Hyperbole, Simile, Metaphor, Invasivore: Messaging around Blue Catfish

D. J. Orth and J. D. Schmitt
Department of Fish and Wildlife Conservation
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061
Email: Don_Orth@vt.edu
Phone: 540-231-5919

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Abstract

Invasive species are those that spread into a new home and have the potential to cause "harm to the economy, the environment, or human health." In the paper, we review basic invasion ecology theory, compare the theory with messaging surrounding the introduction and expansion of Blue Catfish in mid-Atlantic tidal waters, and make modest recommendations about an appropriate path forward regarding the message. The language surrounding the invasive catfish controversy created and reinforced positions of many stakeholders. Invasion is a metaphor that may connote the invasion of a hostile enemy. Three different models of invasion refer to introduced species as passengers, back-seat drivers model, and drivers of ecosystem degradation. Metaphors, such as 'invasional meltdown' and 'nativeness', may give a stronger voice for change and create a sense of urgency. However, in this case metaphor replaces science in informing policy. The 'nativeness' and 'invasiveness' metaphors suggest automatic management positions without examining the full suite of management indicators. In journalist reports on Blue Catfish, the species was often vilified as "biggest threat to the Chesapeake Bay" and greatest environmental threat the Chesapeake Bay have ever faced." Reports that "their black-hole-like mouths vacuum up whatever marine life gets in their way" were hyperbole. Consequently, the public discourse regarding the Blue Catfish in the Chesapeake Bay region continues to be characterized by many terms that evoke threats, danger, toxicity, and the need for caution, all of which make debate and discourse difficult. My modest recommendation is that "we need to talk," and when doing so, tone down the rhetoric. Despite many well-conceived studies that derived estimates of consumption by Blue Catfish in Virginia waters, the findings remain inconclusive because we still lack estimates of population abundance of affected species. The Blue Catfish narrative should shift from the invasiveness metaphor to one of collaborative problem solving for meeting the grand challenges of conserving elements of our natural heritage in the face of growing pressures of urbanizing watersheds.

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Introduction

Blue Catfish were purposefully introduced to many rivers and reservoirs in the Atlantic slope drainages of the USA. Introductions to Virginia's tidal rivers in the 1970s and 1980s were intended to enhance recreational fishing opportunities for catfish at a time when many catfish and many native fishes were in decline. It was another era when fish were more readily traded and planted in new waters. There were no laws, such as the Nonindigenous Aquatic Nuisance Prevention and Control Act, or even conservative guidance on risk assessments associated with fish stocking. The Blue Catfish were known to be just as tasty as Channel Catfish while more likely to attain impressive sizes (Figure 1).

Invasiveness is a metaphor that connotes the invasion of a hostile enemy (Lockwood et al. 2007, Davis 2009). Because invasive species put many fish species at risk (Jelks et al. 2008), the "guilty until proven innocent" rule persists. Scholars from biological and social sciences and humanities have examined the burgeoning number of non-native species introductions. Three problems are clear. First, definitions of "invasive" are inconsistent even among invasion scientists (Richardson et al. 2000; Copp et al. 2005; Valéry et al. 2008; Heger et al. 2013. Second, understanding invasion-related questions requires social–ecological collaborations, yet published studies focus almost entirely (92%) on ecological questions (Vaz 2017). Third, metaphors and hyperboles used in news media and the invasion biology subdiscipline often replace science in informing policy.

Figure 1. Photo of large blue catfish in historic photo. Source unknown.

Invasion biology grew rapidly since 1990 (Thomaz et al. 2015) and multiple camps have emerged. For simplicity, let's call them the 'mainstream' and the 'denialists.' Denialists assert that "non-native species present no real threat to biodiversity (or ecosystems) and are no more likely than natives to cause environmental damage (Didham et al. 2005; Sagoff 2005; Gozlan 2008; Ricciardi and Ryan 2017). The truth may lie in the middle even if one rushes to a label of 'invasive' based entirely on origin (Davis et al. 2011). Most research and management efforts have focused on invasive species transplanted from far distant regions (Wilson et al. 2009). Major disagreements among experts may be partly due to missing deliberations of values or context bias (Humair et al. 2014; Warren et al. 2017). Unfortunately, only after a species becomes abundant and/or widespread can we determine the degree of ecological or economic harm.

Fish are among the most introduced group of aquatic animals in the world and several reviews of freshwater fish introductions have been written (Copp et al. 2005; Gozlan 2008; Gozlan et al. 2010; Thomaz et al. 2015; Toussaint et al. 2016). Emotive and manipulative language used in the field of invasion biology hinders effective management (Gobster 2005; Larson 2005). The 'nativism' bias persists. It is a part of measures, such as the index of biotic integrity, yet, studies do not always demonstrate that non-native species cause biological effects (Parker et al. 1999) nor have they quantified direct economic costs and benefits. In some cases, introduced non-native fishes provide forage for native fishes (e.g., American Shad and Pacific salmonids Petersen et al. 2003) and invasive plants provide refuge to fish prey (Figueiredo et al. 2015).

Introduction of nonindigenous catfish may influence biodiversity through predation, competition, hybridization, habitat modification, and transmission of novel disease (Gozlan et al. 2010), which led to signing the resolution on the invasive catfish (GIT 2012) and a focus to address predation impact of the Blue Catfish and Flathead Catfish (IFTC 2014).

In this paper we make three claims. First, the Blue Catfish storyline has been socially constructed via news reports that often adopted the language of invasion biology, which admittedly has a militaristic tone. Second, metaphors and hyperboles are seldom used in scientific writing, yet have appeared more frequently in news media and the invasion biology subdiscipline. Finally, the findings of many studies of Blue Catfish remain inconclusive because we still lack estimates of population abundance of affected species. The Blue Catfish narrative should shift from the invasiveness metaphor to one of collaborative problem solving for meeting the grand challenges of conserving elements of our natural heritage in the face of growing pressures of urbanizing watersheds.

The Blue Catfish Narrative

Language affects our willingness to change behavior. If Blue Catfish are destroying the Chesapeake Bay, then they must be removed. If pike are 'devil fish,' you know what the response will be (Lee 2001; Elmendorf 2005). The media have been criticized for alarmist metaphors and hyperbolic language (Gobster 2005; Larson et al. 2005). But scientists, in our attempt to make meaning for the general public, are also guilty of making the mistake of using inappropriate language. For example, when journalists write "their black-hole-like mouths vacuum up whatever marine life gets in their way" they are using hyperbole, an exaggerated figure of speech. A simile is the comparison between two unlike things using *like* or *as.* "O my Luve's **like** a red, red rose." by *Robert Burns* is a famous simile. Asian Carp are 'like the feral hogs of water.' Blue Catfish "croak like pigs." Metaphors compares two things and replaces the word or name for one object with that of another. For example, Shakespeare's "Shall I Compare Thee to a Summer's Day" is a famous metaphor.

Fisheries management often relies on human behavior change even though we often get bogged down in the issues of fish. However, the typical stakeholder is seeking simple, meaningful explanation of the problem. Invasive species are defined in federal and state legislation as those that have "harm to the economy, to the environment, or to human health." While metaphors are commonplace in science (Lakoff 1993; Brown 2003; Loetgers 2013; Pauwells 2013) -- think of the 'butterfly effect' and 'survival of the fittest'-- metaphors should not replace science when informing policy. We are not opposed to the use of metaphor in communication. A "metaphor is a device for thinking and talking with, and a good metaphor leads people to think and talk productively about something that they were not previously proficient in thinking or talking about" (Kendall-Taylor et al. 2013). However, inappropriate use of metaphors widens the gap between science and policy maker action.

