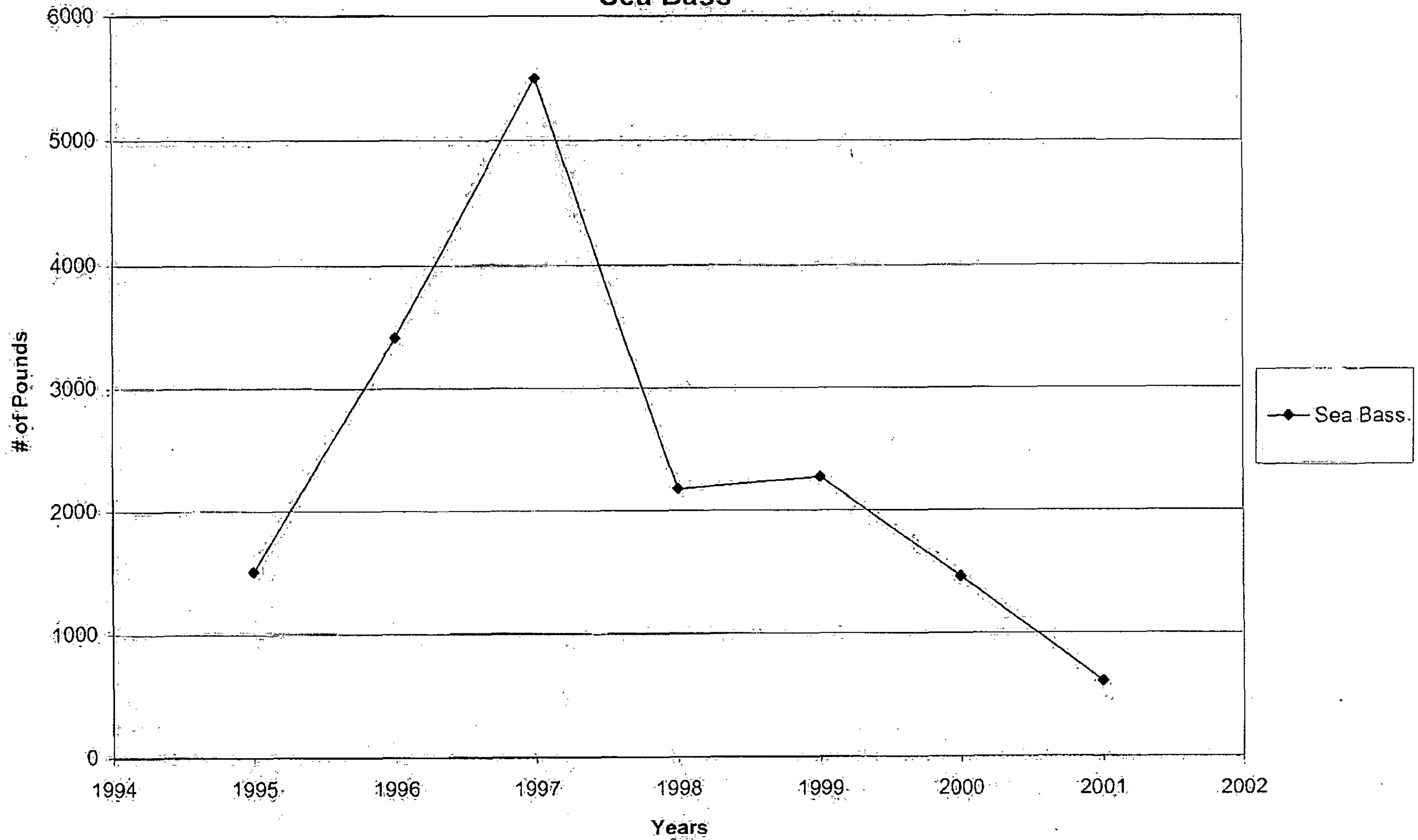


Figure 14
Delaware Bay, River and Tributary Landings, 1995-2001
American Shad

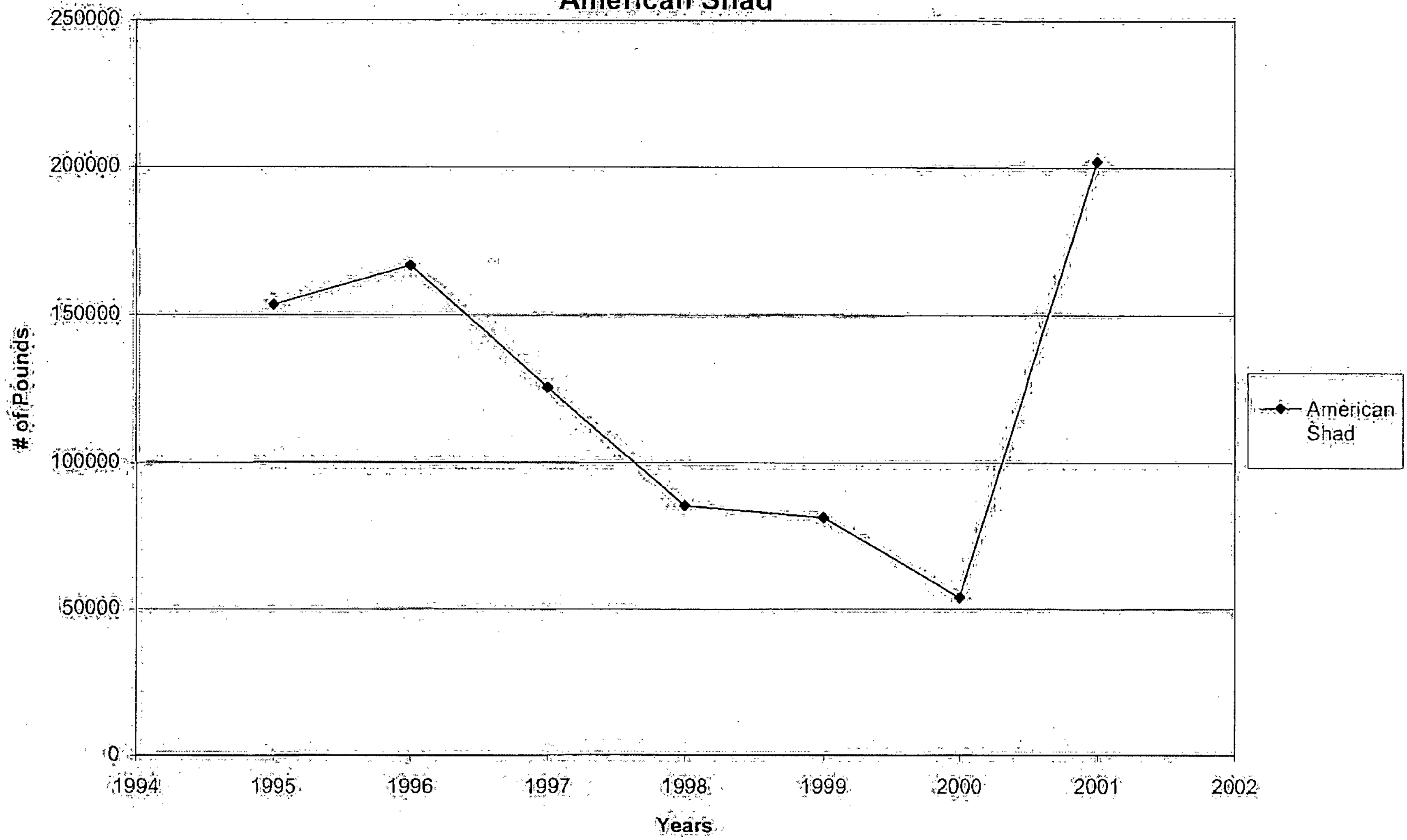


Figure 15
Delaware Bay, River and Tributary Landings, 1995-2001
Sharks

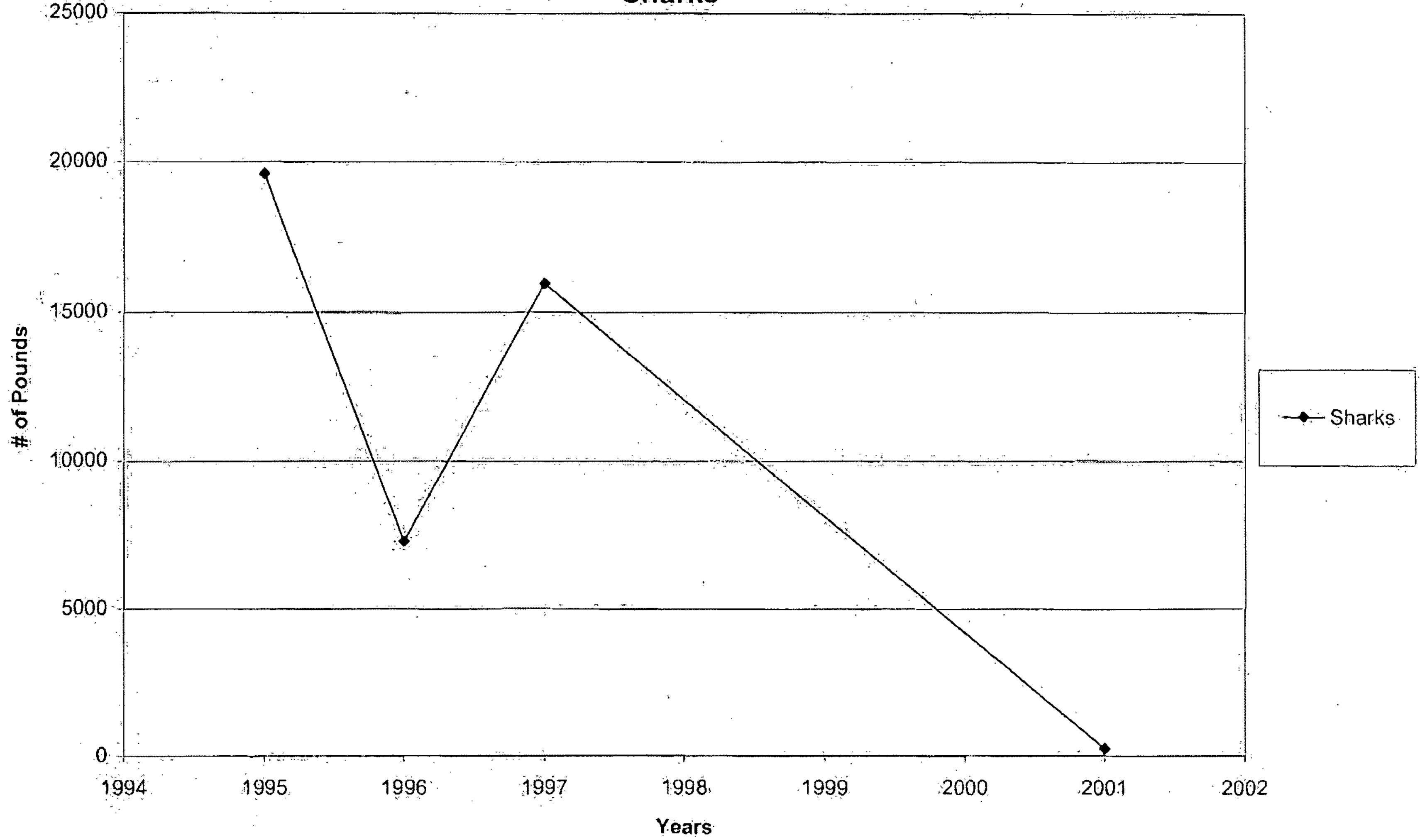


Figure 16
Delaware Bay, River and Tributary Landings, 1995-2001
Spot

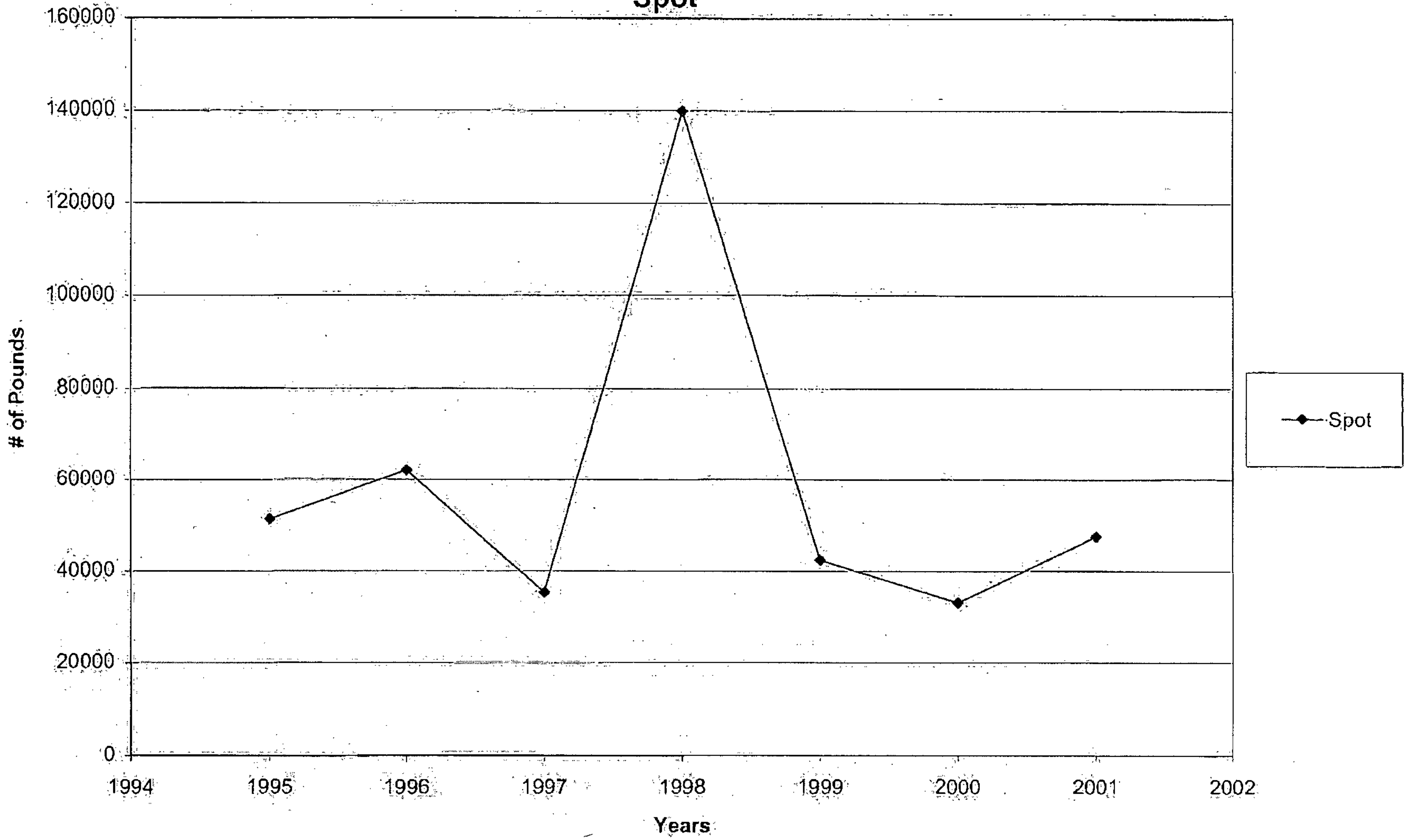


Figure 17
