Green Sturgeon Usage of Shellfish Beds in Willapa Bay, Washington –Comparative Habitat Surveys in 2014 and 2015.

Kim Patten and Scott Norelius
Washington State University Long Beach Research and Extension Unit
pattenk@wsu.edu

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Executive summary: Ten distinct regions in Willapa Bay were surveyed for sturgeon foraging pit densities in 2014 and 2015. The areas surveyed had both shellfish and non-shellfish growing areas and were in locations that sturgeon have been noted to frequent. Within each area surveyed, foraging pit densities were assessed across different habitats within those areas. There was a total of 119 separate sites surveyed. The mean area surveyed for each data point was ~ 0.5 ha. Data on sturgeon pit density were grouped into different habitats and comparisons were made between habitats. Pit density across all shellfish beds (4 feeding pits/ha) was an order of magnitude lower than the density across all non-shellfish beds (30 feeding pits/ha). Within just the nonshellfish bed habitats, four distinct habitats were compared: 1) eelgrass cover <25% and burrowing shrimp < $2/m^2$ (5 feeding pits/ha); 2) eelgrass cover <25% and burrowing shrimp >$10/m^2$ (58 feeding pits/ha); 3) eelgrass cover >75% and burrowing shrimp <$2/m^2$ (1 feeding pit /ha); 4) eelgrass cover >75% and burrowing shrimp >$10/m^2$ (22 feeding pits/ha). The only significant habitat difference was between tideflats with < 25% eelgrass and >10 burrows/m^2 and tideflats with >75% eelgrass cover and <2 burrows/m^2.

Within just shellfish beds there were only enough separate types of habitat to make four distinct comparisons: 1) clam beds with burrowing shrimp < $2/m^2$ (0 feeding pits/ha); 2) ground culture oyster beds with burrowing shrimp <$2/m^2$ (0 feeding pits/ha); 3) longline oyster culture with burrowing shrimp <$2/m^2$ (3 feeding pits/ha); 4) longline oyster culture with burrowing shrimp >$10/m^2$ (42 feeding pits/ha). The longline culture habitat with high burrowing shrimp density was significantly different than other shellfish habitat. Overall, our survey data would indicate that green sturgeon only infrequently use commercial shellfish beds for foraging, especially beds with a gravel or shell surface layer. The one exception to this was longline beds with high burrowing shrimp populations that didn't have a shell base. These preliminary survey data would suggest that longline culture in itself does not limit or inhibit the usage of prime foraging habitat of green sturgeon.

Our preliminary survey results also indicated that green sturgeon in Willapa Bay are not habitat-limited. Much (18%) of the prime foraging habitat we surveyed (no eelgrass coverage and high burrowing shrimp populations) had no green sturgeon foraging pits.

Introduction: The green sturgeon (*Acipenser medirostris*) is considered threatened in the southern U.S. West Coast natal rivers, and a Species of Concern in northern U.S. West Coast rivers and estuaries. Large areas, ~ 33,000 km^2 of estuarine, marsh, and marine coastal habitats, from Monterey Bay, CA, through the Strait of Juan de Fuca, WA, have been designated as "critical" to green sturgeon (NOAA 2009). In many of these estuaries these "critical habitats" are also historical shellfish beds. In Willapa Bay, for example, 20% of the intertidal area is utilized for commercial aquaculture of Pacific oysters (*C. gigas*) and Manila clams (*Ruditapes philippinarum*) (Feldman et al. 2000). There is almost no research examining the interaction between green sturgeon foraging and shellfish farming. A submitted paper by Moser et al. (submitted 2016) does suggest that graveled clam beds have minimal sturgeon foraging, but their surveys were limited in scope and scale, and were not designed to make inferences about green sturgeon usage of shellfish beds. The objective of this project was to compare green sturgeon foraging across different shellfish and non-shellfish habitats in Willapa Bay.

Methods: In 2014 and 2015, ten distinct regions in Willapa Bay were surveyed for sturgeon forage pit densities. The areas surveyed had both shellfish and non-shellfish growing areas and were in locations that sturgeon have been noted to frequent. Within each area surveyed, foraging pit densities were assessed across different habitats within those areas. The number of pits was counted along transects through each habitat. The length and width of each transect was measured by GPS. Transect lengths averaged ~ 500 m, but were limited to the size of each habitat assessed. The width of the transects ranged from 5 to 25 m and was determined by ability to visually detect surgeon feeding pits (narrow in *Z. marina*, wide in bare sand). Data were converted to pits/ha, with the mean area surveyed for each data point ~ 0.5 ha. For each transect, habitat was classified by 1) percent vegetative cover by eelgrass (none, low (1 to 25%); medium (26 - 70%); high(>75%); 2) burrowing shrimp density (none, low (1 to 2/m^2), medium (>4<10/m^2), high(>10/m^2), and 3) usage (oyster, clam or non- shellfish). Oyster habitat was further broken into ground culture with a shell base, ground culture with non-shell base (open bare sediment clearly visible), and longline culture with oysters suspended ~ 0.5 m above bare ground on lines of rope ~1.5 m apart. There was a total of 119 separate sites surveyed. Data on sturgeon pit density were grouped into different habitats and compared between habitats using Kruskal-Wallis One Way Analysis of Variance on Ranks. Post-hoc comparisons were done using Dunnett's T3 analysis for unequal variances ($P<0.05$).

