Comparison of Fish Communities in Open and Occluded Freshwater Tidal Wetlands in the Hudson River Estuary

A Final Report of the 1997 Tibor T. Polgar Fellowship Program

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ABSTRACT

Original nearshore fish community data was collected using beach seines in open shallows and pop nets in *Trapa natans* beds in the freshwater tidal Hudson River at Norrie Point (NP) and Tivoli South Bay (TSB) to determine if the occlusion by the railroad bridges caused a difference in the fish community structure in these areas. The data collected allow the detection of changes in the fish communities of these nearshore habitats of the Hudson River. The two sampling methods at two sites resulted in four different fish community assemblages in open shallows and vegetated shallows. Fourspine sticklebacks and common carp were dominant in *T. natans* in TSB, but brown bullheads, redbreast sunfish, and tessellated darters were the main fishes in the NP *T. natans*. Cyprinids and moronids were dominant in the open water at TSB, while clupeids, cyprinids, and centrarchids dominated the open water at NP. Our TSB pop net data are consistent with previous work, but this does not imply that the fish community in the *T. natans* is representative of the rest of the river. Catch per unit effort differed significantly between the pop net efforts at the two sites and with the two sample methods at TSB. Water temperature significantly differed between the beach seines at the two sites.

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INTRODUCTION

Tidal wetland management is an important aspect of the mission of the National Estuarine Research Reserve (NERR) Program. The Hudson River NERR manages four sites including over 1295 ha of brackish and freshwater tidal wetlands. Tidal fresh wetlands are relatively rare globally and are located primarily along the Atlantic coast of the northeastern United States (Mitsch & Gosselink 1993).

Tidal wetlands are important as areas of high diversity and productivity. A number of economically and ecologically valuable freshwater and anadromous fish species are dependent upon the spawning and nursery habitat of marshes and vegetated shallows (Mitsch & Gosselink 1993). In the freshwater Hudson River, these include forage fish (river herrings, Clupeidae and shiners, Cyprinidae), as well as game fishes (basses and sunfishes, Centrarchidae; and striped bass, *Morone saxatilis*). The forage fish are important for exporting marsh productivity to the main river as fish biomass (Smith & Schmidt 1987). Fish community data exist for a number of fresh tidal marshes on the Hudson River.

The majority of the coastal wetlands of the Hudson River were affected by railroad construction along the shores in the mid-1800s. Cara Lee, environmental director of Scenic Hudson Inc., believes the railroad was second only to the construction of the Federal Dam at Troy as a significant impact upon the river (1996, personal communication). Both projects affected tidal flow and historic spawning areas. The railroad bed added approximately 800 ha of land to connect islands and fill in small coves (Young & Squires 1990). Causeways were constructed in order to straighten the track. Open channels in the causeways allow for water and material exchange between these embayments and the river. In many instances, the channels proved inadequate, constraining circulation and creating sediment traps (Squires 1992). As these embayments filled with sediment, they became sites of new growth of emergent vegetation. These former vegetated shallow water bays have become emergent marshes and later successional stages.

Vegetated bays will gradually fill with sediments as the vegetation decreases the kinetic energy of suspended materials within the currents and tides. This increases the succession rate as the open bay succeeds to a wetland with emergent vegetation replacing the submerged and floating-leafed vegetation. Areas where free current flow and material exchange are inhibited will make this change more rapidly. Kiviat (1978) believed that limited tidal circulation was the greatest threat to the existing open water and low marsh in the Tivoli Bays ecosystem. Pools in Tivoli North Bay (TNB) have been filling in since 1971 (Kiviat 1991).

European water chestnut (*Trapa natans*) is an exotic, floating leafed plant with a distinctive spiked seedpod. It was inadvertently introduced to the Hudson River watershed in the 1860s. It thrives in calm, shallow, nutrient-rich waters and is now established in a majority of these areas on the Hudson, including Tivoli South Bay (TSB). *T. natans* provides significant habitat and provides for a complex food web within the vegetated bays (Yozzo & Odum 1989). The stand of water chestnut in TSB has caused this wetland to begin to act as a more efficient sediment trap (Goldhammer & Findlay 1988). This increasing sedimentation in TSB could result in an emergent marsh like TNB in "several decades" (Kiviat 1978, 1991).