Delaware Bay, River and Tributary Landings, 1995-2001
Tautog

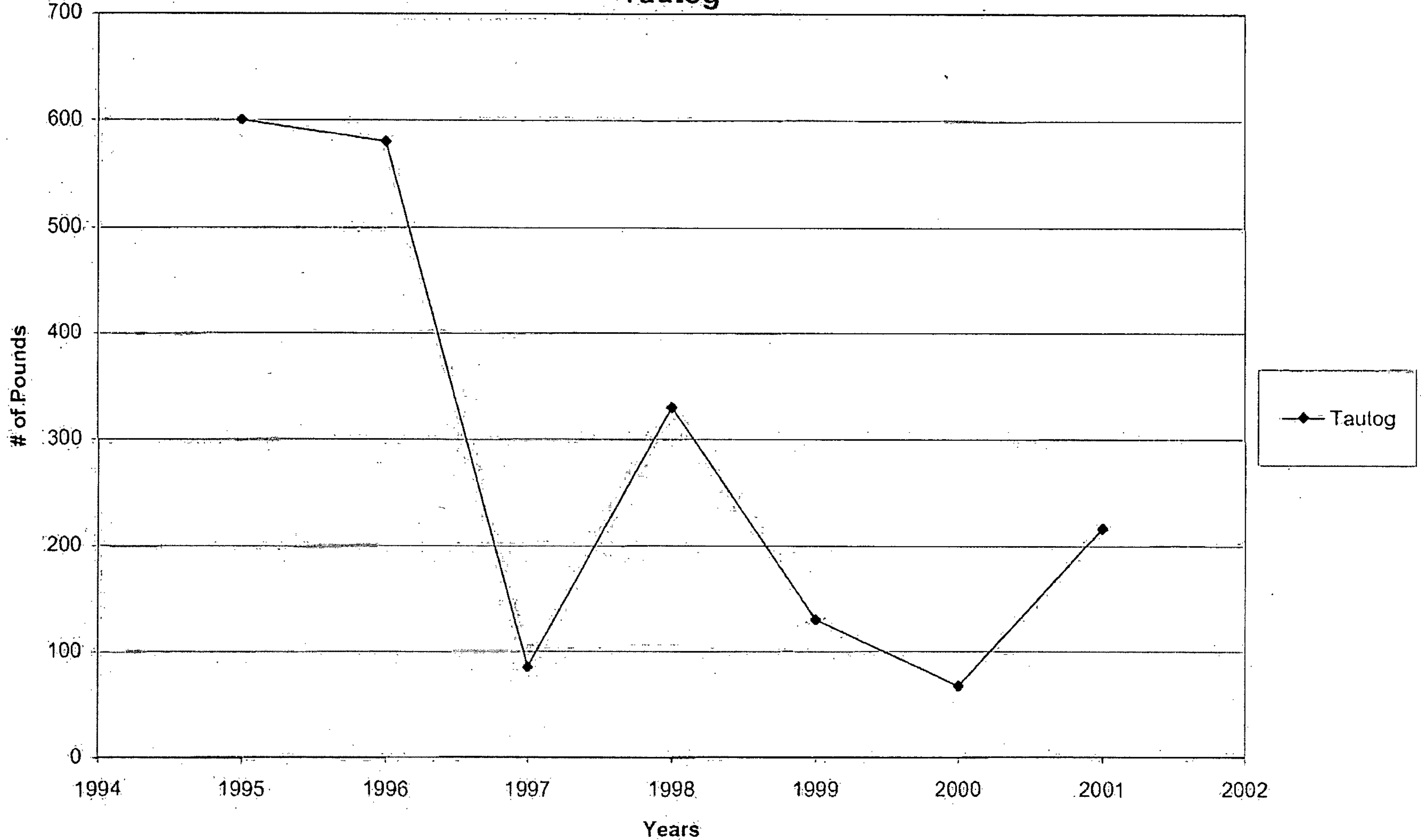


Figure 18
Delaware Bay, River and Tributary Landings, 1995-2001
Weakfish

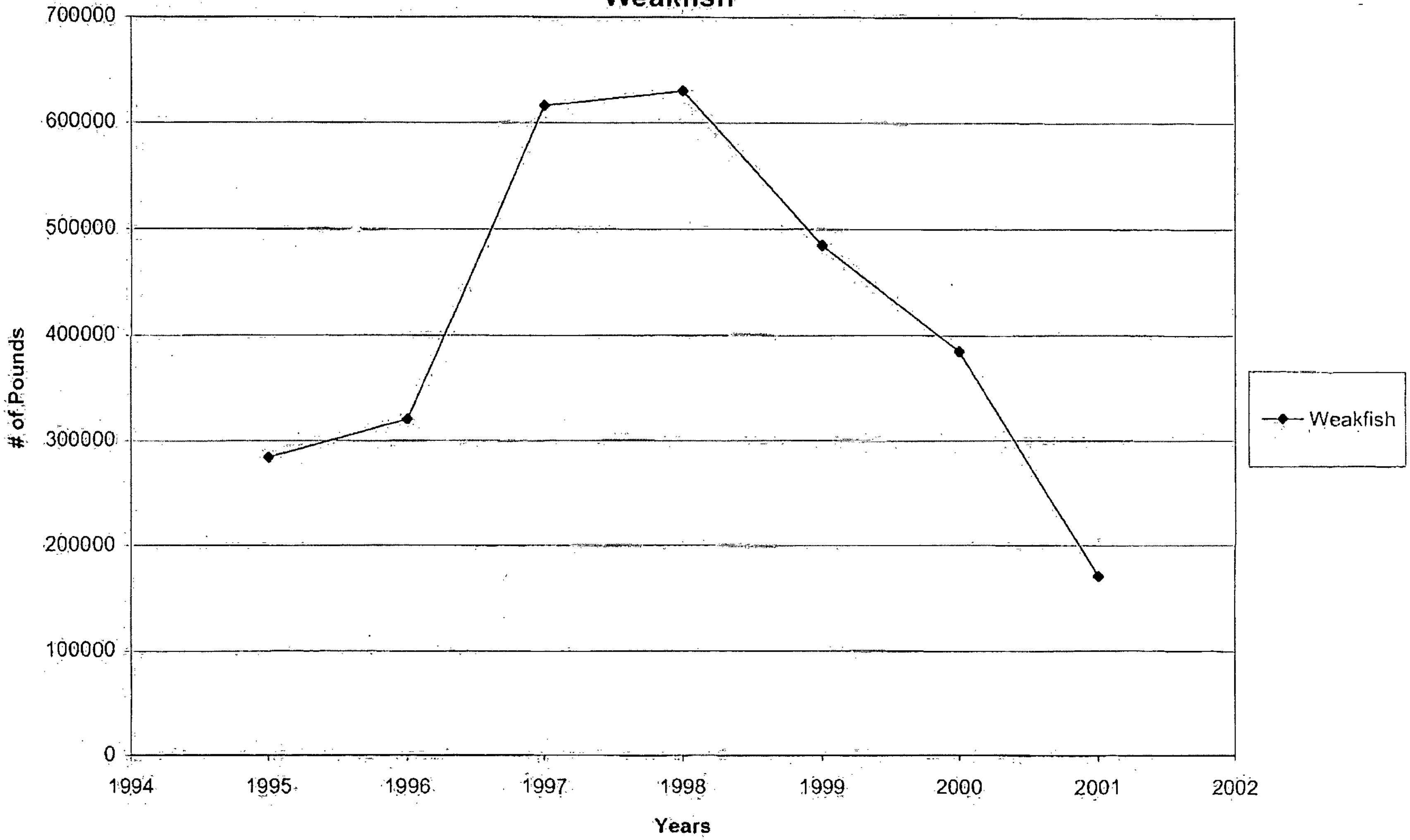


Figure 19 DNREC Juvenile Trawl Data 1991-2002
Striped Bass

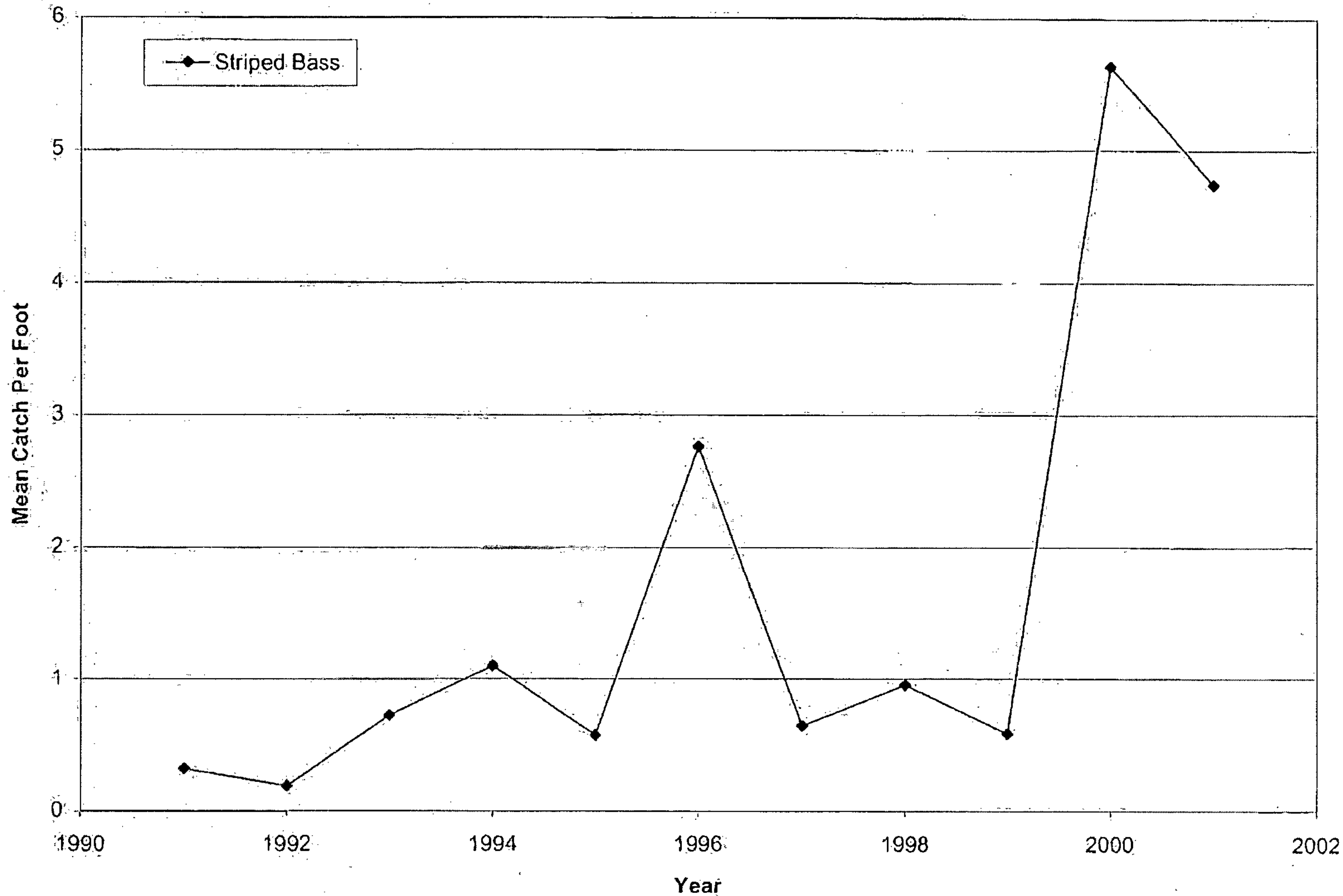


Figure 20 DNREC Juvenile Trawl Data 1991-2002
Weakfish

