July 21, 2015

Dear Dr. Lazzari and Reviewers,

Attached is our revision based upon your suggestions. Two main points were raised in the initial review that we address in a revised manuscript. Our changes are described below. First, we added new text to better justify our selection of the species used for trials. The new text included describes their feeding ecology. Both species are omnivorous but are also opportunists, eating whatever is abundant within their area. Therefore, while the pinfish diet may include a high proportion of seagrass, seagrass consumption occurs mainly when seagrasses are readily available as pinfish need to consume more of it to meet their energy needs. Some authors suggest pinfish consume seagrasses secondarily while trying to consume grazing animals that are eating epiphytes on the seagrass blades. We have included a figure showing the abundances of both pin fish and blue crabs and clearly stated that these are the most abundant species collected by the Texas Parks and Wildlife Department in fisheries-independent surveys. Both species are highly abundant in local waters, and analysis of Texas Parks and Wildlife data indicates that turbidity affects their abundance but in opposite directions with pinfish being more abundant in low turbidity and blue crabs more abundant in elevated turbidity.

Secondly, concerns were expressed about the relevance of our treatment conditions to those found in nature. The Aransas Bay complex, from which animals were collected, is characterized by variable turbidity that is primarily wind driven. The bay system experiences turbidity that ranges from 0 NTU to 900 NTU, but averages ~20 NTU. As such this is a system typically characterized by low turbidity, but, turbidity can increase with changes in wind speed or direction, altering spatial distributions of organisms and potentially affecting their foraging ability (which is what we wanted to test here). We chose 0 and 100 NTU as treatments for logistical reasons. We found that these levels were easily maintained using the water pumps for the duration of the experiments and did not require further interference as intermediate levels did. These levels also allowed us to avoid enhancing foraging by increasing contrast, as has been documented in previous studies with lower levels of turbidity.

We appreciate your willingness to review our paper and provide thoughtful feedback that has led to an improved manuscript. We hope you will find the current submission acceptable. Below we provide a detailed response to each point raised in the review. Comments by reviewers are listed followed by our edits in italics.

Sincerely,

Jessica Lunt and Delbert L. Smee

**Reviewer Comments**

**Reviewer 1 (Anonymous)**

**Experimental design**

Authors should justify the selection of the species they used on ecological arguments.  
*The species we used were chosen because they are abundant and affected by turbidity (Lines 109-112; TPWD data analysis). To better highlight that we added Figure 1, and included more information on their feeding ecology, Ln. 140-148. Pinfish and blue crabs are both mobile, omnivorous predators common throughout estuaries along the Gulf and Atlantic coasts. Both species regularly experience turbidity and flow levels used in this experiment in natural settings.*   
They could provide more information about the relevance of experimental treatments with natural conditions encountered by these organisms  
*We expanded our discussion of turbidity and better described the system from which experimental organisms were collected. The Aransas Bay system has an average turbidity of 20 NTU, but experiences turbidities as high as 900 NTU (Ln 74-87). 0 NTU and 100 NTU treatment levels were chosen as these levels were easily maintained with minimal interference to the tanks, and such a stark comparison would reduce potential enhancement of foraging by turbidity (Ln 159-163). Flow in the treatments is also relevant to natural conditions (Ln 123-125).*   
The relevance of one experimental treatment (mix) is not obvious and should be explained

*The mix treatment was included to ascertain if there would be additive effects of predator type (Ln 157-159).*

**Validity of the findings**

Sample sizes should be specified to better assess the power of the tests  
*Table 1 has been included to help clarify both the experimental design and the sample sizes used (Ln 172-173).*  
While sudden changes in turbidity have been show to affect interspecific interactions (cichlid of the Lake Victoria) authors seem to mainly focus on estuarine species where long term evolutionary process may have shaped the communities. This is confusing and should be avoided or replaced in an appropriate time framework

*The Aransas Bay system has a highly variable turbidity regime that is primarily caused by wind that re-suspends sediments. Thus, sudden changes in turbidity can occur, and the entire study area is prone to variations in turbidity on different spatial and temporal scales. Turbidity ranging from 0-900 NTU has been recorded, and turbidity can vary at small spatial scales (Lunt and Smee 2014). As a result, we believe the changes in abundance seen in previous work (Lunt and Smee 2014) are a result of changes in predation efficiency. We have included a description of our study system to clarify this (Ln 74-87).*

**Comments for the author**

The general idea of testing the relative performance of predators with different perceptual abilities is interesting. It is not very clear whether this has been done before on other species and some hints about its novelty/complementarity should be given for the reader even if it is not an evaluation criterion as such for the journal.