The Blue Catfish narrative played out in the press and social media far ahead of the scientific evidence of ecological effects. The Blue Catfish have been 'vilified' in much of the public discourse. Statements in sensationalized headlines, "Behind pollution, blue catfish are the biggest threat to the Chesapeake Bay," and "The wild blue catfish is one of the greatest environmental threats the Chesapeake Bay has ever faced" (Sughrue n.d.; Springston 2015), have never been examined in any scientific manner. The uncertainty regarding Blue Catfish feeding habitats was repeatedly mentioned by scientists, conservationists, and the news media "Also troubling is their food, which includes some of the same species that wildlife managers are trying to save and restore - the Blue Crab, American Shad, American Eel, river herring, Menhaden." (Harper 2010). However, the uncertainty was accompanied with negative language, for example, Harper (2010) wrote "Up close and in person, Blue Catfish are gruesome creatures. They grow big and ugly and gray. They croak like pigs. And because they have no scales, they are especially slimy, even as fish go." At a time when the population was growing, Blankenship (2011) and others wrote that "Blue Catfish boom threatens region's river ecosystems. Predator accounts for 75 percent of all fish biomass in some places, scientists say."

Concerns were expressed that invasive catfish would control abundance of species at lower trophic levels and have dramatic effects on mussels, crabs, and migratory fishes (Blankenship 2011). A solution to the Blue Catfish problem begins with estimating the unknown numbers. Disruption of the food web of Chesapeake Bay depends on the feeding behavior and abundance of the Blue Catfish. Yet, estimating the true abundance of a new species in the system required developing new field tagging and analysis protocols. Tidal habitats along a 12-km stretch of the James River supported about 1.6 million invasive Blue Catfish (95% CI 0.9 to 2.9 million), or about 544 Blue Catfish/ha (Fabrizio et al. 2017). Bunch et al. (in press) and Hilling et al. (in press) show recent decline in abundance in Powell Creek from 2007 to 2014 and reduction in prevalence of large Blue Catfish.

Preliminary estimates, which were admittedly highly uncertain were spread through the media before any scientific vetting of procedures or publication of findings with appropriate caveats. The "100 million hungry Blue Catfish" could now be compared to high visibility species such as 308 million Blue Crabs and 215 million Striped Bass

Morone saxatilis (Blankenship 2015). Headlines focused on expected effects via predation on other valued fish "Experts from Virginia and Maryland agree their growing presence in local waters spells likely trouble for other fish species, like shad and bass." (Potomac Conservancy 2016). While the role of herbivory or competition are expected effects of invasive animals (Park 2014), the suspected role as apex predators dominated the media. "Blue Catfish are destroying the Chesapeake Bay" as "their black-hole-like mouths vacuum up whatever marine life gets in their way" (Carman 2017). Also "Due to their large size and predatory habits, blue catfish are consuming many native fish species at an enormous rate, and they have few natural predators that can prevent them from out-competing native species. (Gibbons 2015). Tim Sughrue is quoted by McCord (2016) calling the Blue Catfish "a real time environmental catastrophe happening in the Chesapeake Bay right under our noses" that threatens to "100 percent change the dynamic in the Chesapeake over the next two decades."

In summary, the public discourse regarding the Blue Catfish in the Chesapeake Bay region is characterized by terms that evoke threats, danger, and the need for caution, all of which make debate and discourse difficult (Ernwein and Fall 2015). During the same timeframe, James and Potomac Rivers made the list of 10 best rivers for catching monster catfish in 2015 (Hamper 2015). Sutton (2015) and others promoted the development of trophy fishing destinations while claiming "the media is the primary entity responsible for painting catfish as villains." Catfish narrative as reported by the media overstated the severity of impacts (Gibbons 2015, Springston 2015; Taylor 2015, McCord 2016; Carmon 2017).

As invasion biology expanded, the discourse became increasingly militaristic (Larson 2005) as governments and industries are overwhelmed with the pace of change. In the Great Lakes alone, scientists estimate that there are more than 180 indigenous species. Chesapeake Bay currently supports reproducing populations of nearly 150 nonnative aquatic species, including 27 nonnative fishes (Ruiz and Reid 2007). Consequently, ecologists are increasingly questioning the 'nativism' assumption that non-indigenous species are inherently evil (Larson 2005, Sagoff 2005; Warren 2007). Invasive species denialism is increasing in both mainstream media and scholarly journals (Figure 2; Ricciardi and Ryan 2017). This trend partially reflects substantial uncertainty about the future effects of all non-native species and the diversity of effects that occur. Schlaepfer et al. (2011) predict that the proportion of non-native species that are viewed as benign or even desirable will increase as we recognize benefits as well as perceived threats.

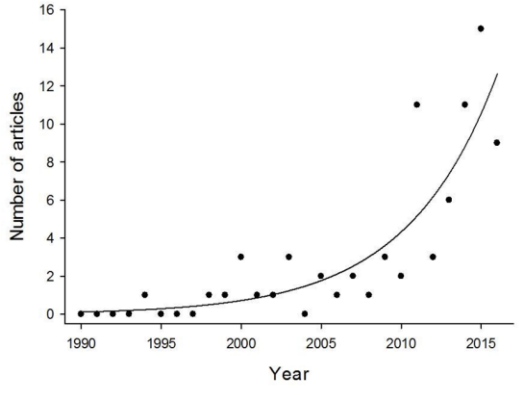

Figure 2. Annual number of published articles that promote invasive species denialism (Ricciardi and Ryan 2017).

Dominant discourse related to the lionfish labeled them "ultimate predators" and a threat that must be met with control efforts or war (Caballo-Cárdenas 2017). Lionfish hunting and consumption by humans were a necessary part of the war effort. Labeling a fish invasive automatically means they are something to battle, not a resource to manage. Invasive species are by definition harmful. The choice is to be precautionary and label any nonindigenous species as invasive (or harmful) without scientific evidence or to delay action until the scientific evidence reveals harm. Metaphors, such as 'invasional meltdown' and 'nativeness', may give a stronger voice for change and create a sense of urgency. The 'invasional meltdown' hypothesis is suggestive of ecosystem collapse by multiple colluding species. Yet the science does not support the 'invasional meltdown' hypothesis (Simberloff 2006).

Metaphors are useful linguistic expressions as long as they help us conceptualize the unfamiliar in terms that are more familiar to us (Figure 3). They are ubiquitous in science (Maasen et al. 2001 cited in Caballo-Cárdenas 2017) and may be good or bad choices to reflect meaning. Two opposite metaphors we often use with respect to species, like Blue Catfish, are 'nativism' and 'cosmopolitanism,' reflect our normative beliefs about good and bad (Callicott et al. 1999, Perretti 1998, Keulartz and van der Weele 2008). 'Nativism' is considered as pure and in harmony where numbers remain roughly constant (Cuddington 2001). This ideal condition is seldom present. 'Cosmopolitanism' considers the reality of an altered ecosystem.

