Methods to Evaluate Constructed and Restored Wetlands as Finfish Nursery Habitats

New York Sea Grant

Cornell University • State University of New York • NOAA

Methods to Evaluate Constructed and Restored Wetlands as Finfish Nursery Habitats

South Shore Estuary Reserve
Early Action Proposal Report

March 28, 1996

Mark Malchoff
NY Sea Grant
3059 Sound Avenue
Riverhead, NY 11901

Introduction

Many of the marshes which originally fringed Great South Bay, Moriches Bay and other components Long Island's south shore estuary, have been degraded or completely destroyed during the rapid development of Long Island during the period 1945 to the present. The exact number of acres of wetlands lost from this system in not readily available. However, it is known that tidal wetland acreage in Suffolk County declined from 20,600 to 12,700 during the period 1950 to 1971 with most of this loss occurring along the south shore (Koppelman, 1991).

Although most of the degraded and filled wetlands have been permanently lost, opportunities have arisen to restore or create small wetlands which can serve as important habitats for invertebrates, wildlife, and marine finfish. In the Great South Bay system, constructed marshes have been completed or are proposed at Ketchum's Creek and Santapogue Creek in the Town of Babylon (R. Groh, personal communication, 1/19/96). Marsh restoration activities to improve the quality of avian habitats have been conducted at the Seatuck National Wildlife Refuge in the Town of Islip (R. Parris, personal communication). In the future, it seems likely that additional sites will be identified as suitable for construction or restoration. While much of this effort will be driven by those interested in creating new habitats, mitigation requirements associated with development permits will also serve to stimulate wetland habitat creation.

If wetlands restoration efforts are to be successful, it is appropriate to ask what wetlands functions (e.g. water quality, wildlife, fisheries) are being sought, and how might the project be evaluated. One of the habitat functions of intertidal wetlands (and an oft quoted justification for wetlands restoration) is that of finfish nursery. Nationally, however, few restoration projects have been evaluated as fisheries habitats or designed as fishery management tools (Havens, et al. 1995; Lewis, 1992; Minello and Zimmerman, 1992) and none were in the Northeast.

In accordance with Goal 5 of the South Shore Estuary Reserve (SSER) Management Plan, it is appropriate to encourage evaluation of future wetland construction projects in the SSER in terms of their value as marine fish nursery habitats. This report was compiled to facilitate such evaluation by reviewing the available information pertinent to this goal. Below is a brief review and synthesis of methods useful in determining the habitat usage, density, and abundance of fishes associated with intertidal wetland environments. It is hoped that this information might serve as a useful tool for those businesses, organizations, and agencies currently planning (or likely to plan) for the creation or restoration of South Shore estuarine wetlands with fishery habitat objectives. Although the evaluation of wetlands as fisheries habitat will likely require the involvement of biologists, this information should be useful to resource managers and those with marsh restoration experience and expertise. The following review may stimulate the inclusion of fishery objectives in restoration or creation projects with other primary objectives (e.g. landscape improvement, erosion control, or water quality improvement)

Of primary interest are the types of gear which are appropriate to assessing wetlands fishery value. Experimental designs are given brief mention only, and interested readers are encouraged to pursue more complete descriptions of research methods in the references cited.

The review concludes with summaries of interviews of scientists who have contributed to the body of knowledge dealing with wetlands fisheries ecology. Contact information is also provided, and interested readers are encourage to initiate discussion with those listed. These individuals have a wealth of information to share, and it is recommended that SSER stakeholders avail themselves of such information prior to wetlands restorations with fishery objectives.

Methods and Gear

Traditional beach seines and other active gears are of little value when used in intertidal vegetated environments. These nets fish poorly and cannot be operated without damaging natural or created vegetated habitats. Other active gears (e.g. lift nets, drop nets, and pop nets), have been developed which overcome problems of efficiency. However, these gear types still result in habitat alteration which precludes sampling the same area repeatedly (Kneib, 1991). Passive gears (e.g. fyke nets) resolve some of the habitat disturbance problems and can sample relatively large areas. However, their design limits most passive gear use to creeks which drain the marsh surface, thereby complicating efforts to estimate catch per unit area. Below are reviews of gears recently developed to address these deficiencies. Although the focus of this report is on gears suitable for use in *Spartina alterniflora* environments, some gears for use in SAV areas are also included. This information may be useful given that restoration of eelgrass beds is also of interest in the SSER.