*The effects of turbidity on predation rates has been well studied within freshwater systems, but not in marine systems (Ln 65-73, 88-97, 188-205). This study is the first to test the effects of turbidity on a chemosensory predator and directly compare that to a visual predator in the same conditions (Ln 214).*  
More generally, I think the introduction may benefit from refocusing. The framework is about how environmental conditions shape trophic networks and in particular select functional traits, sensory abilities for the current system. This seems to me a more integrative approach that would allow the comparison with other ecosystems than estuaries (think of deep sea or underground environments). Then, it would be possible to develop the focus on the specific topic of the manuscript. It may also be useful to link paper with the general theories of sensory ecology.

*The Aransas Bay system has a highly variable turbidity regime that is primarily wind driven. This results in turbidity ranging from 0-900 NTU with in the system, and turbidity that can vary at small spatial scales (Lunt and Smee 2014). As a result, we believe the changes in abundance seen in previous work (Lunt and Smee 2014) are a result of changes in predation efficiency. We have included a description of our study system to clarify this (Ln 74-87). In short, the goal of the study was to measure predation ability of the 2 most abundant species collected, with pin fish more often collected in low turbidity and blue crabs in high turbidity.*

The experiment set is simple and the results are clear. I have one concern. There is no information about the ecology of the species’ used here. Are these specialist of estuarine environments or even exposed to such high level of turbidity? Why were these species selected in the first place? This information is necessary to analyze the results and assess the validity of the discussion.

*The species we used were chosen because they are abundant and affected by turbidity (Lines 109-112; TPWD data analysis). To better highlight that we added Figure 1, and included more information on their feeding ecology, Ln. 140-148. Pinfish and blue crabs are both mobile, omnivorous predators common throughout estuaries along the Gulf and Atlantic coasts. Both species regularly experience turbidity and flow levels used in this experiment in natural settings.*   
I have additional comments about methological choices. In particular, it is not really clear why testing the mix treatment (crab+fish) would bring insight to the question.

*The mix treatment was included to ascertain if there would be interference or additive effects of predators (Ln 159-163).*

Also, authors should justify more clearly the selection of turbidity level so that the reader can linked them to actual conditions encountered by organisms (see below).

*We expanded our discussion of turbidity and better described the system from which experimental organisms were collected. The Aransas Bay system has an average turbidity of 20 NTU, but experiences turbidities as high as 900 NTU (Ln 74-87). 0 NTU and 100 NTU treatment levels were chosen as these levels were easily maintained with minimal interference to the tanks, and such a stark comparison would reduce potential enhancement of foraging by turbidity (Ln 159-163). I measured turbidity and examined the TPWD turbidity record and provide a citation for this information (Lunt 2014).*

Finally, it is should be make clear whether water agitation, necessary to maintain turbidity, is likely to affect the behaviour of predators and preys in a way that would not reflect natural conditions.  
*Flow in the treatments is also relevant to natural conditions (Ln 123-125) and both low and high turbidity treatments used the same pumps. Any artifacts should be consistent between turbidity treatments.*  
Specific comments  
L43 probably “perceptual” instead of “sensory”

*Changed Ln 44*  
I would rather use “indirect” effect of predation instead of “non lethal” effect

*Changed throughout*  
L49 or conceal from predators

*Changed Ln 50*  
L54-57 May be too simplistic. Environmental conditions can limit detection on a particular sensory channel but not on every channel available to an organism or to an alternate predator. Therefore, the assumption about the lower top-down forcing may not be met. I think you may focus more on the selection of functional traits across the trophic network in particular in species involved in prey-predation relationships.