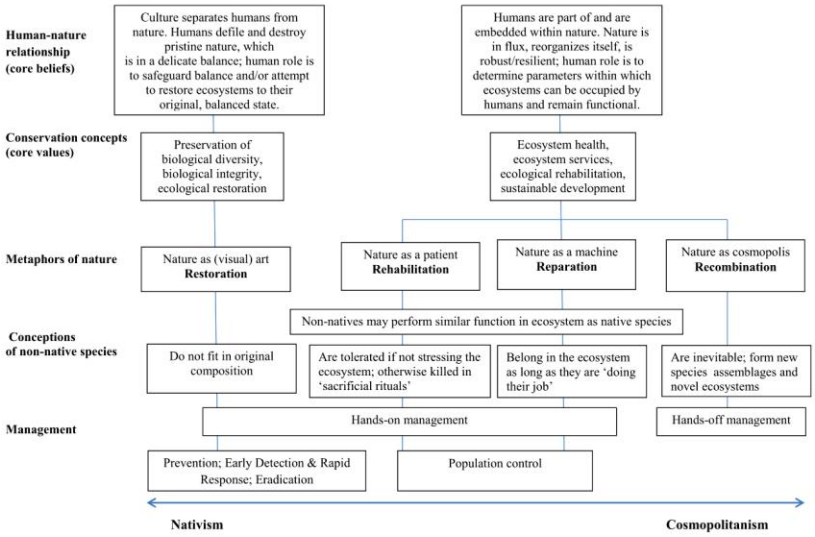

Figure 3. Conceptualizations of nature and implications for non-native species management (Caballo-Cárdenas 2017).

Our natural response to a differing position is to resort to identity-protecting reasoning (Flynn et al 2017 Kahan 2010) that protect our values and beliefs without scientific basis. Pauwels (2013) maintains that "although metaphors are essential in enabling science and in communicating research to the rest of the world, their use can also mislead the public, and even scientists themselves." Metaphors used for messaging related to Blue Catfish must fit with the evidence at hand.

Is the Blue Catfish a Passenger, Back-Seat Driver or Driver of Change?

In framing the language, invasive species may be viewed as "passengers" that spread in response to environmental changes rather than "drivers" of ecological impacts (Didham

et al. 2005; Hart and Lawson 2014). Bauer (2012) proposed "back-seat drivers," as those species that "require or benefit from disruptions of ecosystem processes or properties that lead to declines of native species but also contribute to changes in ecosystem properties and further declines of native species." This framing language affects the public's willingness to take action (Crowl et al. 2008; Hart and Lawson 2014). The driver model emphasizes the characteristics of the species that cause ecological change, whereas the passenger model focuses on characteristics that allow species to thrive under conditions of ecological change. If the driver model is correct, then the reduction of the invasive species should result in proportional change in the system (Figure 4). However, if the back-seat driver or passenger models are more accurate, then efforts to reduce the abundance of the invasive species without concurrent ecosystem restoration actions will not result in the significant changes expected (Figure 4; Prior et al. 2017).

As Kueffer and Larsen (2014) recommend, "when a metaphor is used, it should be introduced as such, and its connection with specific aspects of a scientific concept should be illustrated." If we adopt the 'back seat driver' metaphor we need to admit that population density, development, nutrient loading are also driving ecosystem change (Kemp et al. 2005; Limburg et al. 2011; Jordan et al. 2017). The James and Rappahannock Rivers have total maximum daily load prescriptions that recognize long-standing impairments (Hagy et al. 2001; Linker et al. 2013). Consequently, the back-seat driver model appears to be the most parsimonious hypothesis to describe the Blue Catfish case.

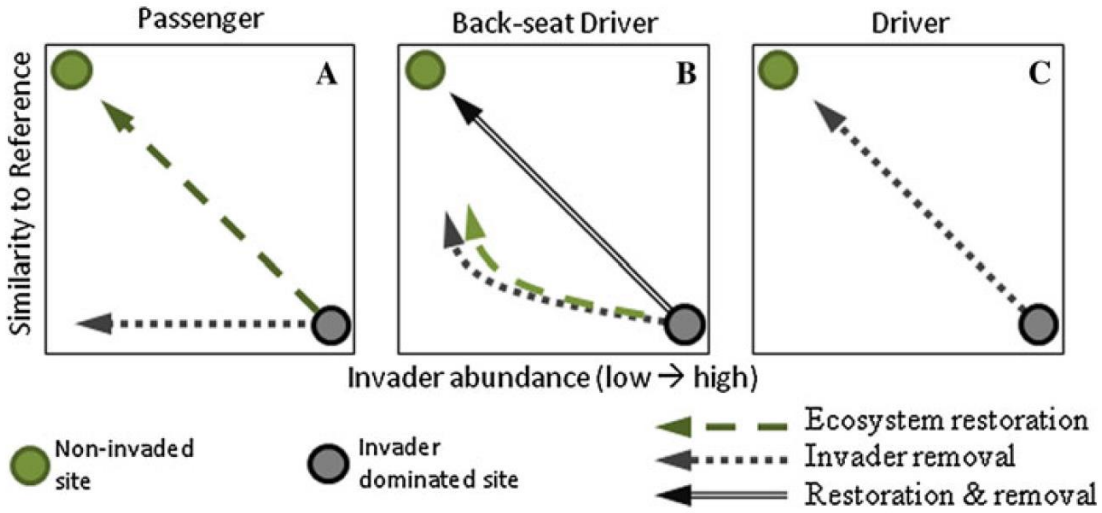

Figure 4. Hypothesized outcomes of invasive species management under three different models of invasion. A represents the passenger model, B represents the back-seat driver model, and C represents the driver model. The x-axis represents abundance of an invasive species at a site and the y-axis represents the similarity of the site to an undisturbed, uninvaded reference site. Effects of invader removal (dotted line) and ecosystem restoration (dashed line) depend on the model of invasion (Bauer 2012).

Context and criteria are critically important to judging impact of the nonindigenous species. Unfortunately, we still lack much needed information to judge the predation impact of Blue Catfish. Describing the early history of catfish fisheries in Virginia, Menzel (1945) reported that the catch in pots in the James River was made up almost entirely of the nonindigenous Channel Catfish, whereas native White Catfish *Amierus catus* and bullheads predominated in the Potomac River. We don't have standardized surveys data from this era, however, indications of catfish overharvest were evident in the 1930's (Menzel 1945). After the end of World War II, harvest of catfish from Virginia increased and declined after a peak in 1960. In the York River from 1967-1971 the White Catfish and Channel Catfish *Ictalurus punctatus* were both abundant in trawl surveys (Markle 1976). Since the introduction of Blue Catfish, catfish landings continued to decline until the early 1990s when Blue Cafish first appeared in standardized surveys. Blue Catfish now make up the majority of the landings in all Virginia coastal rivers. Blue Catfish densities are now high (Bunch et al. in press; Fabrizio et al. 2017) and Blue Catfish have replaced the nonindigenous Channel Catfish and native White Catfish in most of Virginia's tidal rivers. The decline in in Channel Catfish and White Catfish appear to be related to competition with the introduced Blue Catfish.

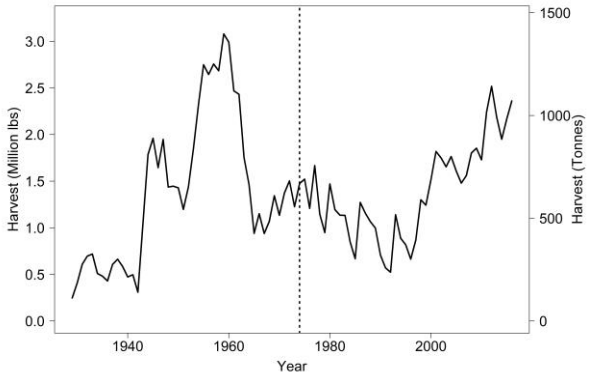

Figure 5. Harvest of all catfish in Virginia waters from 1929 through 2016. Vertical dotted line represents year of first introductions of Blue Catfish in Virginia waters. Source: Virginia Marine Resources Commission.