Do Occlusions to Marshes and Bays Affect Fish Communities?

We hypothesized that fish community diversity will be lower in partially occluded sites in comparison to open sites. Species density will be affected by the causeway by trapping fish within the occlusion. This research involved the collection of original ecological data on fish community structure in tidal wetlands and a review of the existing Hudson River fisheries literature. This information can be used to determine potential trends in the fisheries and fish ecology in the Hudson River. Implications for management of resource species can be drawn from the results. This information can also be used for tidal wetland management. We compared the fish communities among vegetated bays and within fresh tidal marshes in an open tidal flow area (Norrie Point) to a partially occluded area

METHODS & MATERIALS

Description of the Study Area

The Dutchess Community College Norrie Point Environmental Site (NP) is located in Mills-Norrie State Park in Staatsburg, N.Y. (lat 41°49.80' N, long 73°56.40' W) (Figure 1). The site is on a peninsula on the east bank of the Hudson River, 85 mi. (137 km) north of the mouth of the Hudson River at the Battery (Manhattan). Norrie Point has a beach at the east cove with a soft silty bottom that is filled with *T. natans* and watermilfoil (*Myriophyllum spicatum*) from May through October.

Tivoli South Bay (TSB) (lat 42°01.22' N, long 73°55.20' W) (Figure 2) is located at Hudson River Mile (HRM) 98 (HRKM 158). It has a soft silty mud bottom with a small area of rock and gravel at the mouth of the Saw Kill and a small deeper pool at each railroad bridge. This is similar to the east cove at NP. With the exception of restrictions and barriers to tidal flow, the sites are very similar; both have southern exposures, exposed mud flats at low tide, a similar tidal range (ca. 1.2 m) and similar vegetation.