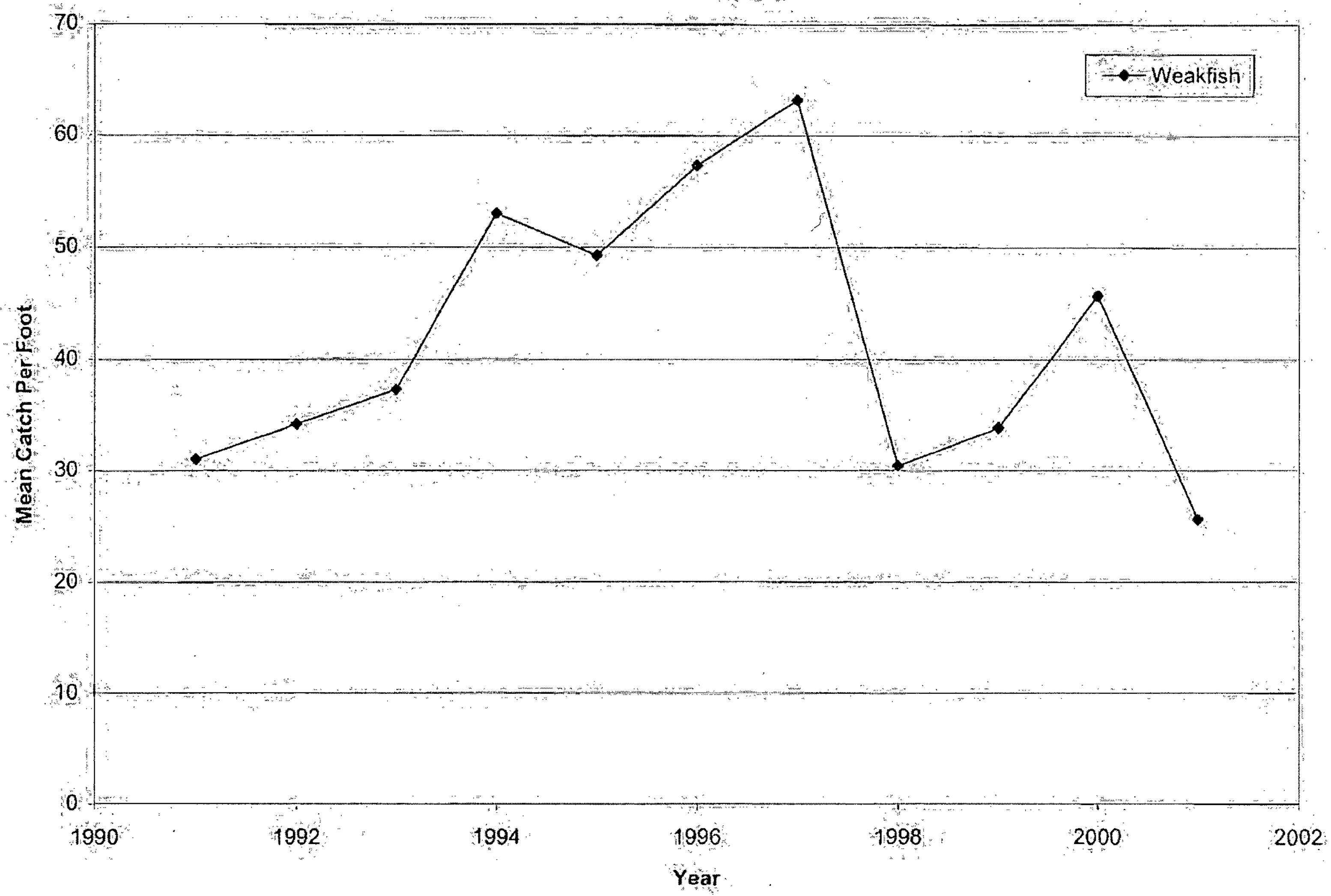


Figure 21 DNREC Juvenile Trawl Data 1991-2002
Atlantic Croaker

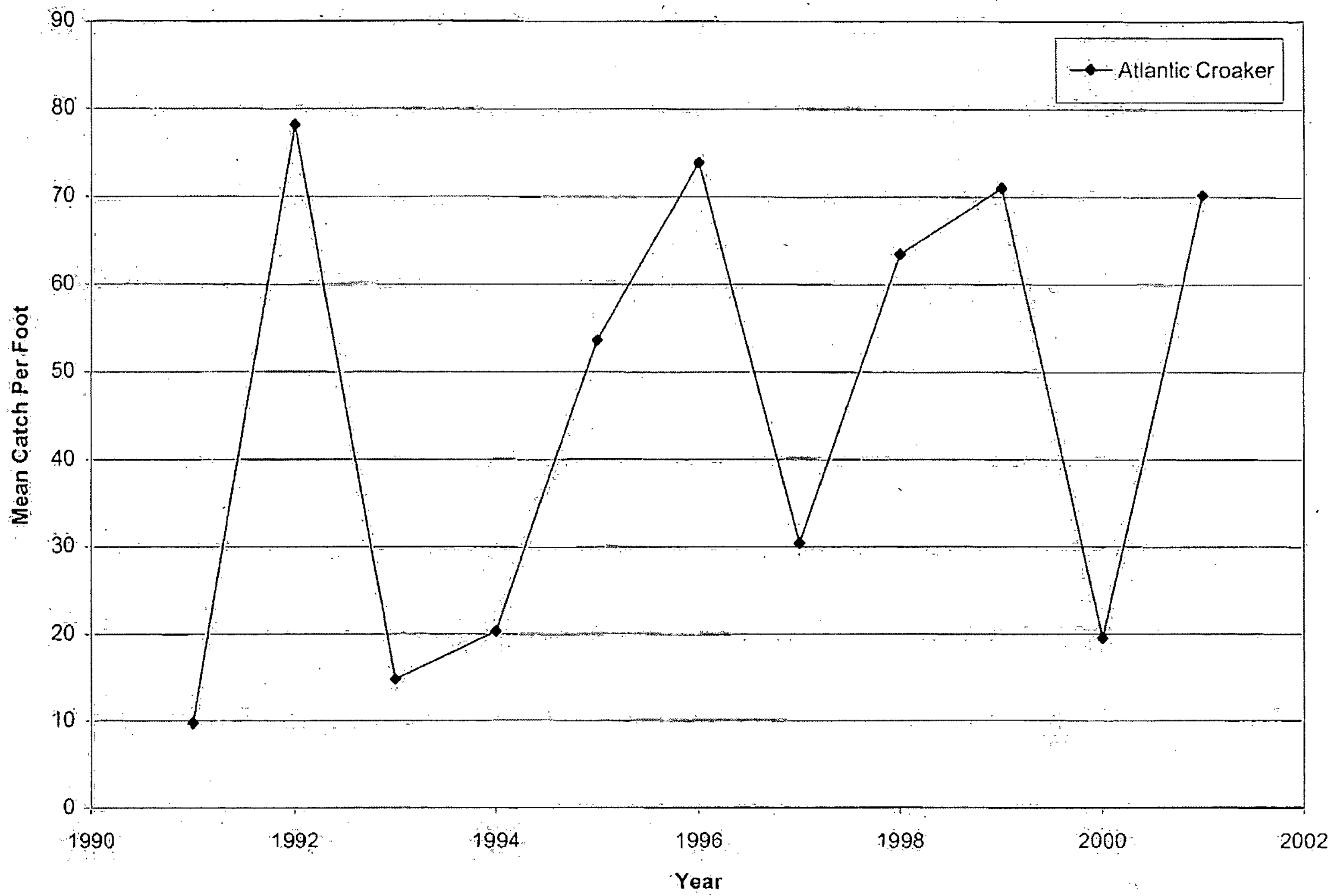


Figure 22 DNREC Juvenile Trawl Data 1991-2002
Summer Flounder

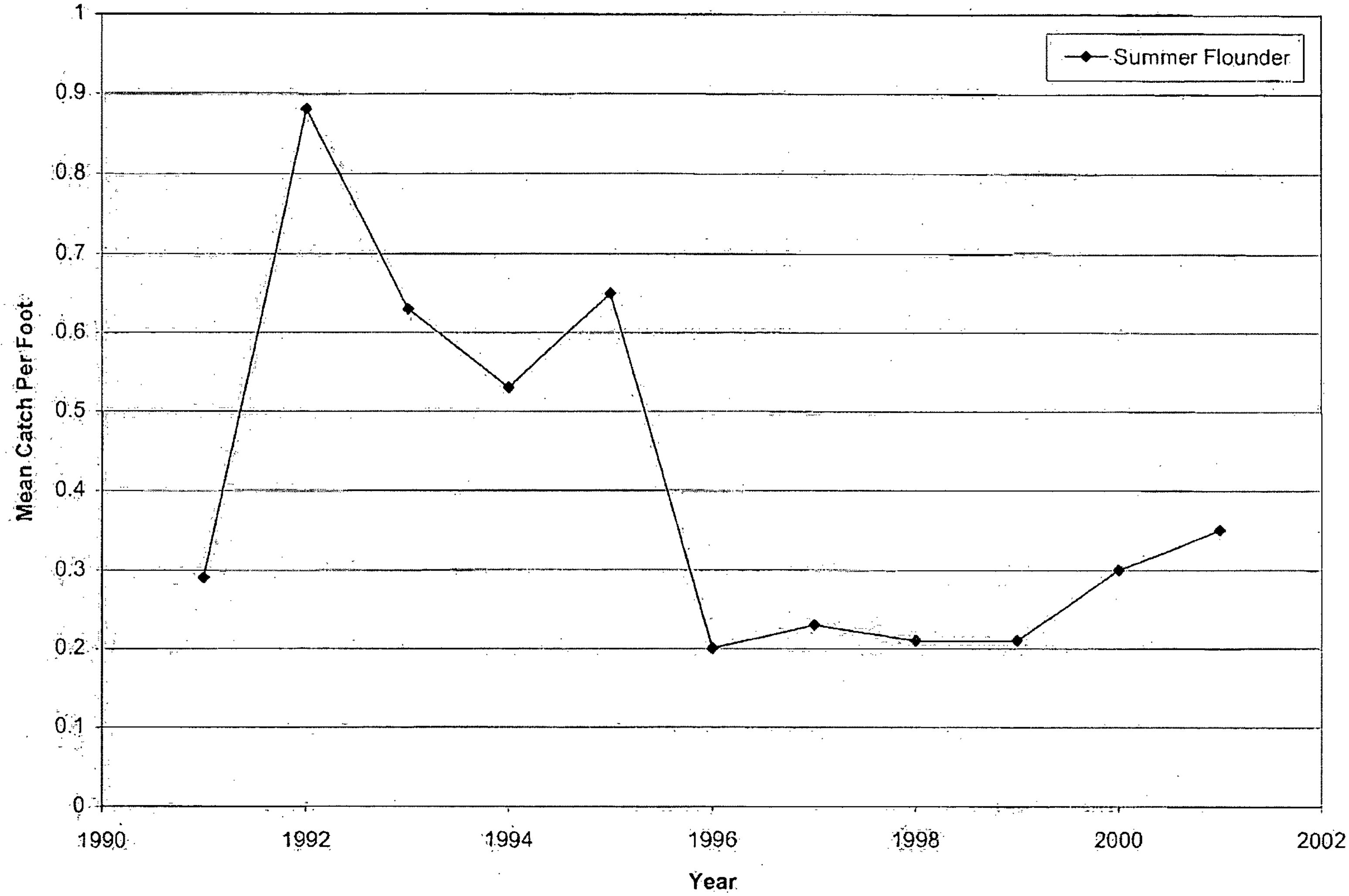
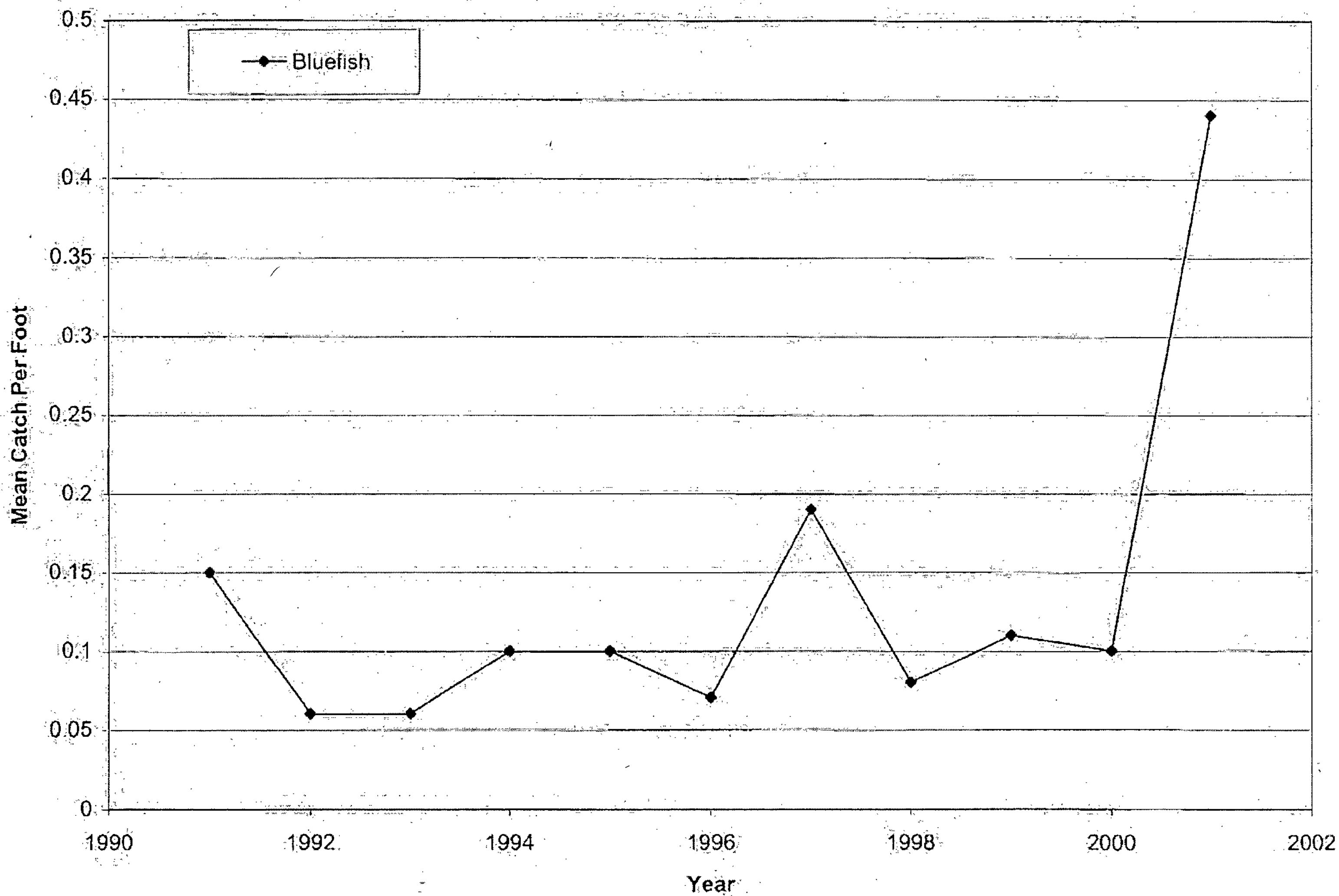


Figure 23 DNREC Juvenile Trawl Data 1991-2002
Bluefish



ATTACHMENT 1

Fish Abundance Survey for the Delaware Estuary