Yet, most concerns continue to be focused on American Shad, America Eel, river herring, Atlantic Sturgeon, and blue crabs. Blue Catfish are opportunistic omnivore and were not a primary cause of decline in American Shad and river herrings (Schmitt et al. 2017). In order to alleviate impacts for migrating alosine fishes, we first must estimate the impacts. However, consumption estimates are highly uncertain and predation impact are even less certain due to the lack of reliable estimates of the prey populations (Orth et al. 2017).

Historical commercial landings of all catfish (Figure 5) tell us:

(1) Similar methods were used by commercial harvesters for 100 years (Menzel 1945).
(2) Catfish have always been a lower value product, demanding a high volume in order to be profitable.
(3) Nonindigenous Channel catfish were likely overexploited in much of the 20th century. However, as a long-term resident species, most accepted them as a 'cosmopolitan' species that belonged in the region.
(4) Contemporary catfish harvests are dominated by Blue Catfish and NOT higher than long term catfish harvest.
(5) Blue Catfish eat blue crab and so did White Catfish and Channel Catfish (Menzel 1945)
(6) Blue Catfish eat river herring, but so did Channel Catfish (Menzel 1945).

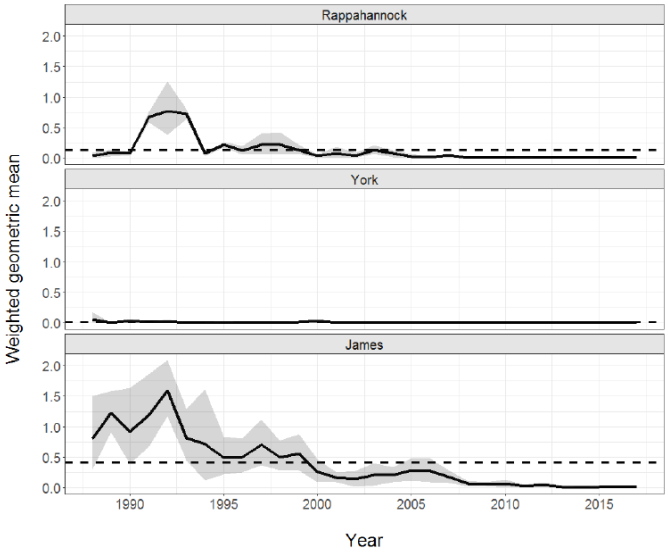

Figure 6. Indices of abundance for age 1+ Channel Catfish and long-term averages (dotted lines) from Rappahannock, York, and James rivers (Tuckey and Fabrizio 2017).

Blue Catfish get larger than White Catfish do and attracted recreational anglers interested in Catch-Photograph-Release. Removals from harvesters has changed the characteristics of the Blue Catfish population. Population densities are now declining (Orth et al. 2017; Bunch in press; Hilling et al. in press) including the angler-caught citation size fish (Figure 7).

Jurisdictions and management agencies took varying positions on Blue Catfish resulting in angler-agency conflicts. In Maryland waters, catch and release is discouraged. Furthermore, Blue Catfish have become a profitable commodity for commercial fishermen and a desirable product for chefs, wholesalers and retailers (Blankenship 2015). Bay Catfish Advocates (2017) have pressed for recreational fishing regulations that would promote sustainable catch of large Blue Catfish, though the Maryland Department of Natural Resources has no interest in supporting trophy catfish and continue to encourage anglers to keep all Blue Catfish and Flathead Catfish caught (Gronaw 2013).

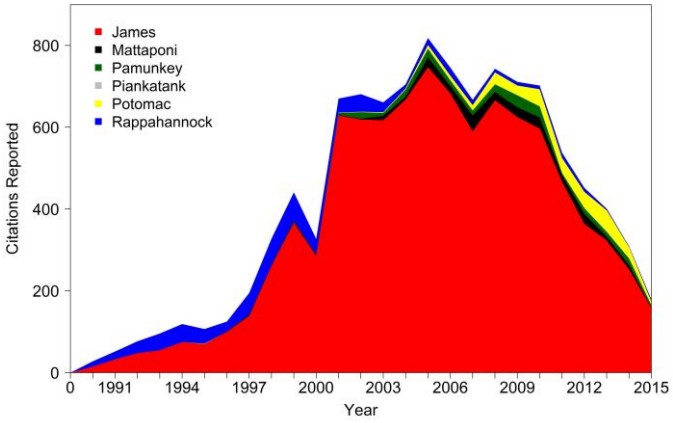

Figure 7. Number of citation size Blue Catfish reported to the Virginia Anger Recognition Program. Source: Virginia Department of Game and Inland Fisheries.

Invasivorism is the only solution actively pursued in the Chesapeake Bay region. Invasivorism literally mean we will eat our way out of the problem. A recognized problem with invasivorism is that when a species has high value that becomes an incentive to increase its spread (Nuñez et al. 2012). Another potential problem with invasivorism is that it takes attention away from the management practices that are actually known to solve the problem. Bilkovic and Ihde (2014) suggested this option would have limited potential because of the

following : "(i) the threat posed to the public by contamination of the fillets with bioaccumulated toxins; (ii) the lack of desire to kill the largest, most fecund fish for the sake of the trophy fishery; (iii) the predicted population response to being fished; (iv) the perverse incentivization of the preservation of these populations to maintain the fishery; and (v) the potential negative consequences to native populations of catfish (through bycatch and misidentification)." Selge et al. (2011) reported that public opposition to the removal of non-native species has repeatedly delayed intervention.

Conclusions

As scientists and managers, it is critically important that we get the Blue Catfish story right and act accordingly. The Blue Catfish storyline emerged **before** many of the scientific studies were completed. The resolutions were precautionary and we support precautionary practices. However, the research recommendations from ICTF (2014) ignored the influence of media, which had greater capacity to ignite policy changes than any scientific evidence (Gozlan et al. 2013).

We need to engage with the public. In science communication, we are urged to use marketing strategies and strong metaphors or dominant news frames to get their message across via social media networks (Liang et al. 2014). Was the Blue Catfish story line accurate? No. "Also troubling is their food, which includes some of the same species that wildlife managers are trying to save and restore - the Blue Crab, American Shad, American Eel, river herring, Menhaden." (Harper 2010). Blue Catfish are opportunistic omnivores, therefore, a long list of fishes in its diet is no surprise and inferring predation impact requires more evidence than a diet description (Schmitt et al. 2017). A lack of abundance data will continue to make it difficult to infer a predation impact.

Scientists corrupt the process when they present findings with hidden policy preferences (Lackey 2007). Simply using the term "invasive" before the science is done illustrates a policy preference. We must get involved in policy deliberations, but play the appropriate role. "Provide facts, probabilities, and analysis, but avoid normative science" (Lackey 2013; Parke and Russell 2018). Scientists have much to lose when they unthinkingly adopt incorrect language, such as "alien invasive" and thereby practice stealth policy advocacy. We should become honest brokers of policy alternatives rather than advocates. Furthermore, science journalists should focus on peer-reviewed literature, fact check articles, and interview peer scientists (Kueffer and Larson 2014).

