The Effects of Pier Shading and Prey Availability on the Growth of Juvenile Fishes in the New York-New Jersey Harbor Estuary

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The overall objective of our research proposal is to identify the factors contributing to low abundance (Able et al. 1998) and poor growth rates (Able et al. 1999; Duffy-Anderson and Able 1999) of juvenile benthic fishes under municipal piers in the New York-New Jersey Harbor Estuary. Growth is a particularly useful measure of habitat quality (Able, 1999). It is function of feeding success, however many factors influence the identification, capture, and ingestion of prey. In particular, the availability of sufficient quantities of suitable prey and adequate light levels to find and capture those prey are critical. Under-pier areas are extremely light-deprived and as such one or both of these crucial elements may be compromised, resulting in the observed conditions of starvation under piers among some juvenile fishes. We proposed a two-year study to ascertain the factor or factors responsible for low rates of growth under large piers.

We have completed successfully completed much work toward this goal. Five papers have been published in peer-reviewed journals, and the work has been accepted for publication as a chapter in a book on the status of the Hudson River Estuary. Based on this work and on other studies conducted in our laboratory, we believe that low light levels under piers (as measured over several years of study) is directly related to their lower habitat value relative to other areas. The few species that are more commonly collected from beneath piers (American eels, Atlantic tomcod, naked gobies, decapod crustaceans) share an ability to utilize alternative sensory systems (chemoreception, mechanoreception) to locate prey in conditions of near-darkness. Visually-feeding fishes generally do not occur under piers, probably because the low-light conditions there interfere with their ability to feed (Duffy-Anderson and Able, 1999; Duffy-Anderson et al., in press; Vivian et al. 2000). Further, two fish species that use visual foraging mechanisms, winter flounder and tautog, show reductions in food intake and poor growth under piers, in spite of having more than sufficient numbers of prey available for consumption (Duffy-Anderson and Able, 2000). Third, these same two species of fish grow well in pile fields, which are areas that are virtually identical in structure to piers themselves but lack the decking that reduce light levels in the water below (Able et al. 1999). Finally, a species of fish that can utilize alternative prey detection mechanisms, the Atlantic tomcod, can grow under piers, albeit at reduced rates compared to other habitats (Metzger et al. 2001). Considered collectively, these findings indicate that under-pier habitats are not utilized by many fish species because foraging is impeded by conditions of intense shading.

Manuscripts and Chapters:

1. Duffy-Anderson, J. T. and K. W. Able. 1999. The effects of municipal piers on growth of juvenile fishes in the lower Hudson River: a study across a pier edge. *Mar. Biol.* 133: 409-418.

ABSTRACT: The growth rates of two fish species, the winter flounder (Pseudopleuronectes americanus, 19.3 - 42.6 mm TL) and the tautog (Tautoga onitis, 23.9 - 55.9 mm TL), were used to evaluate habitat quality under and around municipal piers in the Hudson River estuary, USA. Growth rates were measured in a series of 10 d field caging experiments conducted at two large piers in the summers of 1996 and 1997. Cages (0.64 m^2) were deployed along transects that

stretched from underneath the piers to beyond them encompassing the pier edge, the transitional zone between the pier interior and the outside. Growth in weight was determined at five locations along the transect, 40 m beneath the pier, 20 m beneath the pier, at the pier edge, 20 m beyond the pier, and 40 m beyond. Mean growth rates of winter flounder and tautog were negative under piers ($\bar{x}$ G_W = -0.02 d^{-1}) and rates were comparable to laboratory-starved control fish ($\bar{x}$ G_W = -0.02 d^{-1}). In contrast, mean growth rates at pier edges and in open waters beyond piers were generally positive ($\bar{x}$ G_W ranged from -0.001 to +0.05 d^{-1}), with growth at pier edges often being more variable and less rapid than at open water sites. Analyses of stomach contents upon retrieval of caged fishes revealed that dry weights of food were generally higher among fishes caged at open water stations ($\bar{x}$ range = 0.02 - 0.72 mg dry weight) than at pier edge ($\bar{x}$ range = 0.01- 0.54 mg) or under-pier stations ($\bar{x}$ range = 0.03 - 0.11 mg), though it was apparent that benthic prey were available at all stations on the transect. Our results indicate poor feeding conditions among fishes caged under piers and suboptimal foraging among fishes caged at pier edges. Inadequate growth rates can lead to higher rates of mortality and we conclude that under-pier environments are poor-quality habitats for some species of juvenile fish based on these and other earlier experiments.