<u>Flume Weir</u>

Kneib (1991) described a flume weir which seems to address a number of the

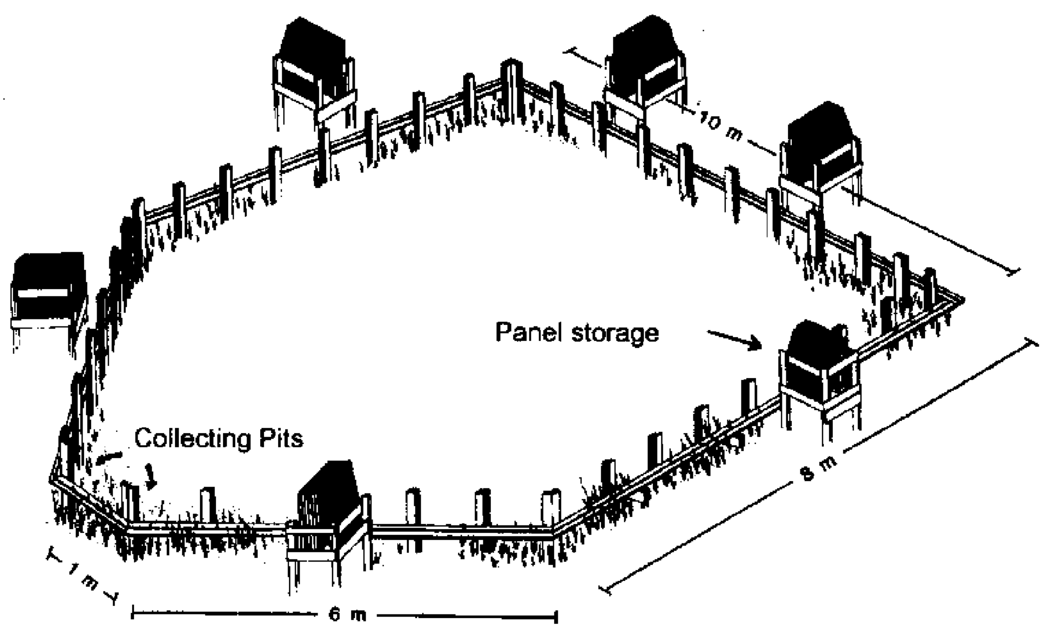

Figure 1. (from Kneib, 1991)

deficiencies associated with previous gears used to collect marsh nekton. The sampling device consists of a set of posts driven into the marsh substrate so as to define a hexagon with unequal length sides, enclosing an area of 1080 ft^2 or 100m^2 (Figure 1). Each post is equipped with a vertical channel constructed by "sandwiching" 1 1/2 inch x 1 3/4 inch stakes between two 1 inch x 6 inch boards. At high tide, a series of screen panels is deployed between the posts, thereby trapping any swimming organisms. As the tide recedes, nekton are carried into two collecting pits near the apex of the structure, which is purposely placed at the lowest elevation in the sampling area. Access to and from the sampler is provided via an elevated boardwalk (not shown).

Among the advantages of this gear is the ability to repeatedly obtain catch per unit area data for those organisms associated with vegetated intertidal habitats (Kneib, 1991). The author reported that two persons could drop all of the enclosing panels in the device within 2.5 to 4 minutes depending on experience, and local conditions. As might be expected, longer deployment times were associated with rain and nightfall.

