Effects of the Inner Harbor Navigation Canal Surge Barrier on Marsh Nekton

Jenny Simon[1] and Frank Jordan[1,2]
[1]Environmental Program and [2]Department of Biological Sciences
Loyola University New Orleans
New Orleans, LA 70118

Contact jordan@loyno.edu for additional information.

Abstract – Humans are increasingly dependent upon water control structures such as the Inner Harbor Navigational Canal Surge Barrier (IHNCSB) to reduce the adverse affect of strong storm surges that were previously prevented by natural coastal wetlands. A potential negative effect of these control structures is restricted tidal flow and limited movement and recruitment of estuarine nekton. The purpose of this study was to determine if limited hydrological connectivity affected the ability of nekton such as fish, crabs, and shrimp to recruit into the remnant marsh interior to the IHNCSB. We used 1-m2 throw traps to quantitatively sample nekton in subtidal edge habitat on the inside and outside of the IHNCSB. There was no difference in the diversity or abundance of nekton on either side of the wall, indicating that existing locks on the IHNCSB allowed adequate movement of nekton. These results should be considered tentative given that we were only able to sample during a single season following completion of the IHNCSB; additional sampling over time is needed to confirm that the wall is not having a long-term effect on nekton.

Introduction

Louisiana has the largest amount of coastal wetlands in North America. These coastal wetlands provide a range of ecosystem services such as absorbing excess nutrients and contaminants, trapping sediments, and reducing the destructive energy of storm surges. From a biological perspective, coastal wetlands are highly productive and provide essential marsh habitat that serves as nurseries for recreationally and commercially important fishes, crabs, shrimps, and other nekton (Herke 1995, Castellanos & Rozas 2001, Kneib 2003). Unfortunately, Louisiana also has the fastest rate of coastal wetland loss due to a variety of human and natural causes. Reduction of water and sediment delivery has resulted in significant subsidence in the Mississippi River delta and surrounding coastal wetlands.

As coastal wetlands are lost, humans become increasingly dependent upon the construction of levees and other engineered solutions to reduce the adverse affect of strong storm surges that were previously prevented by natural wetlands. One of the most impressive (and expensive) of these solutions is the recently completed Inner Harbor Navigation Canal Surge Barrier (IHNCSB), which was designed to protect portions of St. Bernard and Orleans Parishes from storm surges moving westward from Lake Borne and the Gulf of Mexico. Construction of the IHNCSB during the period 2008-2013 divided the existing brackish marsh – the "Golden Triangle" – into a large marsh exterior (eastward) to the barrier and a smaller remnant marsh interior (westward) to the barrier (Figure 1). There are now limited hydrologic connections between these interior and exterior marshes.

Storm surge barriers provide increased protection to densely populated areas such as New Orleans, but they may also have unforeseen environmental costs. Water control structures such as levees can alter both the hydrology and ecology of salt marshes (Hood 2004, Kimball et al. 2010). The IHNCSB may reduce the ability of nekton to move freely between remaining interior and exterior marshes and reduce the ability of these organisms to recruit larvae from Lake Borne and the Gulf of Mexico. The nursery function of these marshes helps subsidize significant recreational and commercial fishing and contributes significantly to Louisiana's economy. Negative consequences on the population of nekton can in turn have negative consequence on the local economy. Additional research is needed to quantify and eventually mitigate the effects of storm surge barriers such as the IHNCSB. The purpose of this study was to determine if limited hydrological connectivity affected the ability of nekton such as fish, crabs, and shrimp to recruit into the remnant marsh interior to the IHNCSB.

Methods

Nekton were sampled at three sites on the interior and three sites on the exterior of the IHNCSB (Figure 1). At each site, 1-m^2 throw traps were used to sample nekton in subtidal habitat immediately adjacent to the marsh edge. Throw traps are an effective gear for sampling nekton in coastal marsh systems because they provide accurate and precise estimates of nekton abundance across a range of plant stem densities and there is no need to alter habitat prior to sampling and (Jordan et al. 1997, Rozas and Minello 1997). Sampling was limited to subtidal edge habitat because the marsh surface was too shallow and uneven due to the presence of dense plant tussocks. Sampling nekton in subtidal habitat along the marsh edge is a common strategy in coastal wetlands because this is where nekton aggregate in significant numbers (e.g., Roth and Baltz 2009). We also limited sampling to edge habitat because we were unable to obtain permission from property owners to access much of the privately leased Golden Triangle area.

At each of the six sites we collected three throw trap samples haphazardly in the selected habitat. The throw trap was cautiously thrown into the habitat and immediately pressed into the substrate to create a solid seal as to eliminate escape opportunities for the nekton. Water depth was then measured to the nearest cm. Plants inside the throw trap were uprooted and shaken to free any remaining nekton back into the trap. Plants were placed in a mesh bag, spun to remove excess water, and weighed to the neared 0.1 kg. After plants were cleared, a bar seine with 3-mm stretch mesh was swept through the throw trap until three consecutive nekton-free sweeps were collected (Jordan et al. 1997). Nekton were euthanized with MS-222 (tricaine mesylate) and then preserved in 10% buffered formalin. Work in the laboratory included identifying nekton to the lowest taxonomic level possible, counting individuals, and measuring them to the nearest mm standard length (SL) for fishes and total length for invertebrates.

