Momenta

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On the cover

Networks of energy. Energy of neurons, of cities in the night, of stars. These networks are all present here, aligned along the web of dark matter in our universe.

Image Credit

Dr. Andrew Pontzen, UCL Physics and Astronomy

momenta (n. pl.) Latin

1. The indwelling forces that are the principle of change.

2. The circumstances that precipitate change.

The papers in this volume are momenta in the sense

[ii] that they are reactions to a set of circumstances (the ideas, the work of understanding, the opportunity to consider those ideas), and also in the sense

[i] that they make contribution to ongoing scholarly discussions and so inevitably change the course of those discussions.

Translated by Darcy Otto, Professor of Philosophy and Classics at Quest University Canada

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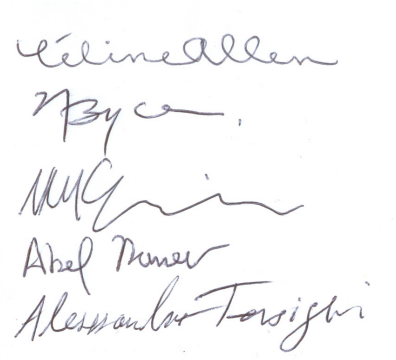
FOREWORDS

Editorial Board

As undergraduate students, we seldom continue our academic projects beyond the duration of the courses we take. Our ideas, analyses, and insights, while well-developed and thought-provoking, sit on hard drives while we move on to new challenges. The goal of *Momenta* is both to provide an opportunity for students to continue developing their best work, and showcase excellent papers written by Quest students. True to our title, these papers do not intend to offer incontrovertible conclusions, but rather a depth of analysis that spurs our continually evolving understanding of complex ideas.

This first installment establishes an avenue that will motivate the pursuit of academic excellence at Quest. We are proud to present to you *Momenta*, volume 1, issue 1—the collective efforts of 70 students, faculty and staff.



Céline Allen
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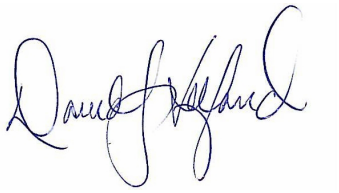
Faculty Review Board

The word "academic" has two meanings in everyday parlance. In its primary use, academic refers to any activity or institution engaged in educational and scholarly pursuits. The second meaning, gaining regrettable prominence, refers to a enterprise or result that is of little or no practical use and can thus safely be ignored, as in "That's just of academic interest."

Unsurprisingly, the Quest faculty abjure the latter usage. We regard academic pursuits—the careful, intellectually rigorous examination of ideas in order to gain a deeper understanding of the natural world and the human condition—as among the highest callings of our species; indeed, it is a capability that distinguishes us from all other life on Earth. An academic exercise is not an irrelevant activity, but one in which our highest cognitive abilities are employed. As such, we applaud the creation of a student-led "Quest Academic Journal".

Learning to do research—whether in the field, the lab, or the library—and to craft a clear and compelling report of the results is a hallmark of a Quest education. The articles contained herein are exemplars of the best work Quest students produce. We are pleased to see this new outlet for student academic work and happy to participate in the nomination and selection of articles.

On behalf of the Faculty Review Board and the University as a whole, I offer the founding Committee congratulations along with the support and best wishes this important new Quest tradition deserves.



David J. Helfand
President & Vice-Chancellor
Quest University Canada
April 15, 2015

Salmon hatcheries in the Pacific Northwest: The long-term risks for wild populations

Elijah Cetas & Mindy Skinner

Over the past century, wild salmon populations (*Oncorhynchus* spp.) have declined in the Pacific Northwest due to overfishing, habitat loss, and the construction of dams (Gresh et al., 2000; Welch et al., 2008). In the Northwest United States, for example, salmonids have disappeared from almost 40 percent of rivers in which they were historically abundant (National Research Council, 1996). To mitigate such declines, hatchery programs were established in Canada and the United States to supplement wild populations with artificially raised stock (Orr et al., 2002; Lichatowich, 1999). Although hatcheries do increase the freshwater survival of salmon (Fisheries and Oceans Canada, 2014), there is accumulating evidence that hatchery salmon threaten wild stocks (e.g. Fraser, 2008; McGinitty et al., 2009; Quiñones et al., 2013). Here we argue that hatchery salmon compete with wild populations and weaken wild genetic stock. Furthermore, hatchery programs may mask the real conditions of wild populations, reducing the chances of legal protection in both Canada and the United States. Instead, we propose habitat restoration and conservation as a more effective long-term solution for protecting wild salmon.

When hatchery populations are mixed with wild populations, competition can lead to a reduction in survival rates for wild salmon. Salmon's major prey, zooplankton, is affected by changing ocean conditions (Francis & Hare, 1994; Levin et al., 2001), and when these conditions are poor, competition for food with hatchery salmon can reduce wild salmon survival (Levin et al., 2001). This was hypothesized in the Klamath River Basin and the Straight of Georgia—in both areas hatchery releases are high, and hatchery salmon continue to have strong return rates while wild salmon returns continually decline (Quiñones et al., 2013; Sweeting et al., 2003). Many factors that affect salmon survival may be at play (including high exploitation rates (Quiñones et al., 2013)), but increased competition along with natural and unnatural stressors can reduce the resiliency and stability of wild salmon populations.

Not only do hatchery salmon increase competition, but hybridization with wild salmon can weaken genetic diversity and thereby reduce the resilience of wild populations. Hatchery salmon are genetically different from wild individuals because they are raised in distinct environments where they endure different selective pressures (Reisenbichler & Rubin, 1999). Moreover, there is a reduction in diversity in hatchery salmon because an unnaturally high number of young are allowed to survive. These genetic differences can lead to successively lower reproductive fitness (Araki et al., 2007; Araki et al., 2008). Hatchery salmon also have reduced survival rates because they are less effective at avoiding predators (Einum & Fleming, 2001). These traits can make interbred populations more vulnerable to climate change and other anthropogenic stressors (McGinnity et al., 2009). For example, a study on interbred Atlantic salmon predicted that continued introduction of hatchery salmon combined with ocean warming would lead to the extinction of wild populations within twenty generations (McGinnity et al., 2009). Hatchery salmon may supplement population numbers, but sustainable management must reflect quality as well as quantity. Interbreeding weakens the resilience of the population, a long-term cost that may outweigh the initial benefits of hatchery programs.

Aside from biological changes to fish populations, hatchery introductions may compromise the legal protection of endangered salmon. In the United States, some salmon species are protected under the Endangered Species Act of 1973 (U.S Fish and Wildlife Ser-

vice, 2015). Under policy promulgated by the National Marine Fisheries Service in 1991, endangered wild populations were considered distinct from hatchery populations (Waples, 1991; NMFS, 1991). This distinction arises because hatchery brood stock are often taken from multiple habitats and are therefore not reproductively isolated, unlike wild populations that return to their natal stream to spawn every year (Waples, 1991; NMFS, 1991; U.S. Fish and Wildlife Service, n.d.). However, in 2005, this policy was changed so that mixed hatchery and wild salmon stocks would be considered one population for the purposes of their legal listing (NMFS, 2005). Under this latest amendment, the presence of genetically inferior hatchery salmon could threaten the legal protection of wild salmon.

In Canada, however, salmon are not federally protected under the Species At Risk Act (SARA) (Species at Risk Act, SC 2002). Populations of sockeye, coho, and chinook salmon have been recommended for listing, but were denied for economic and socio-economic reasons (reflecting biases in the listing process) (Canada Gazette, 2005, 2006, 2010). As the number of hatchery salmon released continues to increase (Mackinlay et al., n.d.), the hatchery population may mask the true population declines of wild salmon present in both Canadian and American waters. There may be reduced political will for, and/or public interest in, conserving wild salmon as the presence of hatchery salmon masks the true numbers of wild salmon in the ecosystem. Without the presence of hatchery salmon, there may be more pressure to protect wild salmon populations.