Disadvantages include the significant investment in time to build the device, and the fact that it samples at a fixed location. Construction time was estimated at up to 80 person hours for pre-assembly and transport, and another 48 to 64 hours for installation. The design is not well suited for large numbers of simultaneous replicate samples (Kneib, 1991)

<u>Lift Net</u>

A much smaller, less permanent piece of gear with many of the same advantages as the flume weir has been described by Rozas (1992). His bottomless lift net consists of a rectangular shaped net (6.6 ft. x 9.8 ft), with four collapsible walls which can be remotely pulled up and out of a shallow, box shaped trench in the marsh surface (Figure 2). The top of the net wall on the 6.6 ft sides includes a sleeve containing a 1 in. x 7 ft. PVC pipe. The net is hoisted by means of ropes attached to the pipes, which pass through pulleys mounted atop a 1½ in. by 3½ in. by 6.6 ft. post driven vertically 3.3 ft. into the marsh surface (Rozas, 1992). As with the flume weir, pit traps were placed at the lowest point in the 65 ft^2 sample area. Efficiencies in catching striped mullet (*Mugil cephalus*), gulf killifish (*Fundulus grandis*), white shrimp (*Penaeus setiferus*), and sheepshead minnow (*Cyprinodon variegatus*) ranged from 58 percent to 93 percent.

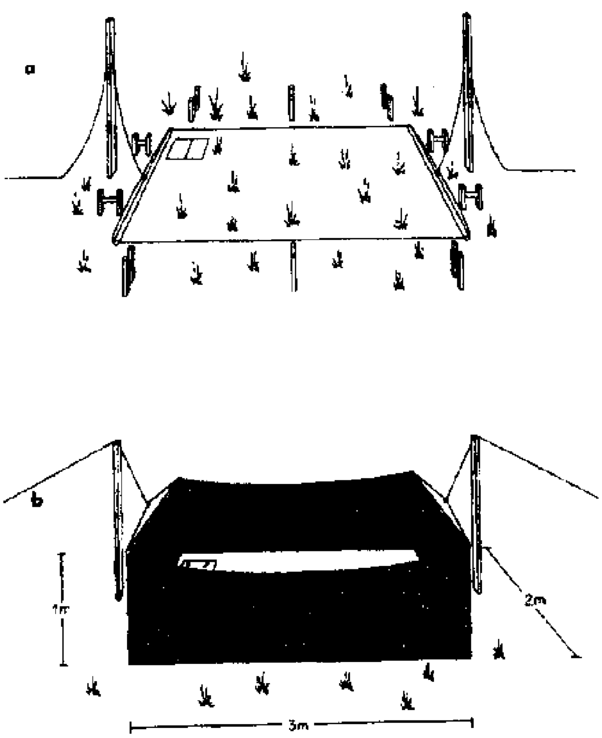

Figure 2. Lift net on marsh surface (a) prior to sampling when net is buried in marsh substrate and (b) after net walls have been raised to enclose sample. Anchor posts are not illustrated in top figure (from Rozas, 1992).

Advantages of the net were its relatively inexpensive cost, along with ease of construction and operation. It is also small enough to be carried across the marsh surface, unlike flume nets, block nets, and drop samplers, which are typically transported by small boats. Like the flume weir, this device samples a fixed area, allowing estimates of nekton densities on the marsh surface. A primary limitation of the net is the relatively small area sampled. While adequate replication can address this deficiency, species that occur in patches or at very low densities are likely to be underrepresented (Rozas, 1992). Where this is a concern, a larger sampling device (e.g. flume weir) should be employed.

<u>Flume Net</u>

McIvor and Odum (1986) describe passive gear, a flume net, which also samples the marsh surface (Figure 3). The device has the ability to sample a cross-section of habitats extending from the marsh creek to the high marsh, by means of two parallel net walls, set perpendicular to the creek axis. At slack high water, researchers complete the net by placing the cod end at the marsh-creek interface. The authors report that three to four person-hours were sufficient to check and repair net damage for six nets deployed