The results of this survey will be kept confidential, only shared with individuals outside the Delaware Riverkeeper Network in summarized form, unless specific written permission is obtained.

Anglers Name: ______________________________
Address: ______________________________
Phone &/or Email: ______________________________

1. I have been fishing the Delaware Estuary (Delaware River south of Rt. I-95, Delaware Bay and all tributaries) since (give approximate year): ____________

2. I am a: (circle one) Commercial fisherman Recreational fisherman

3. How frequently do you fish the Estuary? (days per year) ______________________________
____

4. Where in the Estuary do you fish? (near what town or landmark) ______________________________
____

5. What species of fish do you generally seek?

- ☐ Alewife
- ☐ American Shad
- ☐ American Eels
- ☐ Altantic Croaker
- ☐ Bay Anchovy
- ☐ Black sea bass
- ☐ Bluefish (including "snappers")
- ☐ Blueback Herring
- ☐ Catfish
- ☐ Drum
- ☐ Killies
- ☐ Mullet
- ☐ Pinfish
- ☐ Porgies
- ☐ Shark
- ☐ Silversides
- ☐ Spot
- ☐ Striped Bass
- ☐ Tautog
- ☐ Weakfish
- ☐ White perch
- ☐ Winter or summer flounder
- ☐ Other (Please specify) ____________