We have demonstrated here that hatchery salmon can pose serious problems to wild salmon populations, and hatcheries should no longer be considered a viable solution. The traditional approach of salmon conservation that focuses on numbers of salmon, rather than quality of individuals, is a simplistic reaction to a more complex problem (Rahr & Augerot, 2006). These methods assume that a short-term increase in populations will lead to sustainable wild populations in the long-term, but we have shown here that this is not necessarily the case. Both genetic quality and the state of a population's habitat are important.

For wild salmon populations to return, policies should shift away from technical and costly short-term solutions such as the hatchery program. Instead, what may be more effective are recovery efforts that prioritize restoration of important habitats and the proactive, long-term conservation of existing salmon stocks (Rahr & Augerot, 2006; Pinsky et al., 2009). If existing healthy rivers are effectively protected, and other formerly healthy spawning streams are restored, wild salmon populations may have a greater chance of recovery. Regardless of the solutions adopted in the future, hatchery programs will need thorough re-evaluation to determine if they are meeting their goals of sustaining salmon populations. If we consider the negative effects of hatchery programs, resources may be better directed elsewhere to ensure the long-term conservation of wild Pacific salmon.

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Borges' "Pierre Menard, Author of the *Quixote*": A marriage of reading and writing

Kendra Perrin

Jorge Luis Borges' "Pierre Menard, Author of the *Quixote*" is the story of an obscure 20th-century French academic, Pierre Menard, who goes to painstaking lengths to recreate the *Quixote* (or *Don Quixote*) through a process that initially appears to be little more than a word-for-word transcription of Miguel de Cervantes' *Quixote*[1]. The anonymous narrator of "Pierre Menard, Author of the *Quixote*" (hereinafter referred to as "PM, AQ") suggests, however, that the fruit of Menard's labour is not a mere copy: "Menard's fragmentary *Quixote* is more subtle than Cervantes'" (93). I side with the narrator, arguing that, despite the seeming absurdity and superfluity of Menard's undertaking, what he does with the *Quixote* does not differ from what readers do each time they read a text: they re-write it. Thus, in depicting a character who goes through the physical process of re-writing a text he has read, Borges' story demonstrates literally what readers do figuratively. The difference between Menard's process and that of other readers is not substantive, it is simply material. Menard's reading of the *Quixote* results in a tangible text, whereas the texts re-written by other readers are intangible. In challenging the Romantic[2] notion of a text as an original collection of words written once and then read indefinitely, Borges' "PM, AQ" suggests that there exist many authors associated with each text and, in doing so, blurs the distinction between the role of an author and the role of a reader. An author writes, a reader writes by reading; a reader is an author, an author is a reader.

What is a text but a collection of characters organized into words and put onto paper? This, of course, is the material component of a text, but an exegetical[3] approach to interpretation assumes a text is additionally constituted by something more immaterial: a text has a pre-determined, immutable, and singular meaning. In the course of making my overarching argument, I will explore the origin of this meaning and argue that a text's meaning is neither singular nor permanent.

The words Menard commits to paper in "PM, AQ" are materially the same as Cervantes': "the Cervantes text and the Menard text are verbally identical" (94). However, in the same sentence in which the narrator reports that the texts are verbally identical, he also contends that the texts are different, for "the second [Menard's] is almost infinitely richer. (More *ambiguous*, his detractors will say—but ambiguity is richness.)" (94). Herein lies the central paradox of Borges' story: how can a text be simultaneously the same and different? An investigation into the source of this difference may also reveal the source of textual meaning more generally. Borges' story establishes that the difference between Cervantes' and Menard's texts lies outside the words. The difference between these verbally identical texts stems instead from the basic difference between the people who wrote them and their different contexts, which I will define as a combination of time and place[4]. The radical discrepancy between the two characters' contexts is powerfully captured when the narrator describes what Menard would have

1. The italicized '*Quixote*' will refer to Cervantes' text (17th century, Spain), whereas the non-italicized 'Quixote' will refer to Menard's text (20th century, France)

2. With Romantic, I refer to the ideal of the exalted poet (or author, more generally): a person with the capacity to show laypeople/non-authors some truth or beauty that they are surrounded with yet cannot notice by themselves. Therefore, poets/authors produce a kind of text that their readers simply could not.

3. In an exegetical interpretation, the interpreter presumes the text — particularly a religious text — contains a pre-existing meaning that they can draw out. (Exegesis literally means to 'draw out').

to do to "*be* Miguel de Cervantes"; he would need to "learn Spanish, return to Catholicism, fight against the Moor or Turk, [and] forget the history of Europe from 1602 to 1918" (91). Because of their different contexts, Cervantes and Menard would have meant different things with the same word. Thus, the unique interaction between these men and their Quixotes resulted in texts with unique meanings. Ultimately, it is the context in which a text is read or written that informs its meaning.

Given that context is the source of differences in meaning, we may read "PM, AQ" as a suggestion that when a reader comes in contact with a text, the interaction fills the text's material words with immaterial meaning. Words such as 'beauty,' 'truth,' or 'nobility' can elicit a nuanced concept, feeling, image, or memory within each of us. Your 'power' is not the same as mine, even if we share the same dictionary. Therefore, word/person interactions establish what individual words (or signs) signify — especially those that are highly contestable[5]. The collection of all the word/person interactions constitutes a text/person interaction, and the result of that text/person interaction is textual *meaning*. To decide on the meaning of each word is to decide on the meaning of a text, and these decisions, which are not always conscious, are informed by personal context. This idea of contextual determination of meaning is not new to the secondary literature on "PM, AQ." In his essay "Borges' Revisioning of Reading in 'Pierre Menard, Author of the *Quixote*,'" Howard Giskin states:

> Borges implies the simple yet disturbing supposition that the meaning of literary works is entirely dependent on the varying historical and social contexts in which they are read. Simple because it seems obvious that context plays an enormous part in the determination of meaning of texts; complex and disturbing in its suggestion that literary meaning is constructed through mental processes irrevocably tied to location and period. (103)

Thus, if we take seriously Giskin's assertion "that literary meaning is constructed through mental processes irrevocably tied to location and period," there are grounds for the narrator's seemingly absurd need to distinguish between Menard's Quixote and Cervantes' *Quixote*. Due to the influence that place and time have on meaning, and due to the fact that those who scripted these texts lived in different places at different times, their texts are simply not the same.

In "PM, AQ," the narrator states that Menard handwrote parts of the *Quixote*. In addition, I have argued that Menard constructed meaning for those same parts of the *Quixote*. These two features, physically putting words on paper and constructing meaning, constitute a provisional definition of writing (one that is hopefully not too difficult to accept). The consequence of applying this definition to Borges' story, however, is less palatable, for it means admitting that Menard wrote the *Quixote* just as much as Cervantes did. The former cannot be subordinated to a copier, nor the latter elevated to an author (where the underlying assumption of authorship is that there can only be one). The only person who could copy, rather than re-write, Cervantes' *Quixote* would be Cervantes himself, and only at the same time as he wrote the *Quixote*; anyone else who commits the words to paper would layer on a different context, produce a different meaning, and therefore become one of potentially many different, and legitimate, writers. The narrator explains that Menard was aware of this: "Being, somehow, Cervantes, and arriving thereby at the Quixote—that looked to Menard less challenging (and therefore less interesting) than continuing to be Pierre Menard and coming to the Quixote *through the experiences of Pierre Menard*" (91). No, Menard "had no intention of *copying*" (95) and, as a different person from Cervantes, he could not have copied even if he had intended to. If there is a temptation to elevate one author above the other, it comes from the notion that, chronologically

4. In "Borges' Revisioning of Reading in 'Pierre Menard, Author of the *Quixote*,'" Howard Giskin makes an interesting point about context by including in his definition, "context [is] an 'accidental' aspect of the work, accidental in terms of what we know regarding the genesis of the work" (109).
5. A basic understanding of Ferdinand de Saussure's theory of the linguistic sign, particularly the arbitrary and mutable relationship between the signifier and signified, may be helpful in conceptualizing this idea. The full citation for "Course in General Linguistics" is included in the Works Cited.

speaking, Cervantes wrote the *Quixote* first, making his the "original." However, the very notion that unique meaning is created from each unique interaction between person and text suggests that "originality" is not something that happens just once. Each time a text is written it is original, in that it is like none before and none after.[6] As legitimate writers of the *Quixote*, Cervantes and Menard are, in essence, equal.