2. Metzger, C. M., J. T. Duffy-Anderson, and K. W. Able. 2001. Effects of a municipal pier on growth of young-of-the-year Atlantic tomcod (*Microgadus tomcod*): a study in the Hudson River estuary. *Bull. NJ Acad. Sci.* 46(1): 5-10.

ABSTRACT: The effects of a large, municipal pier on the growth of young-of-the-year (YOY) Atlantic tomcod (Microgadus tomcod) was investigated in two 10-d experiments conducted in the Hudson River estuary. Fish (42-75 mm TL) were confined in benthic cages along a transect that ranged from open water to underneath a pier and consisted of three stations: 40 m beyond the pier edge in open water (+40 m), the pier edge (0 m), and 40 m underneath the pier (-40 m). In both experiments, all fish grew significantly more than in controls. These results contrasted with previously published reports that indicated some species of juvenile fishes lose weight in similar experiments under piers. Mean instantaneous growth rates in weight (G_W d^{-1}) of Atlantic tomcod in the first experiment were +0.02 ± 0.004 d^{-1} under the pier,+0.04 ± 0.006 d^{-1} at the pier edge, and +0.03 ± 0.005 d^{-1} outside of the pier. Results were similar in the second experiment with means of +0.02 ± 0.002 d^{-1}, +0.03 ± 0.002 d^{-1}, and +0.03 ± 0.003 d^{-1} underneath, at the edge, and outside of the pier, respectively. These data demonstrate that YOY Atlantic tomcod can grow in under-pier habitats, though there is a trend toward lower growth compared with edge or open water habitats. Analyses of stomach contents indicate that Atlantic tomcod consumed a diet of benthic invertebrates (harpacticoid copepods, amphipods) and no significant differences in total stomach content dry weights were detected across the transect. Benthic core samples collected along the transect indicated a trend toward higher densities of prey ($\bar{x}$ = 15 ± 3 prey cm^{-3}) underneath the pier. Taken collectively, data suggest that benthic prey are available for YOY Atlantic tomcod across the pier transect and that Atlantic tomcod can grow under piers although feeding and growth is reduced compared with adjacent edge and open water areas. Therefore, under-pier areas are probably sub-optimal habitat for this species, a general observation that is consistent with other species examined.

3. Duffy-Anderson, J. T. and K. W. Able. 2001. An assessment of the feeding success of young-of-the-year winter flounder (*Pseudopleuronectes americanus*) near a municipal pier in the Hudson River estuary, USA. *Estuaries*. 24(3): 430-440.

ABSTRACT: We examined feeding success of young-of-the-year winter flounder (Pseudopleuronectes americanus Walbaum) (20 - 50 mm TL) around a large, municipal pier in the Hudson River estuary, USA. Replicate, 3-hour feeding experiments were conducted using benthic cages (0.64 m^2) deployed under, at the edge, and outside of the pier during late spring and early summer in 1998 and 1999. Significantly more winter flounder caged under piers had empty stomachs ($\bar{x}$ = 71.9%) than at the edge ($\bar{x}$ = 29.2%) or in open water ($\bar{x}$ = 14.4%). Feeding intensity was significantly higher outside of the pier ($\bar{x}$ = 0.40 %) than the edge ($\bar{x}$ = 0.19 %) or under the pier ($\bar{x}$ = 0.03 %). Simultaneous with feeding experiments, benthic core samples were collected adjacent to cages. Variability was high, but abundances of prey were consistently higher under the pier ($\bar{x}$ = 200.14 ± 113.3 sd in 1998; 335 ± 290.2 in 1999) than at the edge ($\bar{x}$ = 126.6 ± 50.2 in 1998; 70.8 ± 68.5 in 1999) or in open water ($\bar{x}$ = 53.4 ± 16.1 in 1998; 123.8 ± 193.9 in 1999). No significant differences in prey biomass were determined, suggesting that small, numerous prey were available under the pier and fewer, larger taxa were present at the edge and outside. Data indicate that feeding is suppressed among young-of-the-year winter flounder caged under piers in spite of sufficient prey available. Based on these and other experiments we submit that areas under piers are not suitable long-term habitat for juvenile fish because they interfere with normal feeding activities.