Results: There was a difference in sturgeon foraging pit density across habitat. Pit density across all shellfish beds was an order of magnitude lower than the density across all non-shellfish beds (Table 1.) Within just the non-shellfish bed habitats, data were collected on enough sites to allow for statistical comparison between four distinct habitats: 1) eelgrass cover <25% and burrowing shrimp < 2/m^2; 2) eelgrass cover <25% and burrowing shrimp >10/m^2; 3) eelgrass cover >75% and burrowing shrimp <2/m^2, and 4) eelgrass cover >75% and burrowing shrimp >10/m^2. Tideflats with < 25% eelgrass and >10 burrows/m^2 had greater foraging pit density than tideflats with <2 burrows/m^2, regardless of eelgrass density (Table 1, Figure 1). Eelgrass reduced foraging pit density in areas with high burrowing shrimp density by half, but those differences were not significant.

Within just shellfish beds there were only enough separate types of habitat to make four distinct comparisons: 1) all clam beds, eelgrass cover <25% and burrowing shrimp < 2/m^2, n=7; 2) eelgrass cover <25% and burrowing shrimp >10/m^2, n= 23; 3) eelgrass cover >75% and burrowing shrimp <2/m^2, n=11, and 4) eelgrass cover >75% and burrowing shrimp >10/m^2, n=7. Oyster beds without shell base on longlines with shrimp densities > 10/m^2 had higher pit densities than clam or oyster beds with shell base without < 10 shrimp/m^2 (Table 1, Figure 2).

Discussion: Our survey data would indicate that green sturgeon only infrequently use commercial shellfish beds for foraging (83% of shellfish beds had no foraging pits, and 5% had > 20 pits/ha). Shellfish beds with a gravel or shell surface layer had almost no sturgeon foraging on them. However, there was ample foraging on shellfish beds that didn't have gravel or gravel surface layers and had ample prey density (burrowing shrimp). This combination is frequently found in longline beds in Willapa Bay, where they are used as a cultural method in areas with sediment too infested with burrowing shrimp to support ground-cultured oysters. This preliminary survey data would suggest that longline culture in itself does not limit or inhibit the usage of prime foraging habitat of green sturgeon. Because only a limited number of longline sites with high shrimp densities were surveyed (n=4), additional surveys will need to be conducted in subsequent years to confirm these initial findings.

Our preliminary survey results would also indicate that green sturgeon in Willapa Bay are not habitat-limited. One fifth (18%) of the prime foraging habitat we surveyed (no eelgrass coverage and high burrowing shrimp populations) no had foraging pits. This lack of usage of prime habitat by green sturgeon could be the result of there being a surplus of ideal foraging habitat in Willapa Bay (no shellfish, minimal eelgrass and dense burrowing shrimp[1]).

Table 1. 2014 & 2015 Willapa Bay survey results of green sturgeon foraging pit densities across habitats

Habitat	Eelgrass (% cover)	Burrowing shrimp (#/m^2)	N	Mean sturgeon pit density (#/ha)	SE
No shellfish beds	0 to 100%	0 to >10	67	29.8 a	8.3
All shellfish beds	0 to 100%	0 to >10	52	3.9 b	1.9
No shellfish beds	<25%	<2	7	5.3 b	3.8
No shellfish beds	<25%	>10	23	58.3 c	17.0
No shellfish beds	>75%	<2	11	1.2 ab	0.9
No shellfish beds	>75%	>10	7	22.3 bc	6.1
Oyster ground w/o shell and longline	0 to 100%	>10	4	41.7 c	17.7
Oyster ground w/ shell	0 to 100 %	<10	18	0 a	0
Oyster ground w/o shell and longline	0 to 100%	<10	7	3.4 ab	3
Clam	0 to 100%	<10	22	0.2 a	0.1

Mean separation within each habitat by Dunnett's T3 analysis (P<0.05).