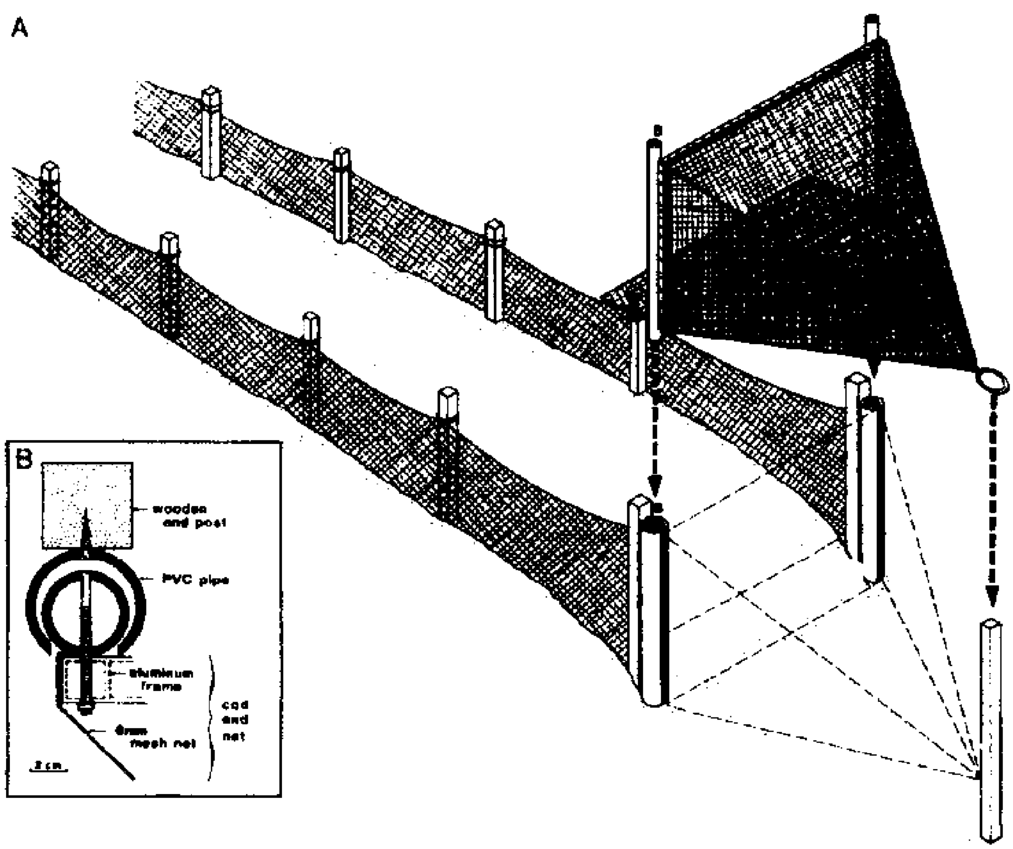

Figure 3. Diagram of flume net on the marsh surface showing cod end net about to be lowered into position at the marsh-creek bank interface. B. Details of end post and cod end net construction (from McIvor and Odum, 1986)

along 0.25 mile section of marsh creek. Like the flume weir, flume nets have the potential to be left on site over long periods of time, when not in use. This capability lends itself to analysis of seasonal trends in species composition and relative abundance (McIvor and Odum, 1986). These nets can also be used to examine differences in microhabitats within and between marshes.

Although the authors state the device is capable of collecting quantitative data, such information is somewhat misleading. In fact it samples only in a plane perpendicular to the creek bank, therefore catch was expressed per $1.5m^{-1}$ of marsh frontage rather than number of organisms m^{-2}. As with other gears discussed here some of the limitations of flume nets can be overcome with experience, skill and common sense. For example, sampling efforts should avoid sites which drain incompletely or unpredictably. Sampling during anomalous meteorological conditions would similarly introduce bias into resulting catch estimated. Thus, this design is appropriate for situations where fishes must gain access to the marsh directly across the main creek-marsh interface, and where sampling sites drain predictably and completely on the ebb tide (McIvor and Odum, 1986).

Catch efficiencies of the net for the three most common fish species at the study site (Virginia tidal freshwater marsh) ranged from 73% to 80%, based on the recovery of planted, fin-clipped fish. Lower efficiencies were recorded for invertebrates and less common fishes (McIvor and Odum, 1986).