I will briefly take stock of what has hitherto been established: 1) texts take on meaning through interacting with individuals and different interactions produce different, equally original meanings, and 2) a writer is someone who scripts and constructs meaning; therefore, Menard and Cervantes are both equally legitimate writers. I will now argue that, apart from the physical phenomenon of his hand moving a pen on paper, what Menard does with the *Quixote* is not fundamentally different from what any individual does with any text: they read it, which is to write it.

Likening what Menard does with the *Quixote* to what any reader does with the *Quixote* requires only recognizing that the material product is not an essential component of Menard's work. Consequently, it requires recognizing that, even if Menard never produced a material Quixote, he would have still done work. The narrator makes this exact contention when he introduces Menard's Quixote, after having listed his other publications:

> This is the full extent […] of the *visible* lifework of Pierre Menard, in proper chronological order. I shall now turn to the other, the subterranean, the interminably heroic production—the *oeuvre nonpareil*, the *oeuvre* that must remain—for such are our human limitations!—unfinished. (90)

This passage implies that the visibility or materiality of a work is not essential for an evaluation of its worth. Menard's "subterranean" work is far more "heroic" than his "*visible*" work, suggesting not only the superiority of his "subterranean" work but also, as a necessary condition of that superiority, its existence. It does not matter if Menard's Quixote is lost, or if it is visible, or if it actually made its way onto paper, it matters only that, by reading the *Quixote*, Menard wrote it. The product of his reading effort need not be material to be considered legitimate.

What, then, is the difference between reading and writing but materiality, which is not essential to either process? "PM, AQ" suggests that there is no significant difference. Alfonso de Toro explains that Borges' position on reading and writing in is:

> […] related to what Roland Barthes (1970) … describes in *S/Z* as the *scriptable*, that is, a practice, activity where both reading and writing are placed in a relation of equivalence by transforming the reading into a re-writing. This leads to an "eternal present" (*S/Z*: 11). (136)

As represented by de Toro, Barthes' thinking engages in a kind of radical literary egalitarianism, for it challenges the Romantic notion of an author as a rare kind of genius distinct from other people. If we extend de Toro's position and place reading and writing in a relation of equivalence, we extrapolate that, so long as someone is literate, exists in a context, and presumably reads with a certain quality of attention and engagement, anyone can be equal to all others as a literary creator.[7]

If, as "PM, AQ" suggests, texts are written every time they are read through a dual process of reading and writing, then texts can be written *infinite* times in *infinite* variations. This claim has significant implications

6. It would be equally just, and not inconsistent, to posit instead that originality *never* happens, for to say that 'every text is original' or 'no text is original' is essentially to say the same thing: all texts are equal in their level of originality or unoriginality. In Roland Barthes' essay "The Death of the Author," he suggests that the nature of language might be responsible for the haziness surrounding questions of originality and unoriginality in texts, because writing "has no other origin other than language itself, language which ceaselessly calls into question all origins" (170). I will continue to use the word "original" (without quotation marks, hereinafter) in this paper, but I intend for it to suggest this paradox of originality/unoriginiality.

7. My guess is that Barthes' argument does not seek to disregard physical laws and therefore does not deny that, in order for the dual processes of writing and reading to begin, a text must come into existence, i.e. it must be materially written. Further, while I cannot for Barthes, I personally do not deny

regarding the meaning of a text, implications that are succinctly captured by Jorge Luis Castillo in his essay, "Pierre Menard and the School of the Skeptics":

> It is easy to see why some of the proponents of the *nouvelle critique*, […] reception theory, […] and other representatives of postmodern philosophy […] have used [Borges'] short story as the paradigm of meaning that is not fixed, ready-made, and author-oriented, but transient, ever-changing, and reader-oriented. (415)

Perhaps it is because of the malleable and unfixed nature of meaning that the narrator insists that Menard's Quixote must remain "unfinished" (90). If "finished" is understood as fixed, then the narrator's insistence rightfully suggests that fixedness is an impossible state for Menard's, or anyone's, Quixote to reach. Barthes' writing, as understood by Giskin, complements the notion of texts as permanently "unfinished" or, to use Barthes' language again, stuck in the "eternal present" (106). Giskin explains that, "The result of all this, according to de Toro, is that each re-reading is 'an *Urtext*, an origin, and consequently ... endless origins, and at the same time none,' allegedly the same theory of literary practice suggested by Barthes in *S/Z*" (106). I wish to extend de Toro's ideas a step further by proposing to eliminate the 're' prefix in discussing the reading and writing of texts. The prefix implies that there is an original writing and reading and then subsequent re-readings and re-writings, when really the notions of constant textual creation and the eternal presence of texts are meant to challenge the very stability of origin. At the hands of those it interacts with, a text is in perpetual motion — motion defined by no beginning and no end.

Upon a cursory reading, "PM, AQ" may seem little more than a humorous short story about a man who is determined to recreate a text that already exists by copying it (although he and the narrator refuse to see his action as copying). However, upon closer analysis and a questioning of reading and writing as distinctly separate acts, Borges' story transforms into an allegory for the process of reading as writing. All that distinguishes Menard from any other reader is the commitment of his labour to paper, his making visible (or making text of) the often-invisible construction of meaning. Writers and literary scholars did not miss the radical suggestions of Borges' story. Giskin explains that, published in 1939, "PM, AQ" was a pre-cursor for postmodern ways of thinking about the acts of reading and writing, a piece about thirty years ahead of its time, that influenced Derrida, Foucault, and Barthes, among others (105). Whether Barthes, famous for his 1967 essay "The Death of the Author," derived his theory from Borges' works or not, I believe that, if he could, Borges would tell his postmodern successor that the birth of the reader does not necessitate the death of the author. Framing writing and reading as a zero-sum game where one must die in order for the other to live suggests that reader and writer are fundamentally distinct categories. Borges' position breaks down the author/reader binary by suggesting that both are constructing meaning, that is, writing (see Footnote 7). Readers are born once the significance of their role is acknowledged. They are not passive consumers of words, empty vessels, or depositories for external meaning. They are reader-authors, actively constructing their own meaning.

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chronology: the writing of a text into material existence does indeed constitute the first writing. What I do challenge, though, is the significance of this chronology - the latent assumption that the first writer becomes the 'author' and therefore more important than all the subsequent people ('readers') who come along and interact with his or her text. All of these people are meaning-makers and thus writers, irrespective of their place in a chronological sequence.

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Reading testimonial literature: How do we bear witness?