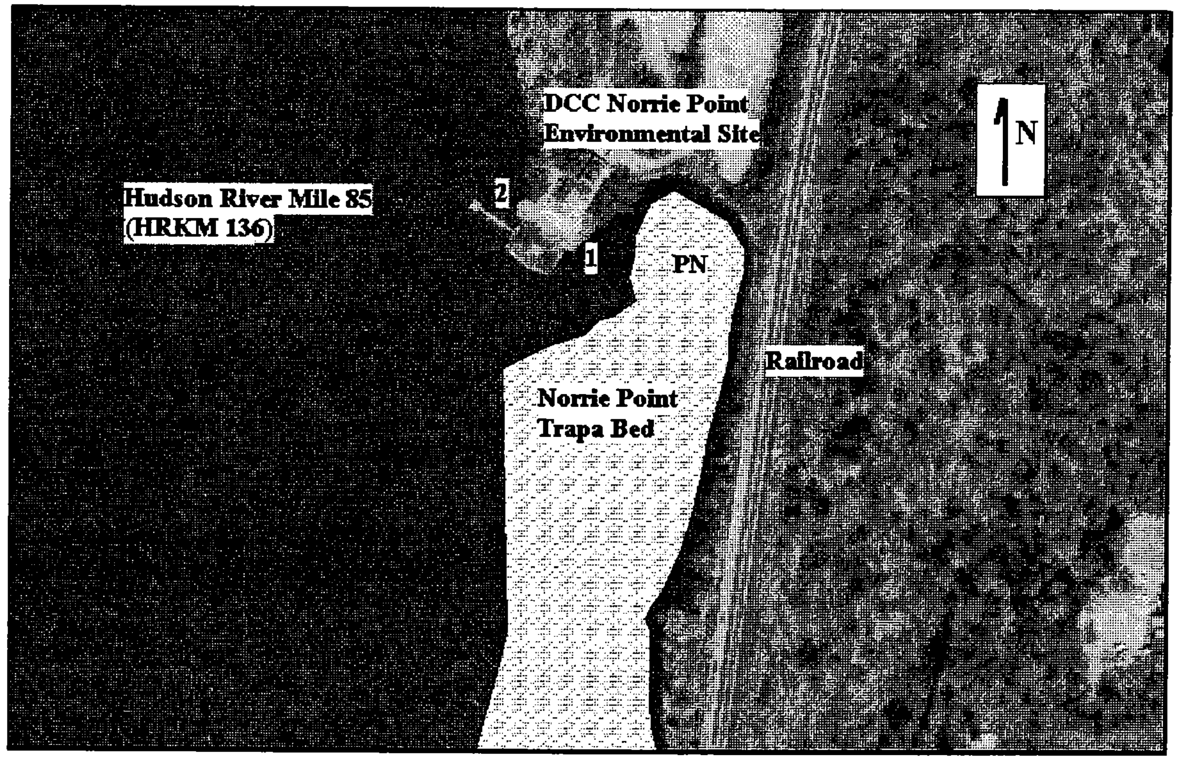

Figure 1: Norrie Point Study Site. The *T. natans* bed is crosshatched and the open water and channel are solid. The number 1 indicates the seining beach and PN indicates the area where pop netting occurred.

TSB is approximately 115 ha. Of this, *T. natans* covers about 95% of the surface from mid-May through October (Anderson & Schmidt 1989). The *T. natans* can grow quite dense. Goldhammer & Findlay (1988) determined the peak dry biomass was 400 $g{\cdot}m^{-2}$; this is denser than most other submerged aquatic vegetation (SAV).

Tidal exchange between the river and TSB is restricted to three bridge openings across the railroad causeway, which represents 3% of the original linear interface. Tidal flow comprises approximately 90% of the annual water budget for the bay (Lickus &

Barten 1989, Zelewski & Armstrong 1997). During sampling, it became evident that differences in tidal flow and scouring existed between NP and TSB. Many logs, trees, and anthropogenic debris presented hazards to wading at TSB. The lack of barriers to tidal flow at NP allows the flotsam and jetsam to typically wash freely in and out of the coves.