In a qualitative study of members of the public as well as professions and ecologists, Selge et al. (2011) discovered the neglected argument of human responsibility regarding invasive species. In particular, they wrote that "Where a detrimental change was seen to be caused by humans, there was often a perceived moral obligation to redress this change." However, the damage was done by multiple processes independent of the introduction of Blue Catfish. Messaging should now focus on human responsibilities and less on hyperbolic descriptions of Blue Catfish.

Current studies and language that focuses on "threat to native species" or "good versus bad" dichotomy are bound to hold back progress (Larson 2007; Vaz et al. 2017). The dualism of 'native' versus 'non-native" is not a valid scientific concept, but rather a socially dynamic concept (Schüttler et al. 2011). Because value-laden messaging hinders communication and action, we must ensure that our message draws on scientific evidence to make itself persuasive and legitimate (Irwin 1995, Hajer 1997; Larson 2005; Kendall-Taylor et al. 2013; Scharff 2013). Kueffer and Larson (2014) propose guidelines for the responsible use of metaphors in science writing and communication that may lead to more effective communication with the policy makers, the media, and the public (Gozlan et al. 2013). Scientists should deal with competing metaphors as multiple hypotheses that should be tested. When metaphors are replaced by similes (i.e., using an X is like Y statement), there is a lower risk that they will be taken literally (Carolan 2006). For those interested in writing for the public, Dunn (2013) provides salient advice and does not advocate adopting metaphorical language. Rather, Dunn suggests "Use strong nouns and verbs. Write simple sentences." The Blue Catfish narrative as reported by the media overstated the severity of impacts although the scientific findings are still incomplete.

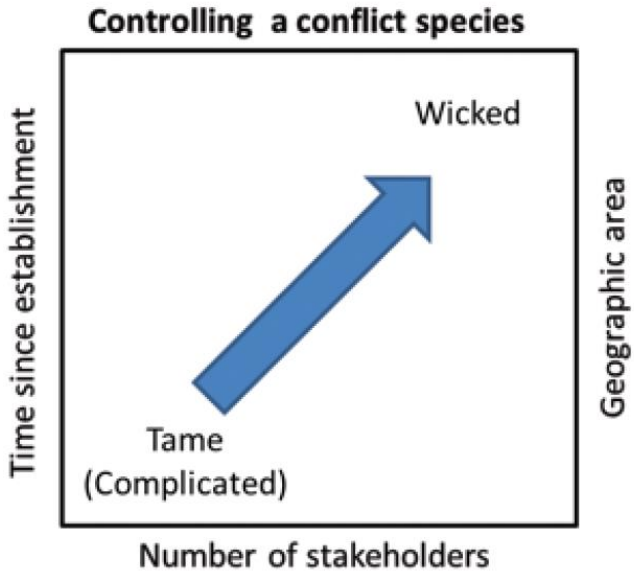

Figure 7. Conceptual diagram for type of problem for a conflict species that is both highly desirable as a resource and detrimental to the aquatic environment in which it establishes. (Woodford 2016)

The Blue Catfish storyline depicts the 'amplification of risk' model where the media helped build a buzz while communicating science (Leiserowitz et al. 2012). However, management of Blue Catfish is complicated by differences in value systems and the risk perceptions of stakeholders and decision makers (Figure 7). Understanding the plural views and values of stakeholders toward Blue Catfish management strategies is a prerequisite to anticipating and then minimize conflict as management programs are implemented (Lee 2001; Evans et al. 2008; García-Llorente et al. 2008, Schüttler et al. 2011; Pasko and Golderberg 2014; Estévez et al. 2015). Failure to engage the public means lead to increased reliance on often unreliable media sources. Furthermore, while some stakeholders have a direct benefit from managing fish, other stakeholders lack a vested interest in ecosystem restoration yet all stakeholders need to play a role in management actions. Cooke et al. (2013) provide strategies, including those focused on environmental education initiatives, for building the public and political will for management action. Efforts with local stakeholders should involve education, building understanding and capacity for citizen science and collaborative problem solving. The

Blue Catfish in our region highlights the shortcomings of managing in a single-species manner when the drivers of ecosystem change support an integrated management approach (Chafffin et al. 2016). Local stakeholders and enthusiasts can certainly support a focus on ecosystem restoration and reduction in nutrient loading if they are convinced of the relationship with protection of flagship species, such as American Shad, American Eel, Atlantic Sturgeon, river herrings, and blue crabs. In fact, collaborative watershed groups engage in management activities and achieve water quality and habitat gains (Scott 2015).

Because Blue Catfish are both negatively and positively evaluated by stakeholders, management decisions must involve tradeoffs. Differing human values associated with Blue Catfish in Virginia means that the path forward should initially proceed with a conflict resolution approach that requires societal discourse. Disagreements are inevitable. The appearance of particular perceptions, beliefs, attitudes, and motivations, related to Blue Catfish were shaped largely by media and past experiences. Consequently, conflict is intractable unless and until beliefs change (Bar-Tal 2000). Managing Blue Catfish will continue to be challenging because uncertainties remain about it current and future effects, divergent values among stakeholders, sparse historical records, and changing goals (Schlaepfer et al. 2011). Other authors have reported that collaborative, structured stakeholder engagement and scenario-based planning help identify conflicting values, their importance, and reveal explicit tradeoffs (Evans et al. 2008; Schüttler et al. 2011; Woodford et al. 2016; Crowley et al. 2017). These workshops should shift the narrative away from inadequate metaphors to focus on collaborative decision-making to alleviate multiple complex interacting threats in our tidal rivers (Jackson et al. 2016; Craig et al. 2017).

References

Bar-Tal, D. 2000. From intractable conflict through conflict resolution to reconciliation: psychological analysis. *Political Psychology* 21:351- 365.

Bauer, J.T. 2012. Invasive species: "back-seat drivers" of ecosystem change? *Biological Invasions* 4:1295–1304.

Bay Catfish Advocates. 2017. Letter to Blazer, Maryland Fisheries Service. Dated February 27, 2017, signed by Brad S. Hierstetter. https://www.facebook.com/baycatfish/photos/pcb.1404344272961040/1404343129627821/?type=3&theater

Bilkovic, D.M. and T.F. Ihde. 2014. Review of the final report of the Sustainable Fisheries Goal Implementation Team Invasive Catfish Task Force. Chesapeake Bay Program Scientific and Technical Advisory Committee. No. 14-007, Edgewater, MD. 46 pp.

Blankenship, K. 2011. Blue catfish boom threatens region's river ecosystems. Bay Journal (May 1). Accessed via http://www.bayjournal.com/article/blue_catfish_boom_threatens_regions_river_ecosystems 7 August, 2017.