Pop Net

Pelczarski and Schmidt (1991) used a pop net for sampling fishes in water chestnut beds in Hudson River Estuary environments. Their design was modified from the designs of Dewey et al. (1989). The device consists of two square PVC pipe frames connected by a four sided box of net material. A negatively buoyant lower frame was constructed out of 1 inch plastic water pipe filled with 3/8 inch concrete reinforcing rods. An air tight positively buoyant upper frame was constructed out of 1 1/2 inch PVC pipe. The net is set by fastening the frames together with removable clamps. Each clamp is tied to a rope leading away from the device, and ending at buoys on opposite sides of the net at a distance of about 20 ft. Sampling is done by pulling the ropes simultaneously thereby removing the clamps and allowing the top frame to quickly float to the surface, pulling the four net walls to the top of the water column. Sampling is completed by seining the enclosed area. This may require the removal of vegetation (as in the case of water chestnut) which could conflict with marsh restoration efforts. However, in freshwater tidal environments, *Vallisneria* sp. beds could be seined without removal owing to lower stem densities and a lack of rigidity of the plant materials. Schmidt suggests that the device would likely be well suited for sampling in eelgrass beds (*Zostera marina*) in the marine environment, provided one could resolve the seining problems (R. Schmidt, personal communication, 3/22/96).

Fish Weir

Most wetlands restoration efforts with fishery related objectives in the SSER are likely to involve intertidal vegetated habitats. However, given that larger projects might encompass intertidal creeks connecting marsh surface areas, it is appropriate to briefly review sampling gear for these environments. Investigators at the Rutgers University Institute for Marine and Coastal Sciences have been engaged in an effort to describe the community structure and nursery function of marsh surface, intertidal creek, and