We used t-tests to compare diversity and densities of nekton in the interior and the exterior of the IHNCSB. Kendall rank correlation was used to compare species ranks the interior and the exterior of the IHNCSB. We rejected the null hypothesis of no difference in a response variable between sides of the IHNCSB when $p<0.05$.

Results

Based on a single season of sampling, the IHNCSB appears to have had little affect on nekton. A total of 1,876 nekton representing 20 different taxa were collected (Table 1). About 57% of these were collected from the interior the IHNCSB, whereas 43% were collected from the exterior the IHNCSB (Table 1). Xanthid crabs and naked gobies dominated the nekton community on both sides of the IHNCSB (Table 1). Overall, species ranks on both sides of the IHNCSB were highly concordant and indicated that samples came from the same or very similar nekton communities (Kendall's tau=0.95, $p<0.0001$). Average diversity (number of species per trap), average density of all fishes combined, average density of all nekton combined, average size (SL and CL), and average number of naked gobies clearly did not differ between the interior and the exterior of the IHNCSB (Figure 3; t-tests, $p>0.05$). Average density of all invertebrates combined, average density of xanthid crabs, and average density of rainwater killifish appeared variable, but differences between the interior and the exterior of the IHNCSB were not statistically significant (Figure 3; t-tests, $p>0.05$).

Discussion

Coastal wetlands are shaped in large part by the movement of water and materials during daily tidal exchanges and storm events (Kneib 2000). Human alteration of water movement patterns is therefore likely to affect ecological function in coastal wetlands. Indeed, there is a substantial body of literature indicating that construction of roads, levees, dikes, culverts, and other structures that restrict tidal and non-tidal flow has strong ecological effects on coastal wetlands. These structures often limit movement of larval, juvenile, and adult nekton within coastal wetlands (e.g., Rogers 1994, Poulakis et al. 2002). However, it appears that not all tidal restrictions are created equal and that smaller culvert-sized restrictions appear to have the greatest negative effects on nekton movement in coastal wetlands (Raposa and Roman 2003, Kimball et al. 2010, Eberhardt et al. 2011, Dibble and Meyerson 2012). Based on results from a single season of sampling, our results indicate that the IHNCSB did not restrict flow enough to significantly reduce recruitment of nekton such as fish, crabs, and shrimp into the interior remnant marsh.

Although sampling was spatially replicated, there were several temporal limitations to our research design. First, sampling was limited to a single season that may not be representative of typical conditions in the Golden Triangle marsh system. We plan on extending our research as a larger study of estuarine dynamics and recruitment in this system. Second, there were no data on the abundance and distribution of nekton in the study area from before our study and therefore we could not use a BACI design to assess effects of IHNCSB on marsh nekton. Third, not enough time may have elapsed since construction of the IHNCSB for negative effects to occur. Given the highly dynamic nature of coastal wetlands, it seems more likely that nekton were resilient to the construction and movement was unhampered because of the large sizes of the tidal gates. However, the results we found could change over time with the continued change in hydrological connectivity between the two sides of the wall. Data from this study may be used to perform a BACI study in the future to help determine the long-term effect of the IHNCSB and other water control structures on marsh nekton.

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Table 1. Total number and relative abundance (%) of nekton collected from the interior and the exterior the IHNCSB.

	Interior		Exterior	
Species	N	%	N	%
Bay anchovy, *Anchoa mitchilli*	1	0.001	100	0.122
Clue crab, *Callinectes sapidus*	2	0.002	1	0.001
Spotted seatrout, *Cynoscion nebulosus*	1	0.001	0	0.000
Gulf killifish, *Fundulus grandis*	1	0.001	0	0.000
Naked goby, *Gobiosoma bosci*	149	0.141	118	0.144
Least killifish, *Heterandria formosa*	1	0.001	0	0.000
Redear sunfish, *Lepomis microlophus*	1	0.001	1	0.001
Rainwater killifish, *Lucania parva*	7	0.007	105	0.128
Ohio River shrimp, *Macrobrachium ohione*	0	0.000	1	0.001
Inland silverside, *Menidia beryllina*	23	0.022	2	0.002
Clown goby, *Microgobius gulosus*	2	0.002	0	0.000
Eastern grass shrimp, *Palamonetes paludosus*	0	0.000	1	0.001
Daggerblade grass shrimp, *Palamonetes pugio*	20	0.019	26	0.032
Marsh grass shrimp, *Palamonetes vulgaris*	0	0.000	1	0.001
Brown shrimp, *Farfantepenaeus aztecus*	1	0.001	1	0.001
White shrimp, *Litopenaeus setiferus*	0	0.000	3	0.004
Sailfin molly, *Poecilia latipinna*	0	0.000	2	0.002
Blackcheek toungefish, *Symplurus plagiusa*	0	0.000	1	0.001
Gulf pipefish, *Syngnathus scovelli*	4	0.004	15	0.018
Mud crabs, *Xanthidae*	844	0.798	441	0.538
Total	1057		819	

Figure 1. Top: Construction of the Inner Harbor Navigational Canal Surge Barrier (IHNCSB) across the Golden Triangle marsh near Chalmette, Louisiana. The remnant interior marsh is in the foreground (westward of the wall) and larger marsh is in the background (eastward of the wall). Image borrowed from the Internet without permission. Bottom: Study area with approximate locations of throw trap sample sites interior (red dots) and exterior (yellow dots) of the IHNCSB (blue line).