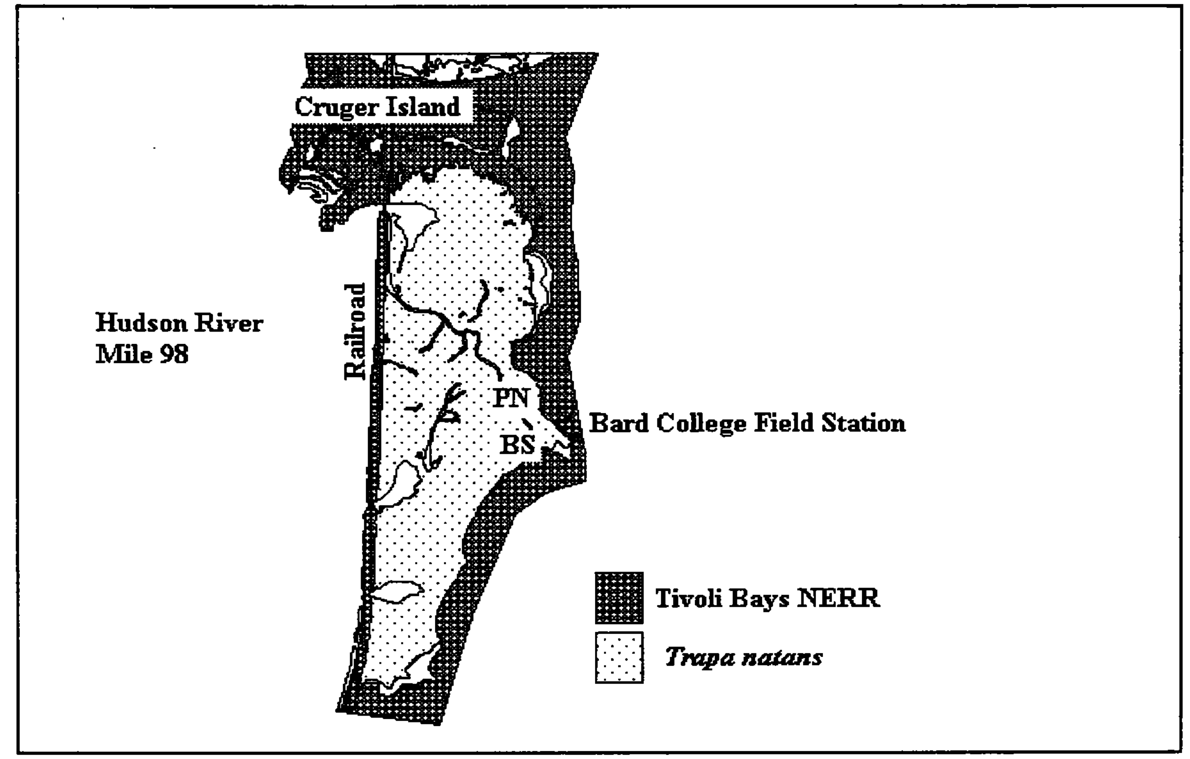

Figure 2: Tivoli South Bay Study Site. PN and BS denote the pop net area and beach seine beaches respectively. The *T. natans* bed is lightly shaded and the open water and channels are solid white.

Collection of Fish in Vegetated Shallows

Modification to Pop Nets

Using the existing pop nets (Figure 3) constructed by my predecessors (Pelczarski & Schmidt 1991; Hankin & Schmidt 1992), I modified the weighted hoop to provide added submerged weight with no carrying or transportation weight penalty. The 1" (2.54 cm) I.D. plastic water pipe and steel reinforcement rods were replaced by 1.5" (3.81 cm) PVC and 3 kg of pea gravel per length. The PVC pipes were drilled through perpendicular axes with ¼" holes at 5 cm intervals. The ends of the tubes were fitted with 3.8 cm diameter x 5 cm long wooden plugs to prevent the gravel from migrating around the elbows during storage and transport (Figure 4). Before setting the net, we shook it to distribute any gravel that had settled in the ends throughout the lengths of the pipes. This modification eliminated any inherent buoyancy of the previous designs. The water added weight to the bottom of the pop net when submerged, but readily drained when lifted to allow easier movement and transport.

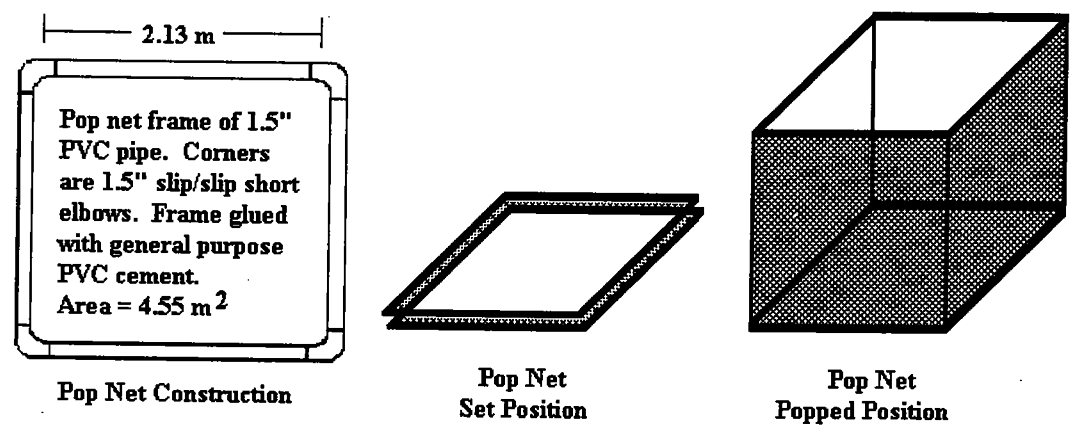

Figure 3: Pop net (L to R) Construction and top view; side views (set and popped).