6. What species of fish do you generally catch, including incidental catch species? (Please check)

- ☐ Alewife
- ☐ American Shad
- ☐ American Eels
- ☐ Altantic Croaker
- ☐ Bay Anchovy
- ☐ Black sea bass
- ☐ Bluefish (including "snappers")
- ☐ Blueback Herring
- ☐ Catfish
- ☐ Drum
- ☐ Killies
- ☐ Mullet
- ☐ Pinfish
- ☐ Porgies
- ☐ Shark
- ☐ Silversides
- ☐ Spot
- ☐ Striped Bass
- ☐ Tautog
- ☐ Weakfish
- ☐ White perch
- ☐ Winter or summer flounder
- ☐ Other (Please specify) ____________

7. What are the methods of fishing you generally use?

- ☐ Chumming
- ☐ Trolling
- ☐ Trawling
- ☐ Casting
- ☐ Drifting Eels
- ☐ Fly Fishing
- ☐ Netting
- ☐ Lining methods

☐ Bottom Fishing ☐ Dredging
☐ Seining ☐ Other (Please specify)_______________

8. Would you be willing to share any log books or notebooks that document your catch by species, measured or estimated size, and time and location of your catches, with the Delaware Riverkeeper Network? (circle one) Yes No Don't have any logbooks

9. The following is a list of fish commonly found in the Delaware Estuary. Please indicate, if possible, whether you experienced an increase, decrease, or no change in numbers during the period between 1995-1997 as compared to previous years. (Relative to the amount of time spent fishing) If you did not fish for a particular species check "Not Fished For".

Fish Species	Increase	Decrease	No Change	Not Fished For
Alewife	☐	☐	☐	☐
American Shad	☐	☐	☐	☐
American Eels	☐	☐	☐	☐
Atlantic Croaker	☐	☐	☐	☐
Bay Anchovy	☐	☐	☐	☐
Bluefish (including "snappers")	☐	☐	☐	☐
Blueback herring	☐	☐	☐	☐
Catfish	☐	☐	☐	☐
Drum	☐	☐	☐	☐
Killies	☐	☐	☐	☐
Mullet	☐	☐	☐	☐
Pinfish	☐	☐	☐	☐
Porgies	☐	☐	☐	☐
Shark	☐	☐	☐	☐
Silversides	☐	☐	☐	☐
Spot	☐	☐	☐	☐
Striped Bass	☐	☐	☐	☐
Tautog	☐	☐	☐	☐
Weakfish	☐	☐	☐	☐
White perch	☐	☐	☐	☐
Winter or Summer flounder	☐	☐	☐	☐
Other (please specify) _______________	☐	☐	☐	☐
Other (please specify) _______________	☐	☐	☐	☐

10. For the period between 1995-1997, did you notice a change in the size (length or weight) of specific fish caught as compared to previous years? Please indicate whether there was an increase, decrease, or no change of fish weight and/or length for the species.

	Increase		Decrease			
Fish Species	Length	Weight	Length	Weight	No Change	Not Fished
Alewife	☐	☐	☐	☐	☐	☐
American Shad	☐	☐	☐	☐	☐	☐
American Eels	☐	☐	☐	☐	☐	☐
Atlantic Croaker	☐	☐	☐	☐	☐	☐
Bay Anchovy	☐	☐	☐	☐	☐	☐
Bluefish (including "snappers")	☐	☐	☐	☐	☐	☐
Catfish	☐	☐	☐	☐	☐	☐
Drum	☐	☐	☐	☐	☐	☐
Killies	☐	☐	☐	☐	☐	☐
Mullet	☐	☐	☐	☐	☐	☐
Pinfish	☐	☐	☐	☐	☐	☐
Porgies	☐	☐	☐	☐	☐	☐
Shark	☐	☐	☐	☐	☐	☐
Silversides	☐	☐	☐	☐	☐	☐
Spot	☐	☐	☐	☐	☐	☐
Striped Bass	☐	☐	☐	☐	☐	☐
Tautog	☐	☐	☐	☐	☐	☐
Weakfish	☐	☐	☐	☐	☐	☐
White perch	☐	☐	☐	☐	☐	☐
Winter or Summer flounder	☐	☐	☐	☐	☐	☐
Summer flounder	☐	☐	☐	☐	☐	☐
Other (please specify) ______	☐	☐	☐	☐	☐	☐
Other (please specify) ______	☐	☐	☐	☐	☐	☐

11. If you noticed changes in fish numbers or size, what seasons did you notice these changes (1995-1997)?

____

____

12. If you noticed changes, fish numbers or size, were these changes seen throughout the area fished?

Yes No

If No, where were these changes noted?

____

13. The following is a list of fish commonly found in the Delaware Estuary. Please indicate, if possible, whether you experienced an increase, decrease, or no change in numbers during the period between 1998-2001 as compared to the period between 1995-1997. (Relative to the amount of time spent fishing) If you did not fish for a particular species check "Not Fished For".

Fish Species	Increase	Decrease	No Change	Not Fished For
Alewife	☐	☐	☐	☐
American Shad	☐	☐	☐	☐
American Eels	☐	☐	☐	☐
Atlantic Croaker	☐	☐	☐	☐
Bay Anchovy	☐	☐	☐	☐
Bluefish (including "snappers")	☐	☐	☐	☐
Blueback herring	☐	☐	☐	☐
Catfish	☐	☐	☐	☐
Drum	☐	☐	☐	☐
Killies	☐	☐	☐	☐
Mullet	☐	☐	☐	☐
Pinfish	☐	☐	☐	☐
Porgies	☐	☐	☐	☐
Shark	☐	☐	☐	☐
Silversides	☐	☐	☐	☐
Spot	☐	☐	☐	☐
Striped Bass	☐	☐	☐	☐
Tautog	☐	☐	☐	☐
Weakfish	☐	☐	☐	☐
White perch	☐	☐	☐	☐
Winter or Summer flounder	☐	☐	☐	☐
Other (please specify) ____________	☐	☐	☐	☐
Other (please specify) ____________	☐	☐	☐	☐

14. For the period of 1998-2001, did you notice a change in the size (length or weight) of specific fish caught as compared to the period between 1995-1997? Please indicate whether there was an increase, decrease, or no change of fish weight and/or length for the species.

	Increase		Decrease			
Fish Species	Length	Weight	Length	Weight	No Change	Not Fished
Alewife	☐	☐	☐	☐	☐	☐
American Shad	☐	☐	☐	☐	☐	☐
American Eels	☐	☐	☐	☐	☐	☐
Atlantic Croaker	☐	☐	☐	☐	☐	☐
Bay Anchovy	☐	☐	☐	☐	☐	☐
Bluefish (including "snappers")	☐	☐	☐	☐	☐	☐
Catfish	☐	☐	☐	☐	☐	☐
Drum	☐	☐	☐	☐	☐	☐
Killies	☐	☐	☐	☐	☐	☐
Mullet	☐	☐	☐	☐	☐	☐
Pinfish	☐	☐	☐	☐	☐	☐
Porgies	☐	☐	☐	☐	☐	☐
Shark	☐	☐	☐	☐	☐	☐
Silversides	☐	☐	☐	☐	☐	☐
Spot	☐	☐	☐	☐	☐	☐
Striped Bass	☐	☐	☐	☐	☐	☐
Tautog	☐	☐	☐	☐	☐	☐
Weakfish	☐	☐	☐	☐	☐	☐
White perch	☐	☐	☐	☐	☐	☐
Winter or Summer flounder	☐	☐	☐	☐	☐	☐
Summer flounder	☐	☐	☐	☐	☐	☐
Other (please specify) ______	☐	☐	☐	☐	☐	☐
Other (please specify) ______	☐	☐	☐	☐	☐	☐

15. If you noticed changes in fish numbers or size, what seasons did you notice these changes (1998-2001)?

____

____

____

____

____

16. If you noticed changes, fish numbers or size, were these changes seen throughout the area fished?
Yes No
If No, where were these changes noted? ______________________________

17. Other than actual fish catch, during the period 1995 to 1997 did you notice any change in the quantity or size of fish in the Delaware Estuary? If yes, please describe these changes including species, location and season.