Blankenship, K. 2015. Analysis estimates Bay's blue catfish at 100 million, with room for expansion. Bay Journal (January 29). Accessed via

http://www.bayjournal.com/article/analysis_estimates_bays_blue_catfish_at_100_million_with_room_for_expansion 7 August, 2017.
Blankenship, K. 2015. Fishermen encouraged to take big bite out of Bay's blue catfish population. Bay Journal http://www.bayjournal.com/article/fishermen_encouraged_to_take_big_bite_out_of_bays_blue_catfish_population accessed 20 June 2017.
Brown, T.L. 2003. Making truth: metaphor in science. University of Illinois Press, 232 pp.
Bunch, A.J., R.S. Greenlee, and E.M. Brittle. In press. Blue Catfish density and biomass in a tidal tributary in coastal Virginia. *Northeastern Naturalist*
Caballo-Cárdenas, E.C. 2016. Controversies and consensus on the lionfish invasion in the Western Atlantic Ocean. *Ecology and Society* 20:24. http://dx.doi.org/10.5751/ES-07726-200324
Carman, T. 2017. Blue catfish are destroying the Chesapeake Bay. The Washington Post https://www.fredericknewspost.com/news/environment/blue-catfish-are-destroying-the-chesapeake-bay/article_c3aedc3d-4556-5ce4-b933-2c0556e162cf.html Accessed 20 September 2017.
Carolan, M.S. 2006. The values and vulnerabilities of metaphors within the environmental sciences. *Society and Natural Resources* 19:921-930.
Chaffin, B.C., A.S. Garmestani, D.G. Angeler, D.L. Herrmann, C.A. Stow, M. Nystrom, J. Sendzimir, M.E. Hopton, et al. 2016. Biological invasions, ecological resilience and adaptive governance. *Journal of Environmental Management* 183: 399–407.
Chew, M. K., and M. D. Laubichler. 2003. Natural enemies – metaphor or misconception? *Science* 301(5629):52-53.
Cooke, S.J., N.W.R. Lapointe, E.G. Martins, J.D. Thiem, G.D. Raby, M.K. Taylor, T.D. Beard, Jr., and I.G. Cowx. 2013. Failure to engage the public in issues related to inland fishes and fisheries: strategies for building public and political will to promote meaningful conservation. *Journal of Fish Biology* 83:997-1018.
Copp, G.H., and 21 coauthors. 2005. To be, or not to be, a non-native freshwater fish? *Journal of Applied Ichthyology* 21:242-262.
Craig, L., Olden, J., Arthington, A., Entrekin, S. Hawkins, C., Kelly, J., Kennedy, T., Maitland, M., Rosi, E., Roy, A., Strayer, D., Tank, J., West, A., Wooten, M. 2017. Meeting the challenge of interacting threats in freshwater ecosystems: A call to scientists and managers. The science and management of multiple, interacting threats in freshwater ecosystems. *Elementa Science of the Anthropocene* 5 DOI: https://doi.org/10.1525/elementa.256
Crowley, S. L., S. Hinchliffe, and R.A. McDonald. 2017. Conflict in invasive species management. *Frontiers in Ecology and the Environment* 15:133-141.
Davis, M. A. 2009. Invasion biology. Oxford University Press, Oxford, United Kingdom
Davis MA, Chew MK, Hobbs R, Lugo AE, Ewel JJ, Vermeij GJ, Brown JH, Rosenzweig ML, Gardener MR, Carroll SP, Thompson K, Pickett STA, Stromberg JC, Del Tredici P, Suding KN, Eherenfeld JG, Grime JP, Mascaro J, Briggs JC (2011) Don't judge species on their origins. *Nature* 474:153–154
Didham, R. K., J. M. Tylianakis, M. A. Hutchison, R. M. Ewers, and N.J. Gemmell. 2005. Are invasive species the drivers of ecological change? *Trends in Ecology & Evolution* 20:470–474.

Dunn, R. 2013. Advice for scientists who want to write for the public. Your Wild Life (website). Accessed 30 January 2018 at http://yourwildlife.org/2013/06/advice-for-scientists-who-want-to-write-for-the-public/

Elmendorf, S., J. Byrnes, A. Wright, S. Olyarnik, R, Fischer, and L. Chamberlin. 2005. Fear and fishing in Lake Davis [Video]. Flag in the Ground Productions, Davis. Available from http://reach.ucdavis.edu/programs/pike/index.shtml. Accessed 20 September 2017.

Ernwein, M. and J.J. Fall 2015. Communicating invasion: understanding social anxieties around mobile species. *Geografiska Annaler: Series B, Human Geography* 97 (2): 155–167.

Estévez, R. A., C. B. Anderson, J. C. Pizarro, and M. A. Burgman. 2015. Clarifying values, risk perceptions, and attitudes to resolve or avoid social conflicts in invasive species management. *Conservation Biology* 29:19-30.

Evans, J. M.,A.C. Wilkie, and J. Burkhardt. 2008. Adaptive management of nonnative species: Moving beyond the either-or through experimental pluralism. *Journal of Agricultural and Environmental Ethics* 21:521–539.

Fabrizio, M.C., T.D. Tuckey, R.J. Latour, G.C. White, A.J. Norris. 2017. Tidal habitats support large numbers of invasive Blue Catfish in a Chesapeake Bay subestuary. *Estuaries and Coasts* DOI 10.1007/s12237-017-0307-1

Figueiredo, B. R. S., R. P. Mormul and S. M. Thomaz, 2015. Swimming and hiding regardless of the habitat: prey fish do not choose between a native and a non-native macrophyte species as a refuge. *Hydrobiologia.* doi:10.1007/s10750-014-2096-x.

Gibbons, J. 2015. Smithsonian Scientists Work to Stop Invasions. http://insider.si.edu/2015/10/smithsonian-scientists-working-to-stop-invasions/. Accessed 6 July 2017.

Gillies, J. 2015. Popular Virginia blue catfish fishery complicates Chesapeake Bay restoration. FISHSENS Magazine (March 13). Available at http://magazine.fishsens.com/popular-virginia-blue-catfish-fishery-complicates-chesapeake-bay-restoration.htm. Accessed 8 December 2016.

GIT (Sustainable Fisheries Goal Implementation Team Executive Committee). 2012. Adoption statement: invasive catfish policy. 4 pp. http://www.chesapeakebay.net/channel_files/17972/final_catfish_policy_git_1-24-12 (with_signatures).pdf. Accessed 12 February 2016.

Gobster, P.H. 2005. Invasive species as ecological threat: is restoration an alternative to fear-based resource management? *Ecological Restoration* 23:261-270

Gozlan, R. E. 2008. Introduction of non-native freshwater fish: is it all bad? *Fish and Fisheries* 9:106–115.

Gozlan, R.E., Burnard, D., Andreou, D. and J.R. Britton. 2013. Understanding the threats posed by non-native species: public vs. conservation managers. *PLoS One* 8(1): e53200. https://doi.org/10.1371/journal.pone.0053200

Hagy, J.D., W.R. Boynton, C.W. Keefe, and K.V. Wood. 2004. Hypoxia in Chesapeake Bay, 1950–2001: long-term changes in relation to nutrient loading and river flow. *Estuaries* 27:634-658.

Hajer, M. A. 1997. The politics of environmental discourse: ecological modernization and the policy process. Oxford University Press, Oxford, UK.

Hale, R.C., T.D. Tuckey, and M.C. Fabrizio. 2016. Risks of expanding the blue catfish fishery as a population control strategy: influence of ecological factors on fish contaminant burdens. Technical Report NOAA NA11NMF4570220. 63 p.

Hamper, A. 2015. 10 best rivers for catching monster catfish. Game & Fish Magazine (Oct 28). Available at http://www.gameandfishmag.com/south/mississippi/10-best-rivers-for-catching-monster-catfish/. Accessed 7 August 2017.

Harper, S. 2010. The rise and gall of blue catfish in Virginia rivers. The Virginian-Pilot (Aug 30). Available at https://pilotonline.com/news/local/environment/the-rise-and-gall-of-blue-catfish-in-virginia-rivers/article_ded1af68-0dae-5887-a988-541f782a1254.html. Accessed 15 June 2017.