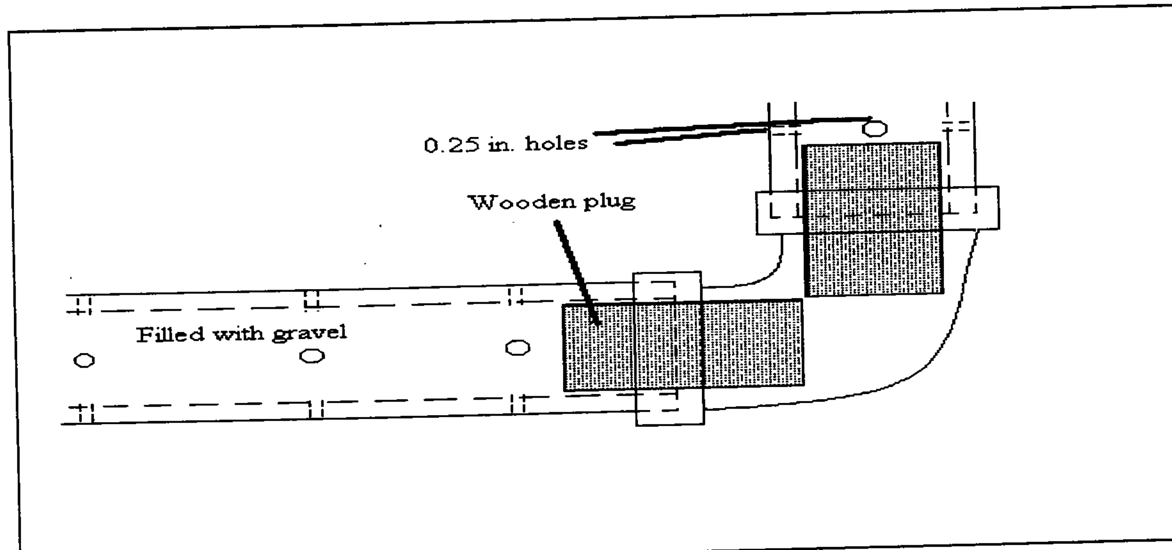

Figure 4: Cross section of pop net modifications to bottom frames.

The trigger clips were also redesigned after speaking with Dennis Mildner (HRNERR) about a potential safety factor. Galvanized U-bolts were previously used and the threads were covered with duct tape. On one occasion, the tape or threads stuck on the netting; when the trigger was pulled, the bolt became a ballistic projectile and injured someone. The new triggers were constructed of 3 x 25 mm aluminum plate bent to fit the pipe frame (Figure 5). The aluminum provided a lower friction surface and easier trigger release. Rubber bands were used to secure the clips to the nets.

Figure 5: Trigger design for pop nets

The trigger release technique was also modified to eliminate possibilities of injury. Rather than pulling the trigger line upward from shoulder height, the trigger pullers would place a foot on the line and hold the buoy. By sliding the foot away from the net and pulling the line using the foot as a pivot point, the clips would release underwater without any possibility of cranial impact.

Collections with Pop Nets

The modified pop nets (after Hankin & Schmidt 1992) were used to sample the fish communities in the densely vegetated areas. The pop nets were set at low tide at random locations within a predetermined sampling area (Figs. 1 and 2). When setting the net, care was taken to clear any debris that may tear the netting. The frames had to be set on the bottom and not upon any vegetation. All *T. natans* rosettes had to be moved either to the inside or outside of the net to prevent the bottom frame from floating or pulling up when the net was popped.

The nets remained in place for approximately 8 h, and were popped 2 h after high tide. Once the net was popped, the *T. natans* was cleared from within the net and around the perimeter to allow sampling with seines. A 6 x 1.2 m nylon seine with 2 mm mesh was used to sample the interior of the pop net. The pop net was seined four times in one direction and then rotated around the pop net in a clockwise manner. The sampling continued until we hauled five consecutive empty seines. This allowed the sampling to be quantitative.

This sampling was most efficient when done by at least three people. This allowed two to pull the seine and the third to collect the fish. Small dip nets were used to make catching of fish in the corners of the pop net easier. Sampling, cleanup, and fish counting typically took 2 to 3 h. A foam "boogie" board served as an effective floating work and transport platform.

Collection of Fish in Open Shallows

Open water sampling was done with a 25 x 1.5 m bag seine of 5 mm square knotless nylon mesh in shallow open waters. Seines were pulled in flowing water at two

hours after low tide. The seine was extended perpendicular to shore and then encircled to the starting point. The seine hauls covered approximately 300 m^2 of water surface area at NP and 150 m^2 at TSB. Seining is a qualitative sampling method used to document species not caught in the pop net (Hankin & Schmidt 1992). This can help to provide a better picture of the species composition within the overall fish community. Additional surveys were also attempted using snorkeling and documenting with underwater still photography (Whitworth & Schmidt 1980; Kirker 1989).