*We have attempted to moderate our argument (Ln 61-62). We do not disagree with this reasoning, and clearly, the simplistic argument of visual and nonvisual species is not universally correct as many species use multiple sensory systems. However, from the extensive TPWD data set and our own published study (Lunt and Smee 2014); we see that pinfish are more abundant in low turbidity with crabs showing the opposite pattern. We also see that fish predation on mud crabs in the field is lower in elevated turbidity (Lunt and Smee 2014). The purpose of this study was explicitly to test what would happen to these species when turbidity changes. In other words, why are pin fish less abundant in turbid conditions? Results here suggest that they cannot forage as effectively, which may cause them to seek out better foraging opportunities.*   
L61-68 You may also refer to species that use electric sensory organs for prey detection and foraging. There are good examples of electric fishes in very turbid and very large rivers like the Amazon.

*We have changed the wording to be more inclusive and added a reference (Ln 70-73).*  
L68-73 This is the primary issue. If prey or predator cannot cope with turbidity a particular structure of the trophic network (including functional traits) can arise.

*Predators within this system are physiologically capable of handling these turbidity levels. More information on the turbidity regime of the local system was added to clarify (Ln 74-87).*   
L84 Why such extreme values? It may be good to give a bit more information about the turbididity regime for instance the annual median and quantiles, if these values exist for the area where experimental preys and predators come from. Why did not you choose to test one or two intermediate treatments?

*We expanded our discussion of turbidity and better described the system from which experimental organisms were collected. The Aransas Bay system has an average turbidity of 20 NTU, but experiences turbidities as high as 900 NTU (Ln 74-87). 0 NTU and 100 NTU treatment levels were chosen as these levels were easily maintained with minimal interference to the tanks, and such a stark comparison would reduce potential enhancement of foraging by turbidity (Ln 159-163).*   
L93 Please give the dimensions of the tank. What was the colour of the tanks as background could affect the contrast with prey colour, and thus detection, it is worth giving this information if you use a visual predator?

*18 gallon, grey, sterilite totes were used as tanks for this experiment (61 cm X 47 cm X 41 cm; Ln 118-119, 121)*  
L92-101 I understand why water circulation was used to keep kaolinite suspended. Could you precise whether this level of water movement is naturally encountered both by preys and predators in natural conditions? If not, could these novel conditions affect predation rate (fish may may more disturbed in anormally agitated waters), which would limit the extrapolation of conclusions?

*The flow within the tanks was within ranges measured in the field (Ln 123-125, Lunt 2014).*  
L92-101 Did you check turbidity level througout the experiment. From my own experience, clay deposit on the bottom of the tanks even when using water pumps, at least if you do not use “tsunami grade” pumps? Given, the initial difference between your treatments this should not be an issue though.

*Maintenance of turbidity was assessed with a HydroLab Data Sonde prior to the beginning of the experiments. Visual inspections were conducted regularly over the course of trials to ensure there were no equipment failures, but turbidity was not checked with a Data Sonde to avoid interfering with the animals within the tanks (ln 128-134). We performed a number of preliminary experiments to figure out what turbidity level could be maintained and for what duration to create turbid treatments.*   
L103-110 Could you give more information about how frequently these preys are consumed by both predators and in which natural conditions encounters occur (turbidity range)? Are they both common preys in each predator’s diet?

*Exact encounter rates are unknown for these species. However, these species are both known to be voracious predators that would regularly encounter both prey types in natural conditions. The turbidity levels are within natural levels (Ln 140-148). These are also the most abundant species collected in fisheries-independent surveys by TPWD, which is why we selected them for study.*  
L111-120 How many trials have been performed? How many crabs and how many fishes were tested? It is hard to tell what your sample size and thus the power of your test. According to your results, turbidity seems to affect both predators but not equally, the crab being more efficient regardless of the treatment.

*Table 1 has been added to clarify; There was no statistical difference in blue crab predation.*  
L114 Why did you test the “mix” treatment? What was your prediction? I do not see clearly the rationale.

*The mix treatment was included to ascertain if there would be additive effects of predator type (Ln 157-159).*

L114 why did you these experimental levels (0 and 100 NTU). There is no information about the turbidity regime encountered by these populations so that it is hard to tell the biological meaning ot either treatment. Could you provide either statistics or a graph of the annual variation of turbidity? It may have been more informative to compare a control (0 NTU) with a high value of turbidity (90th percentile for instance) and a regular condition (median). One can question the actual effect on prey-predator relationships if the high turbidity level occurs rarely.