Anna Borch

I am in a painfully interesting place; I feel the presence of a wound that is not mine to feel. I am intimately aware of the boundaries of an empty space I cannot fill. I have spent three weeks studying what no one who is comfortable with the soft limits of their world chooses to read: testimonial literature. The testimonial is a narrative that, through recounting the lived experience of a marginalized group, both condemns the systemic oppression responsible for their suffering and empowers the oppressed through the act of telling their story (Beverly 25-26). Reading testimonial literature means grappling with the Holocaust, the 1968 massacre of students in Mexico City, slavery in Cuba, and the experience of dying of terminal illnesses such as AIDS. Reading testimonial literature means witnessing how inadequately words represent these subjects, even if we have no experience of what the words describe. Reading testimonial literature, for me, means asking this question: how can I, as a non-member of this marginalized group and sometimes even as a member of the oppressing group, appropriately bear witness? In this essay, I will explore ethical responses to testimonial literature and defend the conclusion that we have agency only to acknowledge and bring awareness to testimonial stories.

Before we can understand how to react to these stories, we need to understand what the testimonial is trying to achieve; in its essence, the testimonial attempts to right an ethical wrong. In the aftermath of the Second World War, French philosopher Jean-François Lyotard used the example of Nazi gas chambers to define a particular type of wrong, called the *differend*, in which a crime cannot be communicated and thus rectified because of "a lack of a rule of judgment" applicable to both the worldview of the perpetrator and the victim (xi). Essentially, the problem Lyotard states is that one cannot convince a Nazi officer that he is a criminal because, within his "argument" or world-view, his actions do not constitute a crime. In order to try to communicate this type of crime, four factors are needed: a "wrong" itself; a witness to the wrong; an empathetic audience willing to listen; and a language within which it is possible to speak of the wrong to people whose worldview, or "argument", conflicts (Lyotard 14). Lyotard argues that the problem of the *differend* can never be solved because of a lack of common "argument". However, I view the testimonial as a transcendence of the *differend* and a mechanism that allows us to express the inexpressible.

How does the testimonial represent an unspeakable or unimaginable event? The very bones of the testimonial, both in structure and in method of creation, include the four provisions necessary to right the wrong of Lyotard's *differend*. Testimonials would be unnecessary without the existence of a crime, thereby satisfying Lyotard's first provision. Second, testimonial literature normally includes the voice of Lyotard's "witness" in a first person narration. Quite often, testimonials are written in tandem, with an editor or compiler transcribing the stories of the oppressed or marginalized. In this case, there is at least one willing and empathetic audience member. The last of the four provisions, a common world-view or language in which to acknowledge and describe the crime, is Lyotard's eventual stumbling-block: what art, what poetry, what music could describe the horrors of Auschwitz? What language exists that can communicate the reality of those crimes (Lyotard 88)?

A simple yet unsatisfying answer is this: the language we use every day. Words are imprecise tools, but they are tools fashioned for the very purpose of represent-

ing occurrences within our physical and emotional worlds. In describing crimes such as the gas chambers at Auschwitz, words *are* doing what we created them to do. The difference, however, is that the occurrences these words represent are much more devastating than their usual subject matter. The modern philosopher Jacques Rancière sums this up in his response to Lyotard by comparing the language of a Holocaust survivor's testimonial to the language used in Flaubert's *Madame Bovary*. Whether about the comparatively petty crime of infidelity or a crime against humanity, both works use the same syntax, the same well-worn words, "the same logic of minor perceptions added to one another" to create their respective crime-scenes (Rancière 124). The same language is appropriate for both the mundane and the unspeakable. And we find that even when words are inadequate to describe the exact details of crimes committed, their power lies in the ability to represent, in some way, the boundaries of what they *cannot* represent. Alain Resnais' film essay *Night and Fog* opens with mundane shots of overgrown fields and rusting railroad tracks – visuals that do not elicit any sort of significance or importance until the narration informs us that they lead to the crumbling gates of Auschwitz. Later in the film, his depiction of the gas chambers at Auschwitz is chilling: a stark, upward pan within the chambers themselves, coupled with this narration:

> The only sign—but you have to know it—
> is this ceiling, dug into by
> fingernails. Even the concrete was torn.

Without the accompanying words, the significance of the visual subject matter is in danger of underrepresentation. But by choosing narration carefully, Resnais forges a link between the overgrown artifacts of history and the atrocities committed, without having to describe the atrocities themselves. Thus, the testimonial succeeds through using what we have always used to represent the non-verbal: words. In doing so it represents the moments of history in which unspeakable crimes have been committed, thus solving Lyotard's problem of the *differend* and allowing the crime to be acknowledged and the conflict alleviated.

A fundamental role of the testimonial is to act as "resistance literature" to restore agency, validity, and justice to those who have suffered (Beverly 25). Although these crimes cannot be rectified, the testimonial enables the willing and empathetic to acknowledge the crime. Even if rectification is impossible, this acknowledgement is still a valuable step in that direction. Thus, the testimonial is, in part, made for those who are in front of the page. The editor can and does fulfil the role of the reader during the creation and compilation of the work (Sklodowska 81). But is that one willing listener enough? We, as *readers* of testimonial literature and peripheral witnesses to present moments of unspeakable and systemic crimes, are the empathetic audience willing to listen. How can the unspeakable be communicated to a reader? What is the reader's duty, and how can this duty be communicated? In summary, how can we ensure that the testimonial *does* transcend the *differend*?

Much of what we *should* do in response to both the raw stories that constitute testimonials and the testimonial pieces themselves stems from a close analysis of what we should *not* do. As a member of the audience, we have not experienced the event in question and thus do not have the ethical agency to represent or appropriate the "I" voice used by the witness. In her poem "In Memory of Tlatelolco," Rosario Castellanos explores what it means to reflect on the testimonials of her countrymen who were caught up in the 1968 massacre of students in the Mexico City district of Tlatelolco. Although she was not present at the massacre and thus was not an eyewitness, she states:

> But I feel pain when I probe right here: here in my memory
>
> it hurts, so the wound is real. Blood mingling with blood
>
> and if I call it my own blood, I betray one and all
>
> (qtd. in Poniatwoska 171)

To feel the presence of the wound, and to actually have been wounded are two very different things. As Castellanos points out, it is not her wound to feel. She avoids betraying those who actually bled by not describing the massacre itself nor refashioning their blood as her own. As a student of the same age who is studying the same subjects as some of those who gave testimony or

were killed, I found reading about eyewitness accounts of the massacre of Tlatelolco a difficult emotional experience. It is all too easy, as audience members, to think that we feel the "real wound" left by events like these; in fact, it is a sign of the empathetic power of the testimonial that readers are affected so. But we must remember that we share in Castellanos' responsibility: any poem, any art we can create in response to the massacre is an inadequate representation of the event's horrible enormity, and refashioning the Tlatelolco slaughter through our small emotional reaction to it is an ethical betrayal. If we purport to say that *our* reaction is a story that can represent Tlatelolco in and of itself, we negate the actual experience of the witnesses by overshadowing it with our own experience of pain. In Lyotard's words, "the 'perfect crime' does not consist in killing the victim or the witnesses … but rather in obtaining the silence of the witness" (8). Fictional portrayals or responses emphasising our own emotional response may obscure the accounts to the point of committing this "perfect crime." By recounting our emotional reaction as though it has historical and testimonial clout all on its own, we silence witnesses and remove their ability to vouch for the damage done to them.

How then can a reader or viewer react to or represent an unimaginable event without unethical appropriation? As stated, we as the audience cannot presume to know what the event was like, but we can still feel the presence of the wound, the empty space where flesh was once whole. However, we do not have the agency to fill this hole with our own words. What we *can* do is represent the wound's quality of absence, and let our words crowd around that empty space without the intent of filling it. In *Night and Fog*, Alain Resnais does not attempt to tell the audience what it was like to be Jewish during the Holocaust, nor does he present an internal musical soundtrack of a worker in a concentration camp. The music in *Night and Fog* is not full of affect-inducing violin swells as in Holocaust films such as *Schindler's List*, whose musical soundtrack has been described as walking the thin line between representation and the production of a convenient emotional experience for the audience (Classen 96). On the contrary, the soundtrack of *Night and Fog* is a creepy half-jaunt with unexpected dissonant notes that suggest the futility of the whole endeavor of musical representation. Instead of trying to portray the Holocaust in the most emotionally convenient way possible, Resnais' musical choice avoids projecting a single clear emotion, and instead becomes a jumpy, broken piece of machinery, a metaphor for the process of representation itself (Alter 26). This music is not trying to speak for the victims of the Holocaust; it leaves the testimonial-giving to the witnesses themselves, *even if* they cannot be present in the film. Through this work, Resnais suggests that, as an artist or a member of the audience, all we have agency to do is acknowledge and bring awareness to what is unspeakable, unknowable, missing: the wound.