[1] USDA survey of Willapa Bay by B. Dumbauld in 2006-2007

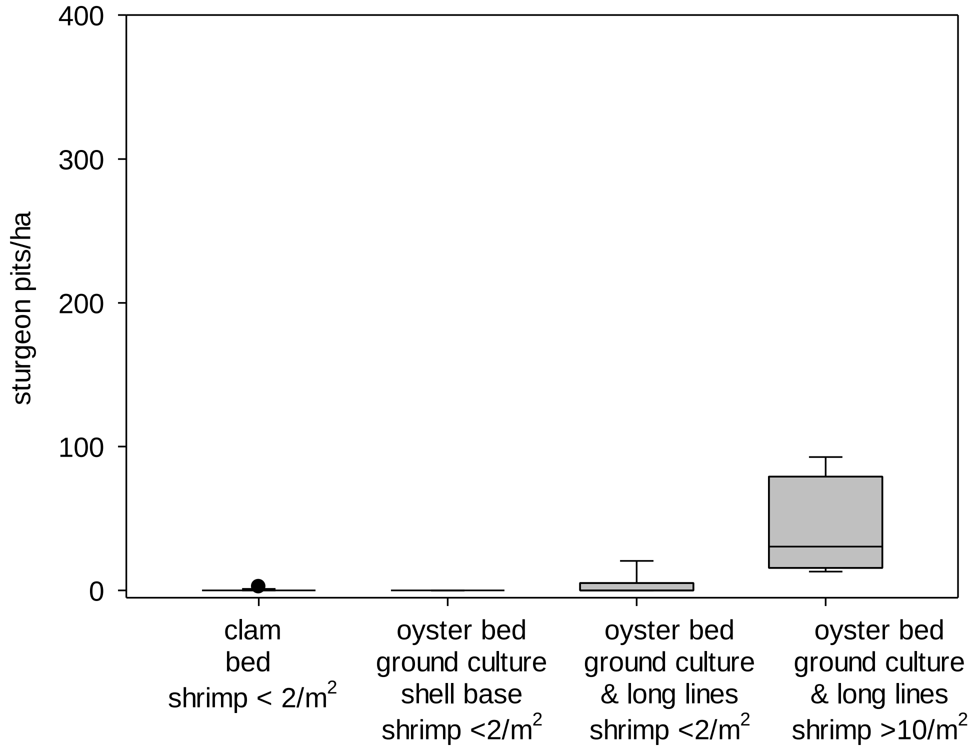

Figure 1. Sturgeon pit densities in Willapa Bay across different shellfish bed habitats.

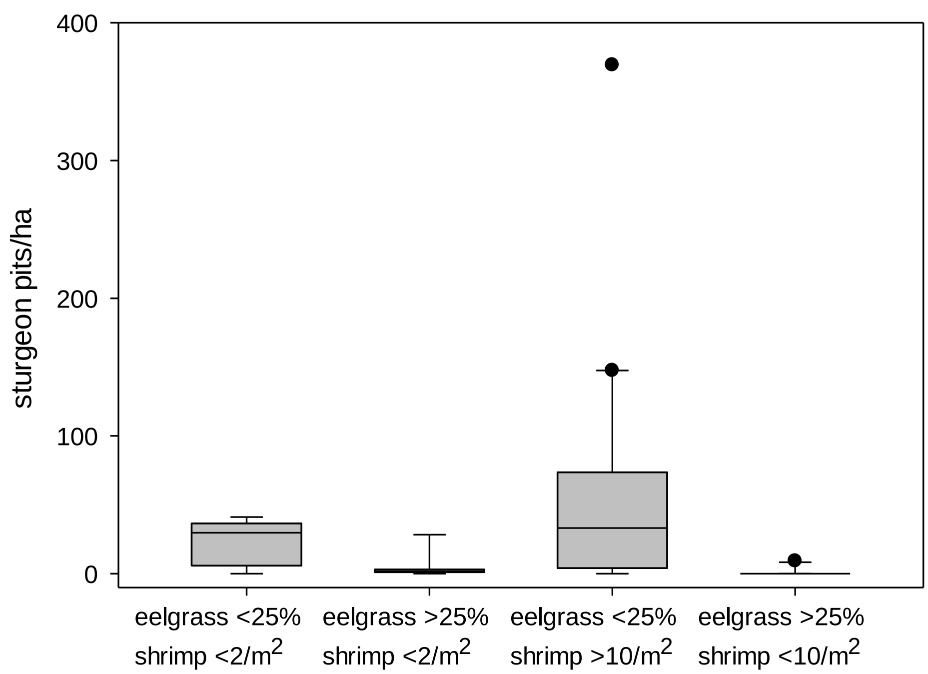

Figure 2. Sturgeon pit density in Willapa Bay across different non-shellfish bed habitats.

Literature cited:

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