Hart, P.S., and B.M.H. Larson. 2014. Communicating about invasive species: How "driver" and "passenger" models influence public willingness to take action. *Conservation Letters* 7: 545-552.

Heger, T., W.-C. Saul, and L. Trepl. 2013. What biological invasions 'are' is a matter of perspective. *Journal for Nature Conservation* 21(2):93-96.

Hilling, C.D., A.J. Bunch, R.S. Greenlee, D.J. Orth and Y. Jiao. In press. Natural mortality and size structure of introduced Blue Catfish in Virginia tidal rivers. *Journal of the Southeastern Association of Fish and Wildlife Agencies*.

Humair, F., P.J. Edwards, M. Siegrist, and C. Kueffer. 2014. Understanding misunderstandings in invasion science: why experts don't agree on common concepts and risk assessments. *NeoBiota* 20:1-30.

(ISAC) Invasive Species Advisory Committee. 2006. Invasive species definition clarification and guidance white paper. National Invasive Species Council. US Department of Agriculture, National Agricultural Library. Washington, DC. Available at http://www.invasivespeciesinfo.gov/docs/council/isacdef.pdf. (July 2017).

Invasive Catfish Task Force (ICTF). 2014. Final report of the sustainable fisheries goal implementation team invasive catfish task force. NOAA Chesapeake Bay Program Office. Annapolis, Maryland. https://www.chesapeakebay.net/channel_files/21127/chesapeake_bay_invasive_catfish_report_and_recommendations_2-20-14_draft.pdf

Jackson, MC, Loewen, CJ, Vinebrooke, RD and Chimimba, CT 2016 Net effects of multiple stressors in freshwater ecosystems: a meta-analysis. *Global Change Biology* 22(1): 180–189. DOI: 10.1111/gcb.13028

Jelks, H.L., S.J. Walsh, N.M. Burkhead, et al. 2008. Conservation status of imperiled North American freshwater and diadromous fishes. *Fisheries* 33(8):372-407.

Jordan, T.E., D.E. Weller, and C.E. Pelc. 2017. Effects of local watershed land use on water quality in mid-Atlantic coastal bays and subestuaries of the Chesapeake Bay. *Estuaries and Coasts* https://doi.org/10.1007/s12237-017-0303-5

Kemp, W.M., et al. 2005. Eutrophication of Chesapeake Bay: historical trends and ecological interactions. Marinen Ecology Progress Series 303:1-29.

Kendall-Taylor, N., M. Erard, and A. Haydon. 2013. The use of metaphor as a science communication tool: air traffic control for your brain. *Journal of Applied Communication Research* 41:412-433.

Kobel, R. 2017. New federal regulation of blue catfish may be eased. Bay Journal. (25 August). Available at

http://www.bayjournal.com/article/switch_from_fda_to_usda_inspectors_burdens_blue_catfish_handlers Accessed 20 September 2017.
Kueffer, C., and B.M.H. Larson. 2014. Responsible use of language in scientific writing and science communication. *BioScience* 64:1-6.
Lackey, R.T. 2007. Science, scientists, and policy advocacy. *Conservation Biology* 21:12-17.
Lackey, R.T. 2013. Normative science. Terra Magazine, Oregon State University 8(2):36
Lakoff, G. 1993. The contemporary theory of metaphor. Pages 202-251 in A. Ortony, editor. Metaphor and thought. Second edition. Cambridge University Press, Cambridge, UK. http://dx.doi.org/10.1017/CBO9781139173865.013
Larson, B.M.H. 2005. The war of the roses: demilitarizing invasion biology. *Frontiers in Ecology and the Environment* 3:495-500.
Larson, B.M.H. 2007. An alien approach to invasive species: objectivity and society in invasion biology. *Biological Invasions* 9:947-956.
Lee, D.P. 2001. Northern Pike control at Lake Davis, California. Pages 55-61in R.L. Cailteux, L DeMong, B.J. Finlayson, W. Horton, W. McClay, R.A. Schnick, and C. Thompson, editors. Rotenone in Fisheries: Are the Rewards Worth the Risk? In:. American Fisheries Society, Bethesda, Maryland.
Leiserowitz, A., Maibach, E., Roser-Renouf, C., Smith, N., & Dawson, E. (2012). Climategate, public opinion, and the loss of trust. *American Behavioral Scientist* 57(6), 818–837.
Liang, X., et al. 2014. Building buzz: (Scientists) communicating science in new media environments. *Journalism and Mass Communication Quarterly* 91(4):772–791.
Limburg, K. E., R. M. Hughes, D. C. Jackson, and B. Czech. 2011. Human population increase, economic growth and fish conservation: collision course or savvy stewardship? *Fisheries* 36(1):27–35.
Linker, L.C., R.A. Batiuk, G.W. Shenk, and C.F. Cerco. 2013. Development of the Chesapeake Bay watershed total maximum daily load allocation. J*ournal of the American Water Resources Association* 49: 986–1006.
Lockwood, J.L., M.F. Hoopes, M.P. Marchetti. 2007. Invasion Ecology, Blackwell Publishing, Oxford, UK
Loettgers 2013. Communications: metaphors advance scientific research. *Nature* 502:303.
Maasen, S., E. Mendelsohn, and P. Mendelsohn, editors. 2001. Biology as society, society as biology: metaphors. Springer, Dordrecht, The Netherlands.
Markle, D. F. 1976. The seasonality of availability and movements of fishes in the channel of the York River, Virginia. *Chesapeake Science* 17:50-55.
McCord, J. 2016. The Invasion of the Blue Catfish. http://wvtf.org/post/invasion-blue-catfish#stream/0. Accessed 6 July 2017.
Menzel, R.W. 1945. The catfish fishery of Virginia. *Transactions of the American Fisheries Society* 73:364-372.
Moyle, P. B., and T. Light. 1996. Biological invasions of fresh water: empirical rules and assembly theory. *Biological Conservation* 78(1):149-161.
Nuñez, M.A., S. Kuebbing, R.D. Dimarco, and D. Simberloff. 2012. Invasive species: to eat or not to eat, that is the question. *Conservation Letters* 5:334-341.

Orth, D.J., Y. Jiao, J.D. Schmitt, C.D. Hilling, J.A. Emmel, and M.C. Fabrizio. 2017. Dynamics and role of non-native Blue Catfish *Ictalurus furcatus* in Virginia's tidal rivers. Final Report, Virginia Department of Game and Inland Fisheries, Henrico, Virginia. 129 pp.

Parke, E.C., and J.C. Russell. 2018. Ethical responsibilities in invasion biology. The Ecological Citizen 2(1): epub-013. Accessed 30 January 2018 from http://www.ecologicalcitizen.net/article.php?t=ethical-responsibilities-invasion-biology

Parker, I.M., D. Simberloff, W.M. Lonsdale, K. Goodell, M. Wonham, P.M. Kareiva, M.H. Williamson, B. von Holle, P.B. Moyle, J.E. Byers and L. Goldwasser. 1999. Impact: toward a framework for understanding the ecological effects of invaders. *Biological Invasions* 1:3–19.

Pasko, S., Goldberg, J., MacNeil, C. and M. Campbell. 2014. Review of harvest incentives to control invasive species. *Management of Biological Invasions* 5(3): 263-277.

Pauwels, E. 2013. Communication: Mind the metaphor. *Nature* 500:523-524.

Peretti, J. H. 1998. Nativism and nature: rethinking biological invasion. *Environmental Values* 7(2):183-192.