*We expanded our discussion of turbidity and better described the system from which experimental organisms were collected. The Aransas Bay system has an average turbidity of 20 NTU, but experiences turbidities as high as 900 NTU (Ln 74-87). 0 NTU and 100 NTU treatment levels were chosen as these levels were easily maintained with minimal interference to the tanks, and such a stark comparison would reduce potential enhancement of foraging by turbidity (Ln 159-163).*  
L125 Could you precise whether your data and residuals meet the assumptions of ANOVA?

*Data was checked for assumptions using diagnostic plots (Ln 170).*  
L156-157 Please refer to these earlier studies

*Sentence reworded to clarify our meaning (Ln 207-208).*  
L158-160 Although I agree on general terms, I would be less affirmative. It is likely that some suspended particles causing turbidity interact with organic compounds released by organisms. Clays can adsorb peptides for instance. Thus, I would expect detection to be lowered in natural conditions even for predators using chemodetection. Remember you used a small tank in a simple chemical environment (kaolinite only) in which the degradation of chemical cues would be reduced.

*We added information to point out that the interactions may be more complex in natural systems (ln 219-221).*  
L161 Here again, moderate your argument.

*We have attempted to moderate our argument (ln 219-221).*  
L179 What novel information bring your own study? You did not make that point clear

*This study is the first to test the effects of turbidity on a chemosensory predator and directly compare that to a visual predator in the same conditions (Ln 214-219, 231-232). Few studies have explored these types of relationships with estuarine species in general*  
L182 “chemical cues” may be more appropriate than “exudates”

*Changed Ln 239*  
L191-192 Why would this increase their abundance in high turbidity sites? It is possible that turbid sites are the main habitat for this species. There is not enough information about the species’ecology to tell.

*We argue that changes in abundance seen in previous work is a result of blue crabs preferentially choosing high turbidity sites as a refuge from their visual predators, as visual predators are less efficient in highly turbid areas but blue crab foraging is unaffected. You are correct. But, our study was examining the foraging ability of pin fish and blue crabs under low and high turbidity regimes, both which these organisms encounter in the field. Blue crabs may seek turbid sites to avoid their own predators, to increase their foraging ability, or both. The goal here was only to assess the foraging ability of these 2 very abundant species.*  
L195-196 and L205 “proliferate” and “decimate” could be replaced by more neutral terms

*This paragraph has been removed to focus the discussion more narrowly on our study.*  
L203-213 I think the concluding paragraph is awkward. One cannot compare bluntly short-term and long term processes. I suspect the cited example of shark overfishing to concern a very recent period. It is not a surprise that sudden and strong events on top predators have cascading effects on the trophic network. In your work you address, foraging performance in estuarine environments where communities have formed over a long period as a response to this particular environment. One can expect selection of species with particular functional traits. Olfaction should prevail over vision for any function foraging or mating.

*We have removed the last two paragraphs to consolidate our arguments to the more specific findings on this study.*