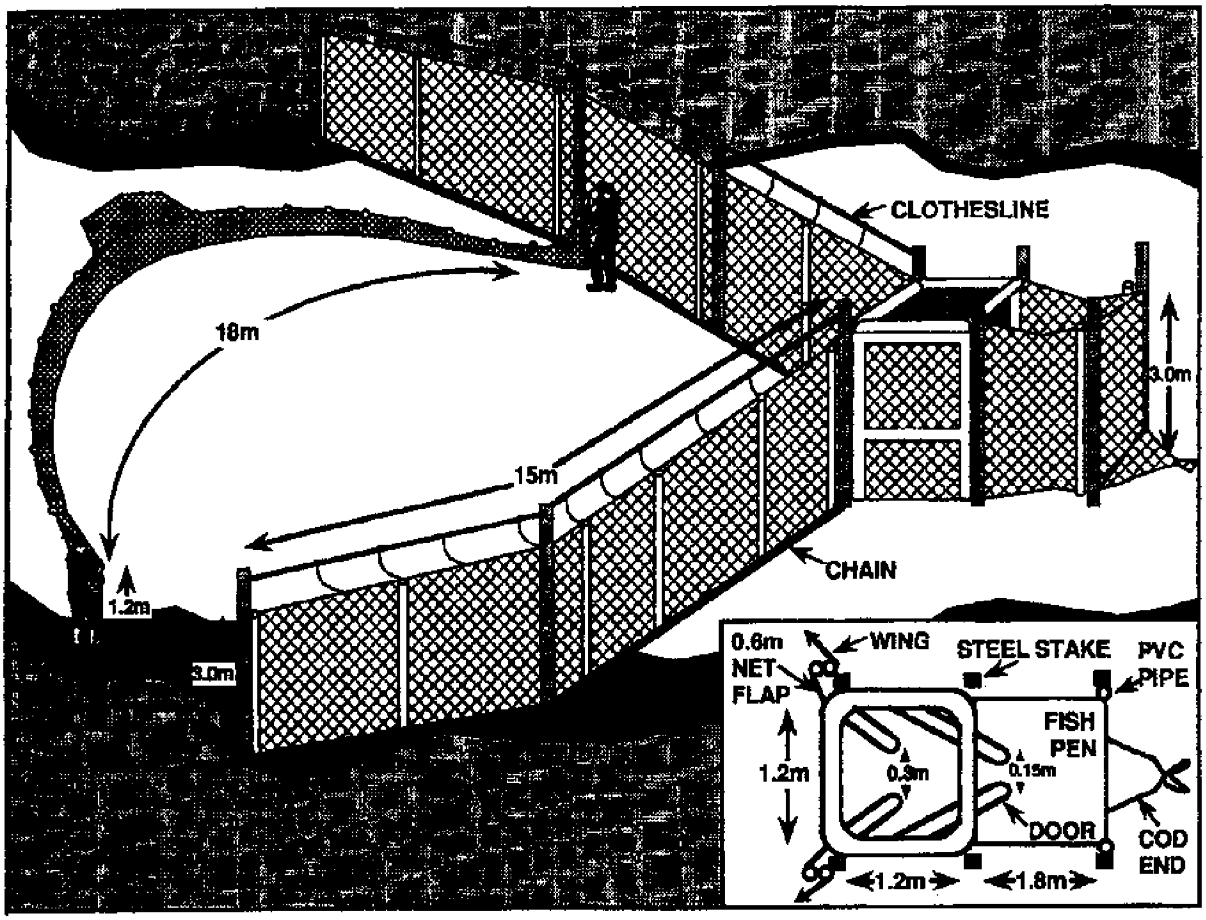

Figure 4. Fish weir and seine methodology (not to scale). Inset: schematic of the weir from an overhead view (from Rountree and Able, 1992)

subtidal creek subhabitats in a southern New Jersey estuarine complex (Rountree and Able, 1992). Among the sampling gears utilized was a weir system developed specifically for use in tidal marsh creeks (Figure 4). The device employed wing nets (50 ft. long by about 10 ft. high) to block off the creek and direct fish into a rectangular weir (4 ft. x 4 ft.). The weir leads in turn to a 4 ft. x 6 ft. fish pen, followed by a smaller cod end (Rountree and Able, 1992). The wings were set just before high tide, and the gear was fished over the entire ebb. At the bottom of the tide a sliding panel was inserted to close of the front of the weir. Ropes were used to raise the weir above the water line and fish were recovered through the cod-end. This system was used in conjunction with a 60 ft. seine to capture less mobile forms and species or individuals capable of actively avoiding the weir by remaining upstream in shallow pools.

By repeated sampling over a two year period, the investigators were able to calculate faunal abundance, biomass and seasonal trend data. During the course of the study, 600,000 fishes representing 64 species were recovered. The authors conclude that marsh creeks represent a significant nursery habitat for many Mid-Atlantic Bight species. The ten most numerically abundant species listed in decreasing order were: silversides (*Menidia menidia*), mummichog (*Fundulus heteroclitus*), bay anchovy (*Anchoa mitchilli*), herring (*Clupea harengus*), fluke (*Paralichthys dentatus*), striped killifish (*Fundulus majalis*) spot (*Leiostomus xanthurus*), menhaden (*Brevoortia tyrannus*), alewife (*Alosa aestivalis*), and dogfish (*Mustelus canis*). They also suggest that information on marsh creek utilization by fishes is greatly lacking north of New Jersey. The observation implies that a comprehensive study of intertidal and subtidal habitat utilization in the SSER system could provide information with both local and regional significance.

<u>Sampling and Restoration Advice</u>

Opinions of several experts in the field of marsh research and/or restoration were sought. Individuals were asked to provide general opinions of sampling gear and brief advice for those who would undertake marsh creation or restoration efforts with fishery habitats objectives. Ron Kneib (personal communication, 3/25/96) offered the following: In natural marshes, species of commercial and recreational importance are not numerically dominant components of the vegetated (i.e. *Spartina* sp.) marshes. These habitats however, are ecologically significant in that forage species such as *Fundulus sp.* utilize both low and high marsh areas as breeding and feeding environments. Energy transport to species of commercial and recreational interest takes place as forage species are partially cropped in nearby refugia, typically intertidal creeks and pools. For constructed marshes to be useful from a fisheries standpoint, it is critical that this pattern be mimicked. A well designed constructed marsh will have viable marsh surfaces adjacent to intertidal creeks, which in turn are adjacent to quality subtidal habitats. Without points of access and low tide refugia, forage species will not colonize the created habitat at a rate commensurate with use of natural habitats.

Mark LaSalle (personal communication, 3/25/96) emphasized that issues of microtopography and hydrology are vital in the design of constructed marshes. He argued that many of the constructed marshes shown to have been deficient as fishery habitats were deficient because they failed to mimic the rivulet/pool/marsh surface characteristics of natural marshes. He also spoke well of the flume weir designed by Ron Kneib. This gear may the best tool available for measuring numbers of fish or biomass per unit area, a measurement of great importance if we hope to build marshes which are functionally equivalent to natural systems. He also suggested that the lift net was a very good substitute for the flume weir, and is cheaper and easier to set up and use. Workers are cautioned, however, that transient species will likely be under-represented by this gear because of the small area sampled.