What happens when the witnesses cannot speak out because they are no longer alive? Does the conclusion we just reached not change when there are *no* testimonial accounts of a crime? Would it not be better to attempt to recreate the event in this case, instead of prodding imprecisely around the wound? In terms of Lyotard's philosophy, the provision of the witness—one of the four essential factors needed to rectify the *differend*—would be missing. For example, soon there will be no living survivors of the Holocaust to provide a credible, ethical, and accurate description of their experience. Luckily, extensive documenting has occurred and many testimonials were recorded after the end of the Second World War. However, if this were not the case and the Nazis had been successful with their "Final Solution," we would be left with a vague sense of some horrible wound, but no victim to describe what it was like to be cut. In this hypothetical case, can the wrong of the Holocaust ever be fully acknowledged? I do not know. But I do know that we would have a choice: try our best to recreate, to fabricate and "fill in" the horror, or talk only *around* the unspeakable in quiet respect for those who can no longer speak themselves, holding our own imperfect representation of the event until, in one way or another, the witnesses could have their wrongs acknowledged. In Castellanos' words "I remember, let us all remember / until justice comes to sit among us" (qtd. in Poniatowska 171).

Our responsibility as the audience does not end, however, with being the cautious and distraught keeper of chronicles. It is not enough to internalize the validity

of a testimonial, or to empathise with another's pain. We could put the book down, turn off the television, and never consider the matter again. Would the testimonial be effective? To break the silencing stronghold of the *differend* case, we must be the voice that speaks and says, "This happened. I do not know what it was like, but I know that it was wrong." This action is important in cases where we as the audience are not a part of the oppressed group that the testimonial speaks for, but it is even more important when we form a part of the oppressing group itself. When we are a part of that second group, we share in the "argument" or idiom of the oppressors or are at least literate in that particular idiom. Without the testimonial, the idiom of those who have been oppressed continues to be muffled and negated through an absence of representation. Testimonials provide access to another's idiom, one we may not have previously considered. When we read or watch these works, we gain access to these previously censored idioms, and at the same time consider our own idiom and the power relationship between them. Insight gained from reading testimonials can allow us to critically analyse the nuanced systemic oppression at play in events of history and of the present.

With this more complete acknowledgement or understanding of events, the audience can do three particular things. First, we can look through the chronicles of history for places where the voices of the witnesses have been silenced and define the edges of wounds, crimes, and unspeakable acts with our own words, keeping in mind the damage that can occur by overshadowing another's story. Second, we can act as an audience for the testimonial and, as mentioned previously, acknowledge and bring awareness to the testimonial case by acting as a translator between idioms. By gaining access to and empathizing with the story of an oppressed group, we also take on the responsibility to bring the oppressors or other members of our idiom to the same understanding. Finally, we can act in the present with regard to events that necessitate the creation of a testimonial. Testimonials are written to fend off the curtains of obscurity, to defy those who wish to commit Lyotard's "perfect crime" (8). If we as the audience act within the social structures that speak in the oppressive idiom, we can combat the very action of silencing that necessitates the testimonial. These actions are a concerted, deliberate use of our privilege in order to help those who have been oppressed, silenced or have suffered because of the *existence* of our privilege. These actions are not only ones we *can* perform, but ones we *need* to perform if we want to be a part of the restoration of justice.

The wounds of a protesting Mexican student, a Holocaust survivor, are not mine to feel nor mine to mend, but they are mine to prevent in the future, insofar as they are anyone's to prevent who has heard tell of them. The blood that has flown from them is not my blood, and it is perverse to hope or pretend that it ever will be. Reacting to testimonial literature suffers from the fine distinction between speaking *for* and speaking *over* those who have given testimony. It is our responsibility to make sure that when we speak, our voices are strong, but softer than those who have born witness to something we could never know. The reader of the testimonial is condemned to the narrow space between their own past naivety and the witnesses' unknowable and complete persecution; it is undoubtedly uncomfortable, but could never be worse than experiencing the unknowable.

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Test of a biodiversity model across an environmental stress gradient

Catherine Gerstle & Kyle Fawkes

Abstract

Environmental stress models attempt to predict local species richness based on abiotic stress gradients and their effects on interspecific interactions (Bruno et al., 2003). Scrosati et al. (2011) synthesized earlier environmental stress models to predict intertidal marine species richness by functional group, based on data from the Atlantic coast. We tested the generality of this model by collecting data using the same survey methods across similar environmental gradients on the Pacific coast. We found 66 species on the Pacific coast, nearly twice the richness found in the Atlantic study. Our richness patterns were similar to both the Atlantic data and model for sessile species, but inconsistent for carnivores, and contradictory for herbivores. We hypothesize that desiccation tolerance[1], terrestrial predation, and abiotic differences in tidal height may explain the differences in diversity patterns between the two coasts. The Scrosati model requires further testing to determine whether the Pacific coast is an unusual exception to the general model, or whether the model's application is limited to the Atlantic coast.

Introduction

Biodiversity patterns in species richness are evident at global, regional, and local scales. Understanding the factors that drive these patterns can help us understand and manage biodiversity both for its intrinsic value, and for extrinsic values such as ecosystem goods and services (Ghilarov, 2000; Wilson et al., 2005). Many descriptive and conceptual models have been proposed to describe patterns of species richness including the latitudinal diversity gradient[2], species-area curves[3], and theories of island biogeography[4] (Stehli et al., 1969; Smith et al., 2005; Renema et al., 2008; Yasuhara et al., 2009; Pompa et al., 2011; Yasuhara et al., 2012; Goldstein et al., 2014; Hobbs et al., 2012; Huntington & Lirman, 2012). Furthermore, many hypotheses have been proposed to explain these models, including the fluctuating resource availability theory[5] (FRAT; Davis et al., 2000) and the intermediate disturbance hypothesis[6] (Connell, 1978). Marine intertidal environments are particularly amenable to the study of biodiversity distribution because the steep environmental gradients from the low- to the high-tide mark lead to dramatic and readily visible spatial patterns. They are important environments to study because they are transitional ecosystems that link marine and terrestrial biodiversity (Wilson et al., 2005).

Due to the daily tide cycle, the intertidal environment is physically stressful for organisms: half the time it is underwater, and half the time it is exposed to air. As a result, intertidal organisms experience extreme fluctuations in temperature, desiccation, oxygen availability, carbon dioxide (CO_2), and pH levels (Helmuth

1. An organism's ability to withstand extremely dry environmental conditions.
2. Differences found in species richness and diversity due to the latitude that a given species inhabits (i.e., poles, tropics, equator).
3. A graphical representation of the relationship between habitat area and the number of species that live in that area.
4. Examining the unique factors present in an isolated community that effect species richness.
5. The relationship between a biological community's susceptibility to invasive species and the abundance of available resources.
6. The concept that species diversity is maximized when ecosystem disturbances are neither too high nor too low in frequency and intensity.

& Hoffman, 2001; Tomanuk & Helmuth, 2002). These stressors, which affect all trophic levels, generally become more intense higher in the intertidal zone, and affect species survival and interspecific interactions (Helmuth & Hoffman, 2001).