**Reviewer 2 (Damian Moran)**

**Specific comments:**  
1) In my opinion, the authors have not characterised the nutritional ecology of the of the pinfish very well at all. According to Montgomery & Targett J. Exp. Mar; Bioi. Ecol., 158 (1992) 37-57  
”The pinfish Lagodon rhomboides (L.) is an abundant omnivore in temperate zone and subtropical seagrass meadows along the Atlantic and Gulf coasts of North America(see Darcy, 1985; Huh, 1986). It is a major consumer of vegetation in these meadows (Darcy, 1985). Studies have reported that seagrasses (i.e., Thalassia testudinum, Syringodium filiforme, and Zostera manna L.) constitute 18-90% of the diet of the pinfish (Hansen, 1969; Adams, 1976; Stoner; 1980; Stoner & Livingston, 1984). Macroalgae (primarily green algae) are also important, constituting as much: as 50% of the pinfish diet (Darnell, 1958; Hansen, 1969; Stoner, 1980) mentioned”  
It would appear these fish are more at least as much herbivore as carnivore, and this might play a significant role in their predatory drive or ability to access nutrition in an area of increased turbidity. If the authors are extending their findings to the ecosystem level (which they do in the Discussion, extensively), then there is an obligation to consider the total nutritional ecology of the species.   
*We have added more information on the feeding ecology of both species to better support our choices (Ln 140-148). While pinfish may have a large proportion of its diet comprised of seagrasses, the Montgomery and Targett (1992) study indicates that this is done if seagrasses are highly abundant in the animals general vicinity as they need to eat much more vegetation to maintain energy needs. Pinfish are known to be voracious feeders and consumed both prey types in the lab prior to experimental trials.*   
2) Changes in turbidity may be advantageous to certain life stages but not at others. For example, increased turbidity can be an advantageous to planktonic predators by increasing the contrast prey.   
Boehlert, G. W., and J. B. Morgan. 1985. Turbidity enhances feeding abilities of larval Pacific herring Clupea harengus pallasi. Hydrobiologia 123:161–170.  
When culturing marine fish larvae clay or microalgae are usually added to the culture tank to improve predation rates. Perhaps it is worth mentioning so that readers can get a sense of the complex relationship between vision, light transmission and turbidity. Turbid may not always equal bad for visual predation, context is important.  
*We appreciate your pointing out this point, as it was an oversight on our point. We have included a mention that turbidity can result in increased contrast and may enhance foraging in some situations (Ln 91-93, 159-163). The high turbidity levels used in our study however make this scenario unlikely ( Ln 162-163).*  
3) Line 85: Change to …chemosensory means of risk detection  
*Changed Ln 109*  
4) Materials and Methods  
The experimental structure needs to be better explained. The way I read it at the moment is:  
There were 2 types of prey, 2 types of predators, and 2 levels of turbidity. The predators were tested in 4 combinations: no predators, pred 1 only, pred 2 only, pred 1+2. The prey were also tested separately. So the design seems to be 4 predator treatments x 2 turbidity treatments x 2 prey treatments = 16 treatment matrix.   
*You are correct, we have included a table to clarify.*  
How many replicate trials were performed per treatment? What was the rationale for choosing that sample size? It looks like there were a different number of trials with mud crab versus shrimp.  
*You are correct, we have included a table to clarify. Sample sizes were determined by animal availability.*  
5) Results  
L130-131: ”Pairwise differences between treatments revealed that turbidity had a significant effect on pinfish foraging, but not in the other treatments (Figure 1).”  
The clause ”but not in the other treatments” is clumsy due to the on-in preposition change from the previous clause. Perhaps simplify (and the other sentence that reads the same later) to:   
Pairwise differences between treatments revealed that turbidity only had a significant effect on pinfish foraging.  
*Changed Ln 180-181, 185.*  
6) L192-194: ”The effects of turbidity on foraging efficiency of visual predators but not chemosensory predators helps explain the reduction in fish and increase in crab abundance when turbidity increases (Lunt & Smee, 2014).”   
From my experience in aquaculture, I have learned that there are many skin and gill related pathologies associated with a high suspended solids load in the water. Could an auxiliary reason that fish avoid turbid areas be due to gill or skin irritation? High levels of dissolved organic material are also associated with lower dissolved oxygen content. Would non-feeding related factors also play a role in the observed reduction in fish density? Or do the authors feel the evidence points to distributional patterns all being down to visual predation capacity?   
The Discussion does venture out into ecosystem wide effects from what is a fairly small controlled tank study (that’s fine with me), but the corollary to such a venture is that a wide range of controlling factors should be considered.  
*We appreciate your insight. We feel that in this system it is primarily foraging constraints that cause the changes in abundance, because these predators are highly mobile and can easily avoid areas of high turbidity which are patchy within the bay system. However, while species abundance (such as pinfish) does decrease in high turbidity areas they do not disappear from these areas which we would anticipate if there were physiological reasons. Low oxygen levels are not an issue within this system, within the 18 year TPWD data set we used to assessed average turbidity levels, the DO levels were never below saturation.*  
7) Figure 1 caption: (+SE) written twice

*Fixed*