Marc Matsil (personal communication, 3/25/96), briefly reviewed some findings from marsh systems in the Arthur Kill which separates New York and New Jersey. A number of intertidal marshes in the Arthur Kill are slowly recovering following a spill from Exxon's Bayway Refinery in January 1990. He was firm in his belief that a rigorous monitoring protocol needs to be followed for restoration to be successful. Among the components of the protocol were provisions for a monitoring and assessment period several years in duration.

Kirk Havens (personal communication, 3/26/96) supplemented recommendations from Haven et al., (1995) as follows: The overall landscape pattern of constructed marshes should mimic the natural landscape. Hence, the widest part of the marsh should occur on the downstream portion of the project, so as not to constrict tidal flows. Secondly, workers should pay close attention to and be creative in the construction of microtopography. How best to construct microtopograhic relief is not easily answered. This may require letting the site overwinter after grading but prior to planting. Then hand grading may be feasible to create rivulets and "runlets". These features are likely critical to providing appropriate access to the marsh surface - in agreement with ideas given by Mark LaSalle above.

Robert Parris (personal communication 1/19/96, 3/25/96) reviewed his experience with open marsh water management at the Seatuck National Wildlife Refuge in Islip. Although these efforts were aimed at improving avian habitats, increases in tidal flow to the marsh via partial removal of a dredge spoil dike had several positive impacts to the system. Several years of monitoring revealed that restoration efforts had produced increases in salinity, increases in the amount of panne habitat, and decreases in Phragmites cover types. Among the responses in the fish community were: increases in total numbers, number of fish species, number of sheepshead minnow (*Cyprinodon variegatus*), number of banded killifish (*Fundulus diaphanus*), and shrimp. No change in the number of marsh killifish (*Fundulus confluentus*) was observed.

Other comments

Gary Mayer (personal communication 3/25/96) reiterated the importance of organic matter considerations. Published information suggests that constructed marshes often suffer from a lack of organic substrate relative to natural marshes. Provisions should therefore be made to supply organic materials to the site and/or to recognize that constructed marshes will be deficient in this respect for many years, until natural processes supply organic enrichment to the site (Havens et al., 1995; Zedler, 1992)

Conclusions and Recommendations

It appears that few quantitative studies assessing the fisheries value *of Spartina alterniflora* marshes have conducted. Recent gear innovations have given researchers the ability to develop catch per unit area estimates of fish using the marsh surface. Although these gear types have been developed and tested in natural marsh systems, they seem well suited for use in created or restored marshes as well. Finally, lessons from a few comprehensive ecological evaluations of wetland have now given us the tools to design, build and evaluate these marshes as fishery habitats. Those who would restore marshes for fisheries purposes are encouraged to pay close attention to microtopography, organic matter sources/development and to make arrangements for follow up monitoring, which should include true estimates of fish density.

<u>Suggested contacts</u>:

Dr. Ronald Kneib
Senior Research Scientist
UGA Marine Institute
Sapelo Island, GA 31327
Phone: (912) 485-2297
e-mail: rtkneib@uga.cc.uga.edu

Dr. Mark LaSalle
Mississippi State University
Coastal Research & Extension Center
2710 Beach Blvd., Suite 1-E
Biloxi, MS 39531
Phone: 601-388-4710

Dr. Marc Matsel
Chief, Natural Resources Group,
NYC Parks
830 5th Avenue, New York, NY 10021
Phone: 212-360-1417

Dr. Gary Mayer
National Sea Grant Office
NMFS, F/PR5, 1335 East-West Highway
Silver Spring, Maryland, 20910-3226.
Phone: 301-713-0174
e-mail: gmayer@rdc.noaa.gov

Robert W. Parris
US Fish and Wildlife Service
Long Island National Wildlife Refuge Complex
P.O. Box 21
Shirley, NY 11967
Phone: 516-286-0485

Dr. Robert Schmidt
Simon's Rock College
84 Alford, Rd
Great Barrington, MA 01230-9702
Phone: (413) 528-0771 ext. 223

Dr. Gordon W. Thayer
National Marine Fisheries Service
SEFC Beaufort Laboratory
101 Pivers Island Road
Beaufort, NC 28516
Phone: 919-228-8747

References

Dewey, M.R., L.E. Holland-Bartels, and S.J. Zigler. 1989. Comparison of fish catches with buoyant pop nets and seines in vegetated and non-vegetated habitats. North American Journal of Fisheries Management 9(2):249-253.