Intertidal biodiversity is not evenly distributed around the globe. Since the 1960s, a series of seminal studies have established the three main factors that determine intertidal diversity: physical stress or disturbance (Connell, 1978; Sousa, 1979), herbivores (Lubchenco, 1978) and carnivores (Paine, 1966; Paine & Vadas, 1969;). These factors were later synthesized into conceptual models known as ESMs (environmental stress models), which aim to predict patterns of intertidal biodiversity based on the interactions between these abiotic and biotic factors (Menge & Sutherland, 1987, Bruno et al., 2003). Most recently, Scrosati and colleagues (2011) presented an updated synthesis of these models focused on functional groups, and tested it on a rocky shore intertidal community located in Nova Scotia, Canada. Hereafter, we refer to this new model as the Atlantic model. If the Atlantic model applies in other areas, it will provide general insights into the dynamics of marine biodiversity. Our goal was therefore to test the Atlantic model against the intertidal biodiversity patterns of the northeast Pacific (Figure 1).

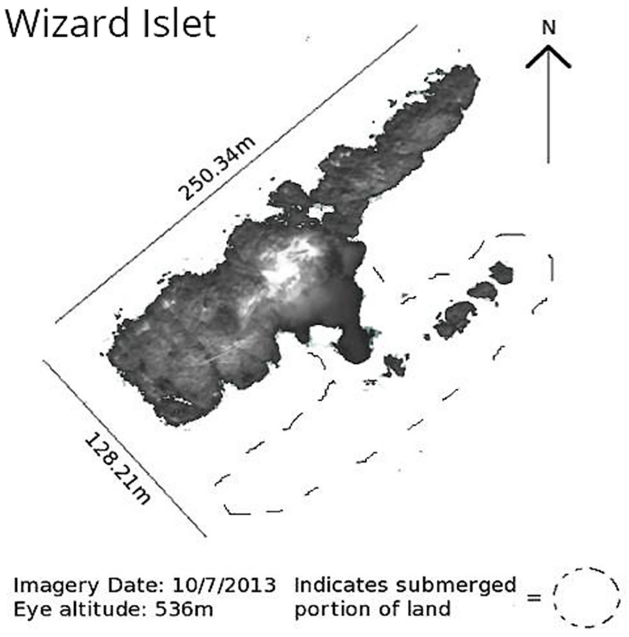

Figure 1. Map of Wizard Islet (48°51'29.15"N, 125°9'35.30"W), located in Trevor Channel, Barkley Sound, on the west coast of Vancouver Island, British Columbia. Image taken from Google Earth, looking down at the islet from an altitude of 536m.

The Atlantic model aims to predict biodiversity along stress gradients. It was developed with respect to two gradients, tidal elevation and wave exposure. Tidal elevation is measured as the vertical height above the baseline chart datum (in Canada, the Lower Low Water Low Tide). The higher an organism's tidal elevation, the more time it is exposed to air. Wave exposure is the force with which waves crash onto the shoreline. The Atlantic model predicts biodiversity patterns across these gradients for species richness and evenness, with different predictions for three functional groups: mobile carnivores, mobile herbivores, and sessile species (Figure 2).

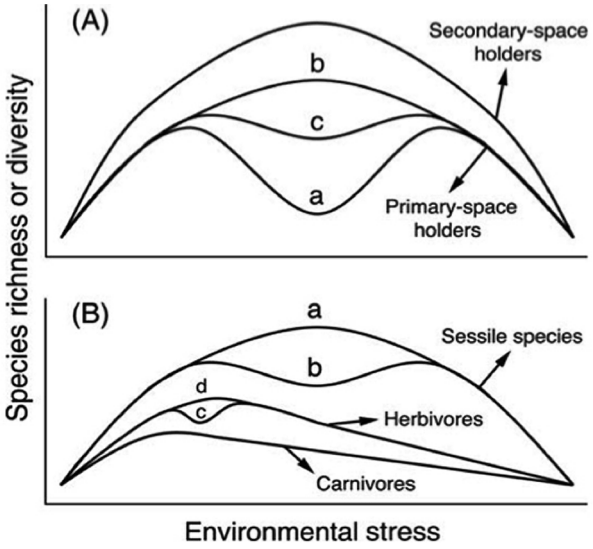

Figure 2. Environmental stress model (ESM) for intertidal species diversity over an environmental stress gradient. A) Classic ESM for secondary and primary space holders (Menge and Sutherland, 1987). B) Recent ESM based on re-categorizing the same taxa into three functional groups (Scrosati et al., 2011; the "Atlantic model") Figure excerpted from Scrosati et al. (2011).

The model predicts that all three functional groups will peak in richness at intermediate stress levels and taper in richness towards extreme high and low stress (Figure 2). Overall, it predicts that richness will be greatest for sessile species, followed by herbivores and finally by carnivores. For each functional group, the model predicts a slightly different pattern. For sessile species there are two possibilities: a unimodal curve or a bimodal curve. The unimodal curve predicts peak richness near the intermediate stress environment. The bimodal curve predicts two peaks, one at the intermediate-low stress level and one at the intermediate-high stress level. The difference depends on com-

petitive exclusion, recruitment and niche partitioning (Scrosati et al., 2011; Figure 2). For herbivores there are again two possibilities, a unimodal or a bimodal curve, where the bimodal distribution accounts for competitive exclusion and the unimodal distribution accounts for niche partitioning and carnivore predation (Scrosati et al., 2011; Figure 2). For carnivores the model only predicts a unimodal curve, which peaks in richness around the intermediate-low stress environment because no higher trophic levels are present (Scrosati et al., 2011; Figure 2).

Scrosati et al. (2011) tested their model using species richness and evenness data from Atlantic Canada, and found moderate to low support for their predictions. However, they sampled the tidal elevation gradient in only three zones, which limited their ability to test for unimodal vs. bimodal curves. We repeated their methods on the northeast Pacific coast, sampling across six tidal elevation zones to generate finer spatial resolution along the stress gradient. In sum, both studies estimated diversity at two wave exposure levels, at three (Atlantic) or six (Pacific) tidal elevation levels, and in terms of species richness and abundance to allow for evenness calculations. In this paper we focus on the biodiversity patterns found within species richness, and across tidal elevation only.

Methods

Study Site

We surveyed the intertidal species richness on Wizard Islet (48°51'29.17"N, 125°09'33.74"W) in Trevor Channel, Barkley Sound, British Columbia. Wizard is a small islet with relatively low elevation; the islet nearly disappears at high tide (Figure 1). In addition to the intertidal algae and invertebrates species we identified, it is populated by seals, seagulls, oystercatchers, and mink, while grasses and small terrestrial vegetation characterize its flora. A scattering of intertidal pools, small crevasses, and surge channels create a moderately complex topography. We surveyed two sides of the islet. The more exposed northwest aspect faces Imperial Eagle Channel and the open Pacific Ocean, whereas the sheltered southeast aspect faces the calmer waters of Trevor Channel (Figure 1). Sampling was conducted on September 10th (predicted low tide 0.3m at 7:49AM) and 11th (0.4m at 8:30AM), 2014, between 6:00AM and 12:00PM each day.

Survey

Our survey team consisted of the eleven members of the Quest University Canada Marine Biodiversity class. In general, we followed the methods of Scrosati et al. (2011). We sampled accessible bedrock surfaces, excluding tide pools and submerged channels. On the exposed survey site, we sampled from a lower limit of 1.3m ± 0.18 (n=5 measurements) to an upper limit of 3.6m ± 0.10 (n=5) above Lower Low Water Low Tide (LLWLT). On the sheltered survey site, we sampled from 0.2m ± 0.08 to 2.9m ± 0.03 above the LLWLT (Figure 3).