We sampled for seven weeks, between 8 July and 21 August 1997. The sites were sampled on an approximately weekly basis. Sampling times were based on the tides and the total process time (pop net set to pop net clean and count), which required up to 13 h. The times were chosen so that the net could be popped and sampled during daylight. This allowed comparison to previous Polgar efforts, which were all diurnal surveys.

Data Quantification

Fish were transferred to pails of river water, identified, and counted. Common fish were identified on sight. Unknown fish were identified using Smith (1985). Recognized experts on regional fish fauna (Tom Lake and Robert Schmidt) verified fish identifications. A representative subsample was preserved in 10% formalin and the fish were measured to the nearest millimeter in total length.

Water temperature, state of tide, and other observations were gathered for each collection. Voucher specimens were maintained at the Dutchess Community College Norrie Point Environmental Site. Additional specimens will be provided to the New York State Museum.

Data were analyzed by comparing relative abundance by species using chi-square analysis. I compared my TSB and NP pop net data against those of my predecessors (Pelczarski & Schmidt 1991; Hankin & Schmidt 1992). At NP, I have a weekly beach seine data set (unpublished) from ice-out to ice-in (4 March 1996 to 6 January 1997) for 1996. Since this is the most comprehensive data for the site, this was set as the expected composition against the NP pop net and beach seine Polgar data. Densities (fish·m^{-2}), catch per sample effort, and water temperatures were analyzed with student *t*-tests. Significance was determined at an $\alpha = 0.05$ level for all tests.

RESULTS

Seven sets of weekly samples (beach seine and pop net) were done at each site (TSB and NP). A total of 1987 fish representing 11 families and 23 species were caught (Tables 1 and 2). Overall, more individuals, species, and families were found at NP than TSB. TSB pop net densities were higher than NP. Pop net densities at both sites were one to two orders of magnitude greater than the densities of the beach seines. Pop netting at both sites caught an equal number of species (13), but the community composition was different. Species diversity in beach seines was higher at NP compared to TSB.

Table 1: Summary of fish caught by location and sampling method. NP = Norrie Point, TSB = Tivoli South Bay, BS = Beach Seine, PN = Pop Net

Sample Location	Sample Method	Number Of Fish	Mean Fish per Sample	Number of Species	Number of Families	Mean Density (fish/m^2)
NP	BS	1270	181.4	20	10	0.61
NP	PN	219	31.3	13	7	6.88
NP	**Total**	**1489**	**106.4**	**20**	**10**	**3.64**
TSB	BS	133	19.0	12	7	0.13
TSB	PN	365	52.1	13	7	11.46
TSB	**Total**	**498**	**35.6**	**17**	**9**	**10.89**

The two sample methods at the two different locations resulted in four different fish communities (Table 2). The fish community assemblages were expected to be different between the two sampling methods since they sample different areas and water conditions. Anderson & Schmidt (1988) found a difference between the ecotone community and the TSB *T. natans* beds and open water areas in both species composition and density due to current. Due to the limited area covered, the ecotone was determined to not present a significant habitat in TSB.

This is not necessarily the case at NP. The ecotone at NP, because of the lack of the railroad causeway, is the entire interface between the main river and the channel. NP has 4.25 ha more open shallow water than TSB. Our hypothesis was that the overall communities would differ between NP and TSB due to the difference in occlusion of tidal flow by railroad bridges and isolation from the main river.

Table 2: List of families and species by location and sampling method. (NP = Norrie Point, TSB = Tivoli South Bay, BS = Beach Seine, PN = pop net)