Havens, K.J., L.M. Varnell, and J.G. Bradshaw. 1995. An assessment of ecological conditions in a constructed tidal marsh and two natural reference tidal marshes in coastal Virginia. Ecological Engineering 4:117-141.

Koppleman, I.E. 1991. A Management Approach. pp. 89-100. *In*: Schubel, J.R., T.M. Bell, and H.H. Carter [Eds.]. 1991. The Great South Bay. State University of New York Press, Albany, 107pp.

Kneib, R.T. 1991. Flume weir for quantitative collection of nekton from vegetated intertidal habitats. Marine Ecology Progress Series, 75:29-38.

Lewis, R.R. III. 1992. Coastal habitat restoration as a fishery management tool. *In* Stemming the tide of coastal habitat loss. ed. R.H. Stroud. Savannah: National Coalition for Marine Conservation, Inc.

Matthews, G. A., and T.J. Minnelo. 1994. Technology and Success in Restoration, Creation, and Enhancement of Spartina alterniflora Marshes in the United States. Vol. 1- Executive Summary and Annotated Bibliography; and Vol. 2 - Inventory and Human Resources Directory. NOAA Coastal Ocean Program Decision Analysis Series No.2. NOAA Coastal Ocean Office, Silver Spring, MD.

McIvor, C.C and W. E. Odum. 1986. The flume net: A quantitative method for sampling fishes and macrocrustaceans on tidal marshes. Estuaries 9(3):219-224

Minello, T.J. and R.J. Zimmerman. 1992. Utilization of natural and transplanted Texas salt marshes by fish and decapod crustaceans. Marine Ecology Progress Series 90:273-285.

Pelczarki, K. and R. Schmidt. 1991. Evaluation of a pop net for sampling fishes from water-chestnut beds in the tidal Hudson River. *In*: Blair, E.A., and J.R. Waldman, (editors) 1991. Polgar Fellowship reports of the National Research Reserve Program, 1990. Hudson River Foundation, New York, NY.

Rountree, R.A. and K.W. Able. 1992. Fauna of polyhaline subtidal marsh creeks in southern New Jersey: composition, abundance and biomass. Estuaries 15(2):171-185.

Rozas, L. P. 1992. Bottomless lift net for quantitatively sampling nekton on intertidal marshes. Marine Ecology Progress Series, 89:287-292.

Zedler, J.B. 1992. Restoring cordgrass marshes in Southern California. pp7-51. *In*: Restoring the nation's marine environment, ed. G.W. Thayer, Maryland Sea Grant College Program, College Park, Maryland.

New York Sea Grant

Institute Office: 115 Nassau Hall
SUNY at Stony Brook, Stony Brook NY 11794–5001
Phone: (516) 632–6905

Extension Offices

207 Jarvis Hall
SUNY College at Buffalo
Buffalo NY 14260–4400
Phone: (716) 645–2088

Rich Hall
SUNY College at Oswego
Oswego NY 13126–3599
Phone: (315) 341–3042

Roberts Hall
Cornell University
Ithaca NY 14853–3001
Phone: (607) 255–2832

125 Nassau Hall
SUNY at Stony Brook
Stony Brook NY 11794–5002
Phone: (516) 632–8730

Cornell Cooperative
Extension Center
21 South Grove Street
East Aurora NY 14052–2398
Phone: (716) 652–7874

Hartwell Hall
SUNY College at Brockport
Brockport NY 14420–2928
Phone: (716) 395–2638

Cornell University Lab
39 Sound Avenue
Riverhead NY 11901–1098
Phone: (516) 727–3910

Cornell Cooperative
Extension Center
74 John Street
Kingston NY 12401–3824
Phone: (914) 338–3494