____

18. What other changes, if any, have you noticed in the Estuary since 1995?

____

19. Other comments? ______________________________

Please return form to:
Delaware Riverkeeper Network, P.O. Box 326, Washington Crossing, PA 18977
Or fax it to us at 215-369-1181

ATTACHMENT 2

Statistical Analysis of DNREC Juvenile Trawl Data Collected from the Delaware River Estuary

Date: 10/13/03
CEA No. 01067

Comparison between the mean catch per foot 1991-1994 and during the period when the power plant was not operating (1995 -1997)

Species	Statistically significant change in numbers of fish caught by fishermen	Direction of change	Average No. of fish before the bed restoration	Average No. of fish during he period the plant was off
Bay anchovy	No			
Weakfish	No			
Atlantic Croaker	No			
White Perch	No			
Spot	No			
Striped Bass	No			
Alewife	No			
American shad	No			
Atlantic silverside	No			
Blueback herring	No			

Comparison: Our statistical analysis compared the average number of fish caught per unit effort for the period 1991 through 1994 to the same data for the period from 1995 through 1997. The Mann-Whitney U test was used to test for any statistically significant differences between the means of these two groups of data. The FASTAT computer program was used to complete the statistical testing.

Statistical Analysis of Fish Abundance 1991-1994 and 1995-1997 (Facility Not Operating)

```
KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR   7 CASES
  DEPENDENT VARIABLE IS BANCHOVY
  GROUPING VARIABLE IS    GROUP$

    GROUP       COUNT   RANK SUM

  prerest         4       12.000
  plantoff        3       16.000

MANN-WHITNEY U TEST STATISTIC =        2.000
PROBABILITY IS        0.157
CHI-SQUARE APPROXIMATION =        2.000 WITH   1 DF


KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR   7 CASES
  DEPENDENT VARIABLE IS WEAKFISH
  GROUPING VARIABLE IS    GROUP$

    GROUP       COUNT   RANK SUM

  prerest         4       11.000
  plantoff        3       17.000

MANN-WHITNEY U TEST STATISTIC =        1.000
PROBABILITY IS        0.077
CHI-SQUARE APPROXIMATION =        3.125 WITH   1 DF


KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR   7 CASES
  DEPENDENT VARIABLE IS ACROAKER
  GROUPING VARIABLE IS    GROUP$

    GROUP       COUNT   RANK SUM

  prerest         4       13.000
  plantoff        3       15.000

MANN-WHITNEY U TEST STATISTIC =        3.000
PROBABILITY IS        0.289
CHI-SQUARE APPROXIMATION =        1.125 WITH   1 DF
```

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 7 CASES
DEPENDENT VARIABLE IS WPERCH

GROUPING VARIABLE IS GROUP$

GROUP	COUNT	RANK SUM
prerest	4	14.000
plantoff	3	14.000

MANN-WHITNEY U TEST STATISTIC = 4.000
PROBABILITY IS 0.480
CHI-SQUARE APPROXIMATION = 0.500 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 7 CASES
DEPENDENT VARIABLE IS SPOT
GROUPING VARIABLE IS GROUP$

GROUP	COUNT	RANK SUM
prerest	4	21.000
plantoff	3	7.000

MANN-WHITNEY U TEST STATISTIC = 11.000
PROBABILITY IS 0.077
CHI-SQUARE APPROXIMATION = 3.125 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 7 CASES
DEPENDENT VARIABLE IS STRIBASS
GROUPING VARIABLE IS GROUP$

GROUP	COUNT	RANK SUM
prerest	4	14.000
plantoff	3	14.000

MANN-WHITNEY U TEST STATISTIC = 4.000
PROBABILITY IS 0.480
CHI-SQUARE APPROXIMATION = 0.500 WITH 1 DF

```
KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR   7 CASES
  DEPENDENT VARIABLE IS  ALEWIFE
  GROUPING VARIABLE IS    GROUP$

    GROUP       COUNT   RANK SUM

  prerest          4      15.000
  plantoff         3      13.000

MANN-WHITNEY U TEST STATISTIC =        5.000
PROBABILITY IS        0.724
CHI-SQUARE APPROXIMATION =        0.125 WITH  1 DF


KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR   7 CASES
  DEPENDENT VARIABLE IS    ASHAD
  GROUPING VARIABLE IS    GROUP$

    GROUP       COUNT   RANK SUM

  prerest          4      20.000
  plantoff         3       8.000

MANN-WHITNEY U TEST STATISTIC =       10.000
PROBABILITY IS        0.157
CHI-SQUARE APPROXIMATION =        2.000 WITH  1 DF


KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR   7 CASES
  DEPENDENT VARIABLE IS  ASILVER
  GROUPING VARIABLE IS    GROUP$

    GROUP       COUNT   RANK SUM

  prerest          4      17.000
  plantoff         3      11.000

MANN-WHITNEY U TEST STATISTIC =        7.000
PROBABILITY IS        0.724
CHI-SQUARE APPROXIMATION =        0.125 WITH  1 DF


KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR   7 CASES
  DEPENDENT VARIABLE IS BHERRING
  GROUPING VARIABLE IS    GROUP$

    GROUP       COUNT   RANK SUM

  prerest          4      14.000
  plantoff         3      14.000

MANN-WHITNEY U TEST STATISTIC =        4.000
PROBABILITY IS        0.480
CHI-SQUARE APPROXIMATION =        0.500 WITH  1 DF
```

TABLE 7-1 DNREC Juvenile Trawl Data 1991-2001										
Year	Bay Anchovy	Weakfish	Atlantic Croaker	White Perch	Spot	Striped Bass	Alewife	American Shad	Atlantic Silverside	Blueback Herring
1991	233.66	31	9.72	3.17	8.39	0.32	0.18	0.12	0.044	0
1992	120.16	34.13	78.12	6.64	0.82	0.19	0.034	0.05	0.05	0.013
1993	94.24	37.17	14.72	3.73	9.15	0.72	0.079	0.063	2.57	0.0084
1994	70.85	53	20.3	12.55	34.14	1.1	0.155	0.042	0.76	0.054
1995	246.86	49.25	53.54	4.92	0.26	0.57	0.17	0	0.11	0.01
1996	158.65	57.29	73.83	10.55	0.16	2.76	0.13	0.06	1.67	0.02
1997	145.23	63.13	30.38	9.28	7.65	0.64	0.11	0.02	0.01	0.03
1998	143.53	30.42	63.45	3.47	0.5	0.95	0.02	0.0042	0.04	0.01
1999	103.21	33.8	71	6.76	1.38	0.58	0.09	0.03	0.11	0.04
2000	117.94	45.66	19.5	1.9	5.23	5.63	0.06	0.01	0.61	0.01
2001	128.39	25.62	70.22	3.9	0.2	4.74	0.14	0	0.18	0.03
All data is reported in Mean Catch per foot.										