Figure 3. Jenny Simon and her trusty field assistant Tom Sevick (UROP 2012) sampling in the Golden Triangle marsh system. Top: testing minnow traps. Bottom left: standing in the water. Bottom right: emptying throw trap with bar seine.

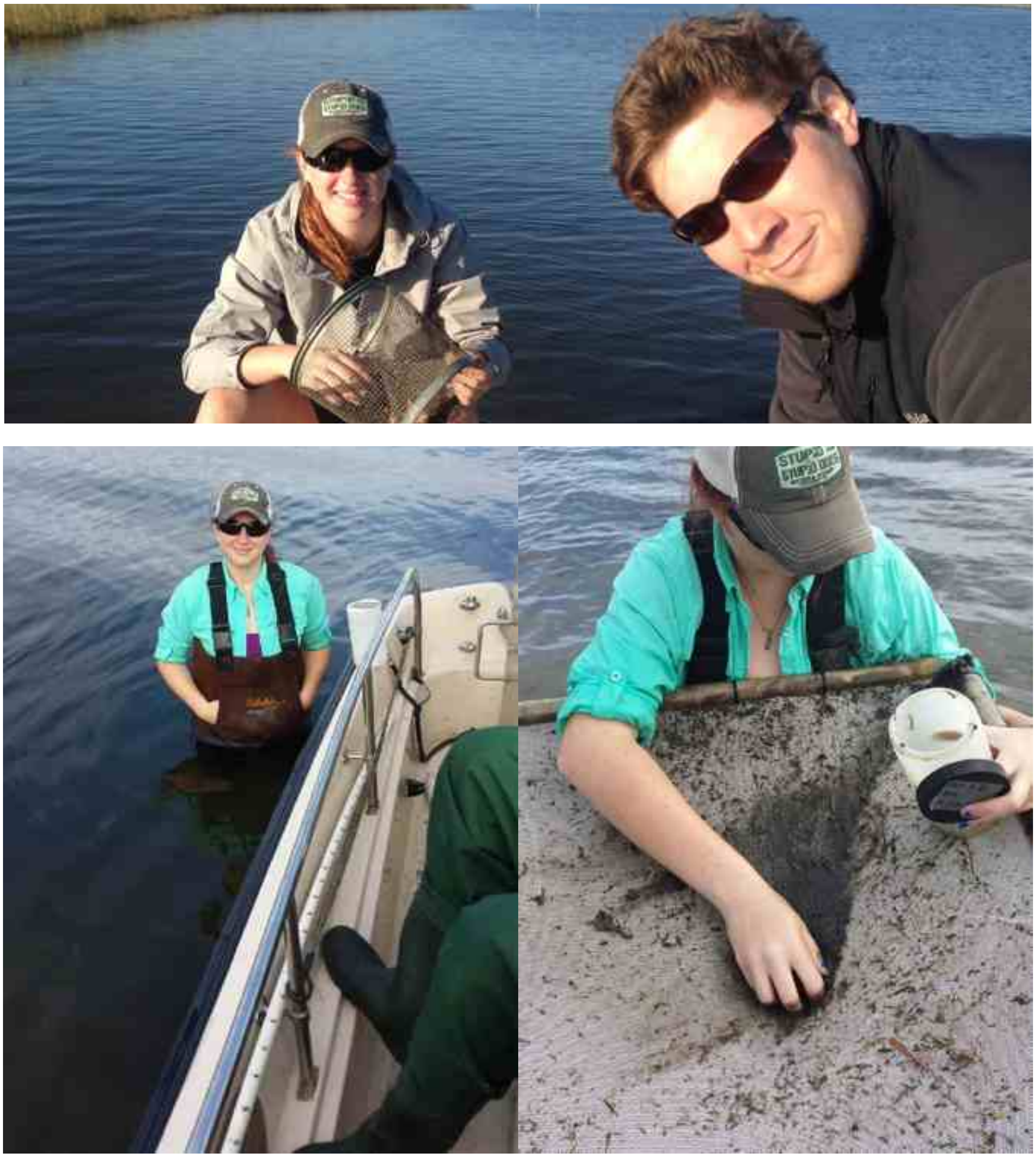

Figure 3. Mean (+1 SE) species richness, total fish density, total invertebrate density, total nekton density, total xanthid density, total rainwater killifish (LUCPAR) density, and total naked goby (GOBBOS) density per m^2 on the interior (in) and exterior (out) of the IHNCSB.