

Effect of Pier Shading on Prey Fish in the Hudson River, Using Dual Frequency Identification Sonar

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INTRODUCTION

Piers are a major structural change that people make to estuaries, and they are currently the subject of debate in New York City as piers that had fallen into disuse are now being viewed as prime real estate (Able and Duffy-Anderson 2006). However, piers may degrade the quality of habitat for juvenile fish due to shading (Able et al. 1998, Able et al. 1999, Duffy-Anderson and Able 1999, Duffy-Anderson and Able 2001). Compared to pile fields and open water in the Hudson, under pier habitats had low fish abundance and species richness.

Previous net and caging studies only sampled benthic species, primarily the juvenile stage of large fishes. A current proposal by Grothues and Able for The Hudson River Foundation seeks to look at pier habitat use by large adult fish. However, what has not been addressed is the effect of shading or unshaded structure on small prey fish (< 30 cm). Small fish may be taking advantage of the absence of visual predators and utilizing under pier habitats.

METHODS

Dual Frequency Identification Sonar (DIDSON)

Pier pilings prevent net sampling and the absence of light under piers makes study of that habitat by traditional filming methods impractical. Also, because this study seeks to understand the effect of shading, it was important that light not be introduced as a bias. DIDSON (Sound Metrics Corp., Lake Forest Park, WA) produces video-like images called "echograms" using sound (1.8 and 1.1 MHz), so light is not required. A DIDSON was mounted to the bottom of a kayak (Fig. 1), which allowed us to sample shallow water without disturbing fish. The kayak was also able to navigate areas where structure would make net sampling difficult. A laptop between the kayaker's knees (Fig. 2) allowed viewing of echograms in real time for adjustments to the sonar.

STUDY SITE

The study site was Pier 57 on the Manhattan side of the Hudson River (Fig. 3). This area has no natural shoreline. Sampling was done in four habitats: open water, pile field, pier edge, and under the pier. Pile fields are collapsed piers that have pilings, but lack over-water structure (Fig. 4b). Daytime sampling was done in September and October of 2007 and June of 2008.

SAMPLING METHOD

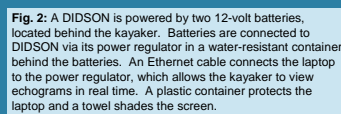
DIDSON transects either ran alongside the pier or ran under and into the pier. Comparative samples were also taken in open water and pile fields closest to Pier 57. Transects lasted about five minutes and were standardized to time (CPUE). During the transect the kayaker took audio notes detailing their location. From the boat, depth was recorded and physical-chemical sampling was taken with a YSI 85 (Yellow Springs Instruments Inc., Yellow Springs, OH).

ECHOGRAM ANALYSIS

We analyzed data from 42 transects at Pier 57. Audio notes helped assigned transects to open water, pile field, pier edge, or edge/under pier. To estimate the number of fish in a school, we laid a grid over a still frame image. Fish counts were averaged from three sub-sample quadrats with fish in them, and a total estimated for the school. Fish size was measured using DIDSON image software. Individual fish were measured to nearest cm; schools were randomly sampled and a size range calculated. Depth of fish schools and of the river bottom was calculated from sonar tilt and distance to reflection.

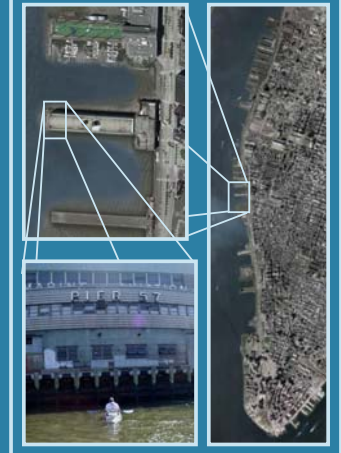


Fig. 1: A DIDSON mounted on the bottom of a kayak, being transported across the Hudson River.



DIDSON Laptop Batteries Power Switch

Fig. 3: Pier 57 is one of a number of piers located on the Manhattan side of the Hudson River.



RESULTS

Principal Components Analysis (PCA) of characteristics measured from echograms revealed a weak gradient in small fish occurrence in different habitats (Fig. 4). More and larger schools tended to occur in edge habitat (Fig. 4, Fig. 5a). Edge/under pier samples had smaller numbers of variably sized fish (Fig. 4), although observational notes show a tendency for schools to disappear further under the pier. Pile field samples (Fig. 4, Fig. 5b) looked similar to open water samples (Fig. 4, Fig. 5c), but varied more. Differences in fish depth may be an artifact of differences in water depth among habitat types.

The standardized average number of fish per minute at the pier edge was greater than in any other habitat (Table 1), and significantly greater than in open water and pile fields (Bonferroni test, 95% confidence interval, Table 2). The occurrence of schools was greatest in open water (Table 1), but not significantly different between any of the habitats (Bonferroni test, 95% confidence interval, Table 2). Fish size was greatest in pile fields and smallest at pier edges (Table 1), but this was the only size difference that was significant (Bonferroni test, 95% confidence, Table 2). Size of schools was largest along pier edges (Table 1), and there was a significant difference between school size in this habitat and all other habitats (Bonferroni test, 95% confidence, Table 2).