4. Vivian, D. N., J. T. Duffy-Anderson, R. G. Arndt, and K. W. Able. 2000. Feeding habits of young-of-the-year winter flounder, *Pseudopleuronectes americanus*, in the New York-New Jersey Harbor estuary. *Bull. NJ Acad. Sci.* 45(2): 1-6.

ABSTRACT: The stomach contents of 326 young-of-the-year winter flounder, Pseudopleuronectes americanus, (20 - 65 mm TL) obtained from caging studies (n = 296) conducted June - July (1996 - 1998) and collected in benthic traps (n = 30) deployed in June - July (1999) in the New York - New Jersey Harbor estuary were examined to determine whether type and/or size of prey ingested varied with fish size. Both the number of prey types and the size of prey items found in the stomachs increased with an increase in fish total length (TL), with a distinct shift in diet occurring at approximately 40 mm. Stomach contents of winter flounder < 40 mm were largely comprised of small (< 0.5 mm) harpacticoid copepods (82% and 44% among caged and trapped fish, respectively). However, in winter flounder > 40 mm, the number of harpacticoid copepods consumed decreased dramatically to 22% and 17% among caged and trapped fish, respectively, and the remainder of the diet consisted of calanoid copepods, gastropods, ostracods, polychaetes, and amphipods. These organisms were larger and ranged in size from 0.5 - 4.0 mm. Mouth gapes of all fishes were measured and the data suggest that winter flounder < 40 mm could have consumed larger prey (1 - 2 mm) than was observed in the stomachs. Shifts in prey size and prey type may decrease intra-specific competition and allow for a greater exploitation of food resources.

5. Duffy-Anderson, J. T., J. P. Manderson, and K. W. Able. In press. A characterization of juvenile fish assemblages around man-made structures in the New York-New Jersey Harbor estuary. *Bull. Mar. Sci.*

ABSTRACT: We deployed benthic traps in the Arthur Kill (1995), Kill van Kull (1996), and Hudson River (1996), U.S.A, near wrecks, pile fields, piers, and in open water areas (no structure). Over 8,300 fish of 31 different species of fish were collected, the majority of which were young-of-the-year individuals (98%). Many typical estuarine species were found in all three waterways and across several habitats, though species abundance and diversity was significantly depressed under piers ($\bar{x}$ CPUE = 0.15 individuals trap^{-1} day^{-1}). Since the majority of the fish were collected from the Arthur Kill (n = 7,812), the assemblage structure in this system was evaluated more thoroughly. Assemblage structure was significantly different among habitat types (wreck, pile field, open water) with mean CPUE in open water areas ($\bar{x}$ = 6.1 individuals trap^{-1} day^{-1}) being lower than near wrecks ($\bar{x}$ = 6.8 individuals trap^{-1} day^{-1}) or pile fields ($\bar{x}$ = 6.6 individuals trap^{-1} day^{-1}). Results suggest that fish assemblage patterns may be a function of structural complexity, though other factors such as shading or water depth may also have measurable effects. Collectively, the data suggest that the New York - New Jersey Harbor estuary provides habitat for a number of economically and ecologically important species.

6. Able, K. W. and J. T. Duffy-Anderson. In press. Impacts of piers on juvenile fishes and selected invertebrates: a review and update. <u>In:</u> Levinton, J. (ed.). <u>The Hudson River Estuary</u>. Oxford University Press.

BOOK CHAPTER CONCLUSION: New York Harbor is home to a variety of marine and estuarine species that depend on informed and responsible management practices. Recognition of the important ecological role this system plays is critical to the overall health of the estuary. Development projects that would reduce species abundance, limit diversity, inhibit feeding, and lower growth should be avoided. We have demonstrated that municipal piers in the lower Hudson River have these consequences, and our studies suggest that acute shading is responsible. We support efforts to reduce the duration, intensity, and area of shading in existing and future pier development projects. New York Harbor and the lower Hudson River continue to be important spawning and nursery grounds to a host of commercial and recreational fisheries so new development projects that have the potential to shade open, shallow-water (<5 m) areas in this system should be carefully evaluated prior to approval. Open water habitats appear to be the most valuable to young-of-the-year fishes as these well-lighted areas promote the fastest growth rates and support the most numerous and diverse species assemblages.

Literature Cited

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