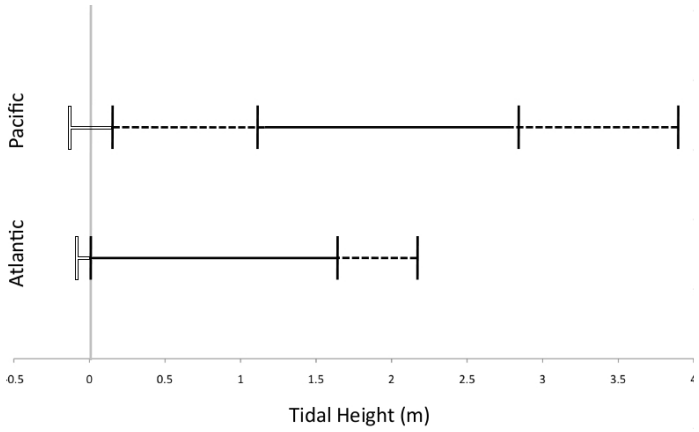

Figure 3. Tidal elevation ranges of the Atlantic (Scrosati et al. 2011) and Pacific (present study) intertidal biodiversity surveys. White indicates the lowest part of the intertidal in each region, which was not surveyed because it was inaccessible. Black (full) indicates survey area. Black (dashed) indicates the range of lower (left) and upper (right) tidal elevations between exposed and sheltered sites.

To sample across the elevation gradient, we divided the exposed intertidal zone into six evenly spaced horizontal 30m band transects parallel to the water line: very low "VL", low "L", mid-low "ML", mid-high "MH", high "H" and very high "VH" (Figure 4). We placed 10 quadrats, each 25x25cm, on the nearest accessible bedrock at randomly chosen points at least 1m apart along the middle of each band. We visually estimated the percent cover of all macroscopic organisms. When percent cover was less than 1%, or a single organism was found (e.g., a very small limpet), that species was

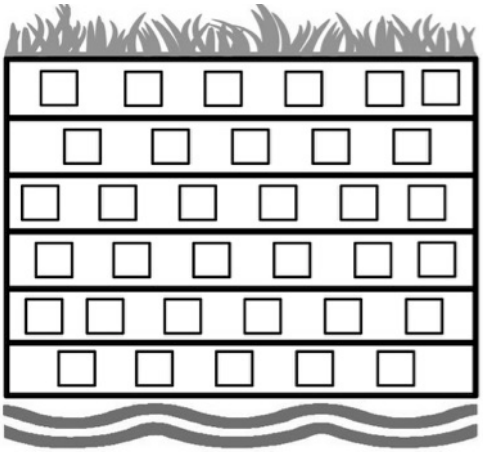

Figure 4. Intertidal biodiversity sampling design on Wizard Islet, BC, September 2014. Six 30m long horizontal band transects spanned the intertidal zone from the water line (wavy lines) up to the top of the upper barnacle line (grass). A total of ten 25x25cm quadrats, separated by at least 1m, were sampled along the midline of each transect (only some quadrats illustrated here).

assigned 0.5% cover. Organisms that could not be identified in the field were brought back to the lab at Bamfield Marine Sciences Center and keyed to the lowest taxonomic level possible. The red alga *Mastocarpus*, which on the Pacific coast includes up to 12 genetically-determined but morphologically indistinguishable species, were pooled as *Mastocarpus* spp. Five unidentified red, green and brown macroalgae were given morphospecies names. Periwinkles were divided into the two field-identifiable morphologies of *Littorina* spp. Very small limpets were identified only to genus *Lottia*, and counted as a species only if no other limpets were present in the quadrat. All species were classified into one of three functional groups: mobile carnivores, mobile herbivores, and sessile species.

Results

We identified 66 species, including 11 carnivores, 17 herbivores, and 38 sessile species, of which 26 were algae and 12 were filter feeders (Figure 5). The most common carnivores were ochre sea stars (*Pisaster ochraceus*), ribbon worms (*Amphiporus* spp.), and leather stars (*Dermasterias imbricata*). The predominant herbivores were sea snails (*Littorina scutulata*), black katy chitons (*Katharina tunicata*), and amphipods (*Gammarus* spp.). The most common filter feeders were two types of acorn barnacles (*Balanus glandula* and *Chthamalus dalli*) and the aggregating anemone (*Anthopleura elegantissima*). The predominant algae were rockweed (*Fucus gardneri*), sea lettuce (*Ulva lactuca*), and filamentous green algae (*Cladophora* spp.)

Although we reported almost twice as many species as were reported in the Atlantic survey (36 total; 4 carnivores, 5 herbivores, and 27 sessile; Scrosati et al., 2011) (Figure 5), the overall structure of the two communities was broadly similar in terms of relative proportions of functional groups (Figure 4) and dominant types of species (based on Watt & Scrosati, 2013): carnivores were dominated by whelks, herbivores were dominated by limpets and periwinkles, sessile filter feeders were dominated by barnacles, and algae were dominated by brown fucoids and red crusts.

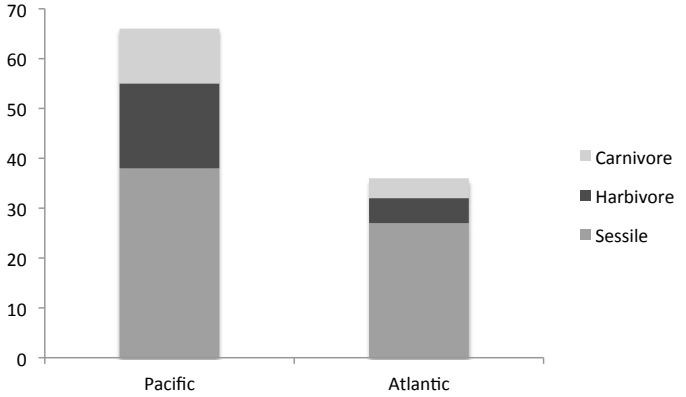

Figure 5. Number of intertidal species identified in the Atlantic (Scrosati et al. 2011) and Pacific (present study; Wizard Islet, BC, September 2014) biodiversity surveys, by functional groups.

For each functional group, species richness patterns differed across the tidal elevation gradient. For carnivores, species richness showed an overall statistically significant decline with increasing tide height from a mean of 0.7 species at very low elevation to 0 at very high elevation (Figure 6a; ANOVA p=0.02, Table 1). The second-lowest richness was at the ML elevation. For herbivores, species richness showed an overall increase with increasing tide height from a mean of 0.7 species at very low elevation to 1.3 at very high elevation, although this trend was not statistically significant (Figure 6b; ANOVA p=0.26, Table 1). For sessile species, species richness showed an overall statistically significant decrease with increasing tide height from a mean of 7.8 species at very low elevation to 3.6 at very high elevation (Figure 6c; ANOVA p=<0.001, Table 1).