CONCLUSIONS

Small fish do not appear to be avoiding any particular habitat. The trend in fish size relative to habitat use was ambivalent, as the PCA only supports the Bonferroni test when analyzed on its second axis. There was a weak trend of increased fish abundance and occurrence of schools at edge habitats. School size was significantly greater in edge samples than in other habitats during daylight.

Small fish could be forming larger schools around the edge because a lack of predation allows them to do so. The difference between edge samples and pile field samples allows us to conclude that it is not structure that is attracting small fish. Small fish are utilizing the edge of the pier, and may be using the shade to escape visual predators. However, that is not to say small fish escape the detriments of shading that afflict large fish. The lower mean school size under the pier may indicate that fish are less likely to form stable schools under the pier. Further explorations of the relationship of small fish to shade would need to address shade on a finer scale than absence or presence.

There is a large amount of variation between habitats. This could owe to dynamic school membership. There may be differences in habitat use that we are missing by not classifying the fish by species, which is not yet possible (see Groundtruthing sidebar).

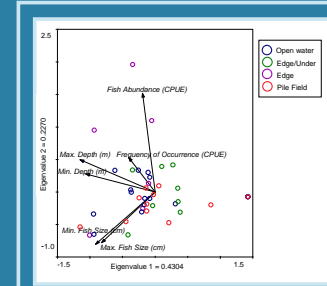


Fig. 4: A PCA of characteristics of schools within a DIDSON file, with habitat class assigned a priori.

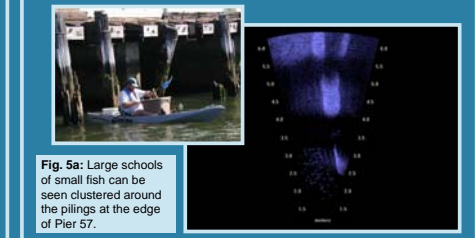


Fig. 5a: Large schools of small fish can be seen clustered around the pilings at the edge of Pier 57.

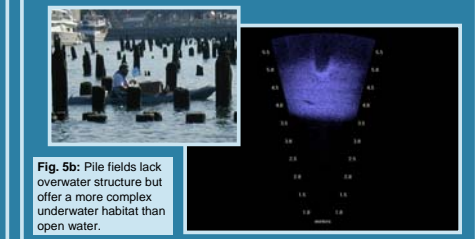


Fig. 5b: Pile fields lack overwater structure but offer a more complex underwater habitat than open water.

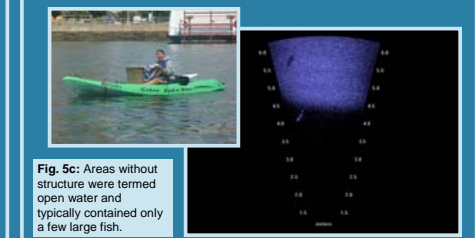


Fig. 5c: Areas without structure were termed open water and typically contained only a few large fish.

Fig. 5: The appearance and corresponding echogram of three of the habitats.

Habitat	Mean Number of Fish in File (CPUE)	Mean Occurrence of Schools in File (CPUE)	Mean Size of Fish in School (cm)	Mean Number of Fish in School (number)
Open Water	1.5	1.1	18.9	3.2
Pile Field	4.1	0.2	22.1	6.8
Pier Edge	45.4	0.8	13.0	81.3
Edge and Under	13.9	0.9	16.7	20.1

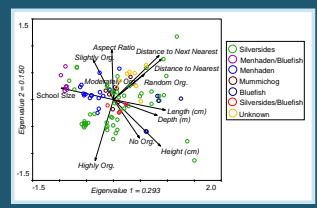
Table 1: Attributes of encountered fish by habitat.

	Mean Number of Fish in File (CPUE)	Mean Occurrence of Schools in File (CPUE)	Mean Size of Fish in School (cm)	Mean Number of Fish in School (number)
edge-open	X		X	X
edge-pile	X		X	X
edge-under				X
open-pile				
open-under				
pile-under				

Table 2: Results of Bonferroni test with a 95% confidence interval. X denotes comparisons that resulted in a significant difference.

GROUNDTRUTHING

A benefit of multi-beam sonar over traditional sonar is image resolution. Individual fins can even be observed, such as with the school of striped bass under Pier 40 (Left Fig.). Motion reveals kinetic characteristics, such as swimming form. Details are less distinguishable for smaller fish, but behaviors may serve as identifying features. We measured characteristics of school organization, size distribution, and spacing from echograms of small fish schools groundtruthed to species by net capture (Right Fig.). Variation in these metrics were reduced to their most important dimensions using principle components analysis (PCA) to allow classification of echogram targets from unknown schools. For instance, one fish in the Menhaden/Bluefish group is readily distinguished as a bluefish. It was also unknown whether the method for estimating fish numbers would be accurate, therefore a manual count was conducted for a number of the Pier 57 samples. Estimation resulted in a 14.76 percent error. These methods will continue to be refined as more groundtruthing occurs.



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References available upon request.