Petersen, J. H., R. A. Hinrichsen, D. M. Gadomski, D. H. Feil, and D. W. Rondorf. 2003. American shad in the Columbia River. Pages 141–155 in K. E. Limburg and J. R.Waldman, editors. Biodiversity, status, and conservation of the world's shads. American Fisheries Society, Bethesda, Maryland.

Potomac Conservancy. 2016. This invasive fish could pose a bigger threat than snakeheads. Available at https://potomac.org/blog/2016/6/16/blue-catfish-population-threat-potomac-river. Accessed 7 August, 2017.

Prior, K.M., D.C. Adams, K. D. Klepsiz, et al. 2017. When does invasive species removal lead to ecological recovery? Implications for management success. *Biological Invasions* 1-17 https://doi.org/10.1007/s10530-017-1542-x

Ricciardi, A., M.F. Hoopes, M.P. Marchetti, and J.L. Lockwood. 2013. Progress toward understanding the ecological impacts of non-native species. *Ecological Monographs* 83:263–282

Ricciardi A., and sixteen coauthors. 2017.Invasion science: a horizon scan of emerging challenges and opportunities. *Trends in Ecology and Evolution* 32:464–474

Ricciardi, A., and R. Ryan 2017. The exponential growth of invasive species denialism. *Biological Invasions* DOI 10.1007/s10530-017-1561-7

Richardson, D. M., P. Pyšek, M. Rejmánek, M. G. Barbour, F. D. Panetta, and C. J. West. 2000. Naturalization and invasion of alien plants: concepts and definitions. *Diversity and Distributions* 6(2):93-107.

Ruiz, G.M., and D.F. Reid. 2007. Current state of understanding about the effectiveness of ballast water exchange (BWE) in reducing aquatic nonindigenous species (ANS) introductions to the Great Lakes Basin and Chesapeake Bay, USA: Synthesis and analysis of existing information. NOAA Technical Memorandum GLERL-I42. National Ocean and Atmospheric Administration. Michigan. 127 pp.

Sagoff, M. 2005. Do non-native species threaten the natural environment? *Journal of Agricultural and Environmental Ethics* 18:215–236.

Sarewitz, D. 2011. The voice of science: let's agree to disagree. *Nature* 478: 7367. doi: 10.1038/478007a

Scharf, C.A. 2013. In defense of metaphors in science writing. *Scientific American.* Website July 9. Accessed on 26 January 2018 at https://blogs.scientificamerican.com/life-unbounded/in-defense-of-metaphors-in-science-writing/

Schlaepefer, M.A., V.F. Sax. J.D. Olden. 2011. The potential conservation value of non-native species. *Conservation Biology* 25:428-437.

Schmitt, J.D. 2016. White catfish, the original catfish of the Chesapeake Bay. Available at https://www.chesapeakecatfish.com/single-post/2016/07/11/White-catfish-the-original-catfish-of-the-Chesapeake-Bay. Accessed 7 September 2017.

Schmitt, J.D., E.M. Hallerman, A. Bunch, Z. Moran, J.A. Emmel, and D.J. Orth. 2017. Predation and prey selectivity by nonnative catfish on migrating alosines in an Atlantic slope estuary. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 9:108–125.

Schüttler, E., R. Rozzi, and K. Jax. 2011. Towards a societal discourse on invasive species management: a case study of public perceptions of mink and beavers in Cape Horn. *Journal for Nature Conservation* 19(3):175-184.

Scott, T. 2015. Does collaboration make any difference? Linking collaborative governance to environmental outcomes. *Journal of Policy Analysis and* Management 34: 537–566. DOI: 10.1002/pam.21836

Selge, S. A. Fischer, and R. van der Wal. 2011. Public and professional views on invasive non-native species – a qualitative social scientific investigation. *Biological Conservation* 144:3089-3097.

Shine, R. and J. S. Doody. 2011. Invasive species control: understanding conflicts between researchers and the general community. *Frontiers in Ecology and the Environment* 9(7):400–406

Simberloff, D. 2006. Invasional meltdown 6 years later: important phenomenon, unfortunate, metaphor, or both? *Ecology Letters* 9:912-919.

Springston, R. 2015. State attempting to 'thin the herd' of blue catfish. The Daily Progress (Aug 17). Available at http://www.dailyprogress.com/news/state/state-attempting-to-thin-the-herd-of-blue-catfish/article_ef968e52-44ea-11e5-92a9-873476c60a51.html. Accessed 20 June 2016

Subramaniam, B. 2001. The aliens have landed! Reflections on the rhetoric of biological invasions. *Meridians: Feminism, Race, Transnationalism* 2(1): 26–40.

Sughrue, T. n.d. Invasive wild blue catfish: The greatest environmental threat the Chesapeake Bay Ecosystem has ever faced. Congressional Seafood Co. (website) Accessed 1 February 2018 at http://congressionalseafood.com/vendor-qr-codes/invasive-wild-blue-catfish/

Sutton, K. 2015. The Chesapeake Bay 'Blues." World Fishing Network. (May 6). Available at http://www.worldfishingnetwork.com/stories/post/the-chesapeake-bay-blues. Accessed 7 August 2017.

Taylor, D. 2015. How eating blue catfish could save the Chesapeake. The Washingtonian. https://www.washingtonian.com/2015/05/14/how-eating-blue-catfish-could-save-the-chesapeake-bay/. Accessed 6 July 2017.

Tuckey, T. D., and M.C. Fabrizio. 2017. 2017 Annual Report: Estimating Relative Juvenile Abundance of Ecologically Important Finfish in the Virginia Portion of the Chesapeake Bay (1 June 2016 - 30 June 2017). Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.21220/V5KF04

Theodoropoulos, D.I. 2003. Invasion biology: critique of a pseudoscience. Avvar Books, Blythe

Thomaz, S.M., K.E. Kovalenko, J.E. Havel, and L.B. Kats. 2015. Aquatic invasive species: general trends in the literature and introduction to the special issue. *Hydrobiologia* 746:1-12.

Thompson, K. 2014. Where do camels belong? the story and science of invasive species. Profile Books, London

Toussaint, A., O. Beauchard, T. Oberdorff, S. Brosse, and S. Villéger. 2016. Worldwide freshwater fish homogenization is driven by a few widespread non-native species. *Biological Invasions*. 18:1295-1304.

Valéry, L., H. Fritz, J.-C. Lefeuvre, and D. Simberloff. 2008. In search of a real definition of the biological invasion phenomenon itself. *Biological Invasions* 10(8):1345-1351.

Vaz, A.S., C Kueffer, et al. 2017. The progress of interdisciplinarity in invasion science. *Ambio* 46:428-442.

Warren, C. R. 2007. Perspectives on the 'alien' versus 'native' species debate: a critique of concepts, language and practice. *Progress in Human Geography* 31(4):427-446.

Warren, II, R.J., J.R. King, C. Tarsa, B. Haas, and J. Henderson. 2017. A systematic review of context bias in invasion biology. *PLoS ONE* 12(8): e0182502 https://doi.org/10.1371/journal.pone.0182502

Wilson, J.R.U, E. E. Dormontt, P. J. Prentis, et al. 2009. Something in the way you move: dispersal pathways affect invasion success. *Trends in Ecology and the Environment* 24:136–44.

Woodford, D. J., D.M. Richardson, H.J. MacIsaac, N.E. Mandrak, B.W. van Wilgen, J.R.U. Wilson, and O.L.F. Wey. 2016. Confronting the wicked problem of management biological invasions. *NeoBiota* 31:63-86.