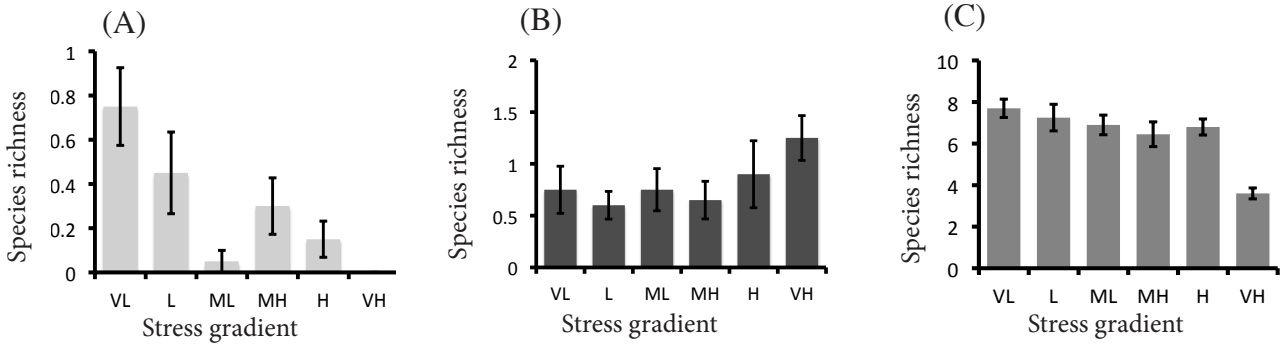

Figure 6. Intertidal species richness over a tidal elevation gradient from very low (VL) to very high (VH) on Wizard Islet, Barkely Sound, British Columbia, in September 2014 for (A) mobile carnivores, (B) mobile herbivores, and (C) sessile species. Bars show the mean of N=20 quadrats; error bars show ±1 SEM. Note different y-axis scales.

Functional Group	Factor	DF	SS	MS	F	p	
Sessile	Wave Exposure	1	0.20	0.20	1.57	0.213	
	Tidal Elevation	5	5.16	1.03	8.26	<0.001	***
	Waves x Height	5	0.91	0.18	1.45	0.213	
	Residuals	108	13.50	0.13			
Herbivore	Wave Exposure	1	0.14	0.14	0.59	0.446	
	Tidal Elevation	5	1.55	0.31	1.33	0.255	
	Waves x Height	5	1.47	0.29	1.27	0.282	
	Residuals	108	25.05	0.23			
Carnivore	Wave Exposure	1	0.76	0.76	9.60	0.002	**
	Tidal Elevation	5	1.08	0.22	2.74	0.023	*
	Waves x Height	5	1.74	0.35	4.40	0.001	**
	Residuals	108	8.52	0.08			

*Table 1.Two-factor ANOVA results for species richness vs. wave exposure (2 levels), tidal elevation (6 levels), and their interaction, for mobile carnivores, mobile herbivores, and sessile species in the intertidal zone of Wizard Islet, BC, September 2014. DF, Degrees of freedom; SS, sum of squared deviations; MS, mean squared deviation; F, F-value; p, probability value. Asterisks indicate statistical significance for $p<\alpha=0.05$ (*** $p<0.001$; ** $p<0.01$; * $p<0.05$).*

Discussion

Part 1: Species richness vs. ESM

Overall, we found more sessile species than herbivores and carnivores. This pattern is consistent with that predicted by the Atlantic model. However, the species richness patterns over the elevation gradient for each functional group were not entirely consistent with the model.

To analyze the differences between the model and our data, we compared the stress gradients between the two coasts. At the sites that were sampled, the intertidal extent was greater in the Pacific (lowest low tide -0.2m, up to the maximum barnacle limit of 2.9m) than in the Atlantic (lowest low tide -0.1m, up to the maximum barnacle limit of 2.2m). As a result, we sampled a larger vertical range than the Atlantic study (Figure 3). However, because of the particular tide heights on our sampling dates, we sampled only as low as 0.2m, leaving a total of 0.4m of the intertidal zone unsurveyed at the low end of the stress gradient. In contrast, the Atlantic survey sampled down to 0m, leaving only 0.1m unsurveyed. Thus, the Atlantic study sampled almost the entire extent of the stress gradient, whereas ours omitted the lowest end of the gradient. These differences may help explain some of the differences between the Atlantic model and the Pacific data

described below.

For mobile carnivores, the Pacific species showed a decline in richness from low to high intertidal (with a notable dip at the ML elevation) (Figure 6a). In contrast, the Atlantic model predicts a peak at moderately low stress levels, and a smooth decline in either direction along the gradient (Figure 2). Our data could be consistent with the model under two conditions. The first is that our sampling spanned only the upper half of the stress gradient, representing only the right-hand side of the curve. This is plausible, as we did not sample the lowest elevations; however, for the data to support the model, the richness would have to drop off very rapidly in the unsampled region. The second is that our ML data were anomalous. These hypotheses could be tested by re-sampling our sites at a time of year when the tide cycle allows access to the lower intertidal, and collecting more samples. Thus, the Pacific carnivore data could be consistent with the Atlantic model.

For mobile herbivores, the Pacific species richness illustrated no statistically significant differences across the environmental stress gradient (Figure 6b). In contrast, the Atlantic model predicts either a unimodal or bimodal distribution (Figure 2). Our data could be consistent with the model if our samples happened to cluster so close together along the curve that they are indistinguishable. However, this scenario is inconsistent with our sampling design, which spanned most of the available vertical gradient and extended entirely to the upper limit of the habitat; furthermore, it is inconsistent with the scenario required if our carnivore data is to support the model. Thus, we find no support for the herbivore component of the ESM.

For sessile species, the Pacific species richness showed no change across the stress gradient up to the medium-high elevation, and dropped somewhat at the very high elevation (Figure 6c). In contrast, the Atlantic model predicts either a unimodal or bimodal curve with peak richness at intermediate levels (Figure 2). Our data could be loosely consistent with the model if, as for the carnivores, we sampled only the upper half of the stress gradient. This scenario would again require that the richness drop off very rapidly in the unsampled region, which could be tested at another time of year. Thus, the sessile species data could be consistent with the model.

In summary, the species richness of the mobile carnivore and sessile functional groups in the Pacific could be consistent with the upper half of the environmental stress gradient model from the Atlantic. However, even if the Pacific survey were extended into the lower intertidal zone, the herbivore data simply could not support the model.

Part 2: Limitations of ESM

At best, the Atlantic ESM could provide an explanation for patterns in Pacific mobile carnivore and sessile species richness in the upper half of the stress gradient, but cannot explain the pattern for mobile herbivores. Thus, the Atlantic ESM is not a general model. More extensive sampling in multiple locations would be required to determine whether the model is specific to the Atlantic coast, or whether it is more widely applicable.

In the meantime, we propose that the ESM would be more biologically useful if it distinguished trophic levels in both the sessile group, as it does in the mobile group, for two reasons. First, we note that the mobile carnivore and mobile herbivore richness in the Pacific appeared not to be strongly positively correlated, as would be expected from the right-hand side of the model; if anything, they tended toward a negative correlation (Figure 3a-b). This pattern would be expected if carnivore diversity controlled herbivore diversity, which would be a reasonable general prediction due to predation. However, these particular carnivores generally do not consume these mobile herbivores (M. Wonham pers. comm.). The herbivore and sessile species richness also appeared negatively correlated, which again would not be predicted from the patterns in the model. This empirical pattern would, however, be expected if herbivore diversity controlled sessile species diversity. Since many intertidal herbivores graze algae and can also "bulldoze" newly settling animals (Shick et al., 1988), this is a biologically reasonable prediction. The mobile carnivores, however, would affect only the sessile animals and not the algae, so sessile species as a group would not be expected to respond in the same way to the diversity of the uppermost trophic

levels. Second, we note that the Atlantic ESM does not consider terrestrial predators such as sea gulls and mink, whose predation would tend to decrease all animal diversity in the upper intertidal zones, nor does it include mobile sub-tidal predators, such as fish and crabs, which would tend to decrease all animal diversity in the lower zones.

To create a more biologically relevant model, ESM predictions should be generated separately for sessile algae versus sessile animals, in the same way that the model splits mobile animals by trophic level. Although they are all in competition for space, the former are consumed by herbivores, while the latter are eaten by carnivores. Given the general importance of herbivory and predation in affecting intertidal diversity (Paine, 1966; Paine & Vadas, 1969; Lubchenco, 1978;), we anticipate that generating separate predictions for these two groups would be more interesting and informative. The model would then be more amenable to testing in the context of the abiotic and biotic drivers of intertidal diversity patterns.

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