	Location **Sampling Method**	**NP BS**	**NP PN**	**TSB BS**	**TSB PN**
Anguillidae	**Freshwater Eels**				
Anguilla rostrata	American Eel	◆	◆		◆
Clupidae	**Herrings**				
Alosa aestivalis	Blueback Herring	◆			
Alosa pseudoharengus	Alewife	◆	◆		
Alosa sapidissima	American Shad	◆			
Cyprinidae	**Carps & Minnows**				
Cyprinus carpio	Common Carp	◆	◆	◆	◆
Luxilus cornutus	Common Shiner	◆	◆	◆	
Notemigonus crysoleucas	Golden Shiner	◆	◆	◆	◆
Notropis hudsonius	Spottail Shiner	◆	◆	◆	◆
Catostomidae	**Suckers**				
Catostomus commersoni	White Sucker	◆		◆	
Ictaluridae	**Bullhead Catfishes**				
Ameiurus nebulosus	Brown Bullhead	◆	◆		◆
Belonidae	**Needlefishes**				
Strongylura marina	Atlantic Needlefish	◆			
Fundulidae	**Killifishes**				
Fundulus d. diaphanus	Eastern Banded Killifish	◆	◆		◆
Fundulus heteroclitus	Mummichog			◆	◆
Gasterosteidae	**Sticklebacks**				
Apeltes quadracus	Fourspine Stickleback			◆	◆
Moronidae	**Temperate River Basses**				
Morone americana	White Perch	◆		◆	
Morone saxatilis	Striped Bass	◆		◆	
Centrarchidae	**Sunfishes**				
Ambloplites rupestris	Rock Bass			◆	◆
Lepomis auritus	Redbreast Sunfish	◆	◆		◆
Lepomis gibbosus	Pumpkinseed Sunfish	◆	◆		◆
Lepomis macrochirus	Bluegill Sunfish	◆	◆		
Micropterus salmoides	Largemouth Bass	◆	◆	◆	◆
Percidae	**Perches**				
Etheostoma olmstedi	Tessellated Darter	◆	◆	◆	◆
Perca flavescens	Yellow Perch	◆			

The fish communities in the TSB *T. natans* beds have been studied in two previous Polgar Fellowships (Pelczarski & Schmidt 1991; Hankin & Schmidt 1992). These were the only two Hudson River *T. natans* pop net surveys I was able to find. This proj-

ect attempted to determine if TSB's fish community was representative of the rest of the Hudson River *T. natans* beds. We compared our data (Table 3) to those of Hankin & Schmidt (1992) using a chi-square test. They were not significantly different (α= 0.05). Our community data, however, were significantly different (X^2=27.46) from those of Pelczarski & Schmidt (1991). Our pop net sampling caught more fish per netting effort, more total fish, and more species than my predecessors, but we are unable to explain why this was the case.

Table 3: Fish caught in pop nets at Tivoli South Bay. RA represents Relative Abundance (percent) of fishes caught. Catch frequency is the frequency that a species was caught in seven samples. The 1991 data are from Hankin & Schmidt (1992) and 1990 data are from Pelczarski & Schmidt (1991).

Species	Common Name	Catch Freq.	Total Fish	1997 RA	1991 RA	1990 RA
Apeltes quadracus	Fourspine Stickleback	7/7	204	55.9	64.0	75.3
Cyprinus carpio	Common Carp	7/7	99	27.1	29.0	18.5
Fundulus d. diaphanus	Banded Killifish	2/7	31	8.5	1.3	2.5
Notropis hudsonius	Spottail Shiner	5/7	11	3.0	---	0.7
Ambloplites rupestris	Rock Bass	4/7	5	1.4	4.0	---
Micropterus salmoides	Largemouth Bass	1/7	4	1.1	---	---
Ameiurus nebulosus	Brown Bullhead	2/7	2	0.5	---	---
Etheostoma olmstedi	Tessellated Darter	1/7	2	0.5	---	2.2
Lepomis auritus	Redbreast Sunfish	1/7	2	0.5	---	---
Lepomis gibbosus	Pumpkinseed	2/7	2	0.5	---	---
Anguilla rostrata	American Eel	1/7	1	0.3	---	0.4
Fundulus heteroclitus	Mummichog	1/7	1	0.3	---	---
Notemigonus crysoleucas	Golden Shiner	1/7	1	0.3	1.3	---
Morone americana	White Perch	---	---	---	---	0.4
Carassius auratus	Goldfish	---	---	---	1.3	---
	Total Fish Collected		**365**	**365**	**75**	**275**
	Mean Catch/Pop Net		**52.1**	**52.1**	**9.4**	**30.6**

The species composition and relative abundance comparisons of the NP beach seine to the NP pop net and the comparisons of NP to TSB all failed the chi-square analysis at an α = 0.05 level of significance (Tables 4-6, Fig. 6). Catch frequencies (frequency that a species was caught in seven samples) did not necessarily reflect the relative abun-